European Agency for Safety and Health at Work

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Musculoskeletal disorders and psychosocial risk factors in the workplace — statistical analysis of EU-wide survey data

Report

European Agency for Safety and Health at Work

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Table of Contents

List of figures and tables

Executive summary

Background

A major challenge for health at work: finding ways to tackle musculoskeletal disorders

Musculoskeletal disorders (MSDs) are the primary work-related health problem in the EU. The most recent publicly available data from the ad-hoc module on 'Accidents at work and other work-related health problems' (2013) of the European Union Labour Force Survey (EU-LFS) indicate that 60 % of all workers with a work-related health problem identified MSDs as their most serious issue, while 16 % pointed to stress, depression and anxiety (EU-OSHA, 2019)([1]). Recent trends in the labour market, in particular digitalisation, the increase in computer use and the reduction in physical labour, even in industry, have resulted in faster and more complex work, more repetition and more work in prolonged static positions and when adopting bad postures, for instance while working from home at an unadjusted workstation. These trends may be associated with an increase in mental health problems, such as stress and mental exhaustion, as well as physical health problems, including MSDs. This is the basis for the two main questions of this study: the first question is whether and how these two health concerns are linked and the second is what preventive strategies are implemented to tackle the problem of MSDs in workplaces across the EU.

Definitions of the core concepts: musculoskeletal disorders, wellbeing, biomechanical factors and psychosocial factors

The study centres around two health outcomes: MSDs and wellbeing. **MSDs** refer to periarticular diseases of the limbs and spine, and to a range of multiple or localised pain syndromes. More specifically, work-related MSDs of the limbs and/or spine are painful diseases of the periarticular soft tissues (muscles, tendons, vessels) and peripheral nerves that are caused by occupational overstraining. MSDs can arise suddenly and be short lived (fractures, sprains and strains) or evolve into lifelong conditions associated with ongoing pain and disability. In this report, three different types of MSDs are studied: backpain, MSDs of the upper limbs and neck, and MSDs of the lower limbs.

Mental **wellbeing** is defined by the World Health Organisation (WHO) as a 'state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community' (WHO, 2005, p. 19). It is a broad concept that encompasses feelings of burn-out, emotional distress, symptoms of depression, somatic symptoms, cognitive symptoms, and symptoms of energy and vitality.

The study also distinguishes two main types of factors associated with health outcomes: biomechanical factors and psychosocial risks. MSDs may be caused by **biomechanical factors** in the physical work environment, in particular **biomechanical stress**, which refers to stress caused by hazardous work positions and to physical stress on the body. It includes lifting heavy loads or people, maintaining a bad posture and prolonged sitting (which also has an important cardiovascular effect). However, despite the natural relationship between such strains and MSDs, few studies to date provide strong evidence of direct links, probably because multiple conditions, including biomechanical factors, psychosocial factors and worker characteristics, together determine whether or not an individual will develop an MSD.

Psychosocial risks are defined by the European Agency for Safety and Health at Work (EU-OSHA) as those aspects of the design, organisation and management of work, and its social and environmental context, that can cause psychological, social or physical harm. The International Labour Organisation (ILO) employs the job demands-resources framework, referring to work-related (mental) stress as being 'determined by psychosocial hazards found in: work organization, work design, working conditions, and labour relations … It becomes a risk to health and safety when work exceeding the worker's capacity, resources and ability to cope is prolonged'.

([1]) For an overview report, see EU-OSHA (2019). *Work-related musculoskeletal disorders: prevalence, costs and demographics in the EU*. European Agency for Safety and Health at Work. https://osha.europa.eu/en/publications/work-related-musculoskeletal-disorders-prevalence-costs-and-demographics-eu/view

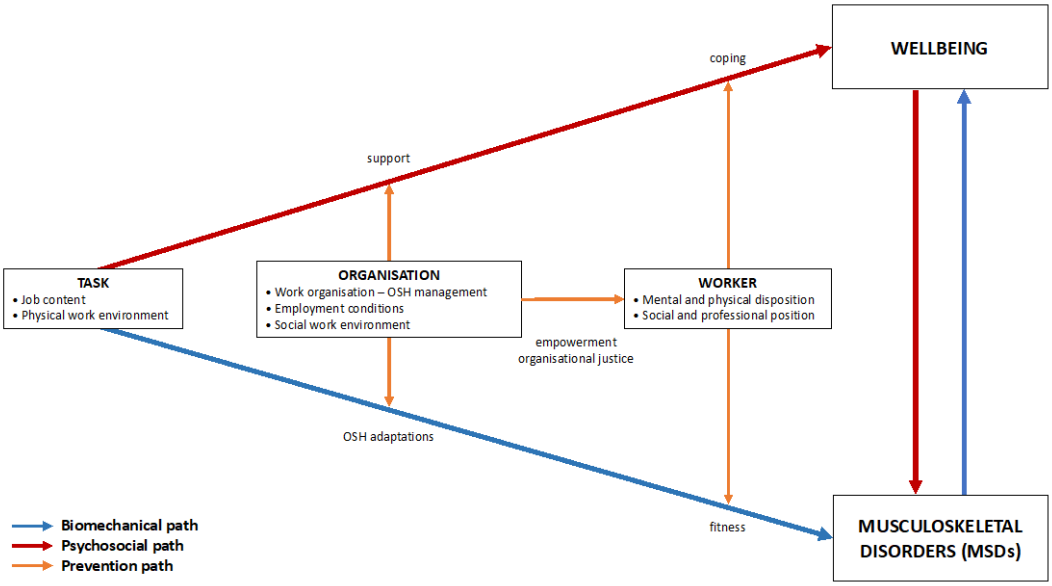
Conceptual model

A conceptual model for work-related mental and physical health risks

The **conceptual framework** adopted in this study (Figure 1) is built on the literature and runs in two directions, explaining MSDs on one hand and wellbeing on the other. This model depicts three paths of interest:

- The **biomechanical path** between physical strains at work and wellbeing relates to factors such as repetitive movements or lifting heavy loads. In this pathway, wellbeing is partly explained by MSDs, which are caused by physical health risks at work.
- The **psychosocial path** goes from psychosocial strains at work to MSDs. Here, MSDs are partly explained by wellbeing, which may be caused by psychosocial factors. In addition to aspects relating to job content and social work environment, various aspects of work organisation are also considered psychosocial factors that may affect the risk of developing MSDs.
- The **prevention path** represents the different ways in which psychosocial factors (e.g. supportive management, autonomy empowering workers to cope with high demands), worker characteristics (e.g. fitness levels) and occupational safety and health (OSH) management practices to activate them (e.g. OSH training) influence the above relationships.

Figure 1: Conceptual framework for analysing work-related risks for MSDs and wellbeing



Source: Authors' elaboration

A multi-method, multi-survey examination

Several quantitative methods were used to examine the research questions (cluster analyses, multivariate analyses). In addition, qualitative feedback was gathered from experts at focus group meetings to verify the findings and add to their interpretation.

For the statistical analyses, large sample data covering the 27 EU Member States (EU-27) from the sixth wave of the European Working Conditions Survey (EWCS, 2015) ([2]) and the third European Survey of Enterprises on New and Emerging Risks (ESENER-3, 2019) ([3]) were used. The EWCS involves asking workers for information on job characteristics and health outcomes. In ESENER, establishments

([2]) Eurofound (2015). *Sixth European Working Conditions Survey*. Available at: https://www.eurofound.europa.eu/surveys/2020/european-working-conditions-survey-2020
([3]) EU-OSHA (2019). The Third European Survey of Enterprises on New and Emerging Risks. Available at: https://visualisation.osha.europa.eu/esener/en/survey/overview/2019

are the basic units and information on management practices is registered. The two datasets have been linked using sector, country and firm size as identifiers.

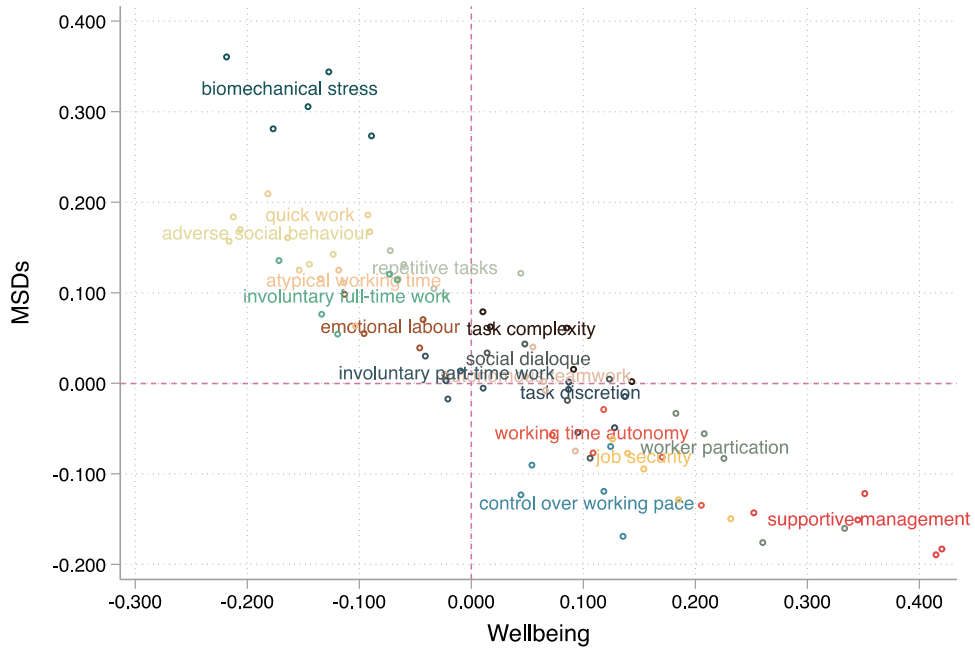
Findings

Musculoskeletal disorders and wellbeing have opposing relationships with the same job characteristics

At the job level, specific job characteristics can have an influence on the wellbeing of the employee and on the MSD-related risks that the employee is confronted with. Figure 2 presents the associations between job characteristics and wellbeing and MSDs. Four main conclusions can be drawn:

1. Job characteristics that have a strong positive correlation with wellbeing (e.g. supportive management) have a strong negative correlation with MSDs, and vice versa (e.g. biomechanical stress).
2. With respect to MSDs, working conditions and in particular biomechanical factors have the strongest effect, while, with respect to wellbeing, employment conditions such as working time-related factors and psychosocial factors related to the social work environment have larger effects.
3. The estimated correlations in different regions of the EU are fairly comparable. The exceptions are for job security and worker participation, for which the correlations are noticeably stronger in the eastern, Baltic and Balkan Member States. This may be due to wider variation with respect to these aspects in regions with a lower degree of labour market institutionalisation.
4. Job characteristics corresponding to job demands tend to be positively associated with MSDs and negatively associated with wellbeing, while job characteristics that are resources are favourable, being negatively associated with MSDs and positively associated with wellbeing.

Figure 2: Cross-country comparisons of correlations between job characteristics, MSDs and wellbeing



Notes: Estimated correlations for five different regions (western Member States, Nordic Member States and Ireland, southern Member States, Baltic and Balkan Member States, and eastern Member States) are marked in the same colour.

Source: Authors' compilation based on EWCS sixth wave (2015) data

Psychosocial factors are associated with musculoskeletal disorders

While biomechanical stress is an important factor in relation to MSDs, as the correlations above suggest, psychosocial factors are also unambiguously connected to MSDs. Moreover, the combined effect of biomechanical and psychosocial factors is substantial and larger than the effects of economic factors (sector, occupation), worker characteristics (gender, age, education, origin) or country.

Table 1 (left-hand columns) shows the associations found between job characteristics and MSDs, thus exploring the evidence for the psychosocial pathway. The restricted model includes the job characteristics, economic factors and country effects; the full model adds controls for worker characteristics and the mediating variables from the conceptual framework (wellbeing and MSDs, as well as work-life balance and general health). It demonstrates that there is a clear direct adverse impact of working time-related variables. By including mediating and control variables in the 'full model', it is found that this effect is only partly mediated by a poor work-life balance, which is one consequence of excessive or irregular working time, leaving room for another consequence that is known to be detrimental for health: exhaustion or a lack of recovery time. Furthermore, there are strong favourable effects of worker participation, supportive management and perceived job security. The beneficial effect of the final two factors is likely to be due to their contribution to wellbeing. This underlines the importance of organisational justice, worker recognition and social support. Contrary to expectations, autonomy-related factors do not have any clear or significant effect.

In terms of the sociodemographic groups, country groupings and the economic categories, differences regarding MSDs have been observed in descriptive analyses (e.g. more MSDs are reported by women, migrant workers, workers in elementary occupations or larger firms); however, when included in the multivariate model, their contribution is minor and the initial differences appear to be due to differences in terms of job characteristics, as well as intermediary outcomes such as general health, work-life balance and wellbeing. In other words, the kind of work that people do and the way that work is organised matter more than who is doing the job. This is not withstanding the fact that individual variation — for example some workers being mentally or physically tougher than others or receiving more social support outside work — may be important; instead, the level of detail in the analyses permits only the conclusion that, in the main, MSDs cannot be explained simply in relation to sociodemographic characteristics.

Table 1: Associations between job characteristics and MSDs and wellbeing, providing evidence for the psychosocial and biomechanical pathways (ordinary least squares regression)

Job characteristic/background variables	MSDs		Wellbeing	
	Restricted model	Full model	Restricted model	Full model
Biomechanical factors				
Biomechanical stress	•••	•••	•••	ns
Repetitive tasks	ns	ns	••	••
Quick work	•••	ns	•••	ns
Job content				
Emotional labour	ns	ns	•	ns
Task complexity	•••	•••	ns	•
Autonomy				
Task discretion	•••	•••	ns	•
Control over work pace	ns	ns	••	ns
Autonomous teamwork	ns	ns	ns	Ns

Employment conditions				
Atypical working time	••	•	•••	ns
Working time autonomy	ns	ns	ns	ns
Involuntary part-time work	••	••	•	•
Involuntary overtime work	•••	•••	•••	•••
Job security	•••	ns	•••	•••
Social work environment				
Adverse social behaviour	•••	•••	•••	•••
Supportive management	•••	ns	•••	•••
Social dialogue	••	•	•••	•••
Worker participation	•••	•••	•••	•••
Worker and firm characteristics				
Gender – female/male (reference: male)		•••		•••
Education – low (reference)				
Educational level— mid/low		•		ns
Educational level — high/low		•••		ns
Age under 25 (reference)				
Age — 25-34/under 25		ns		ns
Age — 35-44/under 25		ns		ns
Age — 45-54/under 25		•••		ns
Age — over 55/under 25		•••		••
Migrant origin		ns		ns
Company size — under 10 employees (reference)				
Company size — 10-249 employees		ns		ns
Company size — over 249 employees		ns		ns
Mediating and control variables				
Wellbeing/MSDs		•••		•••
Work-life balance		•••		•••
General health		•••		•••
Constant and fixed effects				
Constant	•••	•••	•••	•••
FE occupation	Yes	Yes	Yes	Yes
FE sector	Yes	Yes	Yes	Yes
FE country	Yes	Yes	Yes	Yes

Model fit				
R^2	0.187	0.296	0.200	0.344
N	23,550	22,523	23,542	22,523

Notes: • unfavourable relationship, correlating positively with MSDs/negatively with wellbeing.
• favourable relationship, correlating negatively with MSDs/positively with wellbeing.
•p < 0.05; ••p < 0.01; •••p < 0.001
FE, fixed effects, i.e. controlling for occupation, sector and country; ns, not significant; R2, coefficient of determination. The restricted model includes the job characteristics, economic factors and country effects; the full model adds controls for worker characteristics and the mediating variables from the conceptual framework (wellbeing and MSDs, as well as work-life balance and general health).
Source: Authors' compilation based on EWCS sixth wave (2015) data

Biomechanical factors are associated with wellbeing, but psychosocial factors are the main driver

The right-hand side of Table 1 confirms that biomechanical factors are associated with wellbeing, and is derived in the same way as above. However, psychosocial factors are the dominant direct driver, mainly in the domain of the social work environment, where all variables have a highly significant effect on wellbeing. In addition, in terms of employment conditions, involuntary overtime work has a strong direct effect, and atypical working time appears to affect wellbeing by distorting work-life balance. Similarly, biomechanical factors appear to cause MSDs, as in the previous models, and, at the same time, MSDs are correlated with (worse) wellbeing, confirming the importance of biomechanical pathway in influencing wellbeing.

Furthermore, as for the previous models explaining MSDs, the variation between workers is not captured by sociodemographic factors or economic factors such as industry, occupation or company size. Instead, the job characteristics selected for this analysis appear to be decisive.

Establishments can be categorised into six types based on occupational safety and health risks and strategies

At the organisational level, establishments can be categorised based on the types of risks (physical, psychosocial, digital) that employees are confronted with in the organisation and the strategies employed to deal with these risks (participatory, procedural). By using cluster analysis, an OSH typology was developed that divides establishments into six OSH types (Table 2) based on ESENER-3 (2019) data. By linking these ESENER-3 data to the EWCS (2015) data, the different OSH types can be evaluated in terms of health outcomes, such as MSDs and wellbeing. Descriptive analyses suggest that the risks are mainly derived from the sector of economic activity, while the strategies to address them are linked to the size of the company/establishment. The six OSH types can be described as follows:

1. **High risk-high agency (HR-HA).** These establishments can be described as having a high-risk environment, albeit with adequate prevention strategies, including training, in place. In this cluster, employees are nearly always involved in dealing with risks (participatory strategies). This is the largest cluster in terms of the number of employees (accounting for 46 % of employees), but accounting for only 18 % of all establishments, meaning that therefore large establishments are found in this cluster. Despite the presence of OSH management practices in these enterprises, the high risks mean that outcomes in terms of wellbeing and MSDs are unfavourable.
2. **Physical-procedural (PH-PR).** Employees in these establishments are exposed to moderately high levels of biomechanical stress, with average scores for psychosocial hazards and a fairly high degree of preventive practices in place (procedural strategies), but formal worker representation and workers' participation are found less often. This appears to be a cluster with establishments meeting formal requirements but often foregoing employee participation. This cluster accounts for 14 % of employees and 17 % of establishments, and outcomes in terms of both wellbeing and MSDs are worse than in the other clusters.
3. **Psychosocial-procedural (PS-PR).** Employees in establishments in this cluster are exposed to very low levels of biomechanical stress, but some degree of psychosocial risks, and have low levels of formal and informal representation. Instead, there is a clear emphasis on psychosocial

risk prevention and on health awareness programmes, but not on training. In terms of employment, this is a small cluster, covering 6 % of workers in 11 % of establishments. It has favourable outcomes in terms of wellbeing and MSDs.

4. **Digitalisation-low agency (DI-LA).** In this cluster, average biomechanical stress and fairly high psychosocial risks are paired with a high degree of digitalisation. OSH assessments are carried out, but further prevention practices targeting psychosocial risks and health awareness are rare. There is, however, some degree of formal and informal worker participation. This is also a small cluster, covering only 6 % of workers and just 7 % of establishments. In line with the two roles that digitalisation can play, i.e. either relieving or enhancing stress among workers, this cluster has average to slightly unfavourable health outcomes.
5. **Psychosocial-participatory (PS-PA).** This group of establishments faces similar challenges to those in cluster 3 (PS-PR), but responds differently to these challenges. While mainly psychosocial risks are present, companies in this cluster put a strong emphasis on formal worker participation and workers' participation, but undertake a limited number of actions. Establishments in this cluster take action only when called upon to do so by employees. This cluster accounts for 16 % of employees in 19 % of establishments, meaning that these establishments are relatively small in size. This cluster is associated with favourable outcomes in terms of wellbeing and MSDs.
6. **Psychosocial-low agency (PS-LA).** Enterprises in this cluster are the opposite of those in cluster 1 (HR-HA): the cluster has low scores on nearly all dimensions, does not involve employees in dealing with potential biomechanical and psychosocial risks, and undertakes nearly no action to mitigate those risks. This cluster accounts for only 12 % of employees, but represents the largest proportion of establishments (27 %). Although few interventions in the workplace are taken in this cluster, the outcomes in terms of wellbeing and MSDs are favourable. This illustrates the paradoxical correlation that is often found between OSH strategies and (the extent of) worker representation on the one hand and health outcomes on the other: outside legal obligations, interventions usually take place only if and when problems are identified. This leads to the observation of worker participation and representation (related to higher awareness of OSH issues) being associated with unfavourable job outcomes.

Table 2: Prevalence of risks and strategies for the six OSH clusters and their shares (%)

Risks and strategies	Cluster					
	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA
OSH risks†						
Biomechanical stress	69	77	4	45	23	29
Psychosocial risks	66	50	47	60	44	44
Digitalisation	41	18	23	100	2	1
Participatory strategies†						
Formal employee representation	97	9	0	33	72	0
Workers' participation	73	16	14	38	75	0
Procedural strategies†						
OSH assessments	83	56	45	36	18	20
General OSH risk prevention	71	68	4	10	7	0
Psychosocial risk prevention	72	55	98	25	29	0
Health awareness programmes	74	54	54	10	44	23
OSH training	38	45	1	2	2	0
Shares (%)						
Establishments	18	17	11	7	19	27
Employees	46	14	6	6	16	12

Risks and strategies	Cluster					
	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA
Relationship to outcomes‡						
MSDs	- -	-	+ +	-/+	+	+
Wellbeing	- -	-	+ +	-/+	+	+ +

Notes: †Cells for the risks and strategies are coloured blue (low) to red (high), with numbers referring to the share (%) of establishments in the cluster with scores above the median for each of the risks or strategies dimensions (e.g. the numbers in the biomechanical stress row refer to the share of establishments in the cluster that falls within the group of 50 % of establishments with the highest biomechanical stress risks overall).
‡Favourability ratings are ranked as highly unfavourable (- -), unfavourable (-), mixed (+/-), favourable (+) or highly favourable (+ +).

Source: Authors' compilation based on ESENER-3 (2019) data

Conclusions

This study has focused on the characteristics of the jobs of individual workers, including biomechanical and psychosocial factors on the one hand, and on OSH management practices in establishments on the other, exploring how these factors are related to MSDs and wellbeing. The results suggest that substantial improvements in MSDs and wellbeing can be accomplished at the workplace level. Importantly, the main contributing factors are job characteristics and not sociodemographic factors or aspects related to country or economic (industry, occupation and company size) factors.

While some workplace characteristics may be more difficult to disentangle from the nature of the job, psychosocial factors that have a strong influence on MSDs or on wellbeing, including adverse social behaviour, atypical working time, job security, supportive management and worker participation, can be assessed and then addressed, eliminated or reduced. In contrast, when it comes to job autonomy, which was shown in previous research to reduce work-related stress, the preventive action may not be straightforward. This is because, although greater job autonomy may empower workers, it may also be related to poorer work-life balance, overwork or perhaps even isolation. The findings of the multivariate analyses suggest that latitude at individual level (task discretion, control over the work pace), collectively (autonomous teamwork) or in terms of employment conditions (working time autonomy) do not lead to favourable outcomes with respect to with MSDs or wellbeing.

Moreover, workplace risk assessments focusing on negative health outcomes should take into account that the relationship between MSDs and wellbeing goes in two directions, so a holistic approach to risk assessment is most likely to be successful. Further development of guidelines and the exchange of best practices between companies on how to prevent psychosocial risks and create a healthy company culture are needed.

Future research could invest in linking employee-employer data to combine individual level and workplace level information, and examine in more detail the interaction effects between the various biomechanical and psychosocial factors. Using a longitudinal panel design is advised to determine the direction of causality of the relationship between psychosocial factors and MSDs and between OSH interventions and health outcomes.

1 Introduction

Musculoskeletal disorders (MSDs) are the primary work-related health problem in the EU. The most recent publicly available data from the ad-hoc module on 'Accidents at work and other work-related health problems' (2013) of the European Union Labour Force Survey (EU-LFS) indicate that 60 % of all workers with a work-related health problem identified MSDs as their most serious issue, while 16 % pointed to stress, depression and anxiety (EU-OSHA, 2019b) ([4]). Recent trends in the labour market, in particular digitalisation, the increase in computer use and the reduction in physical labour, even in industry, have resulted in faster and more complex work, more repetition and more work in prolonged static positions, for instance while sitting at an unadjusted workstation or in a home office. As a consequence, workers may experience stress and mental exhaustion as well as musculoskeletal and cardiovascular problems (Eurofound & ILO, 2017, p. 80; Cockburn, 2021; EU-OSHA, 2021a, p. 9, b).

This study concerns the link between psychosocial risk factors (PSFs) at work and the occurrence and prevention of work-related MSDs, and how this influences workers' health and wellbeing. It contributes to a growing body of research that establishes the link between PSFs and MSDs. Theoretical models suggest a probable causal relationship between PSFs and MSDs, but this hypothesis needs further evidence and investigation. In addition, this study examines what workplace practices and strategies may be effective in preventing or managing psychosocial risks and MSDs. By connecting the evidence on the relationship between PSFs and MSDs with insights on existing practices, it is possible to assess the need for further action at the workplace or policy level ([5]).

This research is guided by the following main research questions (RQs), which cover the relationship between PSFs and MSDs at individual level, and prevention strategies at establishment level:

- **RQ-1.** Are psychosocial factors at work and MSDs linked?
- **RQ-2.** What factors are involved in such a link?
- **RQ-3.** How do these factors differ by sector, company size and characteristics of workers?
- **RQ-4.** How are psychosocial risks and MSDs, and their association, distributed across the EU?
- **RQ-5.** What preventive strategies are implemented to tackle the problem of MSDs in workplaces across the EU?

In this study, the relationship between PSFs and MSDs is examined using statistical analyses of the sixth wave of the European Working Conditions Survey (EWCS, 2015 data) and the third European Survey of Enterprises on New and Emerging Risks (ESENER-3, 2019a). The conceptual framework underpinning this research is derived from the literature.

The structure of this report is as follows. Chapter 2 defines the key concepts and situates them in a conceptual framework. In Chapter 3, the methodology for the study is described, including the data sources, the sample population, the methods used for the selection and construction of relevant variables for analysis, and the analytical strategy that was followed. Next the research questions related to the worker/individual level (RQ-1 to RQ-4) are investigated in Chapter 4, using descriptive methods, correlation analysis and multivariate analyses, and the research questions related to the establishment level (RQ-1, RQ-2 and RQ-5) are investigated in Chapter 5, using cluster analysis and multivariate analysis on linked data of the EWCS 2015 and ESENER-3. Finally, Chapter 6 concludes and formulates recommendations for policy and future research.

([4]) These data come from the EU-LFS ad hoc module 'Accidents at work and other health-related problems'.
([5]) This research will also contribute to EU-OSHA's 2020-2022 Healthy Workplaces Campaign 'Lighten the Load'. More information on the campaign is available at: https://healthy-workplaces.eu/

2 Conceptual framework

This chapter presents the conceptual framework underpinning the research. It presents the key concepts covered by the study — MSDs, psychosocial factors and the wellbeing of workers — and explains what relationships between these concepts are expected based on theory.

2.1 Definitions and concepts

2.1.1 Musculoskeletal disorders

MSDs is an umbrella term for medically established periarticular diseases of the limbs and spine, and for multiple or localised pain syndromes (Roquelaure, 2018). MSDs can range from those that arise suddenly and are short lived, for example fractures, sprains and strains, to lifelong conditions associated with ongoing pain and disability (WHO, 2020b). More specifically, work-related MSDs of the limbs and/or spine are painful diseases of the periarticular soft tissues (muscles, tendons, vessels) and peripheral nerves, which are caused by occupational overstraining, found in four body parts (Roquelaure, 2018):

- in the wrist, for example carpal tunnel syndrome, or in other words compression of the median nerve at the carpal tunnel, which is involved in gripping and dexterity; and tendinopathies of the extensor/flexor muscles of the fingers;
- in the elbow, for example diseases of the tendons of the external aspect of the elbow (tendinopathies of the lateral epicondyle muscles), which carry out gripping under strain; and ulnar nerve compression syndrome at the elbow;
- in the shoulder, for example diseases of the shoulder rotator cuff tendons (tendinopathies of the shoulder rotator cuff), caused in particular by movements and positions in which the arm is stretched out from the body;
- in the lower back, for example lumbar radicular pain (lower back pain that radiates into the lower limbs or predominantly radicular pain) caused by a herniated disc.

Each syndrome has a particular set of underlying causes (ILO, 2010). This is often a combination of repetition, force, posture and vibration (Buckle & Devereux, 2002). For example, repetitive forceful work may lead to common MSDs such as epicondylitis lateralis (‘tennis elbow’) and carpal tunnel syndrome (Katz & Simmons, 2002; Descatha et al., 2016; Hulshof et al., 2019). MSDs can also vary in severity and may be acute but transient, or may grow over time and become chronic. Note that pains in the lower limbs, such as the hips, legs, knees or feet, are not specified by Roquelaure (2018), or in the International Statistical Classification of Diseases and Related Health Problems (ICD-10) of the World Health Organisation (WHO), arguably because these issues are less common than pain in the upper limbs (Buckle & Devereux, 1999; WHO, 2011). Nevertheless, data from the sixth wave of the EWCS show that, in 2015, while 43 % of workers reported backache and 41 % reported muscular pains in the shoulders, neck and/or upper limbs, 29 % of the workers reported muscular pains in the lower limbs.

2.1.2 Psychosocial risks

Ergonomics is among the oldest of research fields in labour studies (Bernard, 1997), and has historically focused mostly on biomechanical factors. More recently, however, psychosocial factors have been added as both a cause of MSDs and as a basis for preventive strategies (Ariëns et al., 2001; Boisard et al., 2003; Coggon et al., 2013; Eurofound and EU-OSHA, 2014; EU-OSHA, 2020a, p. 23). In contrast to the health risks listed above, there is more ambiguity about the nature of these psychosocial factors, as the risks and consequences are less visible or direct. The European Agency for Safety and Health at Work (EU-OSHA) defines psychosocial risks as ‘those aspects of the design, organisation and management of work, and its social and environmental context, which can cause psychological, social or physical harm’ (EU-OSHA, 2007 p. 13). The French Institut National de la Santé et de la Recherche Médicale (Inserm) summarised the conceptualisations of psychosocial factors in the literature, and found references to ‘the psychological, social and relational constraints resulting from the organisation of work, up to all occupational exposures not involving physical and chemical agents’ (Inserm, 2011). Similarly, the International Labour Organisation (ILO) points to work-related (mental) stress as being ‘determined by psychosocial hazards found in work organisation, work design, working conditions, and labour relations. It emerges when the knowledge and abilities to cope of an individual worker or of a group are

not matched with the demands of the job and the expectations of the organisational culture of an enterprise. It becomes a risk to health and safety when work exceeding the worker's capacity, resources and ability to cope is prolonged' ([6]).

Psychosocial factors associated with jobs may result in work-related stress, which, when prolonged, may be harmful. Mental stress is a biochemical reaction intended to prepare the body for a fight or flight response and provide extra focus when perceiving an external threat (James & Brown, 1997). It is biologically measurable through elevated levels of cortisol and catecholamines (adrenalin, noradrenalin) in the blood and urine (Fried et al., 1984; Sluiter et al., 2000; Lundberg, 2002; Coggon et al., 2013). Although functional when exposed to immediate threats for improving vigilance, focus and reaction speed, in the longer run these hormones are harmful to the joints, as well as to the neurological and cardiovascular systems (Lundberg, 2002; Roquelaure, 2018).

When people are aware that they are under a lot of pressure, surveys can ask about the extent to which workers feel exposed to stressful situations or experience symptoms of stress, such as sleeping problems, headaches and fatigue. These factors can create a vicious circle because a lack of sleep causes additional stress (Sluiter et al., 1998). Psychosocial risk factors, such as time pressure or long working hours, may exhaust workers, and a poor work-life balance increases stress and can potentially lead to MSDs (Coggon et al., 2013). For example, being under severe time pressure is considered an 'attack on the system', leading to hypercontraction of the muscles, resulting in an increased risk of osteoarticular pain (Boisard et al., 2003).

2.1.3 Wellbeing

According to the WHO, health is defined as 'a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity' (WHO, 2020a, p. 1). It therefore equates mental wellbeing (henceforth 'wellbeing') with **mental health**, which is defined as 'a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community' (WHO, 2005, p. 19). Wellbeing is a broad concept that encompasses feelings of burn-out, emotional distress, symptoms of depression, somatic symptoms, cognitive symptoms, and feelings of energy and vitality (Kristensen et al., 2005; Pejtersen et al., 2010). In the research literature, wellbeing is frequently assessed using the WHO-5 (mental) Well-Being Index (Topp et al., 2015). This **subjective wellbeing** index relies on a five-item set of self-assessed Likert-type questions. These items are (1) 'I have felt cheerful and in good spirits', (2) 'I have felt calm and relaxed', (3) 'I have felt active and vigorous', (4)' I woke up feeling fresh and rested', and (5) 'My daily life has been filled with things that interest me'. For each item, workers are asked to indicate to what extent it applies to them — taking into account the preceding 14 days.

However, this conceptualisation is fairly complex for a number of reasons. First, psychological issues may often be harder to diagnose and label than visible, physical problems. It is important to be aware that a small set of questions on wellbeing is only an approximate measure. Second, subjective reporting may be influenced by cultural expectations and individual awareness. People who find themselves in a difficult situation may not express this feeling when comparing themselves with peers who are in a similar situation. Third, as the conceptual model will indicate, wellbeing is a state that can be a precursor, a sign or a consequence of specific mental or physical health problems. This means that contextualisation is important for tackling issues associated with wellbeing.

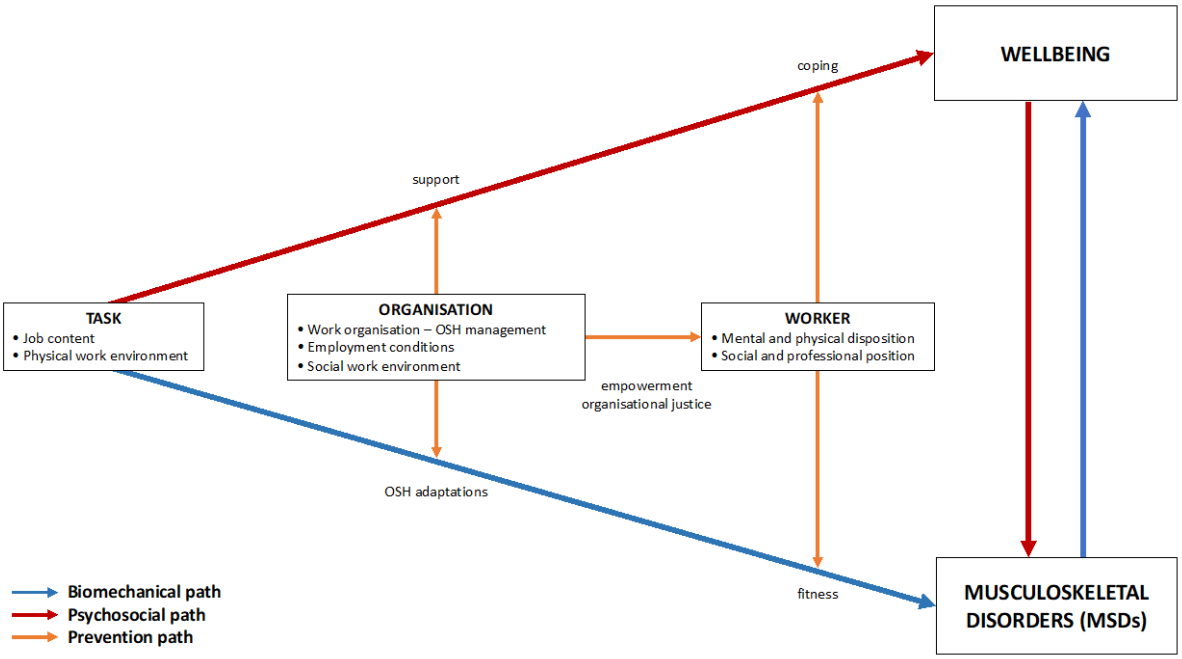
2.2 Modelling the relationship between psychosocial risk factors and musculoskeletal disorders

To assess the association between PSFs at work and work-related MSDs, the study starts from a **conceptual framework** that describes the theoretical links between PSFs and MSDs as identified in the literature and illustrated in Figure 1. The relationships in this framework depict a theoretical link between job characteristics and job outcomes that starts at the **task level**, involving the job content and

([6]) https://www.ilo.org/global/topics/safety-and-health-at-work/areasofwork/workplace-health-promotion-and-well-being/

the physical work environment, and is moderated by **organisational-level** job aspects related to management practices, work organisation and the social work environment, and by **worker characteristics**. It is useful to think about this scheme in terms of 'exogenous' factors that are determined outside the model and 'endogenous' factors that are explained by the model (MSDs, wellbeing). These endogenous factors set out a range of alterable aspects of work, which, under the discretion of the management, can be used as levers to improve work-related mental and physical health outcomes. By contrast, some worker characteristics or long-term dispositions cannot be changed (gender, age, personality, social background and course of life) and managers need to take these into account. Testing the model will show the relative importance of such fixed factors compared with manageable factors.

Figure 3: Conceptual framework underpinning the statistical analyses



Source: Authors' compilation

Job characteristics at task level and organisational level can be divided into the two axes of the job demands-resources model (JD-R model) (Demerouti & Bakker, 2011).

- **Job demands** are aspects of the job that require sustained physical or psychological effort (e.g. quick work, emotional labour, biomechanical stress, atypical working time, adverse social behaviour) and can become job stressors when the employee cannot recover adequately and the demands exhaust the employees' resources — this is called the 'health impairment process'.
- **Job resources** are job aspects that are necessary for the employee to achieve work goals, stimulate personal growth or help to reduce job demands (e.g. task discretion, job security, workers' participation, supportive management). Therefore, these job resources have a motivational potential and promote productivity, work engagement and wellbeing (through a motivational process). Job resources may buffer (through an interaction effect) the impact of job demands and therefore help to limit job strain.

This model has been widely applied to study productivity outcomes (Bakker & Demerouti, 2007; Schaufeli & Taris, 2014) and work-related mental health issues (Schaufeli, 2017; Schaufeli & Bakker, 2004), and less often used to study physical health issues (Bronkhorst, 2015; Schmid & Thomas, 2020; Gonzalez-Mulé & Cockburn, 2021). Other models, such as the perceived effort-reward imbalance model (Siegrist, 1996) and the organisational justice model (Elovainio et al., 2002) have a narrower scope that also fits into this scheme: workers experience stress when there is an imbalance between efforts and rewards (costs and gains), for instance when career opportunities are blocked, and, similarly, procedural unfairness or relational injustice may have negative psychological effects. These factors relate to the individual and collective positions of workers, which can be strengthened by adequate working time, job

security, participation and representation. Factors such as discrimination and, in general, the disadvantaged position of certain groups, for example temporary workers, migrant workers, and women, younger or older age groups, may significantly contribute to such relational injustice ([7]).

The conceptual framework runs in two directions: it explains **MSDs** and **wellbeing**, shown on the right-hand side in Figure 1, and both emerge as job outcomes and as mediating factors ([8]). Based on an overview of job quality indicators (Muñoz de Bustillo, 2011), job characteristics can be organised into three main dimensions: working conditions (job content, physical work environment, work organisation), employment conditions (earnings, working time, career and learning opportunities), and social work environment (social relations, support, participation, representation) (Szekér et al., 2017, p. 55).

The sources of MSDs primarily relate to **biomechanical factors** in the physical work environment (often referred to as ergonomic risks, e.g. Lundberg, 2002), in particular biomechanical stress, which refers to hazardous work positions and physical stress on the body. This includes lifting heavy loads or people, maintaining a bad posture and prolonged sitting (which also has an important cardiovascular effect). (Costa & Vieira, 2010). Despite the natural relationship between such strains and MSDs, no studies provide really strong evidence of this link, according to a summary of the research provided by EU-OSHA (2019b). This may be because combinations of factors cause MSD risks (e.g. lifting weight at old age, when overweight and under mental stress). There is, however, reasonable evidence for the cumulative effect of lifting, heavy physical work, repetitive movements, awkward postures, prolonged sitting, young and old age and gender, and psychosocial factors and conditions (time pressure, lack of support at work, job insecurity, poor mental health and adverse beliefs about MSDs). Note that many observed correlations, notably on the impact of MSDs by gender (e.g. Hooftman et al., 2009; Messing et al., 2009), are inconsistent, which may be due to confounding factors. For instance, differences in the sectoral or occupational distribution by gender, and different risks by sector and occupation, may establish a correlation between gender and specific MSDs and suggest higher risks in male-dominated sectors such as construction and manufacturing, although this depends on the MSD. Looking at MSDs within sectors and occupations, however, it does appear that risks are consistently higher for women (EU-OSHA, 2019b). Roquelaure (2018) summarises earlier research, finding indeed that work-related factors are responsible for a dominant fraction of all MSD risks, and therefore composition effects may be behind differences between sociodemographic groups.

As argued above, the range of **psychosocial factors** is broad, and these factors can be found at various levels and in the different domains of job characteristics, where they appear as demands (e.g. excessive demands or adverse social environment) or resources (e.g. social support, job autonomy), following the conceptual framework outlined above. This is a relatively underexplored area of research, and the accounts thus far use limited sets of psychosocial factors, often including stress, mood, job satisfaction, working time, task discretion, and sociodemographic and behavioural variables on an ad hoc basis (Costa & Vieira, 2010; Coggon et al., 2013).

The complex links between PSFs, on the one hand, and MSDs and wellbeing, on the other hand, can be represented by **three paths in the conceptual framework**:

- First is a **biomechanical path** between physical strains at work and wellbeing (the blue line in Figure 1), relating to factors such as repetitive movements or lifting heavy loads. This has long been the main focus of medical research and safety practices on MSDs at work (Driessen et al., 2010; Kennedy et al., 2010; Van Eerd et al., 2016).
- Second is the **psychosocial path** (the red line in Figure 1), which concerns the mental wellbeing of workers (psychological strains at work), and can translate into MSDs (Lanfranchi & Duveau, 2008). For instance, handling difficult clients, pupils or patients, or working to tight deadlines may increase stress levels and expose the body to hormones (e.g. cortisol, adrenaline, noradrenaline, catecholamine) that affect joints, tendons and muscles (Roquelaure, 2018).
- Third is the **prevention path** (in orange in Figure 1), which interacts with the biomechanical and psychosocial paths in a direct or an indirect manner, as detailed below.

([7]) For a similar discussion on the complex relations between socio-economic status and cardiovascular disease, see Havranek et al. (2015).

([8]) A mediating variable explains the relation between the independent and the dependent variable. It explains how or why there is a relation between two variables. A mediator can be a potential mechanism by which an independent variable can produce changes on a dependent variable.

As the framework shows, the biomechanical path and the psychosocial path overlap, creating a potential loop where the MSDs affect wellbeing and lead to conscious or unconscious behavioural changes, such as 'fear-avoidance', which means avoiding certain natural movements out of fear of pain returning, thereby creating new problems and reinforcing fears (Vlaeyen & Linton, 2000; Sullivan et al., 2005). This shows that causal relationships are difficult to pinpoint at any particular moment in time. Moreover, the relationship between wellbeing and MSDs will also be driven by common factors leading to both outcomes; for example, high demands stemming from work intensification may increase both physical workload and mental pressure leading to stress.

With respect to the direct and indirect prevention strategies, various theoretical approaches come into play. Some workers have a physical or mental disposition that limits or differentiates risks (e.g. physical differences in strength between men and women, or between younger and older workers), but this fitness or coping capability (depending on the pathway) can change over time, for instance with age (Van Eerd & Smith, 2020). In the workplace managers can implement adjustments to reduce biomechanical stress, and take measures to prevent adverse effects of psychosocial factors. Work organisation may give leeway to the workers (autonomy), so that they have control over the work process and the discretion to work in such a way as to minimise health risks (Roquelaure, 2018). In doing so, the management also empowers the workers to develop coping strategies and raises awareness of health risks. Similarly, the 'social work environment' involves communication and consultation, for instance in formal occupational safety and health (OSH) committees, through which OSH adaptations (e.g. assembly line and workstation adjustments) to improve ergonomics may be advocated. However, social dialogue also acts on the psychosocial pathway, providing social support and preventing negative aspects of social relations such as discrimination (organisational justice).

To conclude, **OSH management practices** should be seen as processes leading to improved job characteristics, whether it is by lowering demands (e.g. revised work schedules, automation of tasks), or improving resources (e.g. evaluating the quality of managerial support, improving the ergonomics of workstations). They can thus work via both the biomechanical and the psychosocial path, but the impact of the prevention strategies on health outcomes will depend on the efficacy of these processes.

3 Methodology

This study aims to establish the association between psychosocial risks and MSDs, and to highlight workplace practices for coping with MSD risks. Two EU-wide surveys provide data to approach these tasks: the **European Working Conditions Survey** (EWCS), which covers job characteristics and outcomes for workers, and the **European Survey of Enterprises on New and Emerging Risks** (ESENER), which covers practices at the workplace level. In this chapter, the data will be presented, and the principal constructs that fit in the conceptual framework will be defined and tested. Furthermore, a method to combine the two surveys is worked out, and the analytical strategy for the statistical analyses is explained.

3.1 Data sources

The EWCS is a wide-ranging survey on working conditions conducted by Eurofound every 5 years, beginning in 1990. In this research, data from the sixth wave of the EWCS, carried out in 2015, are used. The full dataset covers 35 European countries and is based on interviews with a total sample of 43,850 workers. With a broad scope focusing on work-related issues, it covers topics such as work organisation, working conditions, physical and psychosocial risks, work-life balance, health and wellbeing. With each EWCS wave, the questionnaire is revised, and questions may be added to address emerging concerns and policy debates. The EWCS is a cross-sectional survey designed to show associations rather than causal effects. However, some questions are retained in the original form across multiple waves to permit trends over time to be studied at an aggregate level. Data are freely available for research purposes and are well documented.

The EWCS 2015 data allow the relationship between musculoskeletal and psychosocial risk factors at the individual level of the **worker** to be studied, and include demographic characteristics and other relevant variables (i.e. occupation, sector) that will be used in the analyses. The EWCS dataset was used in recent Eurofound research on workers' health and wellbeing in the workplace and the relationship with job characteristics (Eurofound, 2017; Eurofound, 2019a,b).

ESENER has been conducted among **establishments** by EU-OSHA every 5 years since 2009. In the third ESENER (ESENER-3), in 2019, 45,420 establishments with at least five employees from 33 participating European countries participated. The survey is answered by the person 'who knows best about health and safety in the establishment' and takes a holistic view on safety and health risks and their management in the workplace. It addresses topics concerning the physical and psychosocial risks present in the workplace and how these risks are managed, the drivers of and barriers to OSH management in the organisation, and worker participation in OSH management. The questionnaire underpinning ESENER-3 was not much different from the questionnaire used for the second ESENER wave, of 2014, to facilitate comparisons over time. However, in the third wave, some questions regarding digitalisation and its potential impact on physical and psychosocial risks were added, and these are considered in the present study.

ESENER-3 allows the relationship between reported psychosocial and MSD risk factors at the level of the **establishment** to be studied, and links this to the measures taken to tackle both issues. Relevant control variables (i.e. company size, sector) are available and can be included in the analyses. Previous analyses conducted by EU-OSHA have used ESENER data and are particularly interesting in light of the current study. The ESENER-3 data can be especially helpful for identifying patterns in managing both psychosocial and MSDs risks, exploring the reported exposure and preventive measures implemented in establishments in different countries and sectors and of different sizes.

3.2 Population

The current study uses data from the current 27 Member States of the EU (EU-27). To present the results in a comprehensible way and map geographical patterns, countries are grouped into four regions (Table 1) that not only are geographically clustered, but also align with the welfare state regimes that are mentioned in the table.

Table 3: Regional groupings of countries used in this study

Region	Welfare state regime	Countries
Western MSs	Christian-democratic welfare states	Belgium, Germany, France, Luxembourg, the Netherlands, Austria
Nordic MSs and Ireland	Social-democratic welfare states and a liberal welfare state	Denmark, Ireland, Finland, Sweden
Southern MSs	Mediterranean welfare states	Greece, Spain, Italy, Cyprus, Malta, Portugal
Baltic and Balkan MSs	Post-socialist welfare state regimes	Bulgaria, Estonia, Croatia, Latvia, Lithuania, Romania, Slovenia
Eastern MSs	Post-socialist welfare state regimes	Czechia, Hungary, Poland, Slovakia

Notes: Welfare state regimes are based on Esping-Andersen (1990) and Iversen & Wren (1998). For the cluster analysis underpinning this proposed typology, see Annex 1. MSs, European Union Member States.

The target population of the EWCS is the employed population. In the current study, the sample was restricted to **employees** (83 % of cases, representing 85 % of the workforce in the EU-27), excluding the self-employed with employees and the solo self-employed (16 % of cases, 15 % of the workforce). The final number of workers in the EWCS subsample after selecting the EU Member States and restricting the sample to employees is 28,217. As mentioned above, the units in ESENER-3 are **establishments** with at least 5 employees. The final number of establishments in the EU-27 included in the ESENER-3 subsample is 37,460 ([9]).

3.3 Variables and constructs

In this section, the variables and constructs used in the analyses are presented ([10]). Additional methodological background, references to the survey questions and graphs comparing the EU-27 Member States (which are briefly discussed below) can be found in Annex 1. All variables have been normalised, meaning that they range from 0 (minimum), which is the lowest possible score (i.e. none of the items apply, or all have the lowest possible value), to 1 (maximum), which is the highest possible score (i.e. all items apply and have the highest possible value). For instance, the wellbeing scale uses five items asking whether respondents felt well, with a six-point scale from ‘at no time’ to ‘all of the time’: a score of 0 would mean that, on each item, the respondent signalled ‘at no time’, while a score of 1 would mean that the respondent answered ‘all of the time’ on all items.

([9]) Cross-country comparative proportional weights (w5), provided in the EWCS, are used to weight cases throughout all analyses. Unless otherwise specified, in ESENER-3 the proportional employee weights (empprop) are used to weight cases so that they reflect the share of employees to which the data applies.

([10]) The scales for the EWCS data draw from earlier research on the sixth wave of the EWCS for Belgium (Lamberts et al., 2016, p. 344) and from work on job types (Szekér et al., 2017), but all scales here have been revised and their reliability was optimised.

Table 4: Selected variables and constructs from the EWCS (2015) and ESENER-3 (2019) data

Dimension	Variables and constructs
Working conditions	Job demands: biomechanical stress [ab], quick work [a], repetitive tasks [a], digitalisation [b], emotional labour [a], psychosocial risks b, task complexity [a] Job resources: autonomous teamwork [a], task discretion [a], work pace control [a]
Employment conditions	Job demands: atypical working time [ab], involuntary overtime work [a], involuntary part-time work [a] Job resources: job security [a], working time autonomy [ab]
Social work environment	Job demands: adverse social behaviour [a] Job resources: formal employee particitpation [b], social dialogue [a], supportive management [ab], worker participation [ab]
Company	Characteristics: sector [ab], size [ab] Prevention strategies: general OSH prevention [b], health awareness programmes [b], OSH risk assessments [b], OSH training [b], psychosocial risk prevention [b]
Worker	Age [a], education [a], gender [a], ethnic origin [a], occupation [a]
Job outcomes	Mental health problems [a], MSD [a], perceived health impact [a], general health [a], wellbeing [a], work-life balance [a]

Note: [a] EWCS data; [b] ESENER data

Table 2 shows the selection of variables and constructs within the three domains of job characteristics: working conditions, employment conditions, social work environment. Each construct or variable used in the analyses is further described below. The job characteristics are categorised as either job demands or job resources, and a distinction can be made between biomechanical factors (biomechanical stress, quick work, repetitive tasks) and psychosocial factors (all other job characteristics in the table). Other worker-level and company-level variables and health outcomes are listed separately. Table 3 and Table 4 show basic statistics and reliability scores for the constructs from the EWCS (2015) and ESENER-3 data. In addition, Figure 8 and Figure 9 in Annex 2 show the distribution of the job characteristics across the EU-27 Member States grouped by country cluster. The main differences are briefly addressed here in the discussion of each job characteristic. As a rule, however, the variation between countries is fairly limited and no strong regional patterns across all job characteristics were detected, which is emphasised by the multivariate analyses.

Table 5: Summary statistics for the constructs based on EWCS data

Variable	EU-27 avg	EU-27 med.	Min.	Max.	SD country	Cr. α KR20	Eigen-val. (#)	Type
Working conditions								
Biomechanical stress	0.27	0.25	0	1	0.03	0.66	1.26 (1)	metric
Repetitive tasks	0.33	0.00	0	1	0.08	0.64	1.27 (1)	metric
Quick work	0.43	0.42	0	1	0.07	0.79	1.09 (1)	metric
Control over work pace	0.62	0.75	0	1	0.05	0.55	1.45 (1)	metric

Variable	EU-27 avg	EU-27 med.	Min.	Max.	SD country	Cr. α KR20	Eigen-val. (#)	Type
Emotional labour	0.47	0.50	0	1	0.05	0.65	1.99 (1)	metric
Task complexity	0.72	0.80	0	1	0.07	0.64	2.17 (1)	metric
Task discretion	0.65	0.67	0	1	0.11	0.76	2.11 (1)	metric
Autonomous teamwork	0.23	0.00	0	1	0.08	0.76	2.24 (1)	metric
Employment conditions								
Atypical working time	0.28	0.23	0	1	0.05	0.68	1.16 (1)	metric
Working time autonomy	0.42	0.33	0	1	0.11	0.54	1.24 (1)	metric
Involuntary part-time work	0.10	0.00	0	1	0.04	n.a.	n.a.	binary
Involuntary full-time work	0.23	0.00	0	1	0.07	n.a.	n.a.	binary
Job security	0.59	0.50	0	1	0.07	0.04	0.02 (0)	metric
Social work environment								
Supportive management	0.72	0.75	0	1	0.03	0.89	3.48 (1)	metric
Adverse social behaviour	0.20	0.00	0	1	0.07	n.a.	n.a.	binary
Social dialogue	0.52	0.67	0	1	0.12	0.70	1.81 (1)	metric
Worker participation	0.49	0.50	0	1	0.06	0.81	2.29 (1)	metric
Health outcomes								
Any MSD	0.59	1.00	0	1	0.09	n.a.	n.a.	binary
MSD	0.39	0.33	0	1	0.07	0.71	1.86 (1)	metric
Backache	0.45	0.00	0	1	0.07	n.a.	n.a.	binary
Shoulder, neck and upper limb pain	0.42	0.00	0	1	0.09	n.a.	n.a.	binary
Lower limb pain	0.29	0.00	0	1	0.07	n.a.	n.a.	binary
Wellbeing	0.69	0.72	0	1	0.03	0.88	2.93 (1)	metric
Mental health problems	0.27	0.20	0	1	0.06	0.61	2.08 (1)	metric
Work-life balance	0.74	0.75	0	1	0.03	0.76	1.92 (1)	metric
Health impact	0.25	0.00	0	1	0.07	0.76	1.55 (1)	binary
General health	0.75	0.75	0	1	0.05	n.a.	n.a.	metric

Notes and abbreviations:

Avg: pooled average; Cr. α/KR20: Cronbach's alpha reliability test/Kuder-Richardson Formula 20 reliability test for constructs with binary items; Eigen-val. (#): size of the Eigenvalue of the first factor and number of factors with Eigenvalue above 1; med.: pooled median; SD country: standard deviation for country means (measure for cross-national variation); n.a.: not applicable; min.: minimum; max.: maximum.

Source: Authors' compilation based on EWCS sixth wave (2015) data

Table 6: Summary statistics for the constructs based on ESENER data

Constructs	EU-27 avg	EU-27 med.	Min.	Max.	SD country	Cr. α KR20	Eigen-val. (#)	Type
Primary constructs								
Biomechanical stress	0.61	0.75	0	1	0.06	0.44	1.05 (1)	metric
Psychosocial risks	0.44	0.50	0	1	0.11	0.55	1.5 (1)	metric
Digitalisation	0.37	0.33	0	1	0.03	0.42	1.71 (1)	metric
Formal employee representation	0.70	1.00	0	1	0.12	n.a.	n.a.	metric
General OSH risk prevention	0.61	0.60	0	1	0.07	0.56	1.58 (1)	metric
Health awareness programmes	0.44	0.50	0	1	0.10	0.66	1.93 (1)	metric
OSH risk assessment	0.64	0.80	0	1	0.11	0.56	1.75 (1)	metric
OSH training	0.55	0.67	0	1	0.07	0.52	1.32 (1)	metric
Psychosocial risk prevention	0.49	0.60	0	1	0.10	0.64	2.04 (1)	metric
Workers participation	0.77	0.67	0	1	0.06	n.a.	n.a.	metric
Secondary constructs								
Difficulty	0.41	0.43	0	1	0.07	0.81	2.72 (1)	metric
Extrinsic motivation	0.85	0.90	0	1	0.05	0.65	1.29 (1)	metric
Inspection	0.52	1.00	0	1	0.15	n.a.	n.a.	binary
Psychosocial risk plan	0.30	0.00	0	1	0.13	n.a.	n.a.	binary
Risk assessment plan	0.86	1.00	0	1	0.11	n.a.	n.a.	binary

Notes and abbreviations: Avg: pooled average; Cr. α/KR20: Cronbach's alpha reliability test/Kuder-Richardson Formula 20 reliability test for constructs with binary items; Eigen-val. (#): size of the Eigenvalue of the first factor and number of factors with Eigenvalue above 1; med.: pooled median; SD country: standard deviation for country means (measure for cross-national variation); n.a.: not applicable; min.: minimum; max.: maximum.

Source: Authors' compilation based on ESENER-3 (2019) data

3.3.1 Working conditions

Working conditions, as defined here, involve the physical work environment (physical risks or hazards), the job content and work organisation. They relate to all aspects of work related to the completion of tasks. The constructs selected include a group of three **biomechanical factors** (biomechanical stress, quick work, repetitive tasks) and seven **psychosocial factors**, which include factors relating to the job content (task complexity, emotional labour) and to the work organisation, in particular the degree of job autonomy with respect to task execution, which is an important job resource in the literature (task discretion, work pace control, autonomous teamwork). Note that the psychosocial factors from the ESENER data (digitalisation, psychosocial risks) encompass a broader range of factors, as explained below.

Biomechanical stress (EWCS and ESENER) refers to work-related hazards that can lead to MSDs. As outlined previously, they are referred to by a range of physical risks that have an impact on posture or joints. The scale derived from the EWCS data accounts for vibrations from tools and machines, tiring or painful positions, lifting or moving people, carrying or moving heavy loads, sitting, and repetitive hand or arm movements. In the EU-27 workers experience biomechanical stress in the workplace with an average score of 0.27 (on a scale from 0 to 1), with very few variations between countries or regions.

The dichotomous items relating to biomechanical stress (in the workplace) in the ESENER questionnaire are similar: lifting or moving people or heavy loads, repetitive hand or arm movements, and tiring or painful positions. Again, based on these items, a normalised scale was computed. The average score across the EU-27, based on responses from workplaces, is 0.61 (on a scale from 0 to 1), again with limited regional variation.

Quick work (EWCS) refers to time pressure, namely to jobs involving working at very high speed or working to tight deadlines. An average score of 0.43 (on scale from 0 to 1) is calculated for workers reporting doing quick work, with moderate variation between regions, as the scores are lower in most Member States in the Eastern region and in the Baltic and Balkan MSs.

Repetitive tasks (EWCS) refer to having to perform tasks of less than 1 minute or less than 10 minutes. Repeating the same movements can increase biomechanical stress and the risk of injury, but repetitive tasks may also cause boredom and reduce the sense of meaningfulness of work and hence worker's wellbeing. The indicator takes a value of 0 if no repetitive tasks of under 10 minutes or under 1 minute are performed, 0.5 if tasks of under 10 minutes but not under 1 minute are performed, and 1 if tasks of under 1 minute are also performed. Across the EU-27, an average score of 0.33 for employees performing repetitive tasks, with 55.03 % of employees not undertaking repetitive tasks, 21.82 % doing tasks of less than 10 minutes but more than 1 minute, and 22.30 % also doing repetitive tasks of less than 1 minute. There is some variation between the Members States of the EU, as jobs with repetitive tasks appear to be more common in the southern Member States.

Digitalisation (ESENER) is one of the technological 'megatrends' of the world of work today, and it poses both opportunities and challenges (Cockburn, 2021; EU-OSHA, 2021b); therefore, it can be considered to have increased both as a job demand and a job resource. The relevant set of questions from ESENER relates to the use of fixed or mobile computers and wearables, interactions with robots and technological control over work processes. The average score on the scale is 0.37 (on a scale from 0 to 1), yet variation between countries is minimal, pointing to the ubiquity and universality of technological change.

Emotional labour (EWCS) is related to the inter-personal contacts that are typical of jobs in the service sector (e.g. health care, accommodation). Emotional labour requires workers to display appropriate but non-genuine emotions, which is mentally stressful (Jeung et al., 2018). In addition to the forced personal emotions, workers who need to deal with people may also need to manage the emotions of the people they interact with. Questions in the EWCS that relate to emotional labour ask whether or not the main paid job involves dealing with people who are not colleagues, handling angry clients, pupils, patients, etc., and being in situations that are emotionally disturbing and depend on direct demands from people, for example customers, passengers, pupils, patients. All variables were dichotomised before making the sum scale, with cut-offs being set at the median for normally distributed variables and around the first tertile for left-skewed distributions. For dealing with non-colleagues this is at 'around half of the time' (52.69 %), for handling angry people at 'around one quarter of the time' (37.57 %), and for being in emotionally disturbing situations also at 'around one quarter of the time' (32.00 %). The average score for emotional labour is 0.47 (on a scale from 0 to 1) across the EU-27, with limited variation between Member States.

Psychosocial risks (ESENER) are covered by one set of questions in the ESENER questionnaire, asking about whether or not workers are exposed to, for instance, time pressure, poor communication or cooperation, dealing with difficult clients, or long or irregular working hours in the workplace. The set of questions also includes a question on the fear of job loss, which was dropped after reliability analysis. A normalised sum scale was computed. The average score on psychological hazards in the EU-27 is 0.44 (on a scale from 0 to 1). Levels are substantially higher in the Nordic and western region than the two eastern regions.

Task complexity (EWCS) may generate a sense of meaningfulness for the worker; however, in the absence of sufficient resources, it can increase stress and exhaustion and have a negative impact on wellbeing. Questions in the EWCS relating to task complexity relate to meeting precise quality standards, self-assessment of the quality of your own work, solving unforeseen problems on your own, complex tasks and learning new things. The set also covers 'monotonous tasks', but this item was excluded to improve the reliability of the construct. The final construct is a normalised sum scale of the selected items. The average score across the EU-27 is 0.72 (on a scale from 0 to 1), with moderate variation across the EU-27; notably, jobs were reported to be more complex in the Nordic region and Ireland, and also in Estonia, Luxembourg, Malta and Austria.

Task discretion (EWCS) refers to whether or not, and the extent to which, the worker can decide when, how and the speed at which work is done, according to what is best for them. The related questions in the EWCS refer to whether or not workers are able to choose or change the order of tasks, methods of work, and speed or rate of work. A normalised sum scale of the items was computed. The average score across the EU-27 is 0.65, and more variation was observed across the EU-27 than with other job characteristics. Task discretion is, on average, high in the Nordic region, as well as in Estonia, Luxembourg, Malta and the Netherlands, and remarkably low scores are recorded in the southern and Balkan regions, namely in Bulgaria, Greece, Cyprus, Portugal and Romania.

Autonomous teamwork (EWCS) is a collective form of job autonomy in which responsibilities for task execution and work organisation are delegated to teams. Autonomous teams (also 'autonomous work groups') are defined as groups of interdependent workers, who regulate much of their own task behaviour around relatively whole tasks. These groups are generally allowed to select and train new members, set their own work pace, supervise most of their own activities and often trade jobs among themselves (Rao et al., 1987). Therefore, benefits partially run through the individual autonomy that autonomous teams provide (Mierlo et al., 2001), but teams in general bring together workers with complementary skill sets, so that individual job demands can be relaxed and talents can be employed with less effort. The EWCS asks whether or not team members can autonomously decide on the division of tasks, the head of the team and the timetable of work. The normalised sum scale of the dichotomous items was computed. The average value in the sample population is 0.23 (on a scale from 0 to 1) %, and there is a fair degree of variation between Member States, with higher values in the Nordic region and Ireland, while most countries in the southern region have much lower scores.

Work pace control (EWCS) is another measure of time pressure as well as latitude. The questions in the EWCS refer to the pace of work being dependent on the work done by colleagues, numerical production or performance targets, automatic speed of a machine or movement of a product, and direct control by the boss. Control over the work pace is at an average score of 0.62 (scale from 0 to 1) in the EU-27, with overall comparable levels across countries.

3.3.2 Employment conditions

Employment conditions are those job characteristics that are exchanged when a worker offers their labour to an employer: working time, remuneration, job security, learning opportunities and career prospects. In this domain, the job demands selected for this study are unpredictable, irregular, insufficient or excessive working hours, while the job resources are having working time autonomy to counter this and job security, which may define the position of the worker within the organisation ([11]). All of these job characteristics are considered psychosocial factors.

Atypical working time (EWCS) refers to unusual and irregular or unpredictable working time arrangements. The negative (long-term) effects of shift and night work on mental and physical health are well documented (Harrington, 2001; Kecklund & Axelsson, 2016). Moreover, working time irregularity makes it difficult to plan one's private life around work, worsening the work-life balance. The EWCS includes questions on unusual working hours (night work, weekend work, shifts of over 10 hours), on regularity (same number of hours every day or week, same number of days every week, fixed starting and finishing time, shift work), and on the notice period given for changes in working time arrangements.

([11]) Wage levels may play a similar role, but, as there are many missing values for the wage questions, and the correlation with the other job demands is strong, wages were excluded from the analyses.

First, the normalised sum scale of each of the three sets of questions was computed, after which the average was taken for this dimension. Atypical working time averages a score of 0.28 (on a scale from 0 to 1) in the EU-27, and is somewhat higher in the Nordic Member States and Ireland, followed by the eastern and western Member States. Atypical working time is below the EU average in all southern Member States.

The EWCS asks workers about the number of hours usually worked per week in their main paid job, and the number of hours they would prefer to work if they could make a free choice. Combining these two questions, involuntary overtime work is defined as working at least 35 hours a week and wanting to work fewer hours. Similarly, involuntary part-time work is defined as working less than 35 hours a week and wanting to work more. The consequence of such a mismatch may be problems with work-life balance or exhaustion from overtime work, or insufficient income or a lack of career opportunities. Typically, involuntary overtime work occurs in a crisis period, when there have been layoffs or a hiring freeze, which increases the workload for the remaining workforce; involuntary part-time work is more common in female-dominated industries, such as cleaning and accommodation. Involuntary part-time work affects 10.04 % of all EU-27 employees. Involuntary overtime work affects, on average, 22.76 % of employees in the EU-27, and is most common in the Nordic Member States.

Working time autonomy (EWCS) is the counterpart of atypical working time, as it is a resource for the worker, allowing employees to arrange their schedules according to their needs (Beckmann, 2015). It is a form of job autonomy with respect to employment conditions (Saragih, 2011). The EWCS includes questions on whether it is the worker or the company that sets working time arrangements, on how often workers can take breaks when they wish, and on the ease of taking an hour or two off to take care of personal or family matters. The three variables were first dichotomised and then the average was taken. Setting working time arrangements within limits or freely, being able to take breaks when they wish always or most of the time, and being able to take an hour or two off easily or fairly easily are considered to be associated with working time autonomy. The average score across the EU-27 is 0.42 (on a scale from 0 to 1), but there is a clear regional pattern, with more working time autonomy in the Nordic countries and Ireland, and in the western region. Germany is the exception in these groups of countries, while Estonia and Malta exceed the EU average in the other groups.

Job security (EWCS) can relate to the current job or the labour market employability of an employee. An open-ended contract may provide additional security, as well as career prospects. In general, workers with a greater sense of job security are in a less precarious position, giving them more bargaining power and the possibility to speak up when things go wrong in the company. The two questions on job security in the EWCS ask whether or not workers might lose their job the next 6 months and, if so, whether or not it would be easy to find a job of similar salary. The normalised sum scale was computed for this construct. Across the EU, the average score on job security is 0.59 (on a scale from 0 to 1), but there is a gradient within and between country clusters, with more job security in the Nordic Member States and Ireland, followed by the western Member States. With the exception of Malta, the lowest scores for job security were observed in southern Member States.

3.3.3 Social work environment

With respect to the social work environment, all variables are again psychosocial factors. Most are considered to be job resources that may be beneficial for workers' health: formal employee participation, social dialogue, worker participation and supportive management. On the other hand, adverse social behaviour is classified as a job demand, albeit of a particular type, as explained below.

Adverse social behaviour (EWCS) has a very strong impact on the wellbeing of employees. Based on the question in the EWCS, both harassment (bullying, physical violence, verbal abuse, humiliation, sexual intimidation) and discrimination based on age, race, nationality, sex, religion, disability and sexual orientation are considered to be adverse social behaviours. These issues are on their own fairly rare among the sampled population, with the exception of verbal abuse, which 12.46 % of employees reported experiencing in the course of the preceding month. Therefore, a dichotomous indicator was constructed instead of a scale to measure the occurrence of any of these forms of harassment or discrimination versus none. On average, 20.1 % of employees were harassed in the course of 1 year, and this number is notably larger in the western and Nordic Member States than in the other Member States. This is sometimes called the 'Nordic paradox'. There are various explanations for this paradox,

relating for instance to the awareness or labour market participation of vulnerable groups in these Member States (Humbert et al., 2021).

Social dialogue (EWCS), as defined by the ILO to 'include all types of negotiation, consultation or simply exchange of information between, or among, representatives of governments, employers and workers, on issues of common interest relating to economic and social policy … Social dialogue processes can be informal or institutionalised, and often it is a combination of the two' ([12]). The EWCS has three items to measure social dialogue: (1) the presence of a trade union, works council or similar committee representing employees; (2) the presence of a health and safety delegate or committee; and (3) the occurrence of regular meetings with employees. The average score on the social dialogue indicator is 0.52 (on a scale from 0 to 1), with a comparatively high degree of variation between countries, as there are higher levels in the Nordic region and in Belgium, France and Luxembourg, and lower levels in Greece, Lithuania, Hungary and Portugal.

Formal employee representation (ESENER) refers to social dialogue through legally recognised bodies. The ESENER questionnaire aims to verify the presence of a works council, trade union representation, a safety and health committee, or a safety and health representative. Following this definition, 83.6 % of the workforce in the EU-27 has some form of formal representation. If none of these bodies is present, the measure for formal employee representation is zero. An additional question asks about the frequency of discussions on safety and health between employee representatives and the management. If such formal discussions take place 'regularly', the maximum score of 1 is given. Intermediate values, where a representative body is present but discussions do not take place regularly, are uncommon. An average score of 71.9 % on this construct is registered for the EU-27, yet there is a comparatively high degree of variation between Member States and regions. Levels of representation are higher in the Nordic Member States and Ireland, and in the western Member States, and lower in the eastern and southern clusters.

Worker participation (EWCS and ESENER) is an informal type of social dialogue, also referred to as 'say'. The questions in the EWCS refer to individual worker participation, asking whether or not workers (1) are consulted before objectives are set, (2) are involved in improving the work organisation, (3) have a say in the choice of work colleagues, (4) are able to apply their own ideas in their work and (5) can influence decisions that are important for their work. A normalised sum scale of these items is computed. The average score on 'say' in the EU-27 is 0.49 (on a scale from 0 to 1). Cross-country variation is limited, although individual worker participation levels are somewhat lower in the southern region, Germany and Slovakia than in other regions.

The questions in ESENER, on the other hand, refer to collective worker participation, asking whether or not employees (1) have a role in the design and setting up of measures to address psychosocial risks and (2) are usually involved in the design and implementation of measures following a risk assessment. A third question asks how often safety and health issues are discussed in staff or team meetings. Similar to the construction of formal employee representation above, the average of the first two, dichotomous, variables was weighted by the frequency of discussions about safety and health issues and normalised to obtain a measure of the intensity of worker participation in establishments: a score of 0 means that workers are not involved and a score of 1 means that they are involved and regular discussions take place. The EU-27 average amounts to 0.77, again with limited cross-country variation.

Supportive management (EWCS) is generally taken to be an employee-centred style of leadership, which contrasts with a task-oriented style (Wood et al., 2020), thereby creating an environment in which workers feel good and show more commitment to the organisation (Onnis, 2015). The questions in the EWCS related to supportive management ask whether or not the immediate boss respects the worker as a person, gives praise and recognition for good jobs, is successful in getting people to work together, is helpful in getting the job done, provides useful feedback, and encourages and supports the worker's development. The normalised sum scale was computed. The average score in the EU-27 is 0.72 (on a scale from 0 to 1) and does not vary much between countries.

([12]) https://www.ilo.org/ifpdial/areas-of-work/social-dialogue/lang--en/index.htm

3.3.4 Company level

At the company level, **background characteristics** (based on NACE Rev. 2 sectors ([13]) and company size) and prevention practices are considered. The latter are referred to below in the analysis of ESENER data as 'procedural strategies', in addition to the forms of worker participation and representation mentioned previously in the domain of the social work environment ('participatory strategies'), and 'OSH risks' (psychosocial risks, biomechanical stress, digitalisation).

OSH risk assessments (ESENER) involve evaluating (1) the safety of machines, equipment and installations, (2) work postures, physical working demands and repetitive movements, (3) exposure to noise, vibration, heat or cold, (4) supervisor-employee relationships and (5) organisational aspects such as work schedules, breaks or work shifts. Another item from the ESENER questionnaire, 'dangerous chemical or biological substances', was excluded from the analysis, as it is unrelated to ergonomic or psychosocial hazards. The normalised sum scale of the selected items was computed. The average score across the EU-27 is 0.64 (on a scale from 0 to 1), and ample cross-country variation exists. In general, the Nordic Member States and Ireland, and the Baltic and Balkan Member States have higher levels. Lower levels are observed in Greece, Cyprus, Luxembourg and Slovakia.

General OSH risk prevention (ESENER) includes measures like (1) the provision of lifting and moving equipment, (2) task rotation to reduce physical strain, (3) encouraging breaks to prevent posture problems, (4) the provision of ergonomic equipment (e.g. chairs, desks) and (5) reducing working hours for people with health problems. The normalised sum scale was computed. The average score across the EU-27 is 0.61 (on a scale from 0 to 1), with some variation, notably higher values (more prevention measures) observed in the Nordic Member States and Ireland, and in the western Member States. The lowest scores are found in Bulgaria, Greece, and Slovakia.

Health awareness programmes (ESENER) are defined here as (1) raising awareness about healthy nutrition, (2) raising awareness on addictions, (3) promoting sports activities and (4) promoting physical exercise. The normalised sum scale of the dichotomous items was computed. The average score in the EU-27 is 0.44 (on a scale from 0 to 1) %, with half of the countries around that level, and some notable exceptions: Slovenia and Finland perform markedly better, while Czechia, Italy and Cyprus have much lower scores.

OSH training (ESENER) includes (1) training concerning the use and adjustment of working equipment, (2) training regarding psychosocial risk prevention and (3) training regarding lifting and moving heavy loads or people. The normalised sum scale of the dichotomous items was computed. The average score across the EU-27 is 0.55 (on a scale from 0 to 1), with higher scores in the Nordic countries and Ireland as well as in Spain, Italy and Slovenia. Training is less often provided (by the establishment) in Bulgaria, Greece, France, Cyprus, Lithuania, Luxembourg and Romania.

Psychosocial risk prevention (ESENER) includes (1) the reorganisation of work to reduce job demands and work pressure, (2) confidential counselling, (3) training on conflict resolution, (4) intervention if excessively long or irregular hours are worked and (5) allowing employees to take more decisions on how to do their job. The normalised sum scale was computed. The average score in the EU-27, is 0.49 (on a scale from 0 to 1), with strong regional variation. Higher scores are found in the Nordic countries and Ireland, as well as in part of western Member States. Furthermore, Malta and Romania perform above average and better than other countries in their country groupings, being on a par with the leading countries in the EU.

3.3.5 Worker characteristics and job outcomes

The sociodemographic background variables of **workers** in the EWCS are gender, age, education (based on the International Standard Classification of Education (ISCED)), occupation (based on the International Standard Classification of Occupations (ISCO-08)) and ethnic origin).

([13]) Eurostat: https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF

The health-related **job outcomes** in this study are MSDs, wellbeing, work-life balance, general health, perceived health impact of work and mental health problems. All outcome variables are found in the EWCS data.

MSDs (EWCS) are measured using three items in the questionnaire referring to problems occurring over the course of the preceding 12 months: (1) backache, (2) muscular pains in shoulders, neck and/or upper limbs, and (3) muscular pains in the lower limbs. The normalised sum scale of the dichotomous items was computed. On average, across the EU-27, a score of 0.39 is calculated, where a score of 1 means that every employee has all symptoms of MSD's. There is no strong geographical pattern: the score on the scale for MSDs varies from 0.25 in Hungary to 0.51 in France, Romania and Finland. As an alternative measure, a simple indicator was developed to account for those cases with any of the three symptoms (no fractional values). On average, this scored 0.59 (on a scale from 0 to 1) fro all employees, with a similar distribution across countries as the scale indicator.

Wellbeing (EWCS) is measured through the items from the WHO-5 scale included in the EWCS questionnaire: (1) 'I have felt cheerful and in good spirits', (2) 'I have felt calm and relaxed', (3) 'I have felt active and vigorous', (4) 'I woke up feeling fresh and rested', and (5) 'My daily life has been filled with things that interest me'. Across the EU-27, the average score for wellbeing is 0.69 on a scale from 0 to 1. Remarkably, there is very little variation between the Member States.

Mental health problems (EWCS) are measured using a question on experiencing stress at work, dichotomised when it occurs always or most of the time; three dichotomous items on headaches, anxiety and overall fatigue; and three items on sleep-related problems, which are dichotomised if any symptom manifests itself at least several times a week. The normalised sum scale of the dichotomised items and item sets was taken. The average score in the EU-27 is 0.27 (on a scale from 0 to 1). The distribution across countries indicates that there are more problems in southern Member States than elsewhere, but there is also variation within regions; for example, the situation is more favourable in Italy than in Malta, and in Germany than in France.

Work-life balance (EWCS) is measured by the frequency of the occurrence of five items: (1) worrying about work when not working, (2) feeling too tired after work to do household jobs, (3) not finding time for family because of work, (4) having concentration difficulties at work due to family responsibilities and (5) not finding time for job tasks because of family responsibilities. The average score across the EU-27 is 0.74 (on a scale from 0 to 1) with very limited cross-country variation.

Health impact of work (EWCS) is assessed using two questions, on (1) whether or not a worker thinks their safety or health is at risk because of work, and (2) whether or not work affects health (negatively). The average of the two items is taken. As data from a cross-sectional survey cannot be interpreted in a causal sense, this variable indicates whether or not workers see a causal link themselves. On average in the EU-27, 30.90 % of employees say that this is the case, but this tends to vary between Member States. The highest figures are recorded in Spain, France and Slovenia, while risks are thought to be much lower in Italy and Portugal.

General health (EWCS) is a control variable to check for the self-assessment of employees. Some people will judge their health to be worse than others, even though they suffer from the same health issues. Hence, by controlling for overall health, outcome variables such as wellbeing and MSDs can be interpreted as 'relative to the overall health of the worker'. The question 'How is your health in general?' was answered based on a five-point scale, from very good to very bad, that was normalised. The EU-27 average score for self-assessed health was 75.9 %. Most countries' scores are concentrated around the mean, but scores in Ireland, Greece and Cyprus are notably higher than the mean, and scores in the Baltic states and Italy are notably lower.

3.4 Analytical strategy

This report primarily gathers **statistical evidence** on the association between psychosocial factors on the one hand and MSDs and wellbeing on the other, and on the prevalence of prevention strategies aimed at improving those outcomes. To verify the results, check interpretations and gather qualitative feedback, two **focus group** sessions were held, bringing together a number of experts from across the EU and from a variety of fields: policy-makers, policy researchers, academic experts and prevention

advisors ([14]). The conclusions and recommendations from the focus groups have been taken into account in the interpretation of the results of the analyses below.

The analyses address the research questions outlined below.

RQ-1. Are psychosocial factors at work and MSDs linked?

Based on the conceptual framework, the association between psychosocial factors and MSDs was studied using multiple methods:

- The correlations between outcomes and between outcomes and job characteristics were investigated and are discussed in sections 4.1.3 and 4.1.4.
- Direct effects and the mediating role of wellbeing and MSDs in explaining one another were investigated in the stepwise multivariate analyses presented in sections 4.2.2 and 4.2.3.

RQ-2. What factors are involved in such a link?

Expanding the research question above, the full range of factors involved was studied in several steps:

- The descriptive statistics on health outcomes, sociodemographic groups, economic categories (firm size, occupation, sector) and geographical regions are discussed in sections 4.1.1 and 4.1.2.
- The correlation analysis of the job characteristics on one hand and MSDs and wellbeing on the other is presented in section 4.1.4;
- The uncontrolled, controlled and mediated effects estimated in the stepwise multivariate analyses are shown in sections 4.2.2 and 4.2.3.

RQ-3. How do these factors differ by sector, company size and characteristics of workers?

Background characteristics have been included in two ways:

- First, the relationship between the background characteristics and the health outcomes was investigated, both in the descriptive statistics (sections 4.1.1. and 4.1.2) and in separate steps in the multivariate models (sections 4.2.2 and 4.2.3).
- Second, by using these variables as controls for the direct effects of the job characteristics in the multivariate models, correlations can be revealed.

RQ-4. How are psychosocial risks and MSDs, and their association, distributed across the EU?

This research question is tackled in different sections:

- The observed prevalence of MSDs by sociodemographic group, economic category (firm size, occupation, sector) and geographical region is described by cross-tabulations in section 4.1.1.
- The observed levels of wellbeing by sociodemographic group, economic category (firm size, occupation, sector) and geographical region are described by cross-tabulations in section 4.1.2.
- The distribution of the association between psychosocial risks and MSDs across the EU-27 is found in section 4.1.4, which presents regional correlations with job characteristics.
- Country effects are accounted for in the multivariate models (sections 4.2.2 and 4.2.3).

RQ-5. What preventive strategies are implemented to tackle the problem of MSDs in workplaces across the EU?

Using ESENER data on preventive strategies and risks at the establishment level, this research question was tackled through the following steps:

- The variation in risks and strategies was represented by six OSH clusters, grouped by the type of preventive OSH strategies in place (section 5.1).
- The distribution of these types of preventive OSH strategies by the background characteristics of establishments is discussed in section 5.2, and the OSH strategy types were qualified in terms of health outcomes by linking the ESENER data to individual data on outcomes from the EWCS.
- Using the same link, the risks and strategies were directly referred to, to explain the prevalence of MSDs and levels of wellbeing (section 5.3).

([14]) We thank the participants from Business Europe, EU; Central Institute for Labour Protection, Poland; European Trade Union Confederation , EU; European Trade Union Institute), EU; Eurofound, EU; IDEWE (external service for prevention and protection at work), Belgium; Institute of Occupational Medicine , United Kingdom; and Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek (TNO), Netherlands.

4 The relationship between psychosocial factors and MSDs at the worker level

4.1 Descriptive statistics and correlation analysis

4.1.1 The prevalence of musculoskeletal disorders in the EU-27

This section presents data about the prevalence of MSDs, as observed in the employed population. Figures by gender and age are provided for the general population, and for country clusters (regions) and other sociodemographic and economic background variables (sector, occupation, organisation size, educational attainment and origin).

MSDs are more prevalent in women than men (61.21 % versus 57.44 %). This is true in all age groups. Moreover, there is an almost linear increase in the prevalence of MSDs by age, with a prevalence in the younger cohort of 49.25 %, compared with 67.88 % in the older cohort (Table 5). On average in the EU-27, 59.31 % of employees indicate suffering from at least one of the three types of MSDs reported (backache, neck pain, shoulder pain and pain in the upper limbs, and pain in the lower limbs).

Table 7: MSD prevalence by gender and age (years) in the EU-27 in 2015 (%)

Gender	Age (years)			
	<35	35-49	>50	All
Male	46.85	59.83	64.91	57.44
Female	51.64	61.10	70.97	61.21
All	49.25	60.45	67.88	59.31

Source: Authors' compilation based on EWCS sixth wave (2015) data

Differences are larger with respect to the geographical region (Table 6): the highest incidence is found in the Nordic countries and Ireland, followed by the Baltic and Balkan Member States. The lowest levels are found in the southern and eastern Member States. This is true for nearly all age groups, irrespective of gender.

Table 8: MSD prevalence by region, gender and age (years) in the EU-27 in 2015 (%)

Region	Gender and age (years)						All
	Male			Female			
	<35	35-49	>50	<35	35-49	>50	
Western MSs	49.27	62.49	65.57	54.71	65.00	70.28	61.42
Nordic MSs and Ireland	61.43	66.86	65.87	73.37	68.07	72.51	68.08
Southern MSs	34.15	55.60	61.38	45.03	54.34	71.64	54.10
Baltic and Balkan MSs	56.36	60.89	71.69	52.72	66.47	76.05	63.69
Eastern MSs	44.18	54.61	63.88	38.96	56.15	68.21	54.01
All	46.85	59.83	64.91	51.64	61.10	70.97	59.31

Notes: See Table 1 for the countries included in each group/region. MSs, European Union Member States.
Source: Authors' compilation based on EWCS sixth wave (2015) data

The prevalence by sector (Table 7) is based on a condensed form of the 1-digit NACE Rev. 2 classification, with 10 main sectors. As found in most of the literature, the sectors with the highest prevalence of MSDs among the workforce are agriculture (70.14 %) and construction (69.39 %), which are male-dominated sectors ([15]). However, in the female-dominated healthcare sector, the incidence is also above average, at 62.64 %. The lowest rates are found in financial services (49.71 %) and education (55.04 %). In all sectors, there is a sharp increase with increasing age and generally this is more pronounced for women than men. However, in commerce and hospitality (difference between the youngest and the oldest cohorts: +27.87 percentage points (p.p)) and health care (+17.54 p.p.), the increased incidence with age is noticeably larger among men.

Table 9: MSD prevalence by sector, gender and age (years) in the EU-27 in 2015 (%)

Sector	Gender and age (years)						All
	Male			Female			
	<35	35-49	>50	<35	35-49	>50	
Agriculture	64.54	68.38	79.35	60.07	62.06	84.05	70.14
Industry	47.15	58.70	66.44	47.00	60.99	78.70	59.28
Construction	59.03	72.67	78.54	59.88	62.37	69.53	69.39
Commerce and hospitality	42.55	61.18	70.42	50.10	61.97	69.76	57.47
Transport	49.89	59.73	61.15	44.63	63.64	74.34	58.90
Financial services	29.67	46.09	49.10	46.01	53.95	68.78	49.71
Public administration and defence	43.42	57.16	58.06	48.43	66.44	66.81	58.23
Education	40.69	47.67	56.28	46.51	57.91	64.81	55.04
Health care	38.94	57.98	56.48	57.37	64.16	70.87	62.64
Other services	46.25	57.56	59.83	54.66	57.93	73.44	58.2
All	46.85	59.83	64.91	51.64	61.1	70.97	59.31

Source: Authors' compilation based on EWCS sixth wave (2015) data

There is some debate regarding the relationship between the prevalence of MSDs and company size. On the one hand, in smaller companies there may be closer contact between management and workers, which may have a protective effect. On the other hand, larger companies may have more means to put safety procedures in place (Hasle et al., 2012; EU-OSHA, 2019b). It has therefore been suggested that workers are most exposed to MSDs in medium-sized companies. Table 8, however, suggests that, overall, there is a higher prevalence of MSDs in medium-sized companies (with 10-249 employees) and large companies (>249 employees) than in small companies (<10 employees) (59.37 % and 62.15 %, respectively, compared with 55.17 % in small companies). However, this relationship is true for only

([15]) For example, see EU-OSHA (2019b, section 3.2.2) for sectoral splits at item level using EWCS (2015) data.

women and young men; men aged between 35 and 49 report a higher incidence in medium-sized companies, and for men of over 50 years of age the prevalence of MSDs is lowest among those who work in large companies and highest among those who work in small companies ([16]).

Table 10: MSD prevalence by organisation size, gender and age (years) in the EU-27 in 2015 (%)

Organisation size (number of employees)	Gender and age (years)						All
	Male			Female			
	<35	35-49	>50	<35	35-49	>50	
<10	40.32	56.56	67.56	42.91	57.56	69.7	55.17
10-249	48.95	62.12	65.58	49.52	58.39	71	59.37
>249	50.68	58.99	62.51	60.71	67.75	72.11	62.15
All	46.85	59.83	64.91	51.64	61.1	70.97	59.31

Source: Authors' compilation based on EWCS sixth wave (2015) data

The relationship between MSDs and educational level is shown in Table 9. It has been suggested that a higher level of education is associated with more training in and awareness of health risks (Woods & Buckle, 2002). However, educational level is also strongly tied to the occupations of men and women, which are associated with different risks. Those educated to tertiary level have a lower prevalence of MSDs than those educated to only primary level (56.29 % versus 67.16 %), and this is true for both men and women. However, within educational levels there is a greater increase in MSD prevalence among women with increasing age than among men, except in the tertiary level (ISCED 3-4) category, where the increase in MSD prevalence with age is similar among men and women. Among men educated to tertiary level, the increase over a career is rather limited, at only around 7 percentage points. In contrast, among those educated to only primary level, the prevalence of MSDs in the over-50 age group is more than twice the level found in the less-than-35 age group.

Table 11: MSD prevalence by level of education, gender and age (years) in the EU-27 in 2015 (%)

Educational level	Gender and age (years)						All
	Male			Female			
	<35	35-49	>50	<35	35-49	>50	
Primary	56.68	71.40	69.82	33.40	67.45	77.60	67.16
Secondary	46.56	61.28	68.48	51.16	61.33	71.94	60.30
Tertiary	46.96	55.17	53.94	53.05	60.22	67.47	56.29
All	46.85	59.83	64.91	51.64	61.10	70.97	59.31

Notes: Primary education, ISCED 1-2; secondary education, ISCED 3-4; tertiary education, ISCED 5-6.
Source: Authors' compilation based on EWCS sixth wave (2015) data

([16]) In addition to effective ageing plans, the composition effects of sectors and countries, and attrition effects may be behind this finding. Composition effects will be controlled for in the multivariate analyses.

Looking at occupations (Table 10), MSDs are most prevalent in manual work occupations (in the lower half of the table: Skilled agricultural, forestry and fishery workers; Crafts and related trades workers; Plant and machine operators, and assemblers; Elementary occupations), and the prevalence is highest among plant and machine operators and assembly line workers (67.6 %). These occupations combine both repetitive strain and the high-impact lifting and moving of goods (EU-OSHA, 2004). However, the rates among service and sales workers (59.36 %) and among technicians and associate professionals (56.63 %), a category that includes nurses, are also elevated compared to desk-based occupations, particularly among women. The lowest levels of MSDs are found among the armed forces (48.35 % on average), but this is a small category that is prone to outliers and attrition in older age groups.

Table 12: MSD prevalence by occupation, gender and age (years) in the EU-27 in 2015 (%)

Occupation	Gender and age, years						All
	Male			Female			
	<35	35-49	>50	<35	35-49	>50	
Armed forces occupations	45.25	43.04	60.51	15.78	80.78	75.11	48.35
Managers	44.97	50.52	65.79	33.9	59.51	68.49	55.63
Professionals	44.22	51.04	53.90	51.45	58.28	64.80	54.82
Technicians and associate professionals	39.02	57.28	58.26	54.81	55.31	72.62	56.63
Clerical support workers	37.14	49.74	56.96	42.73	56.84	62.60	52.69
Service and sales workers	40.13	57.07	61.61	52.23	65.78	75.86	59.36
Skilled agricultural, forestry and fishery workers	54.50	67.51	64.33	74.18	69.51	89.90	66.25
Craft and related trades workers	51.24	67.21	75.62	53.44	68.85	73.78	64.66
Plant and machine operators, and assemblers	58.12	67.89	69.83	67.61	68.70	85.52	67.60
Elementary occupations	56.18	62.72	75.29	56.82	67.46	76.59	66.61
All	46.85	59.83	64.91	51.64	61.10	70.97	59.31

Source: Authors' compilation based on EWCS sixth wave (2015) data

Finally, with respect to origin, the overall difference in the prevalence of MSDs between native and migrant employees is slightly under 5 %, in line with other reports (EU-OSHA, 2020b, p. 13). However, this overall figure hides a very different age and gender distribution among native and migrant workers. As can be seen in Table 11, for both genders the difference is much larger in the 35-49 and over-50 age groups than in the less-than-35 age group, so the relatively small gap can be attributed to the higher share of young men among workers of migrant origin, who still face a higher prevalence of MSDs, but less so than in other age groups (48.33 % among young male migrant workers versus 46.64 % among young male native workers). While age and cohort effects cannot be separated in a cross-sectional survey, these figures suggest that problems related to MSDs are more often found in older age groups.

Table 13: MSD prevalence by origin, gender and age (years) in the EU-27 in 2015 (%)

Origin	Gender and age						All
	Male			Female			
	<35	35-49	>50	<35	35-49	>50	
Native	46.64	58.9	64.38	51.1	60.07	70.44	58.76
Migrant	48.33	66.52	70.43	54.92	69.54	76.05	63.68
All	46.85	59.83	64.91	51.64	61.1	70.97	59.31

Source: Authors' compilation based on EWCS sixth wave (2015) data

4.1.2 Wellbeing of workers in the EU-27

The second area of interest is the wellbeing of workers, which is measured here by the WHO-5 indicator. This section shows the observed variation in wellbeing among sociodemographic groups, for different economic background variables and between country groupings, and therefore aims to address research question 4. As explained in Chapter 3, the levels of wellbeing range between 0 (minimum) and 100 (maximum), and should be interpreted as a score, not a scale, as five items are used to measure wellbeing.

As shown in Table 12, differences between men and women (+2.33 points overall for men relative to women), and between age groups (-2.58 points between the <35 and >50 age groups), are rather limited. The lowest level of wellbeing is found among women between the age of 35 and 49 (66.82), while the highest level of wellbeing is found among men under 35 years (71.78). For women, there is a slightly larger decrease in wellbeing score between the oldest and youngest age groups than in men. This could be a generational effect or a differential ageing effect.

Table 14: Wellbeing (WHO-5) scores by gender and age (years) (values on scale from 0 to 100)

Gender	Age (years)			All
	<35	35-49	>50	
Male	71.78	69.33	69.51	70.10
Female	69.95	66.82	67.04	67.77
All	70.88	68.06	68.30	68.95

Source: Authors' compilation based on EWCS sixth wave (2015) data

With respect to geographical region (Table 13), only the eastern Member States appear to lag behind and report lower than average levels of wellbeing. The main result that stands out here is that the level of wellbeing in the Nordic Member States and Ireland seems to increase with age, with differences of over 5 points for men and around 3 points for women between the youngest and oldest age groups. In contrast, in all other regions, the wellbeing scores are lower among the over-50 age group than the less-than-35 age group.

Table 15: Wellbeing (WHO-5) scores by region, gender and age (years) (values on scale from 0 to 100)

Region	Gender and age (years)						All
	Male			Female			
	<35	35-49	>50	<35	35-49	>50	
Western MSs	71.42	69.57	70.93	69.61	65.8	68.13	69.15
Nordic MSs and Ireland	68.69	69.98	73.87	65.08	68.44	68.08	69.06
Southern MSs	73.61	70.22	67.66	71.42	68.74	65.42	69.44
Baltic and Balkan MSs	72.45	71.1	68.22	69.4	67.94	64.45	69.07
Eastern MSs	71.24	65.21	65.99	71.78	65.1	66.66	67.35
All	71.78	69.33	69.51	69.95	66.82	67.04	68.95

Note: MSs, European Union Member States.
Source: Authors' compilation based on EWCS sixth wave (2015) data

In Table 14, wellbeing scores are considered by sector. Again, there is only minor variation, with slightly lower levels of wellbeing reported in industry (67.66), health care (68.49) and transport (68.19) than in the other sectors. Age patterns are not pronounced, but a sharp improvement in wellbeing with age is found among men in transport (from 64.95 for the youngest cohort to 71.78 for the oldest cohort) and a decrease in wellbeing with age in public administration and defence among women (from 71.34 to 65.90) and men (from 77.28 to 70.38).

Table 16: Wellbeing (WHO-5) scores by sector, gender and age (years) (values on scale from 0 to 100)

Sector	Gender and age (years)						All
	Male			Female			
	<35	35-49	>50	<35	35-49	>50	
Agriculture	75.21	70.11	69.92	74.58	74.36	67.58	71.78
Industry	70.67	68.64	67.2	68.31	63.75	65.5	67.66
Construction	69.64	68.26	67.57	74.97	66.22	68.39	68.57
Commerce and hospitality	73.01	69.2	71.01	69.36	67.65	66.26	69.33
Transport	64.95	68.35	71.78	71.37	63.68	65.41	68.19
Financial services	73.31	70.56	70.82	73.52	65.8	67.42	69.82
Public administration and defence	77.28	71.14	70.38	71.34	66.13	65.90	69.81
Education	74.71	72.74	73.81	71.69	68.41	67.76	70.27
Health	74.76	67.47	69.38	69.41	67.58	67.99	68.49
Other services	73.33	70.42	69.31	69.63	67.06	67.43	69.27

Source: Authors' compilation based on EWCS sixth wave (2015) data

Organisation size, expressed as number of employees, appears to be more important. The highest levels of wellbeing were reported among workers in smaller companies (70.25), and the lowest levels in large companies (68.20), with medium-sized organisations scoring in between (69.06) (Table 15), suggesting a linear effect. However, levels of wellbeing follow a non-linear age pattern in the largest organisations, with a more pronounced dip for women in the 35-49 age group (64.95), which is the lowest score in Table 15.

Table 17: Wellbeing scores by organisation size, gender and age (years) (values on scale from 0 to 100)

Organisation size (number of employees)	Gender and age (years)						All
	Male			Female			
	<35	35-49	>50	<35	35-49	>50	
<10	73.06	70.10	69.29	72.30	69.05	67.83	70.25
10-249	71.70	69.10	69.58	70.99	66.93	67.15	69.06
>249	70.70	69.47	70.00	66.86	64.95	67.16	68.20
All	71.78	69.33	69.51	69.95	66.82	67.04	68.95

Source: Authors' compilation based on EWCS sixth wave data (2015)

With respect to education (Table 16), the overall variation is again very limited. This is remarkable given that the more highly educated are generally regarded as a privileged or fortunate group. For women aged under 49, however, being educated to tertiary level (ISCED 5-6 category) is associated with lower levels of wellbeing. A plausible explanation may be that work-life conflicts are the basis for this ([17])

Table 18: Wellbeing scores by level of education, gender and age (years) (values on scale from 0 to 100)

Educational level	Gender and age (years)						All
	Male			Female			
	<35	35-49	>50	<35	35-49	>50	
Primary	68.01	68.42	70.86	75.79	66.37	62.74	68.02
Secondary	71.79	69.41	68.53	70.64	67.31	67.16	69.03
Tertiary	72.02	69.3	72.12	68.59	65.85	67.43	68.88
All	71.78	69.33	69.51	69.95	66.82	67.04	68.95

Notes: Primary education, ISCED 1-2; secondary education, ISCED 3-4; tertiary education, ISCED 5-6.
Source: Authors' compilation based on EWCS sixth wave (2015) data

More distinct differences are found between occupations. Table 17 shows lower levels of wellbeing for plant and machine operators and assembly line workers (66.92) and elementary occupations (66.90), but also for managers (67.49). This reflects the absence of a large effect played by educational level.

([17]) For a detailed analysis of the differences in the relationships between educational level and well-being among men and women, see Stoilova et al. (2020).

Again, the armed forces can be considered to be an outlier, with vastly different levels among women. It is clear that wellbeing is better among skilled agricultural, forestry and fishery workers in the under 50 age categories than in other occupation/age groups. In the over-50 age group, professionals register high levels of wellbeing.

Table 19: Wellbeing scores by occupation, gender and age (years) (values on scale from 0 to 100)

Occupation	Gender and age, years						All
	Male			Female			
	<35	35-49	>50	<35	35-49	>50	
Armed forces occupations	75.18	75.22	74.38	82.49	37.07	85.68	73.89
Managers	63.72	63.88	69.43	73.33	68.61	66.65	67.49
Professionals	71.72	70.89	73.03	69.07	67.65	68.75	69.80
Technicians and associate professionals	75.01	69.27	70.37	70.16	67.50	68.76	69.81
Clerical support workers	69.10	70.38	71.08	71.49	66.8	68.04	69.05
Service and sales workers	74.30	69.14	70.75	69.66	66.77	66.33	68.95
Skilled agricultural, forestry and fishery workers	78.29	73.77	72.20	78.71	76.30	66.93	74.45
Craft and related trades workers	72.88	69.51	67.38	63.80	64.37	63.93	69.26
Plant and machine operators, and assemblers	67.12	67.45	68.00	63.92	60.91	68.24	66.92
Elementary occupations	68.95	69.98	64.99	71.74	65.90	63.13	66.90
All	71.78	69.33	69.51	69.95	66.82	67.04	68.95

Source: Authors' compilation based on EWCS sixth wave (2015) data

Finally, the wellbeing scores of migrant and native workers, displayed in Table 18, show that migrant workers under the age of 50 report lower levels of wellbeing than native workers in their age cohort. However, for the over-50 age group, there is almost no difference between native and migrant workers.

Table 20: Wellbeing prevalence by origin, gender and age (years) (values on scale from 0 to 100)

Origin	Gender and age (years)						All
	Male			Female			
	<35	35-49	>50	<35	35-49	>50	
Native	72.26	69.58	69.50	70.20	67.08	67.00	69.13
Migrant	68.44	67.51	69.62	68.41	64.69	67.44	67.48
All	71.78	69.33	69.51	69.95	66.82	67.04	68.95

Source: Authors' compilation based on EWCS sixth wave (2015) data

4.1.3 Relationships between health-related outcome variables

Wellbeing and MSDs are examples of mental health and physical health conditions to which the conceptual framework presented at the beginning of this report could generically be applied. To account for correlations with other mental and physical health-related factors that may result in spurious correlations or act as substitutes, a host of different outcome variables has been selected. In addition to MSDs and wellbeing, these include mental health problems, work-life balance, health impact and general health. These variables are explored in this section and are also used in the multivariate models and in the robustness checks, the results of which are presented in section 4.2. For example, psychosocial factors relating to working time may have an impact on work-life balance and on overall wellbeing. General health may be added to the model to control for deteriorating health with age, so that effects on MSDs are not driven by overall health issues. Mental health problems may substitute for wellbeing, and the perceived impact of working conditions on health can be used to filter out those cases where workers themselves connect working conditions with health outcomes, pointing to self-assessed causality.

Before building complex models in which these variables can be instrumental, the bivariate correlations between these outcome variables should be examined to understand their connections. A distinction is made between correlations at country level, based on aggregated data, and at individual level, based on micro-data, in both cases using data from the EWCS.

Table 19 shows the correlations between the outcome variables at country level. The cross-national correlation (as measured by the correlation coefficient *r*) between MSDs and wellbeing is rather weak ($r = -0.181$), while the correlation between MSDs and mental health problems is stronger ($r = 0.599$). For correlations between wellbeing and mental health problems, there appears to be a sufficiency condition: if overall levels of wellbeing are high, only low levels of mental health problems are observed ($r = -0.395$).

The relationships between MSDs and general health and between wellbeing and general health are very weak at country level. The reason for this, as mentioned in the brief description of the data, is that there is little variation in average wellbeing scores between countries. Yet the relationships between the perceived health impact of work and MSDs ($r = 0.510$), and between the health impact of work and mental health problems ($r = 0.492$) are strong. Finally, countries where workers report an unfavourable work-life balance clearly also have a higher incidence of MSDs ($r = -0.617$). Although aggregated figures are merely suggestive of a relationship, these correlation values indicate that the outcome variables are linked in some way, potentially at individual level.

Table 21: Correlations between outcome variables at the macro (country) level

Outcome variable	(1)	(2)	(3)	(4)	(5)	(6)
(1) MSDs	1.000					
(2) Wellbeing	-0.181	1.000				
(3) Mental health problems	0.599	-0.395	1.000			
(4) General health	-0.152	0.219	0.021	1.000		
(5) Health impact	0.510	-0.188	0.492	-0.355	1.000	
(6) Work-life balance	-0.617	0.245	-0.610	-0.217	-0.227	1.000

Source: Authors' compilation based on EWCS sixth wave (2015) data

The correlations at individual (worker) level, shown in Table 20, are consistent with the country-level associations, but provide a clearer picture, indicating that all outcome variables are correlated. The correlation between MSDs and wellbeing ($r = -0.310$) is reasonably strong at the individual level and more comparable to the correlation between MSDs and mental health problems ($r = 0.449$). The relationship between wellbeing and mental health problems is similar at the individual level ($r = -0.440$),

and the correlation with general health is stronger (r = -0.352 for MSDs and r = 0.389 for wellbeing), justifying its use as a control variable. The correlations between MSDs and the health impact of work and work-life balance on the other hand are weaker at individual level than at the country level, while the correlations with wellbeing are stronger, but the signs are all the same as at the country level.

Table 22: Correlations between outcome variables at the individual level

Outcome variable	(1)	(2)	(3)	(4)	(5)	(6)
(1) MSDs	1.000					
(2) Wellbeing	-0.310	1.000				
(3) Mental health problems	0.449	-0.440	1.000			
(4) General health	-0.352	0.389	-0.311	1.000		
(5) Health impact	0.364	-0.262	0.398	-0.262	1.000	
(6) Work-life balance	-0.251	0.342	-0.445	0.211	-0.306	1.000

Source: Authors' compilation based on EWCS sixth wave (2015) data

4.1.4 The relationship between psychosocial factors, and MSDs and wellbeing

The first step in the analytical strategy was to look for factors that correlate with MSDs on the one hand and wellbeing on the other hand. To check whether or not these correlations are robust across countries, and if there are simultaneous correlations between these factors and MSDs and wellbeing, the correlations found in each of the five country groups were plotted on a two-dimensional graph. This analysis permits job characteristics related to working conditions (Figure 2) and job characteristics related to employment conditions and social work environment (Figure 3) to be distinguished.

Three important findings emerge from a comparison of the two graphs in Figures 2 and 3 and the 17 job characteristics included:

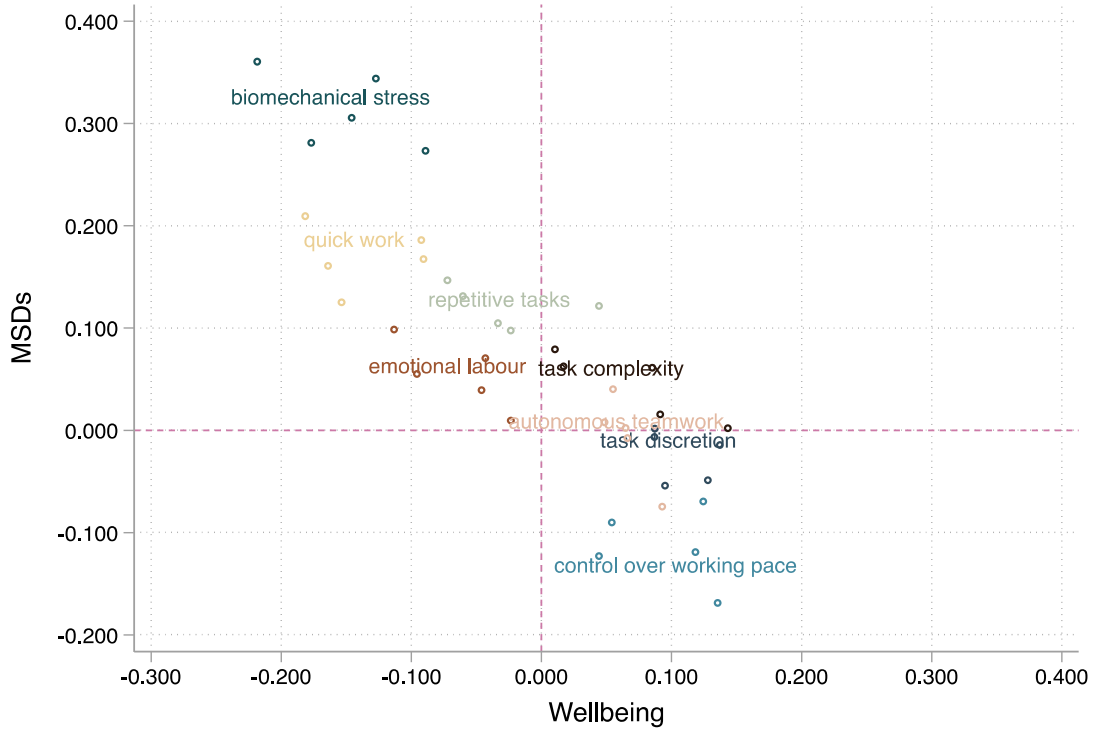
1. Factors that have a strong positive correlation with wellbeing (e.g. supportive management) have a strong negative correlation with MSDs and vice versa (e.g. biomechanical stress) ([18]).
2. The estimated correlations for the same job characteristic in different regions of the EU are fairly comparable. The exceptions are job security and worker participation, both of which have noticeably stronger correlations with MSDs and with wellbeing in the eastern, Baltic and Balkan Member States than in the other Member States.
3. Job characteristics that are job demands tend to be associated positively with MSDs and negatively with wellbeing, while job characteristics that are job resources are favourable, being negatively associated with MSDs and positively associated with wellbeing.

In the domain of working conditions, job demands cover three biomechanical factors (biomechanical stress, quick work and repetitive tasks) and two psychosocial factors (emotional labour and task complexity). Biomechanical stress and quick work show strong correlations with MSDs and wellbeing, while repetitive tasks and psychosocial job demands are unrelated to either MSDs or wellbeing. Furthermore, three job resources are related to autonomy: autonomous teamwork, task discretion and

([18]) A straightforward reason may be that those factors contribute to either MSDs or well-being, and through those outcomes affect each other. By including the two main dependent variables (MSDs and well-being) as intermediary variables in the other model in the multivariate analysis, this hypothesis will be examined.

control over the work pace. Only control over the work pace appears to have a non-negligible impact. This is a surprising finding in light of the hypothesised importance of latitude in connection with MSDs, rooted in the job demands-resources literature. However, it is possible that autonomy conveys not only more control and freedom, but also a sense of insecurity and a lack of guidance and boundaries ([19]). For instance, a non-linear effect between seemingly favourable job characteristics that have become excessive and wellbeing has been described. In such jobs with such characteristics (e.g. managers, sales representatives), in contrast to 'active' jobs with high demands and resources, the level of control associated with, for instance, a high level of responsibility and full decision-making power could be overwhelming, with such jobs being described as 'saturated' or 'over-active' jobs (Holman, 2013; Szekér et al., 2017, p. 55).

Figure 4: Cross-country comparison of correlations between job characteristics and MSDs and wellbeing within the domain of working conditions

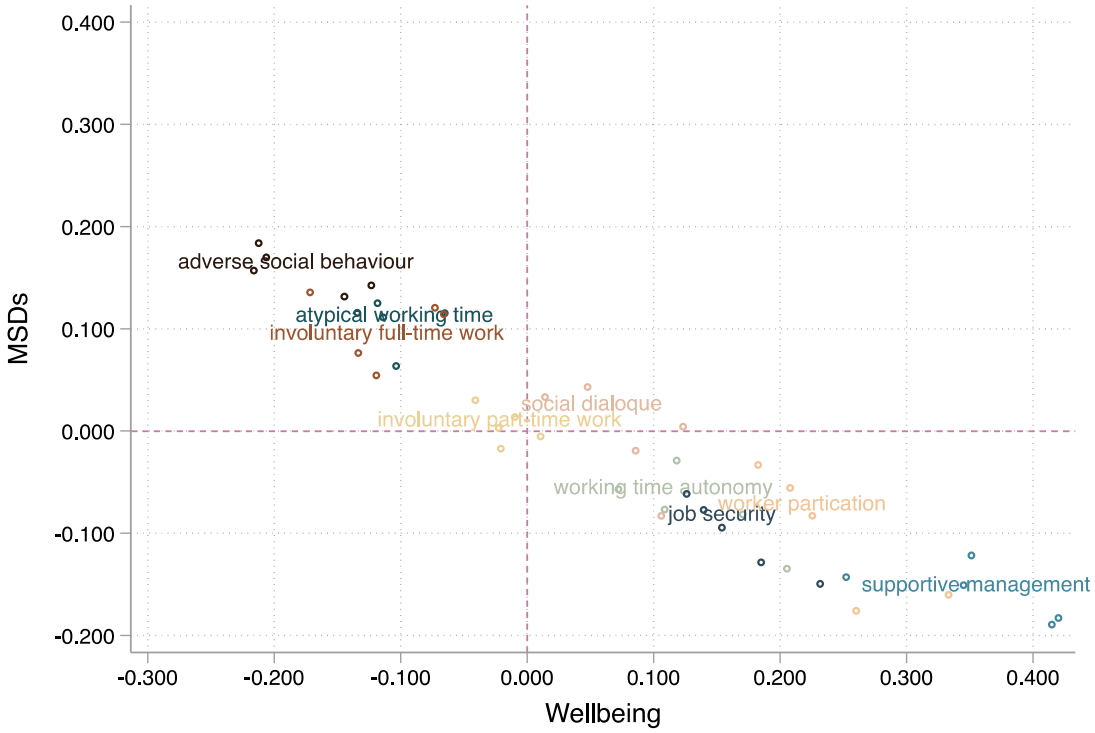


Source: Authors' compilation based on EWCS sixth wave (2015) data

Whereas in the domain of working conditions the strongest relationships are between job characteristics and MSDs (Figure 2), in the domains of employment conditions and social work environment, the strongest relationships are between job characteristics and wellbeing (Figure 3). In particular, this is the case for resources such as supportive management, worker participation and job security. The correlation between social dialogue and working time autonomy is weaker on average. The demands, or rather the challenges and primarily hindrances in this case, that stand out are adverse social behaviour, atypical working time and involuntary full-time work. No effect of involuntary part-time work, on the other hand, is detected. In this case, while an unfavourable effect on both dimensions might have been hypothesised, the opposite reasoning as above for latitude may play out: for some workers who are at the margin of an organisation's workforce, part-time work could be a negative experience and thus weigh on mental and physical health; however, for others, despite the fact that they desire more hours, a lower workload may be beneficial. These types of jobs are referred to as 'passive jobs' (Karasek, 1979). Controlling for other job characteristics and sociodemographic characteristics in the multivariate analysis may filter out such factors contributing to spurious correlations.

([19]) This ambivalent character of job autonomy is typically observed in teleworkers (see Sardeshmukh et al., 2012).

Figure 5: Cross-country comparison of correlations between job characteristics and MSDs and wellbeing within the domains of employment conditions and social work environment



Source: Authors' compilation based on EWCS sixth wave (2015) data

4.2 Multivariate analyses

4.2.1 Hypotheses

Previously, the prevalence of MSDs and the levels of wellbeing for various sociodemographic groups, economic categories and countries have been documented, and the existence of an association between both health outcomes and psychosocial factors was demonstrated. However, more rigorous testing of the conceptual framework should be undertaken using multivariate analysis. By adding sets of variables in a stepwise manner, the direct effects of job characteristics on MSDs and wellbeing can be singled out.

This section reports the direction and certainty of the effects; estimates of the effect size can be found in Annex 3. In addition, three robustness checks have been carried out for the model explaining MSDs, and are reported in Annex 4 and Annex 5:

- Item-level analysis of MSDs was performed using logit regressions (backache, upper limbs and neck, lower limbs).
- The perceived impact of work on health was used to filter out workers who report a self-assessed causality.
- To verify interactions with firm size, the model was tested within large companies separately.

The hypotheses (HYPs) derived from the model and the literature are as follows:

- **HYP-1a:** PSFs are associated with wellbeing.
- **HYP-1b:** PSFs are associated with MSDs.
- **HYP-1c:** PSFs are associated with MSDs through wellbeing.
- **HYP-2a:** biomechanical factors are associated with MSDs.
- **HYP-2b:** biomechanical factors are associated with wellbeing.
- **HYP-2c:** biomechanical factors are associated with wellbeing through MSDs.
- **HYP-3a:** PSFs that are considered to be job demands are positively associated with MSDs and negatively associated with wellbeing.

- **HYP-3b:** PSFs that are considered to be job resources are negatively associated with MSDs and positively associated with wellbeing.
- **HYP-3c:** PSFs that are considered to be job resources moderate the effect of demands on MSDs and wellbeing.
- **HYP-4:** the direct effects of PSFs on MSDs are weaker when sociodemographic and economic background variables are controlled for.

Attempts to model moderation effects (HYP-3c) have failed, despite there being direct effects of the presumed moderating variables (job resources). Another study following the JD-R model similarly failed to uncover interaction effects on psychological and physical wellbeing (Muhonen & Torkelson, 2003). In a Monte Carlo simulation model, it was shown that direct effects instead of true interaction effects may be observed under certain conditions when there is substantial measurement error on both interacting variables.

4.2.2 Explaining the prevalence of musculoskeletal disorders

In this analysis, the three items from the EWCS measuring MSDs (backache, pain in the neck, shoulders and upper limbs, and pain in the lower limbs) have been added up, meaning that there is more variation than in the headcount incidence reported in the previous descriptive analysis ([20]) (see section 4.1). In addition, each item has been investigated separately to verify whether or not specific factors contribute to specific MSDs (see Annex 4).

Table 21 shows the significance and sign (green: favourable; red: unfavourable) of a regression analysis of the estimated effects of job characteristics and control variables on MSD prevalence ([21]). Five models are tested: model 1 includes only job characteristics; model 2 adds fixed effects to control for correlations with other aspects of the job; model 3 includes only background characteristics of the worker and firm size; model 4 combines models 2 and 3; and model 5 includes other outcomes as controls and mediators ([22]).

The regression analysis addresses the primary research question on the relationship between psychosocial factors and MSDs (RQ-1), to confirm that not only biomechanical factors (biomechanical stress, repetitive tasks, quick work) are associated with MSDs (HYP-2a), but that psychosocial factors are also associated with MSDs (HYP-1b). While the effect size of biomechanical stress is by far the largest, the psychosocial factors combined have a comparable effect. These effects also stand after controlling for background characteristics in model 2 (including economic variables and country effects) and model 4 (including sociodemographic variables), contrary to the expectation that sociodemographic and economic background variables would correlate with job characteristics and hence weaken the effect of psychosocial factors when controlled for (HYP-4).

Three psychosocial factors in particular are associated with a lower prevalence of MSDs: supportive management, job security and worker participation. These factors are job resources that empower and protect workers, confirming the hypothesis that PSFs that are considered to be job resources have favourable effects on MSDs and wellbeing (HYP-3b). Yet, not all psychosocial factors appear to be relevant. In particular, psychosocial factors related to individual and collective forms of autonomy (task discretion, control over work pace, autonomous teamwork, working time autonomy) have insignificant or, in the case of task discretion, even unfavourable effects on MSDs. Likewise, social dialogue does not have the expected effect in the uncontrolled model. It therefore appears that the individual relationship between workers and managers is most important in preventing MSDs.

Psychosocial factors may have a direct effect on MSDs, but they can also lead to better wellbeing and a good work-life balance, which explains their indirect impact on MSDs, as the conceptual framework suggests (HYP-1c). Indeed, in the model that includes other outcomes and controls (model 5), wellbeing and work-life balance absorb the direct effects of supportive management and job security, confirming the mediating effect of these on MSD prevalence (HYP-1c). On the other hand, worker participation

([20]) OLS is preferred over logit regression, as there is the potential to cumulate both risks and MSDs.
([21]) Full results are given in Annex 8.3; additional robustness checks are presented in Annex 8.5.
([22]) In separate models (not shown), interaction effects were also tested to check for moderating effects between important demands and resources (biomechanical stress, task discretion, managerial support), but no significant effects supporting HYP-3c were found.

remains favourable in model 5, and, with all the controls included in the model, social dialogue is estimated to have a favourable impact on MSDs, albeit small. The significance and effect sizes for employment conditions related to working time, however, remain mostly unchanged. This means that the effect of employment conditions related to working time on MSDs is not entirely explained by issues with work-life balance or wellbeing, but that exhaustion and fatigue, for instance, may have a direct effect on physical health. Similarly, other factors, such as task complexity and adverse social behaviour, maintain a direct unfavourable effect, confirming that psychosocial job demands may have an unfavourable direct impact on MSDs (HYP-3a).

In summary, the conceptual framework is corroborated by the empirical data analysis, showing that psychosocial factors at work directly and indirectly affect MSDs. Moreover, the importance of job characteristics is clearly underscored by the analysis. This addresses research question 3, on the differences by background variable in factors explaining MSDs (RQ-3). The main drivers of MSDs do not seem to be related to structural factors relating to the composition of the economy in terms of occupations and sectors, country effects capturing institutional variation and culture, or sociodemographic variables, but rather job characteristics related to the nature of work and employment. It should be noted that sociodemographic characteristics are defined in broad categories (by age, gender, origin, education), and, while they do not reflect the major differences in terms of MSDs ([23]), it is possible and likely that personal characteristics (strength, risk awareness, social conditions) do matter but have not been observed.

Table 23: Regression analysis (ordinary least squares) of MSDs on job characteristics and background variables

Job characteristics/background variables	Model number				
	1	2	3	4	5
Biomechanical stress	---	---		---	---
Repetitive tasks	-	ns		ns	ns
Quick work	--	---		---	ns
Emotional labour	ns	ns		ns	ns
Task complexity	-	---		---	---
Task discretion	---	---		---	---
Control over work pace	ns	ns		ns	ns
Autonomous teamwork	ns	ns		ns	ns
Atypical working time	---	--		---	-
Working time autonomy	ns	ns		ns	ns
Involuntary part-time work	---	--		---	--
Involuntary overtime work	---	---		---	---
Job security	+++	+++		+++	ns
Adverse social behaviour	---	---		---	---
Supportive management	+++	+++		+++	ns
Social dialogue	-	--		ns	+
Worker participation	++	+++		+++	+++

([23]) Sociodemographic characteristics of workers do have significant effects, but the explanatory power of this set of variables is weak (3.7 %). In the full model, the effects of educational level, age and origin are reduced. The gender effect, to the disadvantage of women, is limited in the full model, but remains strongly significant.

Job characteristics/background variables	Model number				
	1	2	3	4	5
Gender - female/male (reference: male)			---	---	---
Educational level — low (reference)					
Educational level — mid/low			+++	+	++
Educational level — high/low			+++	+++	+++
Age — under 25 (reference)					
Age — 25-34/under 25			ns	ns	ns
Age — 35-44/under 25			---	---	ns
Age — 45-54/under 25			---	---	---
Age — over 55/under 25			---	---	---
Origin — migrant/native (reference: native)			---	ns	ns
Company size — under 10 employees (reference)					
Company size — 10-249 employees			--	ns	ns
Company size — over 249 employees			---	ns	ns
Wellbeing (WHO-5)					+++
Work-life balance					+++
General health					+++
Constant	---	---	---	-	---
FE occupation	No	Yes	No	Yes	Yes
FE sector	No	Yes	No	Yes	Yes
FE country	No	Yes	No	Yes	Yes
R^2	15.2%	18.7%	3.7%	22.2%	29.6%
N	23,636	23,550	26,667	22,556	22,523

Notes: - unfavourable, correlating positively with MSDs; + favourable, correlating negatively with MSDs.
• p < 0.05; •• p < 0.01; ••• p < 0.001; FE: fixed effects, i.e. controlling for occupation, sector and country; ns: not significant; R2: coefficient of determination.
Source: Authors' compilation based on EWCS sixth wave (2015) data

4.2.3 Explaining differences in wellbeing in the workforce

Following the biomechanical path in the conceptual framework, the association of MSDs with wellbeing can be looked at from another angle, and the relationship between psychosocial factors and wellbeing, which was implicit in the previous analysis, can be evaluated. This again addresses the research questions on the role that psychosocial factors play (RQ-1, RQ-2 and RQ-3).

The structure of the models is the same as in section 4.2.2, but the effects are clearer here. First, the hypotheses that biomechanical factors are associated with wellbeing (HYP-2b) and that this association is through MSDs (HYP-2c) are confirmed: biomechanical stress and quick work have unfavourable

effects on wellbeing, which finally drops when MSDs are included in the full model ([24]). In contrast, repetitive tasks have a positive effect on wellbeing. There is no straightforward explanation for this finding, but 'low strain jobs', where demands are limited and tasks unchallenging, have been associated with favourable wellbeing outcomes (Pelfrene et al., 2002).

Table 24: Regression analysis (ordinary least squares) of wellbeing (WHO-5) on job characteristics and background variables

Job characteristics/background variables	Model number				
	1	2	3	4	5
Biomechanical stress	---	---		---	ns
Repetitive tasks	+++	++		++	++
Quick work	--	---		---	ns
Emotional labour	---	-		-	ns
Task complexity	ns	ns		ns	+
Task discretion	ns	ns		ns	+
Control over work pace	+++	++		++	ns
Autonomous teamwork	ns	ns		ns	ns
Atypical working time	---	---		---	ns
Working time autonomy	ns	ns		ns	ns
Involuntary part-time work	-	-		-	-
Involuntary overtime work	---	---		---	---
Job security	+++	+++		+++	+++
Adverse social behaviour	---	---		---	---
Supportive management	+++	+++		+++	+++
Social dialogue	+	+++		+++	+++
Worker participation	+++	+++		+++	+++
Gender — female/male (reference: male)			---	---	---
Educational level — low (reference)					
Educational level — mid/low			ns	ns	ns
Educational level— high/low			ns	ns	ns
Age — under 25 (reference)			ns	ns	ns
Age — 25-34/under 25			---	---	ns
Age — 35-44/under 25			---	---	ns
Age — 45-54/under 25			---	---	ns
Age — over 55/under 25			---	---	++

([24]) Here, too, as in the models explaining MSDs, all effects are direct and mediating. Tests for interactions between the major stressor (atypical working time) and potential coping variables (control over work pace, worker participation) did not reveal moderating effects, and hence no support for HYP-3c was found.

Job characteristics/background variables	Model number				
	1	2	3	4	5
Origin — migrant/native (reference: native)			--	ns	ns
Company size — under 10 employees (reference)					
Company size — 10-249 employees			-	ns	ns
Company size — over 249 employees			---	ns	ns
MSDs					---
Work-life balance					+++
General health					+++
Constant	+++	+++	+++	+++	+++
FE occupation	No	Yes	No	Yes	Yes
FE sector	No	Yes	No	Yes	Yes
FE country	No	Yes	No	Yes	Yes
R^2	17.4%	20.0%	1.2%	21.0%	34.4%
N	23,628	23,542	26,651	22,550	22,523

Notes: - unfavourable, correlating negatively with wellbeing; + favourable, correlating positively with wellbeing.
• $p < 0.05$; •• $p < 0.01$; ••• $p < 0.001$; FE: fixed effects, i.e. controlling for occupation, sector and country; ns: not significant; R2: coefficient of determination.
Source: Authors' compilation based on EWCS sixth wave (2015) data

Second, as hypothesised, psychosocial factors show a strong association with wellbeing (HYP-1a). The main explanations for wellbeing at work relate to the social work environment. This goes in two directions, following the expected effects of job demands and resources (HYP-3b and HYP-3c): adverse social behaviour — a job demand — has a strong negative effect on wellbeing, while supportive management, job security, social dialogue and worker participation — job resources — all have the expected positive effect and are highly significant.

Working time-related variables, primarily involuntary overtime work and atypical working time, also have clearly unfavourable effects. The direct effect of the former is apparent in the full model, suggesting that overtime work leads to exhaustion, which is reflected in poorer wellbeing. On the other hand, atypical working time is entirely taken up by the set of mediating variables, suggesting that its effect on wellbeing is indirect and due to the distortion of work-life balance.

As in the models explaining MSDs in the previous section, the inclusion of economic variables and country effects, or sociodemographic variables and firm size, does not contribute much to the explanatory power of the model, and it does not alter the effects found in earlier steps. In fact, only gender appears to maintain a significant negative effect on wellbeing if controls are included in the model. Although the main contribution to wellbeing comes from the job characteristics, it should be noted that MSDs, work-life balance and general health strongly increased the power of the model. As they not only mediate the job characteristics, this means there is a separate direct effect from these factors, which may have a cause outside of the sphere of work (e.g. family demands weighing on the work-life balance, health risks from diet).

5 Preventive OSH strategies at the establishment level in the EU-27

5.1 Identification of six types of enterprise in the EU based on preventive OSH strategies

The conceptual framework of this study involves a psychosocial pathway and a biomechanical pathway, both of which are moderated by prevention pathways. These prevention pathways could involve some of the psychosocial factors among the job characteristics discussed in section 4, but also preventive management practices. Data on preventive management practices are not available in the EWCS; however, ESENER provides a source of information dedicated to OSH practices in establishments in the EU.

In this part of the analysis, dedicated to research question 5 (RQ-5: 'What preventive strategies are available to tackle the problem of MSDs in the EU?'), the ESENER data were first looked at using cluster analysis, to divide company establishments into six groups based on the types of preventive OSH strategies in place, as defined by risks and preventive actions. These OSH types will in the next stage be connected to outcomes in terms of MSDs and wellbeing based on the EWCS. The method is explained in section 4.1 and complete data are given in Annex 6.

Risks refer to biomechanical stress, psychosocial stress or digitalisation. Prevention can be either participatory (formal employee representation, workers' participation) or procedural (OSH assessments, general OSH risk prevention, psychosocial risk prevention, health awareness programmes and OSH training). By clustering establishments based on the scores for these OSH characteristics (see Table 23 and Figure 4), six types of establishments were found, which can be defined as follows:

1. **High risk-high agency (HR-HA).** These establishments can be described as having a high-risk environment, albeit with adequate prevention strategies, including training, in place. In this cluster, employees are nearly always involved in dealing with risks. In terms of the number of employees, this is the largest cluster, covering 46 % of employees, although accounting for only 18 % of all establishments, many of which are larger establishments.
2. **Physical-procedural (PH-PR).** Employees in these establishments are exposed to average to moderately high levels of biomechanical stress, with average scores for psychosocial hazards and a fairly high degree of preventive practices in place, but formal worker representation and workers' participation are found less often. This appears to be a cluster with establishments meeting formal requirements but often foregoing employee participation. This cluster accounts for 14 % of employees and 17 % of establishments.
3. **Psychosocial-procedural (PS-PR).** Employees in establishments in this cluster are exposed to very low levels of biomechanical stress, but some degree of psychosocial risks, and have low levels of formal and informal representation. Instead, there is a clear emphasis on psychosocial risk prevention and health awareness programmes, but not on training. In terms of employment, this is a small cluster, covering only 6 % of workers and 11 % of establishments.
4. **Digitalisation-low agency (DI-LA).** In this cluster, average biomechanical stress and fairly high psychosocial risks are paired with a high degree of digitalisation. OSH assessments are carried out, but further prevention practices targeting psychosocial risks and health awareness are rare. There is, however, some degree of formal and informal worker participation. This is also a small cluster, covering only 6 % of workers and just 7 % of establishments.
5. **Psychosocial-participatory (PS-PA)**. This group of establishments faces similar challenges to those in cluster 3 (PS-PR), but responds differently to these challenges. While mainly psychosocial risks are present, companies in this cluster put a strong emphasis on formal employee representation and workers' participation, but undertake a limited number of actions. Establishments in this cluster take action only when called upon to do so by employees. This cluster accounts for 16 % of employees, in 19 % of establishments.
6. **Psychosocial-low agency (PS-LA).** Enterprises in this cluster are the opposite of those in cluster 1 (HR-HA): the cluster has low scores on nearly all dimensions, and enterprises do not involve employees in dealing with potential biomechanical or psychosocial risks, and undertake nearly no action to mitigate those risks. This cluster accounts for only 12 % of employees, but represents the largest proportion of establishments (27 %).

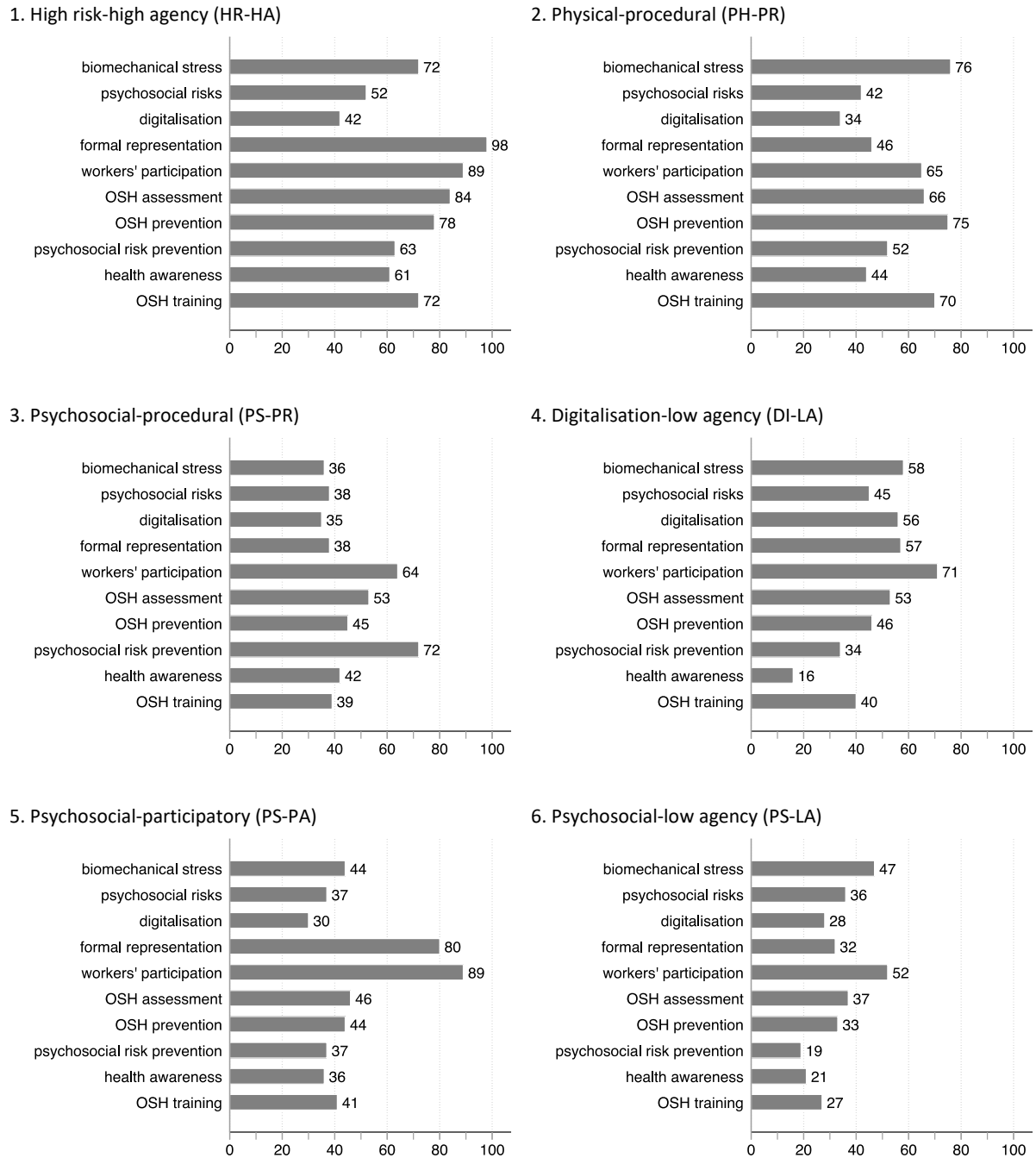
Table 25: Prevalence of risks and strategies among enterprises in the six OSH clusters (%)

Risks and strategies	Cluster					
	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA
OSH risks†						
Biomechanical stress	69	77	4	45	23	29
Psychosocial risks	66	50	47	60	44	44
Digitalisation	41	18	23	100	2	1
Participatory strategies†						
Formal employee representation	97	9	0	33	72	0
Workers' participation	73	16	14	38	75	0
Procedural strategies†						
OSH assessments	83	56	45	36	18	20
General OSH risk prevention	71	68	4	10	7	0
Psychosocial risk prevention	72	55	98	25	29	0
Health awareness programmes	74	54	54	10	44	23
OSH training	38	45	1	2	2	0
Prevalence						
Establishments (*n*)	3,696	3,545	2,206	1,478	3,888	5,575
Establishments (%)	18	17	11	7	19	27
Employees (*n*)	10,436	3,202	1310	1,431	3,713	2,651
Employees (%)	46	14	6	6	16	12
Data points (*n*)	9,826	6,459	3,508	2,724	6,565	8,378
Data points (%)	26	17	9	7	18	22
Relationship to outcomes‡						
MSDs	- -	-	+ +	-/+	+	+
Wellbeing	- -	-	+ +	-/+	+	+ +

Notes: †Cells for the risks and strategies are coloured blue (low) to red (high), with numbers referring to the share (%) of establishments in the cluster with scores above the median for each of the risks or strategies dimensions (e.g. the numbers in the biomechanical stress row refer to the share of establishments in each cluster that falls within the group of 50 % of establishments with the highest biomechanical stress risks overall).
‡Favourability ratings are ranked as highly unfavourable (- -), unfavourable (-), mixed (+/-), favourable (+) or highly favourable (+ +).

Source: Authors' compilation based on ESENER-3 (2019) data

Figure 6: Binary hierarchical cluster analysis of establishments based on 10 dimensions from the ESENER-3 data (%)



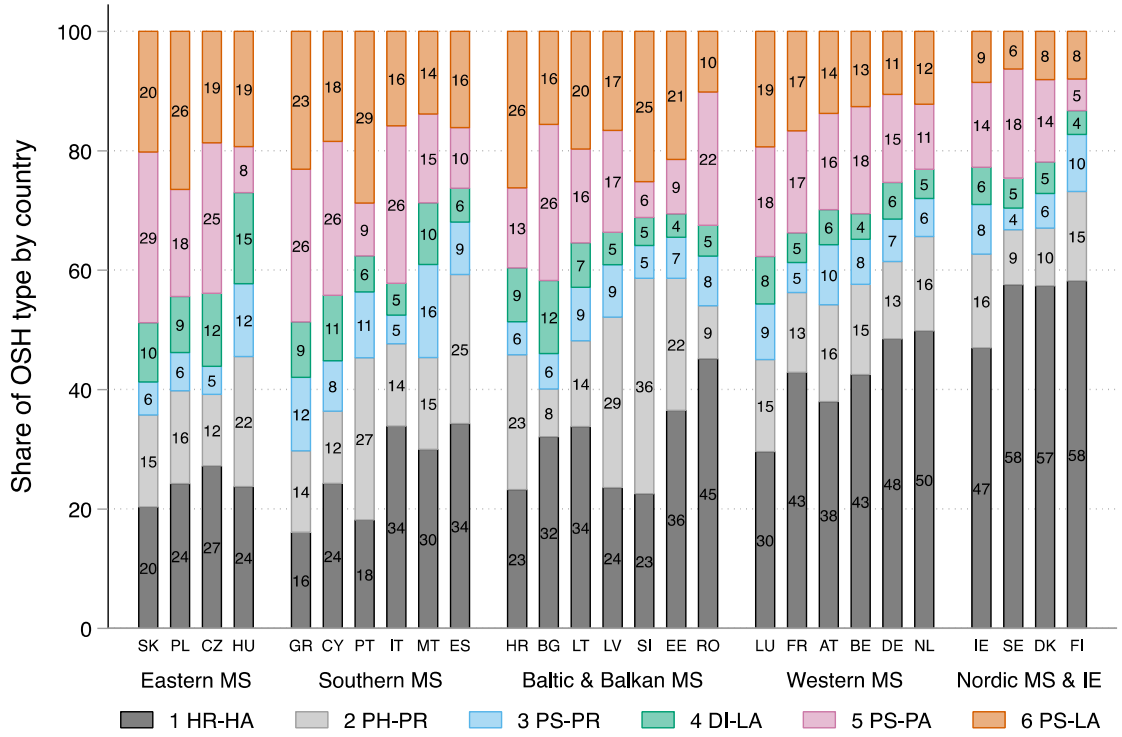
Source: Authors' compilation based on ESENER-3 (2019) data

5.2 Prevalence of the six OSH types among EU enterprises and health outcomes

Figure 5 and Table 24 show the distribution of the six OSH types among enterprises in the countries and regions of the EU. Two types are very common: the HR-HA type (1), which is dominant in the Nordic Member States and Ireland and accounts for 26.23 % of all employees, and the PS-LA type (6), which is more often found in the eastern Member States and accounts for 22.37 % of the workforce. Two types have middle values across the board: the PH-PR type (2), which accounts for 17.24 % of employees, and is typical in the southern Members States and the Baltic and Balkan Member States, and the PS-

PA type (5), which accounts for 17.53 % of the workforce in the EU and is most common in the southern (18.17 %) and the eastern (20.13 %) Member States. The remaining two types each account for less than 10 % of the workforce: the PS-PR type (3) and the DI-LA type (4), with the latter representing very small shares of employees in the western Member States (6.57 %), and the Nordic Member States and Ireland (5.5 %).

Figure 7: Distribution of the six OSH types among enterprises across EU countries and regions (share of employees per country (%))



Source: Authors' compilation based on ESENER-3 (2019) data

Table 26: Share of OSH types by region (%)

Region	Cluster						
	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA	All
Western MSs	29.49	16.12	9.51	6.57	16.83	21.48	100
Nordic MSs and Ireland	42.50	14.73	8.68	5.50	16.22	12.36	100
Southern MSs	19.55	19.87	10.55	7.26	18.17	24.60	100
Baltic and Balkan MSs	24.20	19.38	8.67	6.84	16.57	24.33	100
Eastern MSs	15.16	15.74	8.87	10.79	20.13	29.31	100
All	26.23	17.24	9.36	7.27	17.53	22.37	100

Source: Authors' compilation based on ESENER-3 (2019) data

The cross-country distribution of the OSH types could explained by differences in economic structure, in terms of industry composition or typical company size. Table 25 shows the distribution of the six OSH types in four categories based on establishment size ([25]). Among small establishments (5-9 employees), the PS-LA type (6) is most common (33.77 %), while the HR-HA type (1) is relatively rare. Among large companies, the opposite is true. In fact, it appears that the HR-HA type (1) correlates positively with establishment size, while the PS-PR type (3) and the PS-LA type (6) correlate negatively with establishment size and characterise smaller companies. The PH-PR (2) and PS-PA (5) types are relatively uncommon among large companies.

Table 27: Share of OSH types by establishment size (%)

Establishment size (number of employees)	Cluster						
	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA	All
5-9	11.83	17.53	11.47	6.84	18.57	33.77	100
10-49	22.94	18.29	10.43	8.06	18.49	21.79	100
50-249	40.81	16.82	6.16	7.17	16.62	12.42	100
>250	63.26	12.24	3.29	5.31	11.18	4.72	100
All	26.23	17.24	9.36	7.27	17.53	22.37	100

Source: Authors' compilation based on ESENER-3 (2019) data

Looking at the distribution of enterprises of the various OSH types within sectors (Table 26), a different pattern appears, which appears to be associated with the nature of the safety and health risks. The HR-HA type (1) is particularly common in industry (35.97 %), transport (28.22 %) and health care (39.96 %). The PH-PR type (2) is found slightly more often in agriculture (22.61 %) and construction (21.97 %), while the PS-PR type (3) is clearly typical for service jobs, such as in commerce and hospitality (10.65 %), financial services (13.28 %), education (10.92 %) and other services (14.29 %). The DI-LA type (4) is found primarily in sectors with a high degree of automated processes and robotics, such as agriculture (11.37 %), industry (10.66 %) and transport (11.51 %). The PS-PA type (5) is strongly tied to education (26.18 %) and, finally, the PS-LA type (6) is dominant in the service sectors, but not health care, and also agriculture (21.70 %) and construction (22.30 %).

In summary, the distribution of the six OSH types across sectors and by establishment size confirms that establishment size determines whether a strategy is likely to involve the participation of workers (more common in larger establishments, in part because of legal requirements) or be based on procedures or show little agency (i.e. follow predefined managerial steps, which is more common in smaller establishments). Note that in enterprises of the PS-PR type (3) , such procedures mainly involve psychosocial risk prevention — which includes confidential counselling and granting more latitude to workers — as well as health awareness programmes. Sectoral activities, on the other hand, determine the extent and the kind of risks to which workers are exposed (physical, psychosocial). Combining both aspects, it can be seen that, among the HR-HA type (1), larger companies in at-risk sectors, such as the manufacturing industry, construction and health care, exploit all preventive strategies but are faced with high levels of biomechanical stress, psychosocial risks and digitalisation.

([25]) Full figures by country and by establishment size are presented in Annex 6.

Table 28: Share of OSH types by sector (%)

Sector	Cluster						All
	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA	
Agriculture	20.65	22.61	7.97	11.37	15.69	21.70	100
Industry	35.97	17.53	4.97	10.66	14.36	16.51	100
Construction	26.69	21.97	4.62	6.33	18.09	22.30	100
Commerce and hospitality	19.42	19.42	10.65	7.18	16.39	26.95	100
Transport	28.22	17.12	7.98	11.51	16.14	19.03	100
Financial services	19.44	9.38	13.28	7.94	19.03	30.94	100
Public administration and defence	26.03	18.35	5.73	4.93	17.71	27.25	100
Education	23.62	13.04	10.92	3.73	26.18	22.51	100
Health care	39.96	18.67	8.05	3.73	18.62	10.97	100
Other services	21.52	13.78	14.29	7.37	17.44	25.60	100
All	26.23	17.24	9.36	7.27	17.53	22.37	100

Source: Authors' compilation based on ESENER-3 (2019) data

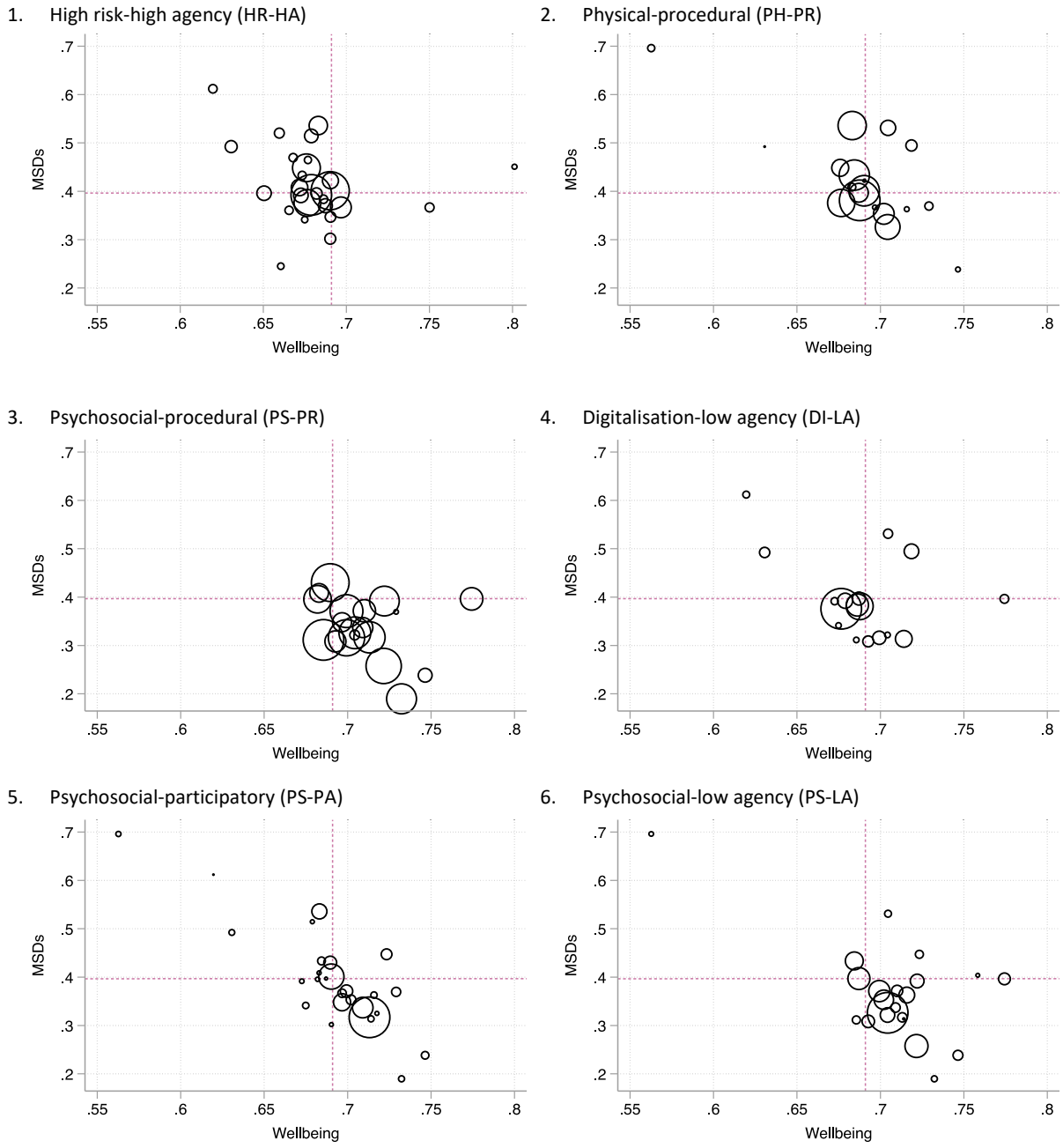
These ESENER-3 data on risks and strategies can be linked to EWCS data on job outcomes using the cell-average method, based on three key identifiers: sector (based on 1-digit or 2-digit NACE), company size (three categories) and country. This exercise allows verification of whether or not certain OSH types are indeed more favourable than others. Annex 7 discusses the method, an alternative and its limitations.

Figure 6 shows the levels of MSDs and wellbeing for sector-company size combinations represented by circles, weighted by the presence of each OSH type. In other words, the same sector-company combinations are shown in each graph, but the size of their circle depend on the share of the OSH type minus the average share of OSH types in this combination. For instance, if the average share of the establishments of 10-249 employees in accommodation and food services within OSH types is 4.44 %, PS-PR type (3) has a weight of 1.69 % above this, at 6.10 %. Combinations with less than 10 companies in the ESENER-3 data are not shown.

The graphs (Figure 6) show whether an OSH type has more or less favourable outcomes in terms of MSDs and wellbeing than the population averages for each dimension, indicated by the guiding lines that divide the plots into four quadrants. Enterprises of the HR-HA type (1) are clearly more present in a number of sector-company size combinations, with high levels of MSDs and below average levels of wellbeing. In comparison, levels of MSDs and wellbeing among enterprises of the PH-PR type (2) are closer to the population average, yet some sector-company size combinations have particularly high levels of MSDs; however, there is less variation with respect to wellbeing. For the PS-PR type (3), data points are clearly concentrated in the lower right-hand side of the graph, meaning that enterprises of this type generally have low levels of MSDs and high levels of wellbeing; this is also the case for the PS-PA (5) and PS-LA (6) types. The pattern of data points for the DI-LA type (6), on the other hand, is very diffuse.

The unfavourable outcomes of the HR-HA type (1) illustrate the paradoxical correlation that is often found between OSH strategies and (the extent of) worker representation on the one hand and health outcomes on the other hand: outside legal obligations, interventions usually take place only if and when problems are identified. This leads to the observation of worker participation and representation (related to higher awareness of OSH issues) being associated with unfavourable job outcomes.

Figure 8: Wellbeing and MSD outcomes among enterprises by OSH type



Source: Authors' compilation based on EWCS sixth wave (2015) and ESENER-3 (2019) data

5.3 Exploring the relationship between preventive OSH strategies and health outcomes

Linking the EWCS and ESENER-3 datasets allows the quality of the preventive strategies to be tested, which would address research question 5 (RQ-5): 'Which preventive strategies are most effective in alleviating MSDs or improving workers' wellbeing?' The following analyses attempt to establish such relationships. However, this task presents a methodological challenge.

When linking the data based on country, firm size and sector, the precision of the average for this combination (a "cell") depends on the number of establishments. For this reason, different estimates are given in Table 27 (NACE 1-digit, more cases per cell, weaker identification) and Table 28 (NACE 2-digit, fewer cases per cell, stronger identification). In addition, the tables present all available data ('Full sample', left-hand columns) and data for only cells with over 10 establishments ('Cells > 10 establishments', right-hand columns). These different approaches aim to overcome issues related to the use of linked data from different datasets ([26]). Nevertheless, the results in both groups of establishments are comparable and will be discussed together.

The first model in Table 27 explains the variation in MSDs using the 10 risks and preventive strategies. Biomechanical stress increases the likelihood of MSDs, as expected, supporting HYP-2a, described above (biomechanical factors are associated with MSDs), but digitalisation reduces the incidence, while no effect is found for psychosocial risks, which goes against HYP-1b (PSFs are associated with MSDs), at the establishment level.

A seemingly puzzling outcome is that worker participation and OSH risk assessment are positively related to MSDs. This should not be too surprising, however, as the clustering and mapping of the OSH types in section 5.2 suggest that high risks and extensive preventive strategies are connected (see the results for the HR-HA type (1)). Sectors and companies that have a higher occurrence of MSDs may have plans and employee participation in place, or preventive strategies may be put in place in response to problems in the workplace ([27]). Moreover, the measurement of worker participation includes a question on the frequency of discussions on safety and health issues (see Table 29), which in organisations that employ participatory strategies should be higher when faced with more risks. However, contrary to this logic, formal employee representation and OSH training are negatively associated with the occurrence of MSDs, which is favourable. The results are therefore somewhat conflicting ([28]).

The explanatory power (as measured by the coefficient of determination, R^2) of both NACE 1-digit models (i.e. one looking at MSDs and the other at wellbeing; Table 27) is rather limited, at just over 2 %. The effects estimated based on the EWCS and ESENER-3 linked data (on NACE-2 digit) in Table 28 are comparable and explain between 1.7 % and 3 % of the occurrence of MSDs. Note that, while this indicates low explanatory power, the identifying variables included as dummies (fixed effects) in the models at the individual level explain a similar share of the variation in MSDs. In other words, the OSH practices do appear to cover this share of the variance.

The second model in each table regresses wellbeing on the ESENER-3 variables. Similar to the MSD models in section 4, a negative effect of workers' participation on wellbeing was found, yet positive effects of health awareness programmes were observed in the full sample and of psychosocial risk prevention in full and restricted samples. The explanatory power values (R^2) are also low, at 1.3 % and 1.4 % in the NACE 1-digit models for the full sample and the restricted sample, respectively (Table 27). In the NACE 2-digit model for the restricted sample, the positive effects of digitalisation, psychosocial risk prevention and health awareness programmes are confirmed, and workers' participation remains

([26]) The issues are (a) precision of the averages in small cells (discussed in Annex 8.7), (b) reduced variation, as linked data effectively limits the sample size to the number of combinations in the establishment data, and (c) collinearity, as the imputed values correlate perfectly with the usual control variables, which were used as identifiers to link the data. In addition, the drawbacks of using survey data are potential measurement errors (e.g. responses based on social desirability) and the subjectivity of self-reporting. Finally, for current purposes, panel data are needed to untangle the complex causalities.

([27]) This could indicate endogeneity or reverse causality.

([28]) Paradoxical and inconsistent effects of participation, representation and union presence have often been observed in the literature. Certainly in a cross-sectional design, without longitudinal data, the improvements in well-being due to formal representation are difficult to find. For a discussion and analysis, see Wood (2008).

strongly negatively associated with wellbeing, as does formal employee representation in the full model (Table 28). Again, reverse causality is a likely explanation, as issues with wellbeing may lead to more frequent formal and informal discussions with employees. Here, the explanatory power is equally low, at 0.8 % for the full model and 1.4 % for the stricter sample.

In summary, these models show a number of plausible relationships, but also indicate unexpected associations that may be related to sector, company size and country. As these variables together determine the link between EWCS and ESENER data, they cannot be controlled for. At the worker level, the same ambiguity has been noted with respect to social dialogue, namely that it is not necessarily connected with better job outcomes. However, based on cross-sectional data, these findings suggest that the relation between job outcomes and social dialogue deserves further exploration, as it appears even in the examination of rudimentary linked data.

Table 29: Ordinary least squares regression of MSDs, wellbeing and psychological problems on OSH risks and preventive strategies

OSH risks and strategies	Full sample		Cells > 10 establishments	
	MSDs	Wellbeing	MSDs	Wellbeing
Biomechanical stress	0.295***	0.038	0.425***	-0.003
Psychosocial risks	-0.012	-0.028	-0.060	-0.016
Digitalisation	-0.403***	0.071*	-0.488***	0.078
Formal employee representation	-0.106***	-0.024	-0.137***	-0.011
Workers' participation	0.331***	-0.168***	0.446***	-0.236***
OSH risk assessments	0.196***	-0.031	0.148***	0.010
General OSH risk prevention	0.097	-0.069*	0.126	-0.059
Psychosocial risk prevention	0.103*	0.085***	0.087	0.117***
Health awareness programmes	-0.052	0.061***	0.005	0.036
OSH training	-0.240***	0.026	-0.275***	0.013
Constant	0.100**	0.778***	0.023	0.809***
R^2	2.0%	1.3%	2.4%	1.4%
N	26,023	25,996	21,111	21,090

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Notes: Linked by country, sector (NACE Rev. 2, 1-digit) and company size (three categories).

Source: Authors' compilation based on EWCS sixth wave (2015) and ESENER-3 (2019) data

Table 30: Ordinary least squares regression of MSDs, wellbeing and psychological problems on OSH risks and preventive strategies

OSH risks and strategies	Full sample		Cells > 10 establishments	
	MSDs	Wellbeing	MSDs	Wellbeing
Biomechanical stress	0.187***	0.021	0.463***	-0.043
Psychosocial risks	0.052*	-0.013	-0.058	-0.020
Digitalisation	-0.256***	0.026	-0.616***	0.181***
Formal employee representation	-0.042*	-0.035***	-0.066*	-0.029
Workers' participation	0.165***	-0.070***	0.417***	-0.207***
OSH risk assessments	0.124***	-0.018	0.152**	0.016
General OSH risk prevention	0.105*	-0.040	0.045	-0.010
Psychosocial risk prevention	-0.016	0.066***	0.121*	0.062*
Health awareness programmes	-0.039	0.031*	-0.040	0.059*
OSH training	-0.142***	0.020	-0.287***	-0.001
Constant	0.208***	0.731***	0.072	0.784***
R^2	1.7%	0.8%	3.0%	1.4%
N	24,223	24,196	13,539	13,525

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Note: Linked by country, sector (NACE Rev. 2, 2-digit) and company size (three categories).

Source: Authors' elaboration on European Working Conditions Survey sixth wave (2015) and ESENER-3 (2019) data

6 Conclusions

The primary aim of this study was to examine the relationship between psychosocial factors at work and work-related MSDs, using EWCS (2015) and ESENER (2019) data. Building on a conceptual framework that was derived from the literature, three pathways linking job characteristics to health outcomes were explored:

1. a biomechanical pathway, which connects physical strains to MSDs and can affect wellbeing as a secondary outcome;
2. a psychosocial pathway, which connects mental strain to wellbeing and can translate into MSDs as a secondary outcome; and
3. prevention pathways, which indicate where organisational characteristics, workplace practices and worker characteristics can intervene directly in the biomechanical and psychosocial pathways.

The research questions were investigated by means of descriptive analyses, correlation analyses, cluster analyses and multivariate analyses. In addition, qualitative feedback was gathered from experts at focus group meetings to verify the findings.

6.1 Psychosocial factors are associated with musculoskeletal disorders

First, a correlation between biomechanical factors and psychosocial factors on the one hand, and MSDs and wellbeing on the other hand, were found and presented. This answers the first research question (‘Are psychosocial factors at work and MSDs linked?’). Generally speaking, there is a negative association between wellbeing and MSDs. Moreover, the correlations between MSDs and wellbeing are consistent across the different regions of the EU (see research question 4: ‘How are psychosocial risks and MSDs, and their association, distributed across the EU?’). This validates the relationships found and justifies analysing the association between psychosocial factors and MSDs at the EU level.

With respect to the sociodemographic characteristics of workers, country groupings and economic categories (industry, occupation, company size) (in relation to research question 4: ‘How are psychosocial risks and MSDs, and their association, distributed across the EU?’), there are some apparent differences with respect to MSDs. For example, MSDs are reported less in the southern and eastern regions, in the financial services and education sectors, in small organisations and by more highly educated workers. However, when such factors are included in the multivariate model, their contribution is found to be minor and the initial differences appear to result from differences in more precise job characteristics, as well as intermediary outcomes such as general health, work-life balance and wellbeing. In other words, the kind of work people do and the way work is organised matter more than who is doing the job.

This means that the factors that lead to a certain risk for MSDs or a certain level of wellbeing also have an effect independent from the industry, the company size and the characteristics of workers (research question 3: ‘How do these factors differ by sector, company size and characteristics of workers?’). This is not withstanding the fact that individual variation — for example some workers being tougher mentally or physically than others or some workers being more careful than others when performing tasks — still plays a major role, as the incidence of MSDs remains largely unexplained, as, unavoidably, not all personal information can be known. However, it appears that, in the main, MSDs cannot be explained simply in relation to sociodemographic characteristics.

Going into detail regarding job characteristics (research question 2: ‘What factors are involved in such a link’?), biomechanical stress (e.g. exposure to vibrations, tiring or painful positions, lifting or moving people, repetitive hand or arm movements) is as expected an important factor, but psychosocial factors are also unambiguously connected to MSDs, and the combined effect of biomechanical and psychosocial factors is substantial. For example, there is a clear direct adverse impact of working time-related variables. This adverse impact is only partly mediated by a poor work-life balance, which is one consequence of excessive or irregular working time. This leaves room for another consequence that is known to be detrimental to health, which is exhaustion or a lack of recovery time. Furthermore, there

are strong favourable effects in terms of worker participation, supportive management and perceived job security. The beneficial effect of the final two factors is likely to be due to their contribution to wellbeing. This underlines the importance of organisational justice, worker recognition and social support. Contrary to expectations, autonomy-related factors do not have any clear or significant effect. This may be because autonomy is related not only to more control and freedom, but also to a sense of insecurity, isolation and a lack of guidance and boundaries.

6.2 Biomechanical factors are associated with wellbeing

The second part of the conceptual framework includes the biomechanical pathway to explain wellbeing, and also to address research questions 1-4. This biomechanical pathway links job characteristics at the task level to MSDs, which in turn have an impact on workers' wellbeing. The relationship between job characteristics at the task level and MSDs is moderated by job aspects at the organisational level and by workers' characteristics. First, from the descriptive statistics, it appears that wellbeing is a variable with very little variation at the aggregate level, as country differences are not pronounced. Rather, wellbeing seems to vary much more between individual workers. Yet, as with MSDs, this variation is again not captured by sociodemographic factors or economic factors such as industry, occupation or company size. Instead, it is job characteristics that are decisive. The role of work-related variables is important, although wellbeing is shaped not only at work but also in private life; yet, these social spheres cannot be separated, and workplace social support, for instance, may also absorb issues brought to work from home. The autonomy-related variables, however, are not substantially associated with wellbeing, similar to the findings for MSDs. Instead, wellbeing is associated with all variables in the domains of the social work environment and with work-life balance, which is linked to working time but not to working time autonomy. In terms of working conditions, biomechanical stress is strongly correlated with both MSDs and wellbeing, and the current study shows that workers who have developed MSDs as a result of biomechanical stress may also suffer in terms of wellbeing.

6.3 Establishments can be categorised into six types based on OSH, combining risks and preventive strategies

The OSH typology found through cluster analysis divides establishments into six types, addressing research question 5 ('What preventive strategies are available to tackle the problem of MSDs in the EU?'). In this typology, 'risks' refer to biomechanical stress, psychosocial stress or digitalisation, while 'prevention' can be participatory (formal employee representation, workers' participation) or procedural (OSH assessments, general OSH risk prevention, psychosocial risk prevention, health awareness programmes and OSH training).

The six clusters identified are:

7. high risk-high agency (HR-HA), in which establishments are high-risk environments but have matching prevention strategies in place;
8. physical-procedural (PH-PR), where establishments have moderate levels of biomechanical stress and average psychosocial risks, coupled with a fairly high degree of preventive practices but less formal worker participation;
9. psychosocial-procedural (PS-PR), in which establishments report very low levels of biomechanical stress and some psychosocial risks, and focus on psychosocial risk prevention and health awareness programmes;
10. digitalisation-low agency (DI-LA), in which establishments report average levels of biomechanical stress, fairly high levels of psychosocial risks and a high degree of digitalisation, and there is some degree of worker participation but prevention practices are rare;
11. psychosocial-participatory (PS-PA), in which establishments report very low levels of biomechanical stress and some psychosocial risks, which are addressed through formal worker participation; and
12. psychosocial-low agency (PS-LA), which has low risks overall, but lacks formal employee participation and prevention strategies.

As the mapping exercise indicates, three of the OSH types are associated with unfavourable health outcomes: high risk-high agency (type 1), physical-procedural (type 2) and to some degree digitalisation-low agency (type 4). On the other hand, three of the OSH types are associated with favourable outcomes: psychosocial-procedural (type 3), psychosocial-participatory (type 5) and psychosocial-low agency (type 6). Establishments of the types that face predominantly psychosocial risks have lower risks overall, while establishments classified as unfavourable OSH types have to deal not only with high levels of physical risks, but also with high levels of psychosocial risks. As physical and psychosocial risks are connected directly and indirectly through common factors that were explored at the worker level and discussed in section 4, this finding is quite plausible.

From the description of the clusters, it appears that risks are mainly related to economic activity (industry), while the strategies to address them (which in general are either procedural or participatory) are linked to the company/establishment size. This was an expected outcome.

By combining ESENER data on OSH practices in establishments with EWCS data on MSDs and wellbeing in a multivariate analysis, it was found that formal employee representation and OSH training are associated with lower MSD risks, and psychosocial risk prevention is associated with better wellbeing. However, some apparently paradoxical effects were also found, which may point to a reversal of cause and effect: problems may lead to coping efforts or ways to deal with these problems. For example, MSDs were found to be positively associated with worker participation and OSH risk assessments, while wellbeing was found to be negatively associated with worker participation. An alternative explanation for these unexpected findings is that there are higher levels of awareness and openness about problems in workplaces with higher levels of worker participation, meaning that problems are more likely to be reported in these workplaces. This might explain why more MSDs are reported in the Nordic Member States and Ireland.

6.4 Implications for the practice

This study focused on workplace-level job characteristics, including biomechanical and psychosocial factors, and on OSH management practices, exploring how these factors are related to MSDs and wellbeing. The results indicate that substantial improvements in MSDs and wellbeing can be accomplished at the workplace level. Importantly, the main contributing factors are job characteristics, not sociodemographic factors or aspects related to country or economic (industry, occupation and company size) factors.

While some workplace characteristics may be more difficult to disentangle from the nature of the job, psychosocial factors that have a strong influence on MSDs or on wellbeing (adverse social behaviour, atypical working time, job security, supportive management and worker participation) can be assessed and then eliminated or reduced. Moreover, workplace risk assessments focusing on negative health outcomes should take into account that the relationship between MSDs and wellbeing works in two directions, so a holistic approach to risk assessment is most likely to be successful. Further development of guidelines and the exchange of best practices between companies on how to prevent psychosocial risks and create a healthy company culture in which sufficient attention is paid to raising workers' awareness of safety and health risks and consequences are needed.

In addition, the study has shown that OSH training can be effective against MSDs. However, when it comes to job autonomy, the preventive approach may not be straightforward, as a high level of job autonomy — while often positive and protective in terms of mental health — may also be related to a poorer work-life balance, overwork or perhaps even isolation. The current study suggests that latitude at the individual level (task discretion, control over the work pace), collectively (autonomous teamwork) or with respect to employment conditions (working time autonomy) is not associated with MSDs or wellbeing. It is unclear at this stage whether this finding is due to there being no effect or to the positive effect of some aspects of job control being cancelled out by the negative effects of other aspects. Job autonomy should in any case always be linked to proper OSH training and a healthy work culture that shapes workers' attitudes and behaviours in terms of preventing MSDs.

6.5 Future research

This study has unveiled the relationship between psychosocial factors and MSDs. Nevertheless, a number of limitations were encountered that could be addressed in future research.

The main challenge is to bring together job outcomes and OSH prevention practices; however, this requires linked employee-employer data, which are difficult to obtain. Combining two surveys returned plausible outcomes, but the explanatory power was weak, and it would be desirable to simultaneously include job characteristics, economic factors, sociodemographic factors and OSH prevention strategies.

Moreover, it was not possible to demonstrate the presumed interaction effects (e.g. with autonomy and professional position on either the biomechanical or psychosocial pathway), although direct effects are clearly driving the model. This suggests that interactions do exist, but that it may be necessary to go into more detail on specific areas of the work field and focus on particular factors, instead of using an integrated model as presented here. In that case, however, the explanatory power might of course drop and any correlations between the variables could be overlooked. In contrast, while this research had an EU-wide scope, justified by the similarity of the patterns in different countries, it may be interesting to set up a comparative framework using a multi-level design, in an attempt to find important institutional factors and policies affecting wellbeing and MSDs.

Finally, the best approach to distinguish between association and causality would be to have longitudinal or panel data at workplace level and at employee level. Having such data would not only resolve paradoxical effects due to reverse causality, but could also allow the complications of the relationship between MSDs and wellbeing, including the bidirectional relationship, the effect of chronic exposure and the factors involved in the vicious mental loop that may worsen MSDs (e.g. posture problems or fear avoidance), to be explored.

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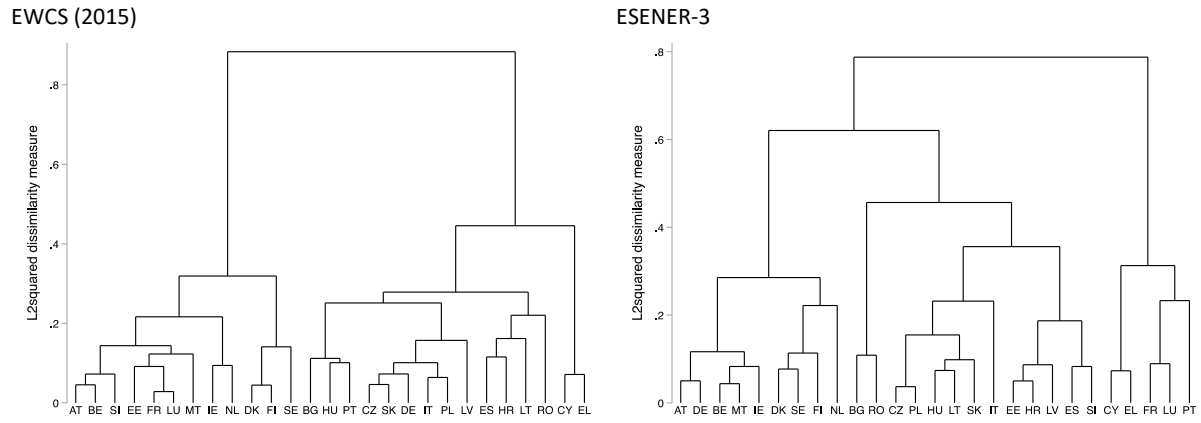
Annex 1 Population

To corroborate the grouping of Member States into five regions, a cluster analysis was carried out on the constructs proposed in this study, aggregated at the country level, and some additional variables with more cross-country variation. Figure 7 shows the dendrograms of these analyses based on EWCS 2015 and ESENER-3 2019 data. In both cases, a five- or six-cluster solution is optimal, and the resulting clusters are similar, although some countries are difficult to consistently assign to country groupings (e.g. Germany, Italy, Malta, Slovenia). Taking into consideration these cluster solutions, this study opts to keep certain blocks of countries together, such as the Mediterranean, Baltic and Balkan countries. The sole liberal welfare state, Ireland, was added to the Nordic cluster for presentational reasons.

Figure 9: Country groupings based on cluster analysis using EWCS and ESENER data



Note: Clustering is based on complete linkage and squared Euclidean distances. For the EWCS clustering, all constructs from this study were used. For the ESENER-3 clustering, five additional variables and constructs were added, which reflect the countries' compliance, enforcement and accessibility of OSH measures: the existence of a risk assessment plan (Q250), the existence of a stress prevention plan (Q300), inspection visits (Q154), difficulties to implement OSH measures (Q263_1-7), and the degree to which actions are extrinsically motivated (image, productivity, fines, etc.) (Q264_1-6).

Annex 2 Variables and constructs

The following data cleaning and testing strategy was adopted to retain as much variation and as many cases as possible in the sample.

First, the issue of missing values needed to be tackled. Missing values on just one of the items of a scale make it impossible to compute the scale, and when using many variables in regressions or data reduction methods like cluster analysis, cases drop out and the weighting scheme may be affected, as the composition of the sample changes. Advanced methods, such as missing value imputation or regressions to estimate the missing values can be considered. Easier methods include replacing missing values by the average, the modal category, or reasonable assumptions using logical expressions. The advantage of the latter type is that the choice is understandable; for example, on the question of doing shift work, if the respondent does not answer 'yes', any other answer can be interpreted as 'not yes'. This is the main assumption made in this study, which is defendable when the number of missing values on most items separately is low. For other constructs using non-dichotomised variables no missing value adjustments are made, as no such sensible assumptions could always be made, and this is indicated below. The only exception were the biomechanical stress items, for which the non-response was interpreted as an absence of biomechanical stress, which for all items was the modal category.

The second consideration is the calculation of the constructs. In general, a normalised sum scale was computed, summing all items and normalising this sum by dividing it by the theoretical maximum. This is possible for dichotomous and metric variables. In other cases, nominal variables were first dichotomised and then entered into the sum scale. As such, for all constructs, a score of 0 means a total absence of all items, and a score of 1 means all items are present. Higher values always mean 'more'. For single dichotomous variables, this score can be interpreted as a share. Because of the normalisation, direct effects in an ordinary least squares (OLS) regression are not only marginal effects, but can also be interpreted in a similar way as elasticities: the effects found reflect the change in the dependent variable for a 100 % increase in the explanatory variable ([29]).

The third issue is testing the reliability of the constructs. It should be clear that both the ESENER-3 and the EWCS sixth wave are surveys with a broad scope. The corollary of this is that often only a limited number of items per scale are available. Stringent reliability analyses may therefore be disappointing. Here, a twofold strategy was followed: as a first check, sum scales were tested with the Cronbach's alpha reliability test for metric or pseudo-metric ([30]) variables, and the KR-20 ('Kuder-Richardson Formula 20') test for dichotomous variables. The critical value of 0.70 on either of these tests is used as a rule-of-thumb to distinguish scales with sufficiently strong inter-item correlations. The interpretation of this test is that the items measure the same concept, and therefore their expected correlation (alpha-value) should be sufficiently high. Falling short of this threshold, factor analyses are executed to check whether or not there is a single factor with an Eigenvalue greater than 1, which means the factor covers more variance than any single item by itself, and to verify factor loadings point in the same direction. The interpretation of this test is that there is a common factor that is expressed by different items. In the case of dichotomous variables, which is true for the majority of scales presented here, factor analyses are based on polychoric correlation matrices suited for this type of variable. Items have been selected to optimise the reliability, as well as respecting conceptual logic. For instance, it is possible that items have no correlation at all, but the consequences are the same or similar (e.g. lifting weights and lifting people), and those items can either substitute or complement each other. This is described in the discussion of the constructs.

([29]) It is good practice to speak of explanatory variables (regressors) and not of 'independent variables', as explanatory variables may not be independent but rather endogenously determined or correlated to the error term. The variable to be explained (the regressand), on the other hand, can be thought of as the 'dependent' variable. Note that 'explaining' in this sense does not imply a causal relationship, but rather explaining the variance in the dependent variable.

([30]) A pseudometric variable is not a metric variable (e.g. an ordinal variable), but is treated like one nevertheless. For instance, in time scales ranging from always to never, the difference between 'always' and 'most of the time' is not exactly the same as between 'never' and 'rarely'. For practical purposes, one can proceed as if it were.

Table 31: Selected questions and items from the EWCS (2015) and ESENER-3 (2019) questionnaires

Variable/construct	Questions and items
EWCS questionnaire	
Adverse social behaviour	Q72 Have you been subjected to any of the following forms of discrimination over the past 12 months? — *1 yes, 2 no* ▪ Race, ethnic background or colour ▪ Nationality ▪ Sex ▪ Religion ▪ Disability ▪ Sexual orientation Q80 Over the last month, during the course of your work have you been subjected to any of the following? — *1 yes, 2 no* ▪ Verbal abuse ▪ Unwanted sexual attention ▪ Threats ▪ Humiliating behaviours Q81 And over the past 12 months, during the course of your work have you been subjected to any of the following? — *1 yes, 2 no* ▪ Physical violence ▪ Sexual harassment ▪ Bullying/harassment
Atypical working time	Q37 Normally, how many times a month … — *number* ▪ Do you work at night, for at least 2 hours between 10.00 pm and 05.00 am? ▪ Do you work on Sundays? ▪ Do you work on Saturdays? ▪ Do you work more than 10 hours a day? Q39 Do you work … — *1 yes, 2 no* ▪ The same number of hours every day? ▪ The same number of days every week? ▪ The same number of hours every week? ▪ Fixed starting and finishing times? ▪ Shifts? Q43 Do changes to your working time arrangements occur regularly? How long before are you informed about these changes? — *1 no, 2 yes, the same day, 3 yes, the day before, 4 yes, several days in advance, 5 yes, several weeks in advance*
Autonomous teamwork	Q60 For the team in which you work mostly, do the members decide by themselves … — *1 yes, 2 no* ▪ On the division of tasks? ▪ Who will be the head of the team? ▪ The timetable of the work?
Biomechanical stress	Q29 Are you exposed at work to … — *1 all of the time, 2 almost all of the time, 3 around 3/4 of the time, 4 around half of the time, 5 around 1/4 of the time, 6 almost never, 7 never* ▪ Vibrations from hand tools, machinery etc.? Q30 Does your main paid job involve … — *1 all of the time, 2 almost all of the time, 3 around 3/4 of the time, 4 around half of the time, 5 around 1/4 of the time, 6 almost never, 7 never*

Variable/construct	Questions and items
	▪ Tiring or painful positions? ▪ Lifting or moving people? ▪ Carrying or moving heavy loads? ▪ Sitting? ▪ Repetitive hand or arm movements?
Emotional labour	Q30 Does your main paid job involve … — *1 all of the time, 2 almost all of the time, 3 around 3/4 of the time, 4 around half of the time, 5 around 1/4 of the time, 6 almost never, 7 never* ▪ Dealing directly with people who are not employees at your workplace such as customers, passengers, pupils, patients etc.? ▪ Handling angry clients, customers, patients, pupils etc.? ▪ Being in situations that are emotionally disturbing for you? Q50 Is your pace of work dependent on … — *1 yes, 2 no* ▪ Direct demands from people such as customers, passengers, pupils, patients, etc.?
General health	Q75 How is your health in general? — *1 very good, 2 good, 3 fair, 4 bad, 5 very bad*
Health impact	Q73 Do you think your health or safety is at risk because of your work? — *1 yes, 2 no* Q74 Does your work affect your health? — *1 yes, mainly positively, 2 yes, mainly negatively, 3 no*
Involuntary part-time or overtime work	Q24 How many hours do you usually work per week in your main paid job? Q25 Provided that you could make a free choice regarding your working hours and taking into account the need to earn a living: how many hours per week would you prefer to work at present?
Job security	Q89 To what extent do you agree or disagree with the following statements about your job? — *1 strongly agree, 2 tend to agree, 3 neither agree nor disagree 4 tend to disagree, 5 strongly disagree* ▪ I might lose my job in the next 6 months ▪ If I were to lose or quit my current job, it would be easy for me to find a job of similar salary
Mental health problems	Q61 For each of the following statements, please select the response which best describes your work situation — *1 always, 2 most of the time, 3 sometimes, 4 rarely, 5 never* ▪ You experience stress in your work Q78 Over the last 12 months, did you have any of the following health problems? — *1 yes, 2 no* ▪ Headaches, eyestrain ▪ Anxiety ▪ Overall fatigue Q79 Over the last 12 months, how often did you have any of the following sleep related problems? — *1 daily, 2 several times a week, 3 several times a month, 4 less often, 5 never* ▪ Difficulty falling asleep ▪ Waking up repeatedly during the sleep ▪ Waking up with a feeling of exhaustion and fatigue

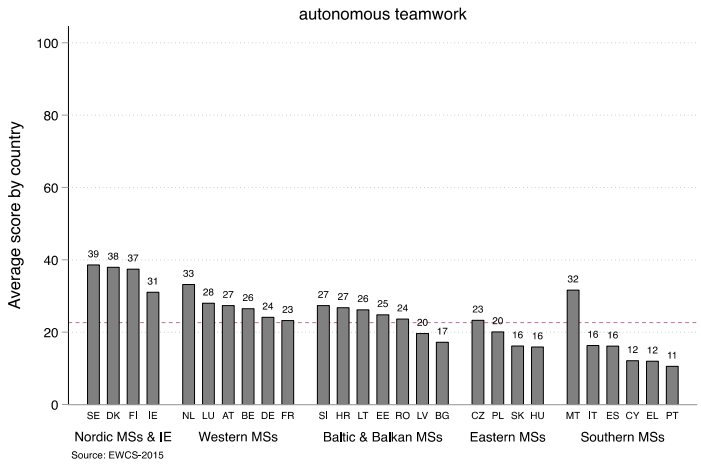
Variable/construct	Questions and items
MSDs	Q78 Over the last 12 months, did you have any of the following health problems? — *1 yes, 2 no* ▪ Backache ▪ Muscular pains in shoulders, neck and/or upper limbs (arms, elbows, wrists, hands etc.) ▪ Muscular pains in lower limbs (hips, legs, knees, feet etc.)
Quick work (time pressure)	Q49 Does your job involve … — *1 all of the time, 2 almost all of the time, 3 around 3/4 of the time, 4 around half of the time, 5 around 1/4 of the time, 6 almost never, 7 never* ▪ Working at very high speed? ▪ Working to tight deadlines?
Repetitive tasks	Q48 Does your job involve short repetitive tasks … — *1 yes, 2 no* ▪ Of less than 1 minute? ▪ Of less than 10 minutes?
Social dialogue	Q71 Does the following exist at your company or organisation … — *1 yes, 2 no* ▪ Trade union, works council or a similar committee representing employees? ▪ Health and safety delegate or committee? ▪ A regular meeting in which employees can express their views about what is happening in the organisation?
Supportive management	Q63 To what extent do you agree or disagree that your immediate boss … — *1 strongly agree, 2 tend to agree, 3 neither agree nor disagree 4 tend to disagree, 5 strongly disagree* ▪ Respects you as a person? ▪ Gives you praise and recognition when you do a good job? ▪ Is successful in getting people to work together? ▪ Is helpful in getting the job done? ▪ Provides useful feedback on your work? ▪ Encourages and supports your development?
Task complexity	Q53 Does your main paid job involve … — *1 yes, 2 no* ▪ Meeting precise quality standards? ▪ Assessing yourself the quality of your own work? ▪ Solving unforeseen problems on your own? ▪ Complex tasks? ▪ Learning new things? *Not included from this set: monotonous tasks*
Task discretion	Q54 Are you able to choose or change … — *1 yes, 2 no* ▪ Your order of tasks? ▪ Your methods of work? ▪ Your speed or rate of work?
Wellbeing	Q87 How have you been feeling over the last two weeks? — *1 all of the time, 2 most of the time, 3 more than half of the time, 4 less than half of the time, 5 some of the time, 6 at no time* ▪ I have felt cheerful and in good spirits ▪ I have felt calm and relaxed ▪ I have felt active and vigorous ▪ I woke up feeling fresh and rested ▪ My daily life has been filled with things that interest me
Work pace control	Q50 Is your pace of work dependent on … — *1 yes, 2 no*

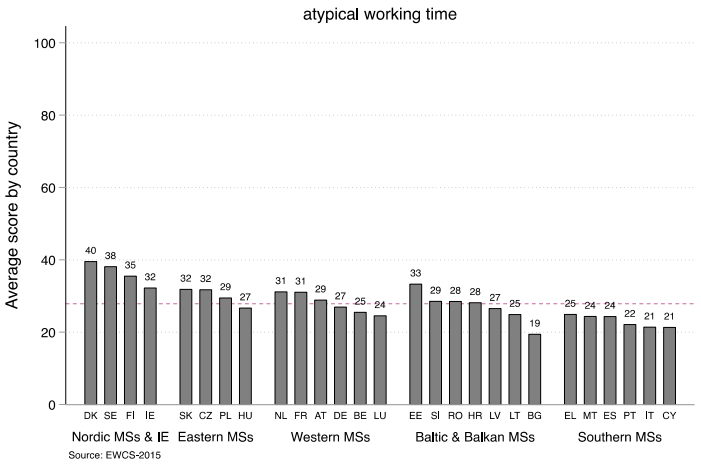
Variable/construct	Questions and items
	▪ The work done by colleagues? ▪ Numerical production targets or performance targets? ▪ Automatic speed of a machine or movement of a product? ▪ The direct control of your boss? *Not included from this set: direct demands from people such as customers, passengers, pupils, patients etc.*
Work-life balance	Q45 How often in the last 12 months, have you .../Since you started your main paid job, how often have you ... —*1 always, 2 most of the time, 3 sometimes, 4 rarely, 5 never* ▪ Kept worrying about work when you were not working? ▪ Felt too tired after work to do some of the household jobs which need to be done? ▪ Found that your job prevented you from giving the time you wanted to your family? ▪ Found it difficult to concentrate on your job because of your family responsibilities? ▪ Found that your family responsibilities prevented you from giving the time you should to your job?
Worker participation	Q61 What describes your work situation best? — *1 always, 2 most of the time, 3 sometimes, 4 rarely, 5 never* ▪ You are consulted before objectives are set for your work ▪ You are involved in improving the work organisation or work processes of your department or organisation ▪ You have a say in the choice of your work colleagues ▪ You are able to apply your own ideas in your work ▪ You can influence decisions that are important for your work
Working time autonomy	Q42 How are your working time arrangements set? — *1 they are set by the company/organisation with no possibility for changes, 2 you can choose between several fixed working schedules determined by the company/organisation, 3 you can adapt your working hours within certain limits (e.g. flexitime), 4 your working hours are entirely determined by yourself* Q61 What describes your work situation best? — *1 always, 2 most of the time, 3 sometimes, 4 rarely, 5 never* ▪ You can take a break when you wish Q47 How easy or difficult is it to take an hour or two off during working hours to take care of personal or family matters? — *1 very easy, 2 fairly easy, 3 fairly difficult, 4 very difficult*
ESENER questionnaire	
Biomechanical stress	Q200 Depending on the type of work there are different types of risks and hazards. Please tell me for each of the following risk factors whether it is present or not in your establishment, regardless of whether it is currently under control and regardless of the number of employees it affects — *1 yes, 2 no* ▪ Lifting or moving people or heavy loads ▪ Repetitive hand or arm movements ▪ Tiring or painful positions
Digitalisation	Q310 We now have a few questions on potential health hazards related to digitalisation. Does your establishment use any of the following digital technologies for work? — *1 yes, 2 no*

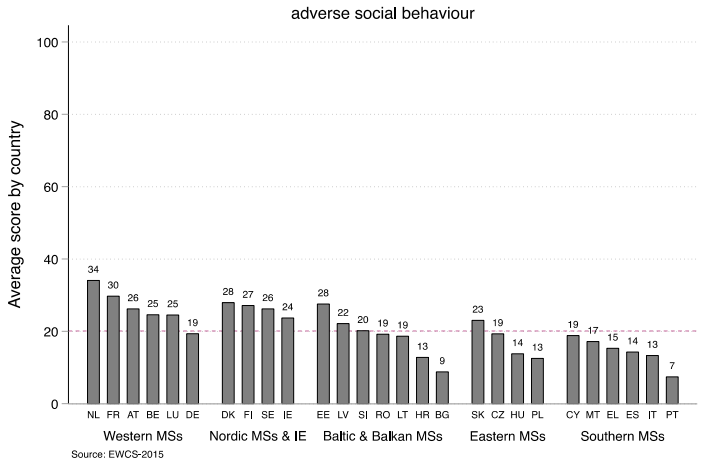
Variable/construct	Questions and items
	▪ Personal computers at fix workplaces ▪ Laptops, tablets, smartphones or other mobile computer devices ▪ Robots that interact with workers ▪ Machines, systems or computer determining the content or pace of work ▪ Machines, systems or computer monitoring workers' performance ▪ Wearable devices, such as smart watches, data glasses or other (embedded) sensors
Formal employee representation	Q350 Which of the following forms of employee representation do you have in this establishment? — *1 yes, 2 no* ▪ A works council ▪ A trade union representation ▪ A health and safety committee ▪ A health and safety representative Q352 How often is health and safety discussed between employee representatives and the management? —*1 regularly, 2 occasionally, 3 practically never*
General OSH risk prevention	Q202 Has your establishment taken any of the following measures? — *1 yes, 2 no* ▪ Provision of equipment to help with the lifting or moving of loads or other physically heavy work ▪ Rotation of tasks to reduce repetitive movements or physical strain ▪ Encouraging regular breaks for people in uncomfortable or static postures including prolonged sitting ▪ Provision of ergonomic equipment, such as specific chairs or desks ▪ The possibility for people with health problems to reduce working hours
Health awareness programmes	Q157 Does your establishment take any of the following measures for health promotion among employees? — *1 yes, 2 no* ▪ Raising awareness about healthy nutrition ▪ Raising awareness on the prevention of addiction, e.g. to smoking, alcohol or drugs ▪ Promotion of sports activities outside working hours ▪ Promotion of back exercises, stretching or other physical exercise at work
OSH risk assessments	Q252 Which of the following aspects are routinely evaluated in these workplace risk assessments? —*1 yes, 2 no* ▪ The safety of machines, equipment and installations ▪ Work postures, physical working demands and repetitive movements ▪ Exposure to noise, vibrations, heat or cold ▪ Supervisor-employee relationships ▪ Organisational aspects such as work schedules, breaks or work shifts *Not included from the set: dangerous chemical or biological substances*
OSH training	Q355 On which of the following topics does your establishment provide the employees with training? — *1 yes, 2 no* ▪ The proper use and adjustment of their working equipment and furniture ▪ On how to prevent psychosocial risks such as stress or bullying ▪ On how to lift and move heavy loads or people
Psychosocial risk prevention	Q304 Has your establishment used any of the following measures to prevent psychosocial risks? — *1 yes, 2 no* ▪ Reorganisation of work in order to reduce job demands and work pressure ▪ Confidential counselling for employees ▪ Training on conflict resolution

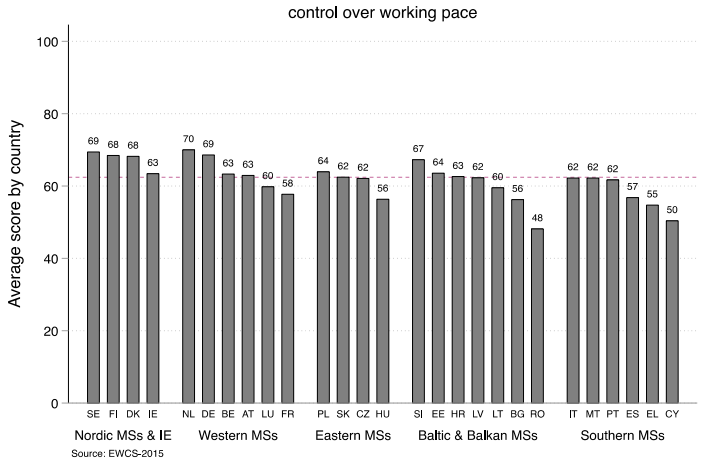
Variable/construct	Questions and items
	▪ Intervention if excessively long or irregular hours are worked ▪ Allowing employees to take more decisions on how to do their job
Psychosocial risks	Q201 Depending on the type of work there are different types of risks and hazards. Please tell me for each of the following risk factors whether it is present or not in your establishment, regardless of whether it is currently under control and regardless of the number of employees it affects — *1 yes, 2 no* ▪ Time pressure ▪ Poor communication or cooperation within the organisation ▪ Having to deal with difficult customers, patients, pupils etc. ▪ Long or irregular working hours *Not included from the set: fear of job loss.*
Worker participation	Q306 Did the employees have a role in the design and set-up of measures to address psychosocial risks? — *1 yes, 2 no* Q258 If measures have to be taken following a risk assessment: Are employees usually involved in their design and implementation? — *1 yes, 2 no, 8 that depends on the type of measures* Q357 How often are health and safety issues discussed in staff or team meetings? — *1 regularly, 2 occasionally, 3 practically never*

Figure 10: Country scores for the variables and constructs from the EWCS (2015) data

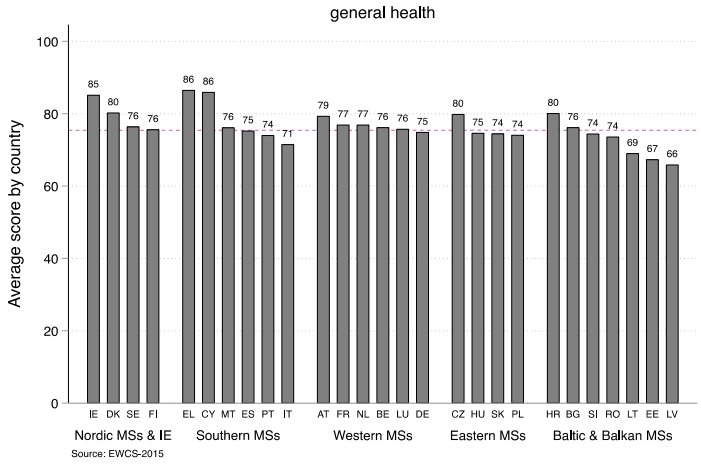


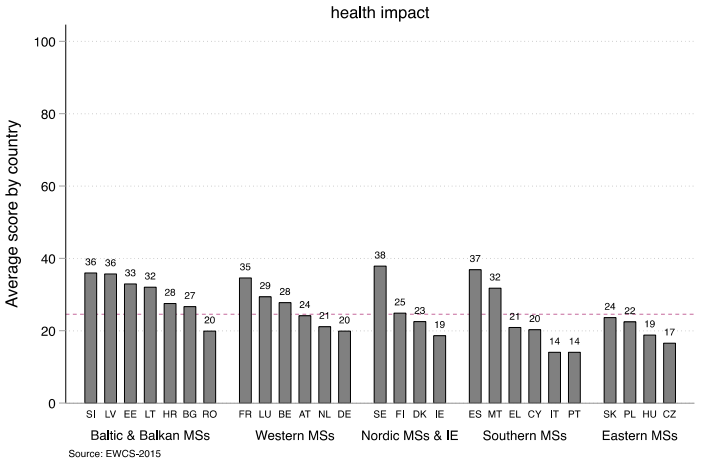


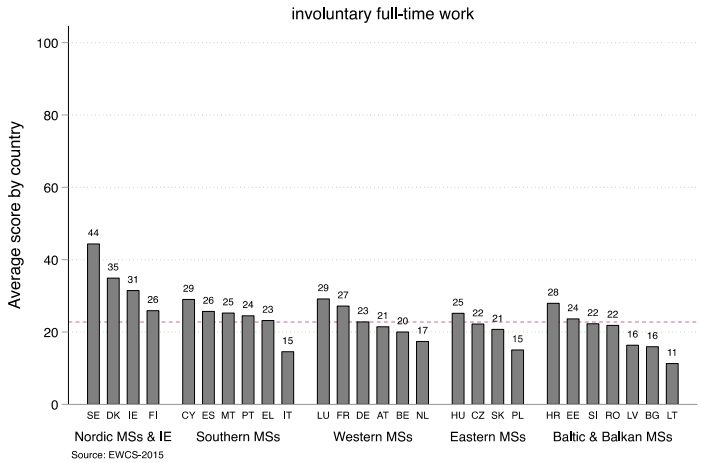


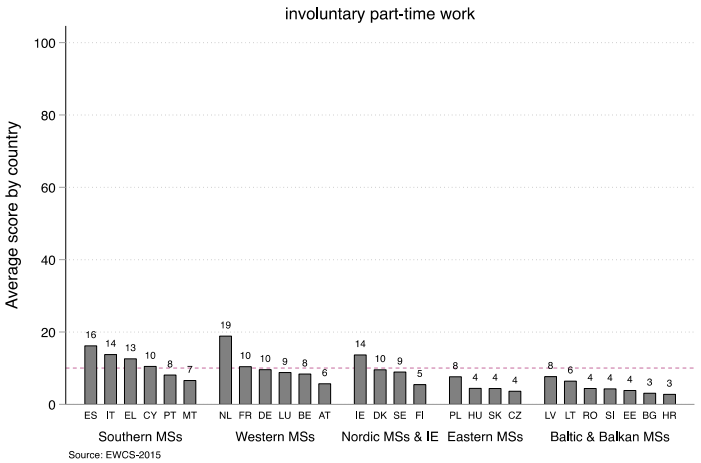

control over working pace
Average score by country
0
20
40
60
80
100
69 68 68 63
70 69 63 63 60 58
64 62 62 56
67 64 63 62 60 56 48
62 62 62 57 55 50
SE FI DK IE
NL DE BE AT LU FR
PL SK CZ HU
SI EE HR LV LT BG RO
IT MT PT ES EL CY
Nordic MSs & IE
Western MSs
Eastern MSs
Baltic & Balkan MSs
Southern MSs
Source: EWCS-2015

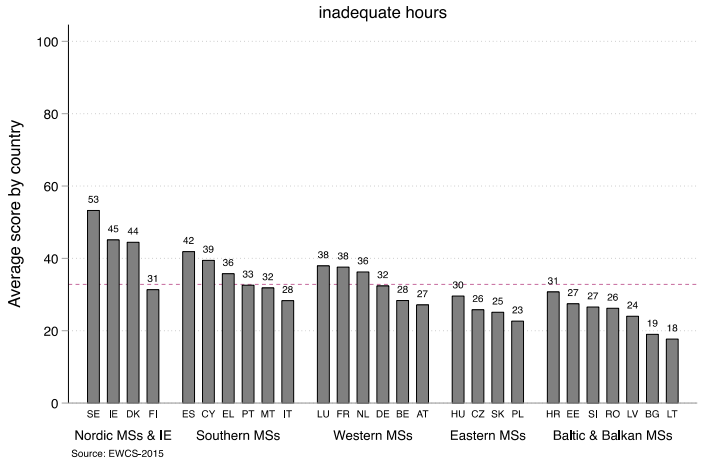

emotional labour
Average score by country
0
20
40
60
80
100
56 55 54 52 44 44
50 48 46 45
52 50 47 44 44 41
52 52 50 49 41 41 40
45 42 40 37
EL CY ES MT PT IT
SE IE FI DK
FR LU AT DE BE NL
LT HR RO SI EE LV BG
PL SK CZ HU
Southern MSs
Nordic MSs & IE
Western MSs
Baltic & Balkan MSs
Eastern MSs
Source: EWCS-2015

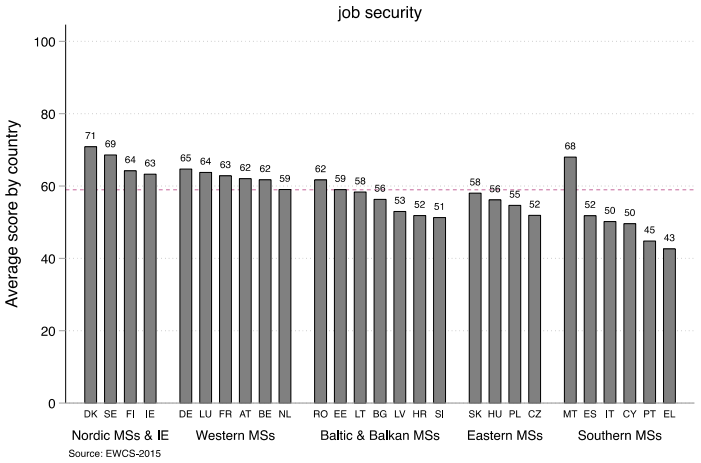

general health
Average score by country
0
20
40
60
80
100
85 80 76 76
86 86 76 75 74 71
79 77 77 76 76 75
80 75 74 74
80 76 74 74 69 67 66
IE DK SE FI
EL CY MT ES PT IT
AT FR NL BE LU DE
CZ HU SK PL
HR BG SI RO LT EE LV
Nordic MSs & IE
Southern MSs
Western MSs
Eastern MSs
Baltic & Balkan MSs
Source: EWCS-2015

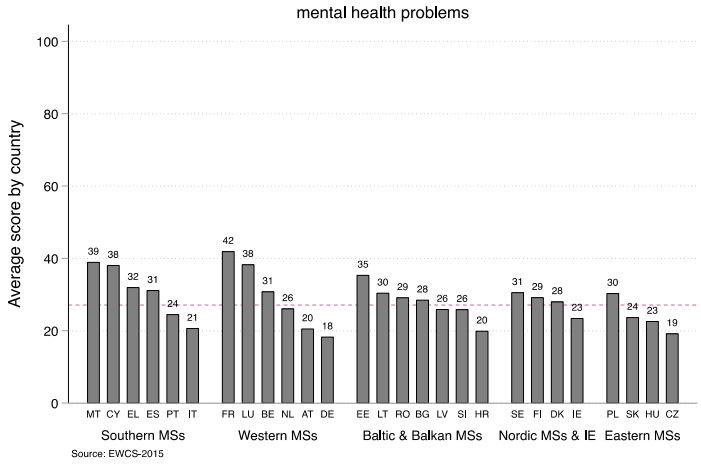

health impact
Average score by country
0
20
40
60
80
100
36 36 33 32 28 27 20
35 29 28 24 21 20
38 25 23 19
37 32 21 20 14 14
24 22 19 17
SI LV EE LT HR BG RO
FR LU BE AT NL DE
SE FI DK IE
ES MT EL CY IT PT
SK PL HU CZ
Baltic & Balkan MSs
Western MSs
Nordic MSs & IE
Southern MSs
Eastern MSs
Source: EWCS-2015

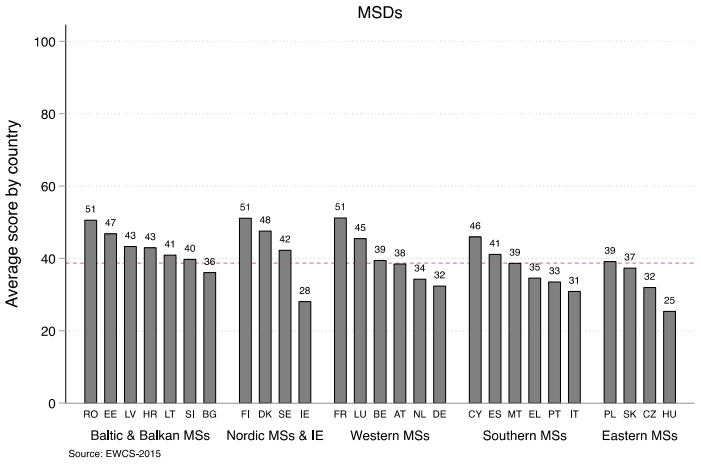

involuntary full-time work
Average score by country
0
20
40
60
80
100
44 35 31 26
29 26 25 24 23 15
29 27 23 21 20 17
25 22 21 15
28 24 22 22 16 16 11
SE DK IE FI
CY ES MT PT EL IT
LU FR DE AT BE NL
HU CZ SK PL
HR EE SI RO LV BG LT
Nordic MSs & IE
Southern MSs
Western MSs
Eastern MSs
Baltic & Balkan MSs
Source: EWCS-2015

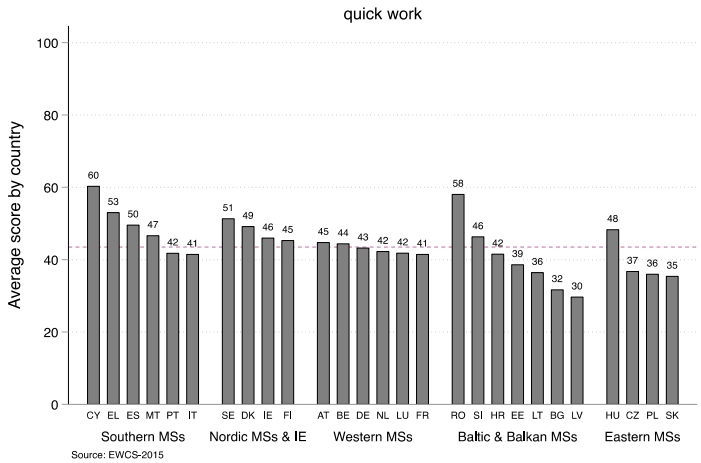

involuntary part-time work
Average score by country
0
20
40
60
80
100
16 14 13 10 8 7
19 10 10 9 8 6
14 10 9 5
8 4 4 4
8 6 4 4 4 3 3
ES IT EL CY PT MT
NL FR DE LU BE AT
IE DK SE FI
PL HU SK CZ
LV LT RO SI EE BG HR
Southern MSs
Western MSs
Nordic MSs & IE
Eastern MSs
Baltic & Balkan MSs
Source: EWCS-2015

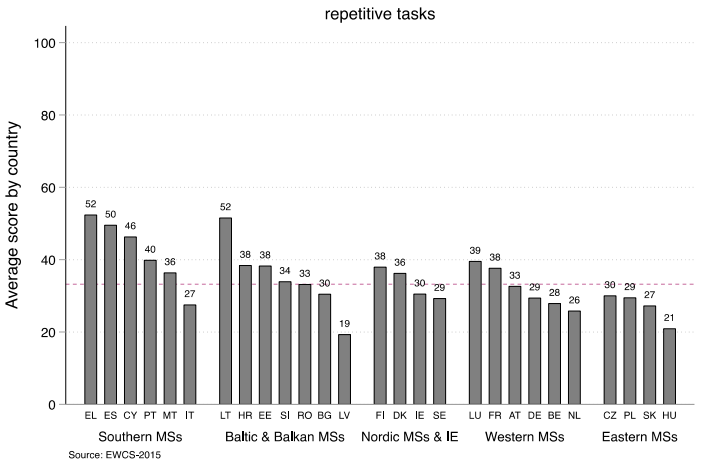

inadequate hours
Average score by country
0
20
40
60
80
100
53 45 44 31 42 39 36 33 32 28 38 38 36 32 28 27 30 26 25 23 31 27 27 26 24 19 18
SE IE DK FI ES CY EL PT MT IT LU FR NL DE BE AT HU CZ SK PL HR EE SI RO LV BG LT
Nordic MSs & IE
Southern MSs
Western MSs
Eastern MSs
Baltic & Balkan MSs
Source: EWCS-2015

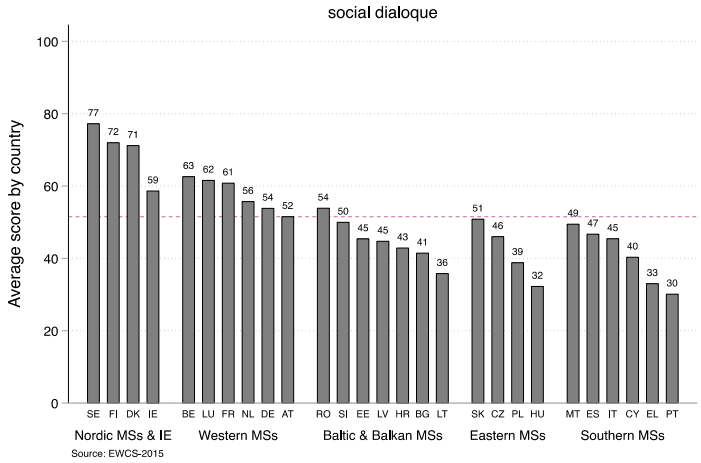

job security
Average score by country
0
20
40
60
80
100
71 69 64 63 65 64 63 62 62 59 62 59 58 56 53 52 51 58 56 55 52 68 52 50 50 45 43
DK SE FI IE DE LU FR AT BE NL RO EE LT BG LV HR SI SK HU PL CZ MT ES IT CY PT EL
Nordic MSs & IE
Western MSs
Baltic & Balkan MSs
Eastern MSs
Southern MSs
Source: EWCS-2015

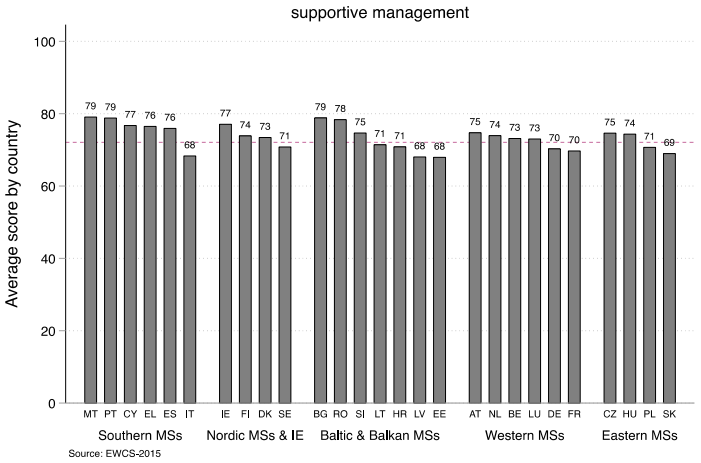

mental health problems
Average score by country
0
20
40
60
80
100
39 38 32 31 24 21 42 38 31 26 20 18 35 30 29 28 26 26 20 31 29 28 23 30 24 23 19
MT CY EL ES PT IT FR LU BE NL AT DE EE LT RO BG LV SI HR SE FI DK IE PL SK HU CZ
Southern MSs
Western MSs
Baltic & Balkan MSs
Nordic MSs & IE
Eastern MSs
Source: EWCS-2015

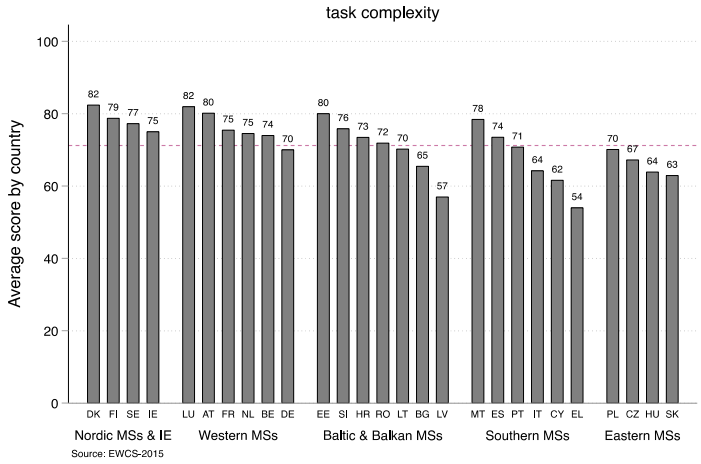

MSDs
Average score by country
0
20
40
60
80
100
51 47 43 43 41 40 36 51 48 42 28 51 45 39 38 34 32 46 41 39 35 33 31 39 37 32 25
RO EE LV HR LT SI BG FI DK SE IE FR LU BE AT NL DE CY ES MT EL PT IT PL SK CZ HU
Baltic & Balkan MSs
Nordic MSs & IE
Western MSs
Southern MSs
Eastern MSs
Source: EWCS-2015

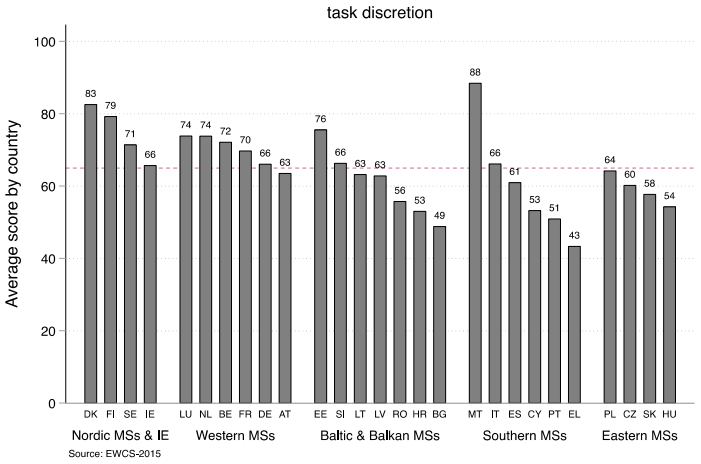

quick work
Average score by country
0
20
40
60
80
100
60 53 50 47 42 41 51 49 46 45 45 44 43 42 42 41 58 46 42 39 36 32 30 48 37 36 35
CY EL ES MT PT IT SE DK IE FI AT BE DE NL LU FR RO SI HR EE LT BG LV HU CZ PL SK
Southern MSs
Nordic MSs & IE
Western MSs
Baltic & Balkan MSs
Eastern MSs
Source: EWCS-2015

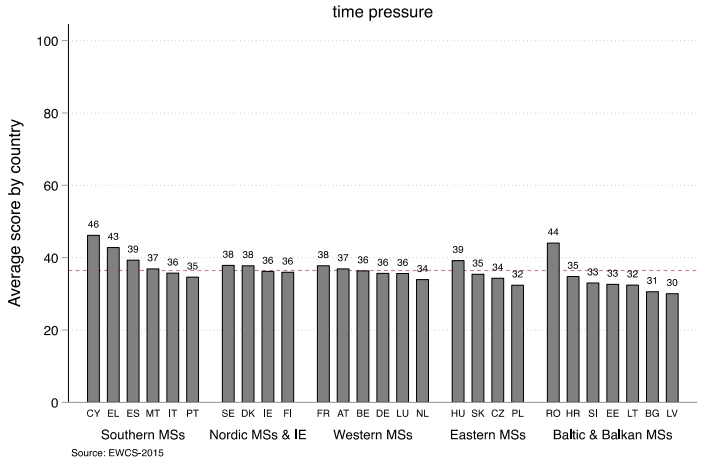

repetitive tasks
Average score by country
0
20
40
60
80
100
52 50 46 40 36 27 52 38 38 34 33 30 19 38 36 30 29 39 38 33 29 28 26 30 29 27 21
EL ES CY PT MT IT LT HR EE SI RO BG LV FI DK IE SE LU FR AT DE BE NL CZ PL SK HU
Southern MSs
Baltic & Balkan MSs
Nordic MSs & IE
Western MSs
Eastern MSs
Source: EWCS-2015

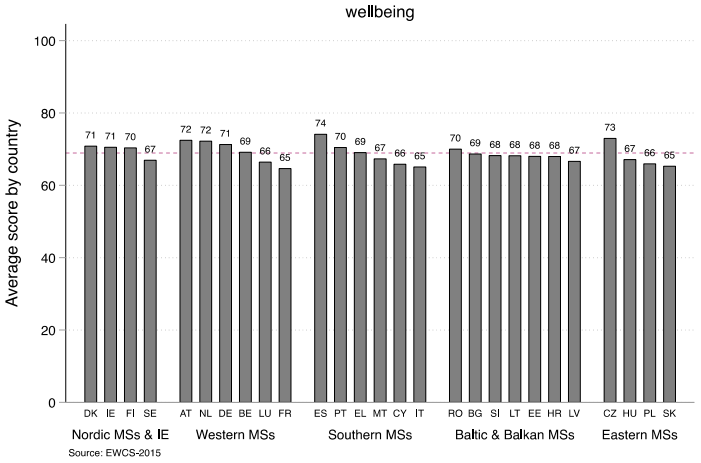

social dialoque
Average score by country
0
20
40
60
80
100
77 72 71 59
63 62 61 56 54 52
54 50 45 45 43 41 36
51 46 39 32
49 47 45 40 33 30
SE FI DK IE
BE LU FR NL DE AT
RO SI EE LV HR BG LT
SK CZ PL HU
MT ES IT CY EL PT
Nordic MSs & IE
Western MSs
Baltic & Balkan MSs
Eastern MSs
Southern MSs
Source: EWCS-2015

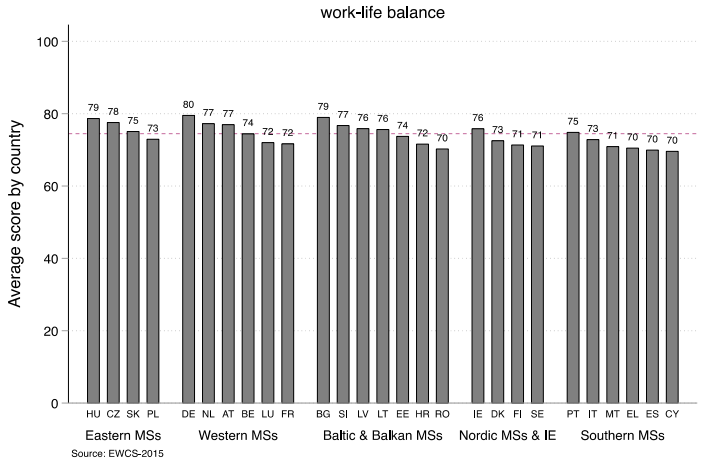

supportive management
Average score by country
0
20
40
60
80
100
79 79 77 76 76 68
77 74 73 71
79 78 75 71 71 68 68
75 74 73 73 70 70
75 74 71 69
MT PT CY EL ES IT
IE FI DK SE
BG RO SI LT HR LV EE
AT NL BE LU DE FR
CZ HU PL SK
Southern MSs
Nordic MSs & IE
Baltic & Balkan MSs
Western MSs
Eastern MSs
Source: EWCS-2015

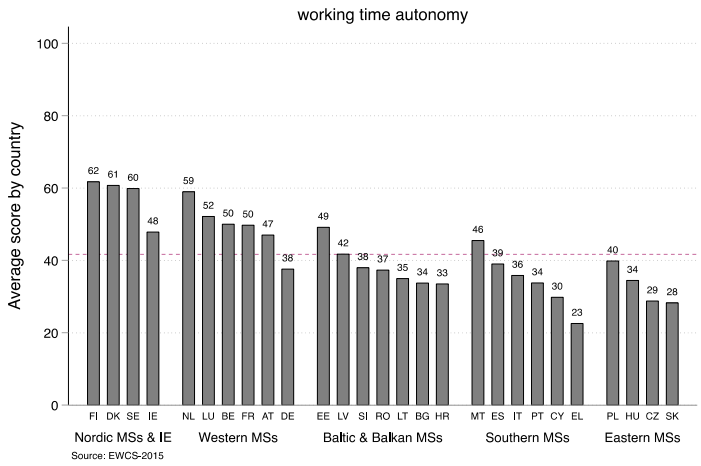

task complexity
Average score by country
0
20
40
60
80
100
82 79 77 75
82 80 75 75 74 70
80 76 73 72 70 65 57
78 74 71 64 62 54
70 67 64 63
DK FI SE IE
LU AT FR NL BE DE
EE SI HR RO LT BG LV
MT ES PT IT CY EL
PL CZ HU SK
Nordic MSs & IE
Western MSs
Baltic & Balkan MSs
Southern MSs
Eastern MSs
Source: EWCS-2015


task discretion
Average score by country
0
20
40
60
80
100
83 79 71 66
74 74 72 70 66 63
76 66 63 63 56 53 49
88 66 61 53 51 43
64 60 58 54
DK FI SE IE
LU NL BE FR DE AT
EE SI LT LV RO HR BG
MT IT ES CY PT EL
PL CZ SK HU
Nordic MSs & IE
Western MSs
Baltic & Balkan MSs
Southern MSs
Eastern MSs
Source: EWCS-2015


time pressure
Average score by country
0
20
40
60
80
100
46 43 39 37 36 35
38 38 36 36
38 37 36 36 36 34
39 35 34 32
44 35 33 33 32 31 30
CY EL ES MT IT PT
SE DK IE FI
FR AT BE DE LU NL
HU SK CZ PL
RO HR SI EE LT BG LV
Southern MSs
Nordic MSs & IE
Western MSs
Eastern MSs
Baltic & Balkan MSs
Source: EWCS-2015

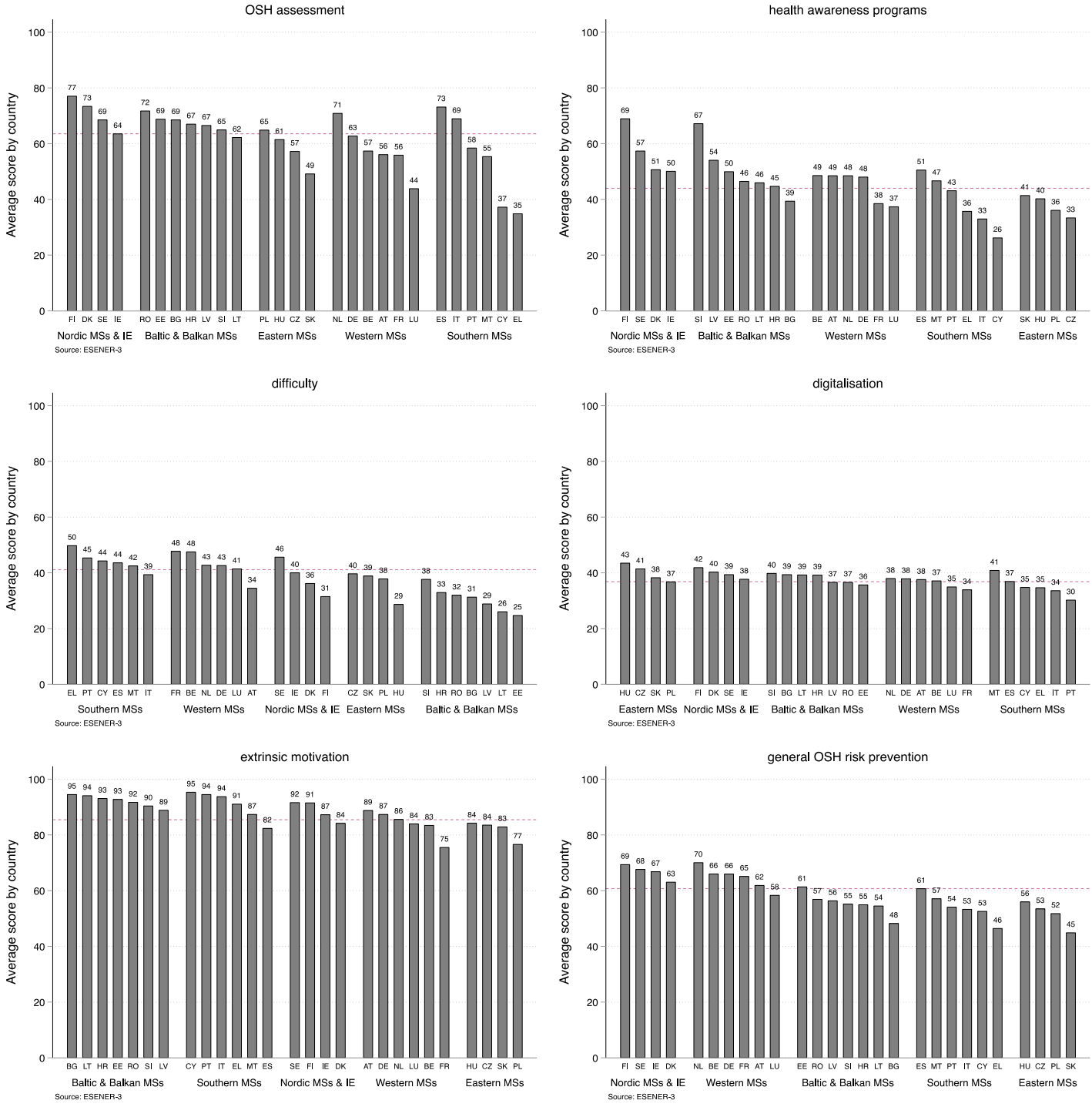

wellbeing
Average score by country
0
20
40
60
80
100
71 71 70 67
72 72 71 69 66 65
74 70 69 67 66 65
70 69 68 68 68 68 67
73 67 66 65
DK IE FI SE
AT NL DE BE LU FR
ES PT EL MT CY IT
RO BG SI LT EE HR LV
CZ HU PL SK
Nordic MSs & IE
Western MSs
Southern MSs
Baltic & Balkan MSs
Eastern MSs
Source: EWCS-2015

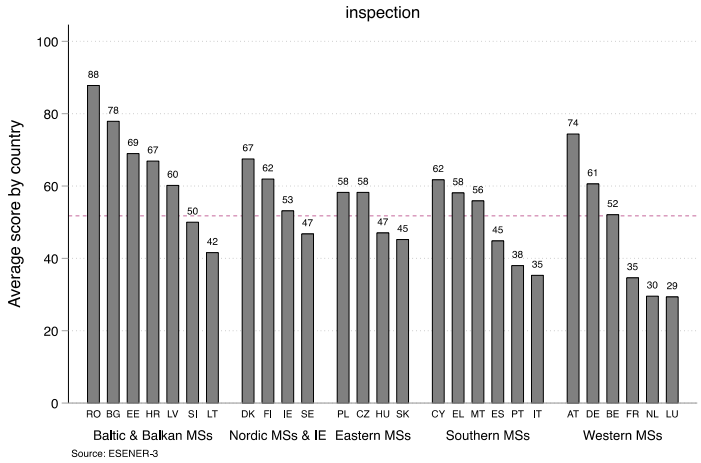


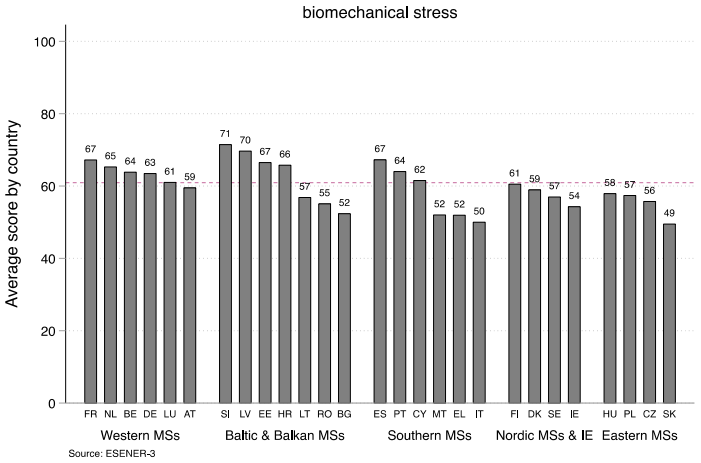


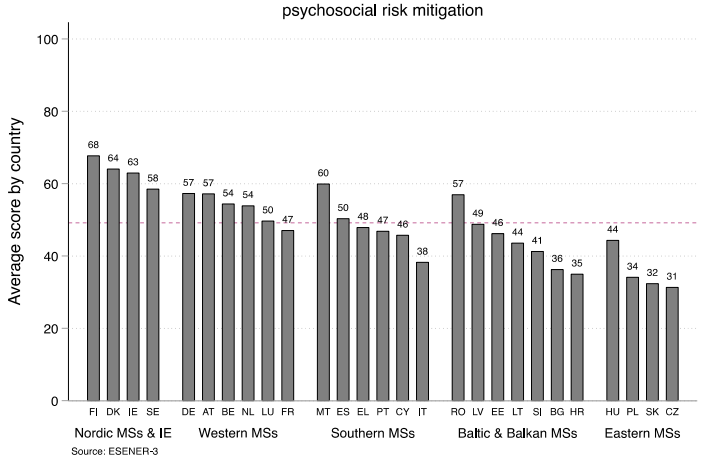
Note: MSs:European Union Member States

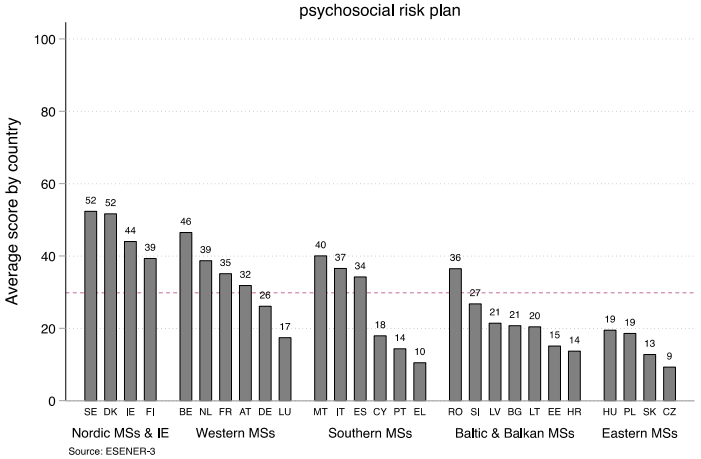
Figure 11: Country scores for the variables and constructs from the ESENER-3 data

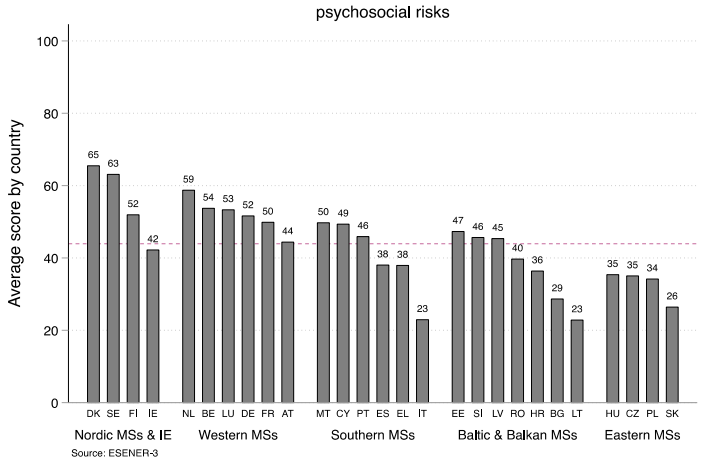


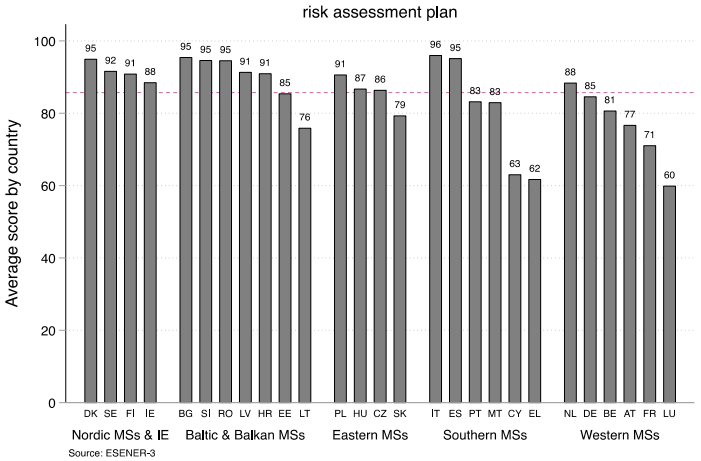

inspection
Average score by country
0
20
40
60
80
100
88 78 69 67 60 50 42
67 62 53 47
58 58 47 45
62 58 56 45 38 35
74 61 52 35 30 29
RO BG EE HR LV SI LT
DK FI IE SE
PL CZ HU SK
CY EL MT ES PT IT
AT DE BE FR NL LU
Baltic & Balkan MSs
Nordic MSs & IE
Eastern MSs
Southern MSs
Western MSs
Source: ESENER-3

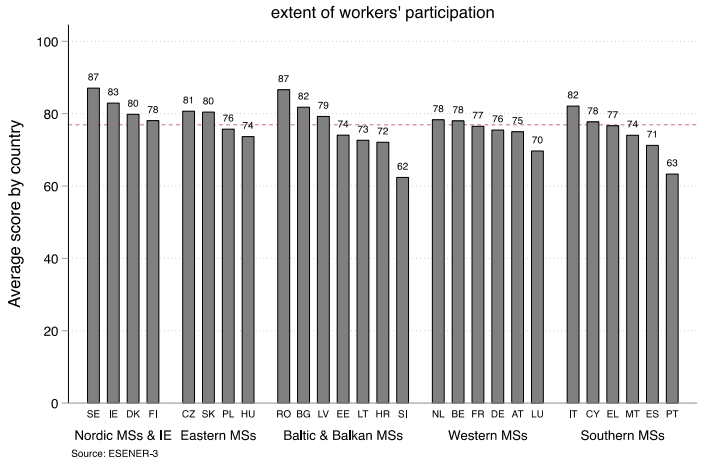

biomechanical stress
Average score by country
0
20
40
60
80
100
67 65 64 63 61 59
71 70 67 66 57 55 52
67 64 62 52 52 50
61 59 57 54
58 57 56 49
FR NL BE DE LU AT
SI LV EE HR LT RO BG
ES PT CY MT EL IT
FI DK SE IE
HU PL CZ SK
Western MSs
Baltic & Balkan MSs
Southern MSs
Nordic MSs & IE
Eastern MSs
Source: ESENER-3

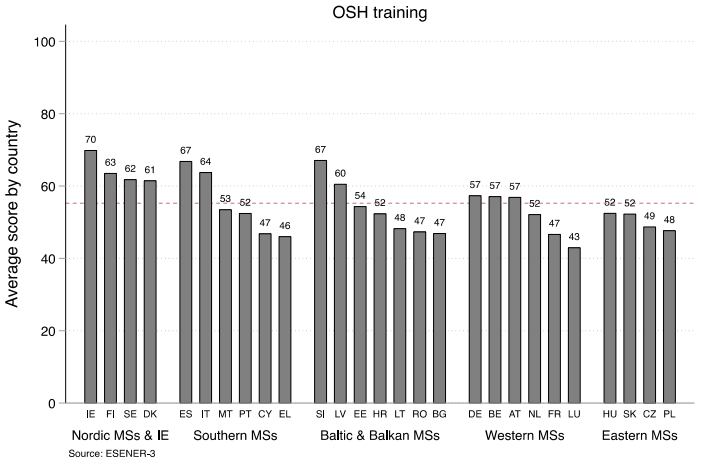

psychosocial risk mitigation
Average score by country
0
20
40
60
80
100
68 64 63 58
57 57 54 54 50 47
60 50 48 47 46 38
57 49 46 44 41 36 35
44 34 32 31
FI DK IE SE
DE AT BE NL LU FR
MT ES EL PT CY IT
RO LV EE LT SI BG HR
HU PL SK CZ
Nordic MSs & IE
Western MSs
Southern MSs
Baltic & Balkan MSs
Eastern MSs
Source: ESENER-3


psychosocial risk plan
Average score by country
0
20
40
60
80
100
52 52 44 39
46 39 35 32 26 17
40 37 34 18 14 10
36 27 21 21 20 15 14
19 19 13 9
SE DK IE FI
BE NL FR AT DE LU
MT IT ES CY PT EL
RO SI LV BG LT EE HR
HU PL SK CZ
Nordic MSs & IE
Western MSs
Southern MSs
Baltic & Balkan MSs
Eastern MSs
Source: ESENER-3


psychosocial risks
Average score by country
0
20
40
60
80
100
65 63 52 42
59 54 53 52 50 44
50 49 46 38 38 23
47 46 45 40 36 29 23
35 35 34 26
DK SE FI IE
NL BE LU DE FR AT
MT CY PT ES EL IT
EE SI LV RO HR BG LT
HU CZ PL SK
Nordic MSs & IE
Western MSs
Southern MSs
Baltic & Balkan MSs
Eastern MSs
Source: ESENER-3


risk assessment plan
Average score by country
0
20
40
60
80
100
95 92 91 88
95 95 95 91 91 85 76
91 87 86 79
96 95 83 83 63 62
88 85 81 77 71 60
DK SE FI IE
BG SI RO LV HR EE LT
PL HU CZ SK
IT ES PT MT CY EL
NL DE BE AT FR LU
Nordic MSs & IE
Baltic & Balkan MSs
Eastern MSs
Southern MSs
Western MSs
Source: ESENER-3





Note: MSs:European Union Member States

Annex 3 Ordinary least squares regression models

The tables below show the estimated regression coefficients for Table 21 and Table 22 in the report.

Table 32: Regression analysis (OLS) of MSDs on job characteristics and background variables

Job characteristics/background variables	Model number				
	1	2	3	4	5
Biomechanical stress	0.696***	0.624***		0.603***	0.496***
Repetitive tasks	0.023*	0.006		0.004	0.009
Quick work	0.040**	0.058***		0.066***	0.027
Emotional labour	-0.014	-0.015		-0.005	-0.022
Task complexity	0.035*	0.057***		0.064***	0.065***
Task discretion	0.074***	0.071***		0.064***	0.062***
Control over work pace	-0.017	-0.007		-0.022	-0.001
Autonomous teamwork	-0.006	-0.008		0.004	0.003
Atypical working time	0.073***	0.048**		0.075***	0.037*
Working time autonomy	-0.009	-0.007		-0.012	-0.010
Involuntary part-time work	0.047***	0.034**		0.044***	0.035**
Involuntary overtime work	0.044***	0.051***		0.052***	0.034***
Adverse social behaviour	0.096***	0.084***		0.092***	0.063***
Supportive management	-0.124***	-0.128***		-0.089***	0.022
Job security	-0.103***	-0.119***		-0.065***	-0.005
Social dialogue	0.021*	0.033**		0.018	0.027*
Worker participation	-0.062**	-0.083***		-0.101***	-0.077***
Gender — female/male			0.034***	0.062***	0.042***
Educational level — low			0.000	0.000	0.000
Educational level — mid/low			-0.088***	-0.056*	-0.043*
Educational level — high/low			-0.160***	-0.100***	-0.086***
Age — under 25			0.000	0.000	0.000
Age — 25-34/under 25			0.012	0.020	-0.016
Age — 35-44/under 25			0.071***	0.075***	0.018
Age — 45-54/under 25			0.138***	0.159***	0.077***

Job characteristics/background variables	Model number 1	2	3	4	5
Age — over 55/under 25			0.151***	0.189***	0.097***
Origin — migrant			0.049***	0.001	-0.004
Company size — under 10 employees			0.000	0.000	0.000
Company size — 10-249 employees			0.028**	0.013	0.008
Company size — over 249 employees			0.048***	0.003	-0.001
Wellbeing (WHO-5)					-0.289***
Work-life balance					-0.148***
General health					-0.416***
Constant	0.241***	0.293***	0.325***	0.147*	0.815***
FE occupation	No	Yes	No	Yes	Yes
FE sector	No	Yes	No	Yes	Yes
FE country	No	Yes	No	Yes	Yes
R^2	15.2%	18.7%	3.7%	22.2%	29.6%
N	23,636	23,550	26,667	22,556	22,523

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Notes: FE, fixed effects, i.e. controlling for occupation, sector and country; R^2, coefficient of determination.
Source: Authors' compilation based on EWCS sixth wave (2015) data

Table 33: Regression analysis (OLS) of wellbeing (WHO-5) on job characteristics and background variables

Job characteristics/background variables	Model number				
	1	2	3	4	5
Biomechanical stress	-0.111***	-0.119***		-0.112***	-0.004
Repetitive tasks	0.019***	0.014**		0.014**	0.012**
Quick work	-0.024**	-0.036***		-0.035***	0.002
Emotional labour	-0.022***	-0.013*		-0.014*	0.002
Task complexity	0.008	0.010		0.010	0.017*
Task discretion	-0.005	0.001		0.004	0.012*
Control over work pace	0.026***	0.021**		0.023**	0.008
Autonomous teamwork	0.002	0.002		0.000	0.004
Atypical working time	-0.031***	-0.035***		-0.042***	-0.006
Working time autonomy	-0.011	-0.003		-0.003	-0.009
Involuntary part-time work	-0.014*	-0.014*		-0.016*	-0.015*
Involuntary overtime work	-0.030***	-0.031***		-0.030***	-0.014***
Adverse social behaviour	-0.042***	-0.040***		-0.042***	-0.020***
Supportive management	0.215***	0.200***		0.193***	0.138***
Job security	0.083***	0.085***		0.077***	0.039***
Social dialogue	0.012*	0.020***		0.027***	0.028***
Worker participation	0.069***	0.074***		0.079***	0.073***
Gender — female/male			-0.023***	-0.029***	-0.013***
Educational level — low			0.000	0.000	0.000
Educational level — mid/low			0.013	0.011	-0.001
Educational level — high/low			0.015	0.003	-0.011
Age — under 25			0.000	0.000	0.000
Age — 25-34/under 25			-0.039***	-0.032***	-0.007
Age — 35-44/under 25			-0.053***	-0.041***	0.002
Age — 45-54/under 25			-0.057***	-0.051***	0.010
Age — over 55/under 25			-0.051***	-0.046***	0.024**

Job characteristics/background variables	Model number				
	1	2	3	4	5
Origin — migrant/native			-0.019**	-0.007	-0.003
Company size — under 10 employees			0.000	0.000	0.000
Company size — 10-249 employees			-0.011*	-0.002	0.001
Company size — over 249 employees			-0.021***	-0.008	-0.007
MSD					-0.069***
Work-life balance					0.221***
General health					0.281***
Constant	0.502***	0.558***	0.773***	0.622***	0.198***
FE occupation	No	Yes	No	Yes	Yes
FE sector	No	Yes	No	Yes	Yes
FE country	No	Yes	No	Yes	Yes
R^2	17.4%	20.0%	1.2%	21.0%	34.4%
N	23,628	23,542	26,651	22,550	22,523

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Notes: FE, fixed effects, i.e. controlling for occupation, sector and country; R^2, coefficient of determination.

Source: Authors' compilation based on EWCS sixth wave (2015) data

Annex 4 Logit regression models

Table 32 investigates the item level of the three musculoskeletal problems that comprise the scale used in the OLS models. For each item, model 4 of the models in Annex 3 has been replicated, which includes all fixed effects, sociodemographic factors and company size, as well as model 5, which adds three outcome variables as controls and to check for mediation effects. As the dependent variable, the reported presence of MSDs, is dichotomous (yes or no), the effects are estimated using logistic regression ([31]).

Models 1a and 1b show the odds for backache. Biomechanical stress is the dominant explanatory variable, but quick work, task complexity, atypical working time, involuntary part-time and overtime work, and adverse social behaviour further increase the risks, as does task discretion, as discussed in Annex 3. Except for quick work and atypical working time, these effects are still significant in the mediated model 1b, adding controls for wellbeing, general health and work-life balance. As in the linear model, supportive management and worker participation appear to have a strongly protective effect, and supportive management seems to be entirely mediated by the added factors in model 1b, while worker participation remains equally important, effectively reducing the odds of backache by two. Surprisingly, job security appears to be positively associated with backache in this model, all else being equal.

With respect to worker and company characteristics, the greater likelihood for women to suffer from MSDs is confirmed, while only the high education group has significantly lower risks. Age starts playing a role in categories above 45 years of age in the final model. Finally, company size and ethnic origin are insignificant here as well. The pseudo-R^2 values are 11.1 % and 15.6 %, which is lower than the R^2 in the linear model, but otherwise the logit and the linear model are very similar.

Models 2a and 2b estimate the effect of job characteristics on neck pain, shoulder pain and pain in the upper limbs. The general pattern is almost the same as that observed in models 1a and 2b, so only differences are reported here. There is a protective effect of job security in the unmediated model, but not in the mediated model, in line with the linear model, suggesting it contributes to wellbeing. There is a minor significant favourable effect of emotional labour in the mediated model, and finally education is neither a substantial nor significant factor in these models, which have a pseudo-R^2 of 13.1 % and 17 %, respectively. Again, the overall pattern is in line with the linear model.

Models 3a and 3b, which look at lower limb disorders, are different to the other MSDs. The effect of biomechanical stress is still strong, but less pronounced than with the other MSDs. In this case, a significant effect of repetitive tasks is found, but no effect of task complexity or involuntary part-time or overtime work, and no effect of worker participation or gender in the mediated model 2b, but the effect of education is stronger. Pseudo-R^2s are 11.8 % and 15.9 % for models 3a and 3b, respectively. Nevertheless, the basic conclusions from the linear model also hold for this model: strong effects of biomechanical stress and psychosocial stress in the form of atypical working time and adverse social behaviour, mitigated through improved wellbeing owing to supportive management and worker participation. Effects from sociodemographic variables and company size are limited or non-existent.

These results fully support the findings discussed in section 4.2 and the OLS estimates in Annex 3.

([31]) The table reports exponentiated betas, which represent the change in the odds (the odds ratio, OR) for an increment in the explanatory variable. As all variables are normalised to the range [0 1], this means the effect is the OR between the maximum and the minimum. If the odds are 1, the probability of having an MSD is the same as not having an MSD, meaning it is 50 %. If the exponentiated beta (OR) is above 1, the odds change towards a greater incidence of having an MSD; if below 1, the odds shrink, which in this case is favourable. To convert between odds O and probabilities P, the following formulas apply: $O = \frac{P}{1-P}$ and $P = \frac{O}{O+1}$.

Table 34: Logit regression analysis of the reported presence of backache (1a-b), neck pain, shoulder pain and pain the upper limbs (2a-b), and lower limb disorders (3a-b) on job characteristics and background variables (exp ß)

Job characteristics/background variables	Backache		Neck, shoulder and upper limbs pain		Lower limbs pain	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Biomechanical stress	20.052***	13.532***	30.183***	21.181***	10.199***	6.444***
Repetitive tasks	0.920	0.941	1.049	1.085	1.118	1.157*
Quick work	1.444***	1.206	1.384***	1.166	1.321**	1.084
Emotional labour	1.046	0.956	0.864	0.789*	1.061	0.965
Task complexity	1.402**	1.444***	1.641***	1.713***	1.170	1.193
Task discretion	1.368***	1.375***	1.349***	1.356***	1.461***	1.479***
Control over work pace	0.920	1.025	0.883	0.973	0.886	0.980
Autonomous teamwork	1.119	1.115	0.964	0.957	0.989	0.981
Atypical working time	1.276*	1.054	1.472***	1.243	1.653***	1.380**
Working time autonomy	1.012	1.033	1.025	1.042	0.797*	0.817*
Involuntary part-time work	1.287**	1.267**	1.303**	1.283**	1.162	1.141
Involuntary overtime work	1.317***	1.224***	1.342***	1.246***	1.228***	1.125
Job security	0.893	1.244*	0.712**	0.962	0.577***	0.783*
Adverse social behaviour	1.512***	1.340***	1.650***	1.470***	1.491***	1.313***
Supportive management	0.629***	1.093	0.665**	1.176	0.651***	1.114
Social dialogue	1.066	1.115	1.171*	1.241**	1.054	1.105
Worker participation	0.519***	0.560***	0.572***	0.634***	0.737*	0.811
Gender — female/male	1.322***	1.215***	1.584***	1.478***	1.189**	1.086
Educational level — low	1.000	1.000	1.000	1.000	1.000	1.000
Educational level — mid/low	0.816	0.869	0.775	0.821	0.734*	0.779
Educational level — high/low	0.643**	0.681*	0.714*	0.759	0.515***	0.536***
Age — under 25	1.000	1.000	1.000	1.000	1.000	1.000
Age — 25-34/under 25	1.164	0.959	1.156	0.980	0.965	0.803
Age — 35-44/under 25	1.639***	1.221	1.561***	1.214	1.191	0.899

Job characteristics/background variables	Backache		Neck, shoulder and upper limbs pain		Lower limbs pain	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Age — 45-54/under 25	2.331***	1.554***	2.366***	1.684***	1.935***	1.325*
Age — over 55/under 25	2.853***	1.805***	2.523***	1.716***	2.351***	1.539**
Origin — migrant	0.990	0.954	0.953	0.922	1.088	1.062
Company size — under 10 employees	1.000	1.000	1.000	1.000	1.000	1.000
Company size — 10-249 employees	1.116	1.092	1.076	1.052	1.009	0.989
Company size — over 249 employees	1.100	1.085	0.948	0.924	1.014	0.995
Wellbeing (WHO-5)		0.245***		0.183***		0.257***
Work-life balance		0.454***		0.524***		0.416***
General health		0.086***		0.142***		0.117***
Constant	0.159***	5.676**	0.102***	2.412	0.307*	8.962***
FE occupation	Yes	Yes	Yes	Yes	Yes	Yes
FE sector	Yes	Yes	Yes	Yes	Yes	Yes
FE country	Yes	Yes	Yes	Yes	Yes	Yes
R^2	11.1%	15.6%	13.1%	17.0%	11.8%	15.8%
N	22,556	22,523	22,556	22,523	22,556	22,523

*p < 0.05; **p < 0.01; ***p < 0.001.

Notes: FE, fixed effects, i.e. controlling for occupation, sector and country; R^2, coefficient of determination.

Source: Authors' compilation based on EWCS sixth wave (2015) data

Annex 5 Robustness checks for the ordinary least squares model

The following tables show the regression coefficients for the models from sections 4.2.2 (MSDs) and 4.2.3 (wellbeing), as well as Annex 3, but for a selected population. The first selection is of workers signalling a health impact of work, reflecting the perception of a link between the risks and the experienced MSDs. The second selection reduces the sample to workers employed in large companies with more than 250 employees. This should be indicative of an interaction effect between company size and other explanatory variables. The main effects are, indeed, confirmed by these robustness checks, although the effects on working time and work-life balance variables in the sample with workers who indicate a health impact of work appears to be much less clear.

Table 35: Regression analysis (OLS) of MSD on job characteristics and background variables if workers signal a health impact of work

Job characteristics/background variables	Model number				
	1	2	3	4	5
Biomechanical stress	0.574***	0.525***		0.512***	0.458***
Repetitive tasks	0.026	0.010		-0.005	0.003
Quick work	0.061**	0.067**		0.062**	0.036
Emotional labour	0.008	0.028		0.026	0.013
Task complexity	-0.013	0.043		0.053	0.069**
Task discretion	0.085***	0.062**		0.060**	0.063***
Control over work pace	0.007	0.024		-0.009	0.004
Autonomous teamwork	-0.000	-0.001		0.012	0.014
Atypical working time	-0.043	-0.040		0.003	-0.011
Working time autonomy	-0.069**	-0.046*		-0.038	-0.040
Involuntary part-time work	0.047*	0.036		0.035	0.025
Involuntary overtime work	0.034*	0.050***		0.055***	0.043**
Job security	-0.011	-0.038		0.008	0.060*
Adverse social behaviour	0.043**	0.035*		0.042**	0.024
Supportive management	-0.068*	-0.053		-0.025	0.045
Social dialogue	-0.011	0.016		0.014	0.028
Worker participation	-0.061	-0.059		-0.067*	-0.052
Gender — female/male (reference: male)			0.104***	0.119***	0.093***

Job characteristics/background variables	Model number 1	2	3	4	5
Educational level — low (reference)			0.000	0.000	0.000
Educational level — mid/low			-0.026	-0.025	-0.026
Educational level — high/low			-0.153***	-0.093*	-0.092*
Age — under 25 (reference)			0.000	0.000	0.000
Age — 25-34/under 25			-0.011	0.033	0.010
Age — 35-44/under 25			0.033	0.080*	0.045
Age — 45-54/under 25			0.105**	0.158***	0.098**
Age — over 55/under 25			0.115***	0.184***	0.112***
Origin — migrant/native (reference: native)			0.038*	-0.000	-0.011
Company size — under 10 employees (reference)			0.000	0.000	0.000
Company size — 10-249/under 10 employees			-0.018	-0.011	-0.017
Company size — over 249/under 10 employees			-0.018	-0.020	-0.028
Wellbeing (WHO-5)					-0.265***
Work-life balance					-0.065
General health					-0.329***
Constant	0.395***	0.372***	0.456***	0.171	0.649***
FE occupation	No	Yes	No	Yes	Yes
FE sector	No	Yes	No	Yes	Yes
FE country	No	Yes	No	Yes	Yes
R^2	10.2%	15.0%	06.1%	20.1%	26.2%
N	8,190	8,168	9,107	7,845	7,832

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Notes: FE, fixed effects, i.e. controlling for occupation, sector and country; R^2, coefficient of determination.
Source: Authors' compilation based on EWCS sixth wave (2015) data

Table 36: Regression analysis (OLS) of MSD on job characteristics and background variables for workers employed in large companies

Job characteristics/background variables	Model number				
	1	2	3	4	5
Biomechanical stress	0.693***	0.625***		0.606***	0.484***
Repetitive tasks	0.016	0.005		-0.001	0.001
Quick work	0.032	0.050*		0.059*	0.022
Emotional labour	0.020	0.004		0.007	-0.008
Task complexity	0.038	0.048		0.062*	0.049
Task discretion	0.057**	0.055**		0.060**	0.057**
Control over work pace	-0.026	-0.008		-0.025	-0.003
Autonomous teamwork	0.003	0.007		0.010	0.009
Atypical working time	0.054*	0.035		0.071**	0.049
Working time autonomy	-0.032	-0.027		-0.024	-0.017
Involuntary part-time work	0.064**	0.054*		0.057*	0.042
Involuntary overtime work	0.020	0.025		0.022	0.007
Job security	-0.109***	-0.138***		-0.085**	-0.023
Adverse social behaviour	0.096***	0.093***		0.098***	0.067***
Supportive management	-0.126***	-0.118***		-0.101***	0.009
Social dialogue	0.048*	0.044*		0.032	0.047*
Worker participation	-0.092**	-0.105**		-0.121***	-0.087**
Gender — female/male (reference: male)			0.080***	0.069***	0.050***
Educational level — low (reference)			0.000	0.000	0.000
Educational level — mid/low			-0.056	-0.013	0.014
Educational level — high/low			-0.107*	-0.062	-0.036
Age — under 25 (reference)			0.000	0.000	0.000
Age — 25-34/under 25			-0.032	-0.021	-0.043
Age — 35-44/under 25			0.015	0.037	-0.005
Age — 45-54/under 25			0.068*	0.105***	0.043

Job characteristics/background variables	Model number 1	2	3	4	5
Age — over 55/under 25			0.089**	0.139***	0.066*
Origin — migrant/native (reference: native)			0.033	-0.013	-0.009
Wellbeing (WHO-5)					-0.283***
Work-life balance					-0.137***
General health					-0.404***
Constant	0.255***	0.233	0.323***	0.149	0.775***
FE occupation	No	Yes	No	Yes	Yes
FE sector	No	Yes	No	Yes	Yes
FE country	No	Yes	No	Yes	Yes
R^2	16.1%	18.9%	03.0%	22.0%	29.7%
N	7,920	7,904	8,925	7,870	7,856

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Notes: FE, fixed effects, i.e. controlling for occupation, sector and country; R^2, coefficient of determination.
Source: Authors' compilation based on EWCS sixth wave (2015) data

Table 37: Regression analysis (OLS) of wellbeing on job characteristics and background variables if workers signal a health impact of work

Job characteristics/background variables	Model number 1	2	3	4	5
Biomechanical stress	-0.041	-0.075**		-0.073**	0.019
Repetitive tasks	0.026**	0.017		0.026**	0.023**
Quick work	-0.037**	-0.041**		-0.041**	-0.002
Emotional labour	-0.036**	-0.026		-0.020	0.007
Task complexity	0.017	0.025		0.028	0.032*
Task discretion	-0.002	0.009		0.011	0.015
Control over work pace	0.013	0.011		0.015	0.001
Autonomous teamwork	0.014	0.022		0.021	0.029**
Atypical working time	-0.012	-0.012		-0.029	-0.003
Working time autonomy	0.001	0.013		0.008	0.003
Involuntary part-time work	-0.009	-0.005		0.001	0.005
Involuntary overtime work	-0.026**	-0.024**		-0.025**	-0.007
Job security	0.072***	0.089***		0.079***	0.040**
Adverse social behaviour	-0.044***	-0.036***		-0.034***	-0.019*
Supportive management	0.175***	0.151***		0.150***	0.097***
Social dialogue	0.024*	0.043***		0.047***	0.048***
Worker participation	0.059**	0.052*		0.049*	0.052**
Gender — female/male (reference: male)			-0.053***	-0.051***	-0.022*
Educational level — low (reference)			0.000	0.000	0.000
Educational level — mid/low			-0.036	-0.017	-0.026
Educational level — high/low			-0.032	-0.017	-0.030
Age — under 25 (reference)			0.000	0.000	0.000
Age — 25-34/under 25			-0.037*	-0.028	-0.004

Job characteristics/background variables	Model number 1	2	3	4	5
Age — 35-44/under 25			-0.031	-0.027	0.016
Age — 45-54/under 25			-0.046*	-0.043*	0.020
Age — over 55/under 25			-0.057**	-0.045*	0.028
Origin — migrant/native (reference: native)			-0.036**	-0.031**	-0.025*
Company size — under 10 employees (reference)			0.000	0.000	0.000
Company size — 10-249 employees			-0.005	0.004	0.009
Company size — over 249 employees			-0.018	-0.004	-0.003
MSDs					-0.081***
Work-life balance					0.278***
General health					0.292***
Constant	0.470***	0.509***	0.781***	0.617***	0.176**
FE occupation	No	Yes	No	Yes	Yes
FE sector	No	Yes	No	Yes	Yes
FE country	No	Yes	No	Yes	Yes
R^2	12.5%	17.7%	2.3%	19.3%	33.6%
N	8,186	8,164	9,099	7,842	7,832

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Notes: FE, fixed effects, i.e. controlling for occupation, sector and country; R^2, coefficient of determination.
Source: Authors' compilation based on EWCS sixth wave (2015) data

Table 38: Regression analysis (OLS) of wellbeing on job characteristics and background variables for workers employed in large companies

Job characteristics/background variables	Model number 1	2	3	4	5
Biomechanical stress	-0.121***	-0.123***		-0.118***	0.012
Repetitive tasks	0.014	0.006		0.007	0.004
Quick work	-0.031*	-0.040**		-0.037**	0.007
Emotional labour	-0.027*	-0.018		-0.015	0.007
Task complexity	-0.007	-0.003		-0.006	0.013
Task discretion	-0.006	0.004		0.005	0.011
Control over work pace	0.030*	0.021		0.024*	0.003
Autonomous teamwork	0.003	0.002		0.001	0.007
Atypical working time	-0.008	-0.005		-0.015	0.023
Working time autonomy	-0.014	0.000		-0.001	-0.010
Involuntary part-time work	-0.004	-0.005		-0.003	0.005
Involuntary overtime work	-0.032***	-0.029***		-0.027***	-0.011
Job security	0.088***	0.104***		0.100***	0.057***
Adverse social behaviour	-0.047***	-0.046***		-0.046***	-0.019*
Supportive management	0.217***	0.202***		0.202***	0.139***
Social dialogue	0.015	0.021		0.022	0.018
Worker participation	0.076***	0.079***		0.077***	0.059***
Gender — female/male (reference: male)			-0.036***	-0.034***	-0.017*
Educational level — low (reference)			0.000	0.000	0.000
Educational level — mid/low			0.025	0.015	-0.013
Educational level — high/low			0.009	0.004	-0.022
Age — under 25 (reference)			0.000	0.000	0.000
Age — 25-34/under 25			-0.026	-0.016	0.003

Job characteristics/background variables	Model number 1	2	3	4	5
Age — 35-44/under 25			-0.032*	-0.022	0.019
Age — 45-54/under 25			-0.031*	-0.025	0.029*
Age — over 55/under 25			-0.025	-0.017	0.048**
Origin — migrant/native (reference: male)			-0.026*	-0.011	-0.015
MSDs					-0.072***
Work-life balance					0.290***
General health					0.296***
Constant	0.502***	0.603***	0.747***	0.654***	0.188***
FE occupation	No	Yes	No	Yes	Yes
FE sector	No	Yes	No	Yes	Yes
FE country	No	Yes	No	Yes	Yes
R^2	17.8%	2.16%	1.3%	22.3%	37.9%
N	7,917	7,901	8,920	7,867	7,856

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Notes: FE, fixed effects, i.e. controlling for occupation, sector and country; R^2, coefficient of determination.

Source: Authors' compilation based on EWCS sixth wave (2015) data

Annex 6 OSH clusters

With respect to the prevention practices, the 10 constructs composed from the ESENER-3 are first used to cluster establishments into six 'OSH types', depending on their configuration of risks (physical, psychosocial, digital) on one hand and preventive strategies (participatory, procedural) on the other. Cluster analysis is a data reduction technique that looks for patterns across the units in the sample population, and presents multiple numbers of possible groupings, as well as statistics to decide which number of groupings is optimal. At the same time, this should be a small enough number of groupings to be able to make sense of the patterns in the data. For this analysis, first hierarchical clustering was used, and then the outcome was checked for robustness using latent class analysis (LCA). The two methods work in opposite ways: hierarchical clustering groups units based on their distance from one another on all dimensions (variables) combined, and groups the closest neighbours with the most similar pattern of values until there are two groups left. In contrast, LCA is a likelihood-based algorithm that is increasingly complex because it involves constructing more latent classes. For both methods, the dimensions are first dichotomised using the median as a cut-off value. A positive score of 1, therefore, refers to an above-median level of the dimension, and a null score refers to a below-or-median level of the dimension. For hierarchical cluster analysis, this means a straightforward matching score can be used as the distance measure.

The cluster analysis was executed in Stata 14.2 on a subsample of 4,000 cases. The local optimum Je(2)/Je(1) score of 0.9087 is found for the six-cluster solution using Ward's linkage and the Duda-Hart stopping rule. Next, the cluster outcome for the entire sample of 37,460 establishments was predicted using multinomial regression on the 10 dimensions that make up the clustering. This regression has a pseudo-R^2 of 83.11 % and results in 90.65 % matches with the original clustering.

Table 37 describes the six types of OSH clusters derived from the 10 dimensions included, with colour formatting ranging from dark blue (minimum value — 0 %) to dark red (maximum value — 100 %), to reveal the patterns. This was carried out for the cases in the cluster sample (n = 4,000, upper part of the table) and in the full sample (n = 37,460, lower part). The six clusters are the high risk-high agency (HR-HA), the physical-procedural (PH-PR), the psychosocial-procedural (PS-PR), the digitalisation-low agency (DI-LA), the psychosocial-participatory (PS-PA) and the psychosocial-low agency (PS-LA).

Finally, using the **polca** package in R, these results are compared with a six-cluster solution from LCA modelling. The results are shown in Table 38, and are highly comparable, as Table 39 indicates (chi^2 = 5.8E03, p < 0.001).

Table 39: Binary hierarchical cluster analysis of establishments on ten dimensions from the ESENER-3 data (share within clusters in %)

Sample type	OSH prevention type cluster					
Cluster sample (n = 4,000)	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA
OSH risks						
Biomechanical stress	70	74	6	43	23	29
Psychosocial risks	65	49	44	58	45	42
Digitalisation	41	19	20	100	4	1
Participatory strategies						
Formal employee representation	95	14	0	40	67	0
Workers' participation	72	17	22	45	77	0
Procedural strategies						
OSH assessments	84	59	46	45	16	18
General OSH risk prevention	71	66	5	11	10	0
Psychosocial risk prevention	69	53	98	26	36	0

Sample type	Sample typ	Sample typ	Sample typ	Sample typ	Sample typ	Sample type
Cluster sample (n = 4,000)	Cluster sa	Cluster sa	Cluster sa	Cluster sa	Cluster sa	Cluster sample (n = 4,000)
Health awareness programmes	72	52	59	10	47	21
OSH training	39	48	1	3	2	0
Shares						
Establishments (n)	444	392	232	123	365	615
Establishments (%)	20	18	11	6	17	28
Employees (n)	1,036	368	137	159	381	296
Employees (%)	44	15	6	7	16	12
Data points (n)	1,057	676	373	276	679	939
Data points (%)	26	17	9	7	17	23

Sample type	OSH prevention type cluster					
Full sample (n = 37,460)	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA
OSH risks						
Biomechanical stress	69	77	4	45	23	29
Psychosocial risks	66	50	47	60	44	44
Digitalisation	41	18	23	100	2	1
Participatory strategies						
Formal employee representation	97	9	0	33	72	0
Workers' participation	73	16	14	38	75	0
Procedural strategies						
OSH assessments	83	56	45	36	18	20
General OSH risk prevention	71	68	4	10	7	0
Psychosocial risk prevention	72	55	98	25	29	0
Health awareness programmes	74	54	54	10	44	23
OSH training	38	45	1	2	2	0
Shares						
Establishments (n)	3,696	3,545	2,206	1,478	3,888	5,575
Establishments (%)	18	17	11	7	19	27
Employees (n)	10,436	3,202	1,310	1,431	3,713	2,651
Employees (%)	46	14	6	6	16	12
Data points (n)	9,826	6,459	3,508	2,724	6,565	8,378
Data points (%)	26	17	9	7	18	22

Notes: †Cells for the risks and strategies are coloured blue (low) to red (high), with numbers referring to the share (%) of establishments in the cluster with scores above the median for each of the risks or strategies dimensions (e.g. the numbers in the biomechanical stress row refer to the share of establishments in each cluster that falls within the group of 50 % of establishments with the highest biomechanical stress risks overall).
‡Favourability ratings are ranked as highly unfavourable (- -), unfavourable (-), mixed (+/-), favourable (+) or highly favourable (+ +).

Source: Authors' compilation based on ESENER-3 data (2019)

Table 40: Binary latent class cluster analysis of establishments on ten dimensions from the ESENER-3 data (share within clusters in %)

Sample type	OSH prevention type cluster					
Cluster sample (*n* = 4,000)	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA
OSH practices						
Biomechanical stress	81	84	0	0	27	83
Psychosocial risks	70	61	64	23	40	62
Digitalisation	48	29	16	16	11	40
Participatory strategies						
Formal employee representation	93	0	63	78	2	100
Workers' participation	75	22	55	82	6	67
Procedural strategies						
OSH assessments	98	63	48	39	14	64
General OSH risk prevention	97	68	7	0	1	56
Psychosocial risk prevention	93	43	100	29	16	35
Health awareness programmes	92	45	78	39	21	48
OSH training	71	28	9	8	1	16
Shares						
Establishments (*n*)	150	403	242	237	937	202
Establishments (%)	7	19	11	11	43	9
Employees (*n*)	534	351	242	291	461	498
Employees (%)	22	15	10	12	19	21
Data points (*n*)	492	723	450	474	1,394	467
Data points (%)	12	18	11	12	35	12

Sample type	OSH prevention type cluster					
Full sample (*n* = 37,460)	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA
OSH practices						
Biomechanical stress	79	82	0	0	27	84
Psychosocial risks	70	60	65	24	43	64
Digitalisation	47	29	23	15	11	37
Participatory strategies						
Formal employee representation	92	0	66	82	4	100
Workers' participation	78	24	56	75	7	66
Procedural strategies						
OSH assessments	94	60	54	43	14	59
General OSH risk prevention	97	66	7	0	1	57
Psychosocial risk prevention	93	47	100	21	18	37
Health awareness programmes	94	47	82	43	19	47
OSH training	71	25	7	6	1	17

Sample type	OSH prevention type cluster					
Full sample (*n* = 37,460)	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA
Shares						
Establishments (*n*)	1,298	3,556	2,000	2,501	8,929	2,104
Establishments (%)	6	17	10	12	44	10
Employees (*n*)	5,293	3,165	2,511	2,417	4,469	4,888
Employees (%)	23	14	11	11	20	21
Data points (*n*)	4,532	6,715	4,220	4,383	13,072	4,538
Data points (%)	12	18	11	12	35	12

Source: Authors' compilation based on ESENER-3 data (2019)

Table 41: Comparison of the binary hierarchical cluster solution (WARD) and the binary latent class solution (LCA) (employment share in %)

WARD	LCA						
	1	2	3	4	5	6	Total
1	10.66	0.86	4.19	1.17	0.03	9.32	26.23
2	1.40	12.45	0.57	0.30	2.14	0.39	17.24
3	0.04	0.81	3.30	0.23	4.98	0.00	9.36
4	0.00	1.95	0.4	1.22	3.01	0.69	7.27
5	0.00	1.03	2.81	8.78	3.20	1.71	17.53
6	0.00	0.83	0.00	0.00	21.54	0.00	22.37
Total	12.10	17.93	11.27	11.70	34.90	12.11	100

Pearson $chi^2(25) = 5.8e+04$ Pr = 0.000

Table 42: Share of OSH types by country and company size (%)

Country	Company size (number of employees)	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA	All
Austria	5-9	13.98	15.71	14.75	7.47	19.54	28.54	100
	10-49	23.23	17.63	11.53	7.58	19.60	20.43	100
	50-249	42.62	21.10	8.02	5.06	13.92	9.28	100
	250+	68.61	12.41	5.84	3.65	8.76	0.73	100
	All	27.21	17.03	11.58	6.79	17.70	19.69	100
Belgium	5-9	7.34	15.90	11.62	7.34	18.35	39.45	100
	10-49	16.25	22.36	14.72	7.22	17.22	22.22	100
	50-249	50.17	14.09	4.47	4.81	19.59	6.87	100
	250+	74.40	6.55	1.19	0.60	16.07	1.19	100
	All	27.36	17.60	10.56	6.04	17.80	20.65	100

Country	Company size (number of employees)	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA	All
Bulgaria	5-9	13.78	11.42	5.91	5.51	29.92	33.46	100
	10-49	20.83	8.33	6.94	13.89	23.96	26.04	100
	50-249	39.84	7.32	6.50	13.01	26.02	7.32	100
	250+	43.33	7.78	5.56	12.22	24.44	6.67	100
	All	24.24	9.14	6.36	10.73	26.36	23.18	100
Cyprus	5-9	6.97	15.57	12.30	8.20	29.51	27.46	100
	10-49	16.24	10.83	13.39	10.54	25.93	23.08	100
	50-249	29.23	15.38	3.85	12.31	29.23	10.00	100
	250+	68.75	6.25	3.13	12.50	3.13	6.25	100
	All	17.70	12.95	10.96	10.17	26.68	21.53	100
Czechia	5-9	6.91	11.51	7.57	3.29	26.64	44.08	100
	10-49	12.95	11.90	5.12	12.20	32.83	25.00	100
	50-249	26.72	13.74	5.34	13.99	25.45	14.76	100
	250+	44.50	13.61	2.62	15.71	13.61	9.95	100
	All	19.14	12.50	5.35	11.34	27.38	24.29	100
Germany	5-9	14.13	15.22	15.94	9.42	18.66	26.63	100
	10-49	28.85	16.25	11.25	7.71	18.85	17.08	100
	50-249	50.00	13.72	6.64	4.65	17.26	7.74	100
	250+	74.67	6.67	2.00	4.67	8.67	3.33	100
	All	35.56	14.22	10.25	7.11	17.14	15.72	100
Denmark	5-9	22.47	16.30	10.37	6.67	23.46	20.74	100
	10-49	39.89	13.30	10.75	6.08	16.83	13.15	100
	50-249	68.87	7.78	2.33	5.84	12.06	3.11	100
	250+	87.50	2.78	0.69	2.78	4.86	1.39	100
	All	44.68	12.16	8.26	5.88	16.66	12.36	100
Estonia	5-9	6.97	21.31	12.70	4.10	9.02	45.90	100

Country	Company size (number of employees)	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA	All
	10-49	19.94	26.17	10.90	4.67	8.41	29.91	100
	50-249	43.45	26.21	4.14	4.83	11.03	10.34	100
	250+	70.83	10.42	2.08	2.08	6.25	8.33	100
	All	23.48	23.61	9.63	4.35	8.97	29.95	100
Spain	5-9	10.01	33.03	9.75	5.59	9.75	31.86	100
	10-49	18.53	31.25	11.42	7.65	8.41	22.74	100
	50-249	41.00	25.76	7.76	4.99	8.86	11.63	100
	250+	64.42	11.54	5.77	3.37	12.98	1.92	100
	All	23.43	29.17	9.75	6.13	9.36	22.15	100
Finland	5-9	20.95	23.24	16.60	6.02	7.26	25.93	100
	10-49	40.36	23.17	14.05	5.53	7.47	9.42	100
	50-249	76.35	6.40	4.43	3.94	4.43	4.43	100
	250+	90.07	4.64	1.99	1.32	1.99	0	100
	All	43.99	19.07	12.36	5.05	6.45	13.09	100
France	5-9	6.69	18.03	12.30	5.46	16.12	41.39	100
	10-49	20.77	19.41	8.35	6.09	16.14	29.23	100
	50-249	52.27	13.38	2.02	4.80	20.20	7.32	100
	250+	77.22	5.49	0	1.69	14.77	0.84	100
	All	27.68	16.44	7.64	5.20	16.70	26.34	100
Greece	5-9	5.38	14.03	16.31	10.77	22.84	30.67	100
	10-49	9.25	12.18	18.18	12.18	26.95	21.27	100
	50-249	23.76	15.35	7.92	10.40	20.30	22.28	100
	250+	31.43	15.71	7.14	7.14	25.71	12.86	100
	All	10.66	13.52	15.52	11.13	24.32	24.85	100
Croatia	5-9	3.27	21.50	10.75	3.74	12.62	48.13	100
	10-49	13.91	24.83	9.27	9.93	12.25	29.80	100

Country	Company size (number of employees)	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA	All
	50-249	32.45	21.19	1.32	7.95	13.25	23.84	100
	250+	46.58	24.66	1.37	8.22	9.59	9.59	100
	All	17.84	23.11	7.30	7.57	12.30	31.89	100
Hungary	5-9	7.29	17.57	21.31	11.78	12.52	29.53	100
	10-49	10.86	23.01	15.88	15.24	11.51	23.50	100
	50-249	23.28	19.40	8.19	18.10	8.19	22.84	100
	250+	46.67	25.00	5.83	11.67	1.67	9.17	100
	All	14.36	20.68	15.82	14.16	10.57	24.40	100
Ireland	5-9	24.42	16.11	8.47	5.98	21.93	23.09	100
	10-49	37.17	15.88	9.29	5.32	21.20	11.13	100
	50-249	56.18	16.48	7.49	4.49	13.11	2.25	100
	250+	71.13	15.46	5.15	2.06	6.19	0	100
	All	37.52	16.01	8.60	5.25	19.61	13.01	100
Italy	5-9	14.61	16.02	5.84	5.09	27.27	31.17	100
	10-49	28.64	14.09	5.59	7.05	27.18	17.45	100
	50-249	41.39	9.93	4.30	5.30	27.48	11.59	100
	250+	61.07	16.03	1.53	2.29	17.56	1.53	100
	All	26.48	14.44	5.29	5.73	26.70	21.37	100
Lithuania	5-9	10.74	6.61	7.85	8.68	27.27	38.84	100
	10-49	16.96	14.84	13.07	10.95	20.14	24.03	100
	50-249	42.38	17.22	7.28	4.64	15.23	13.25	100
	250+	53.85	12.82	8.97	10.26	7.69	6.41	100
	All	23.87	12.47	9.81	8.89	20.16	24.80	100
Luxembourg	5-9	7.81	17.71	15.63	7.81	15.10	35.94	100
	10-49	19.39	15.45	13.03	7.88	18.18	26.06	100
	50-249	35.39	15.17	7.30	12.92	17.98	11.24	100

Country	Company size (number of employees)	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA	All
	250+	45.21	15.07	5.48	1.37	21.92	10.96	100
	All	22.64	15.91	11.64	8.41	17.72	23.67	100
Latvia	5-9	8.84	17.01	13.27	5.44	22.11	33.33	100
	10-49	16.84	25.93	11.11	8.75	16.50	20.88	100
	50-249	24.32	32.43	9.01	7.21	14.41	12.61	100
	250+	50.00	33.33	5.56	0	7.41	3.70	100
	All	17.20	23.94	11.24	6.61	17.72	23.28	100
Malta	5-9	6.74	14.61	19.10	11.24	14.61	33.71	100
	10-49	19.02	21.95	12.20	9.27	15.12	22.44	100
	50-249	42.24	11.21	12.93	10.34	13.79	9.48	100
	250+	51.16	13.95	11.63	9.30	11.63	2.33	100
	All	25.61	17.00	13.69	9.93	14.35	19.43	100
The Netherlands	5-9	12.05	16.96	5.36	10.04	14.73	40.85	100
	10-49	25.54	15.38	9.54	7.38	16.62	25.54	100
	50-249	49.61	19.38	6.20	4.65	12.79	7.36	100
	250+	74.55	12.73	3.03	2.42	6.06	1.21	100
	All	30.97	16.24	7.03	7.17	14.27	24.33	100
Poland	5-9	4.58	14.27	9.29	5.89	17.80	48.17	100
	10-49	8.62	16.90	8.97	8.85	20.11	36.55	100
	50-249	21.05	14.68	6.37	9.42	20.78	27.70	100
	250+	50.59	13.73	1.96	10.98	13.33	9.41	100
	All	14.00	15.29	7.87	8.18	18.67	36.00	100
Portugal	5-9	4.18	20.38	14.46	4.88	8.89	47.21	100
	10-49	11.51	27.18	13.49	5.16	9.52	33.13	100
	50-249	14.19	28.38	14.53	5.07	10.81	27.03	100
	250+	36.97	26.05	6.72	5.88	7.56	16.81	100

Country	Company size (number of employees)	1 HR-HA	2 PH-PR	3 PS-PR	4 DI-LA	5 PS-PA	6 PS-LA	All
	All	11.25	24.72	13.53	5.09	9.38	36.03	100
Romania	5-9	25.11	13.68	10.09	3.81	25.78	21.52	100
	10-49	36.60	12.56	10.87	6.13	20.06	13.78	100
	50-249	51.91	4.68	7.23	5.96	24.26	5.96	100
	250+	60.24	9.64	3.61	6.02	15.66	4.82	100
	All	38.20	11.33	9.27	5.40	21.93	13.87	100
Sweden	5-9	26.35	14.04	9.29	7.13	23.11	20.09	100
	10-49	43.85	11.85	5.08	6.31	23.38	9.54	100
	50-249	64.47	8.42	2.20	4.40	17.95	2.56	100
	250+	82.54	4.76	1.59	2.38	7.94	0.79	100
	All	45.44	11.31	5.56	5.89	21.03	10.78	100
Slovenia	5-9	6.01	29.43	10.44	7.28	6.96	39.87	100
	10-49	11.08	33.50	6.55	6.80	10.83	31.23	100
	50-249	16.79	42.16	5.60	5.60	2.61	27.24	100
	250+	55.81	27.91	2.33	0	4.65	9.30	100
	All	14.62	34.02	7.12	6.09	7.12	31.02	100
Slovakia	5-9	3.83	9.57	6.70	11.00	27.27	41.63	100
	10-49	8.99	13.90	4.09	11.72	29.16	32.15	100
	50-249	21.64	19.40	7.46	8.96	29.85	12.69	100
	250+	45.65	17.39	2.17	6.52	26.09	2.17	100
	All	12.04	13.89	5.29	10.71	28.57	29.50	100

Source: Authors' compilation based on ESENER-3 data (2019)

Annex 7 Linking the EWCS and the ESENER data

Linking the EWCS and the ESENER data faces a number of methodological challenges. As the basic units in both surveys are different (workers in EWCS versus establishments in ESENER-3), a multi-variable indicator needs to be used. In addition to country and company size, this involves NACE 1-digit or 2-digit as an identifier, which will be explored here.

First of all, the company size questions in both surveys are not aligned and need to be recoded. The smallest establishment is 5-9 employees in ESENER-3 (question Q102), compared with 1 and 2-9 employees in EWCS (question Q16A). The question on establishment sizes in the EWCS, however, has only been asked to respondents working in businesses (organisations) with multiple sites. To all other respondents, the categories were limited to 1, 2-9, 10-249 and 250+ employees in the business, over all sites (question Q16B). Table 41 compares the frequencies on the three variables, grouping together responses with under 10 and over 250 employees. To merge the two datasets, the 'organisation' categories need to be used, accepting the absence of companies of less than five employees in the ESENER data.

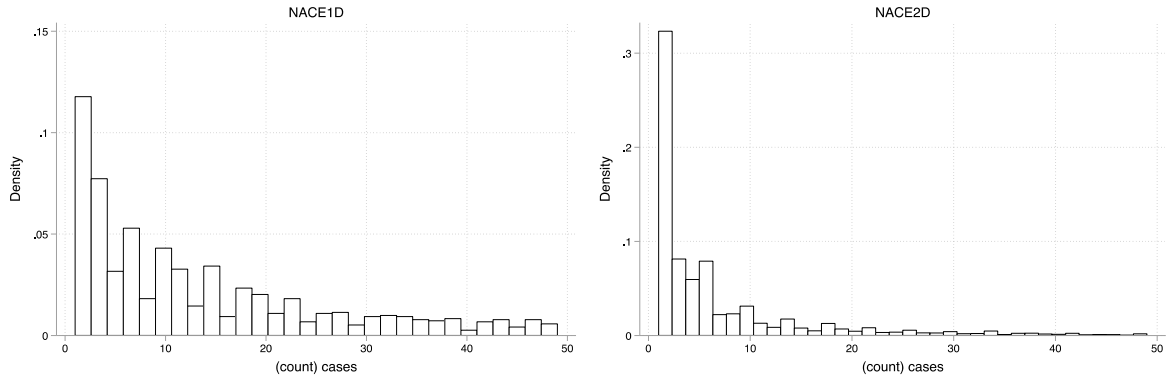
Table 43: Establishment sizes and unweighted frequencies in EWCS (2015) and ESENER-3

ESENER-3 establishment			EWCS-2015 establishment			EWCS-2015 organisation		
Size	Frequency	%	Size	Frequency	%	Size	Frequency	%
5-9	12,518	31.52	1-9	2,619	20.75	1-9	6,393	22.67
10-49	16,680	42.00	10-49	3,972	31.46	10-249	12,056	42.75
50-249	6,928	17.45	50-249	3,423	27.12			
250+	3,585	9.03	250+	2,610	20.67	250+	9,751	34.58
Total	39,711	100	Total	12,624	100	Total	28,200	100

Source: Authors' compilation based on EWCS sixth wave (2015) and ESENER-3 (2019) data

The next challenge is to produce data for the identification crossing. Two options are explored: cell averages and predicted values. The first approach uses the country, organisation size (three categories, as discussed above) and sector (NACE at 1-digit and 2-digit level) as common background variables, similar to the EU-OSHA report *Health and safety risks at the workplace: a joint analysis of three major surveys* (2017). A dataset is compiled on preventive measures by country and sector using ESENER-3 and taking the employee-proportional weights into account so that the findings are representative for all employees working in companies with more than five employees. This new dataset is then used as input to explain differences in the prevalence of MSDs found in the EWCS-2015. The drawback of this approach is that the number of observations in each country-sector cell is lower than 30 in 235 out of the 364 cells, and even lower than 10 in 73 cells. If establishment size is added to the identification keys, cell sizes are further reduced (see Figure 10, cut-off at 50). As a result, preventive measures are not very precisely estimated in these cells and extreme values are more likely.

Figure 12: Distribution of cell sizes in the ESENER-3 for establishment size, NACE and country crossings



Source: Authors' compilation based on ESENER-3 (2019) data

The alternative approach uses regression models to predict the ESENER-3 variables using country, sector (NACE 1-digit and 2-digit), and company size (5-9 employees; 10-249; 250+) as explanatory variables. OLS was used for the scales that were constructed based on the ESENER data. However, for single, dichotomous items, probit should be used. This strategy means that patterns in the data (e.g. OSH risk prevention being more common in larger companies, regardless of country or sector) are exploited to obtain more precise estimates in cells with a low number of observations. The predicted values for country-sector-company size combinations can then be calculated, even for those cells for which there are no observations. For instance, ESENER-3 did not interview any company with more than 250 employees in the construction sector in Sweden. Still, the prevalence of preventive measures in companies of this type can now be imputed by extrapolating estimates from large construction companies in other countries and from smaller construction companies in Sweden. The predicted variables based on ESENER-3 are then included in the EWCS. The drawback of this approach is that it does not take into account interactions between country, company size and sector, which could be crucial variation, as sectors in different countries may be more or less tied to companies of a particular size.

Table 42 shows the correlations within the ESENER-3 data between the observed values on the constructs on one hand, and expected values based on the regressions and based on cell averages on the other hand. Note that the small cell sizes shown in Figure 10 mean that the correlation with cell averages will be higher (14 % difference at the NACE 1-digit level, 24 % at the NACE 2-digit level). Despite this, the regression estimates have a similar correlation, meaning little information is lost by not interacting the three explanatory variables (which would be the same as calculating cell averages). However, the correlations are not very high.

Table 44: Correlation between observed and expected values in the ESENER-3 data

Constructs	NACE 1-digit		NACE 2-digit	
	Predicted	Average	Predicted	Average
Biomechanical stress	0.366	0.443	0.383	0.525
Psychosocial risks	0.450	0.503	0.460	0.575
Digital	0.382	0.454	0.407	0.557
Voice (intensity)	0.491	0.547	0.501	0.604
Say (intensity)	0.314	0.385	0.332	0.482

Constructs	NACE 1-digit		NACE 2-digit	
	Predicted	Average	Predicted	Average
OSH assessments	0.403	0.459	0.413	0.530
General OSH prevention	0.434	0.488	0.442	0.561
Psychosocial risk prevention	0.366	0.431	0.376	0.518
Health awareness programmes	0.415	0.488	0.427	0.563
OSH training	0.387	0.446	0.399	0.531
Average correlation	0.401	0.464	0.414	0.545

Source: Authors' compilation based on ESENER-3 (2019) data

The choice of method depends on a trade-off between precision (advantage of using cell averages) and coverage (advantage of using predicted values). The regression approach seems more flexible and less sensitive to outliers than the cell average approach, but it is even noisier and has consistently weaker correlations with the observed values. Therefore, average cell values are chosen as the preferred approach for the analysis. Still, since both the predicted values and the average cell values are determined solely by the three identification keys, one should be careful when including these variables in the micro-level model, as there is a risk for multicollinearity: the proxy for the ESENER-3 is fully determined by the three keys. A simple solution is to not control for these background variables in multivariate analyses, which was done in the analysis.

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The European Agency for Safety and Health at Work (EU-OSHA) contributes to making Europe a safer, healthier and more productive place to work. The Agency researches, develops, and distributes reliable, balanced, and impartial safety and health information and organises pan-European awareness raising campaigns. Set up by the European Union in 1994 and based in Bilbao, Spain, the Agency brings together representatives from the European Commission, Member State governments, employers' and workers' organisations, as well as leading experts in each of the EU Member States and beyond.

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