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European Agency for Safety and Health at Work

Work-related musculoskeletal disorders: why are they still so prevalent?

Evidence from a literature review

European Risk Observatory

Report

European Agency for Safety and Health at Work

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Executive Summary

The aim of this exploratory review is to examine the continuing high levels of musculoskeletal disorders (MSDs) in the working population and to examine the evidence in relation to prevention.

The review has been prepared as part of a larger project, 'Review of research, policy and practice on prevention of work-related MSDs'. The project's objectives are:

- to improve knowledge of new and emerging risks and trends in relation to factors that contribute to work-related MSDs and to identify the related challenges;
- to identify gaps in current strategies for tackling work-related MSDs at both policy and workplace levels;
- to investigate the effectiveness and quality of workplace interventions and risk assessment approaches; and
- to identify new approaches for more effective prevention of MSDs.

The reported rates of MSDs across the Member States of the EU (EU-28)[1] increased from 54.2 % in 2007 to 60.1 % in 2013 (according to the results of the EU Labour Force Survey carried out in those years). Data from the European Working Conditions Survey do not show a significant reduction in the incidence of musculoskeletal pain in the lower limbs or upper limbs or of back pain between 2010 and 2015. It appears that, although there are legislative requirements to ensure that workplace hazards that might cause MSDs are controlled, there is limited evidence that this is happening.

Methods

To examine the topic of prevention of MSDs, an exploratory literature review was undertaken. This involved initial searching to identify hypotheses before conducting focused searching of the literature to explore research findings to test these hypotheses. The research questions to be addressed in this exploratory review were as follows:

- Why is there a continuing high prevalence of work-related MSDs?
- What are the changes in the world of work that potentially contribute to the high prevalence?
- What is the impact of demographic change?
- What is the impact of individual risk factors?
- What are the gaps in current prevention and risk assessment approaches?
- Do they also consider psychosocial risks, gender differences and/or age?

Scoping searches were carried out and followed by focused searches for each of the hypotheses identified. Research papers were procured and data extracted from each of them.

Results

Hypotheses generated

Twelve hypotheses were identified within the body of research including:

- The impact of digitalisation and information and communications technology (ICT)-enabled technologies may expose individuals to increased MSD risks.
- New forms of employment, including the gig and platform economies, have the potential to reduce workers' level of occupational safety and health (OSH) protection.

[1] At the time of the publication of this literature review, the United Kingdom is no longer a Member State of the European Union. Nevertheless it was still part of the European Union when the research was carried out in 2019, henceforth in this report the United Kingdom is referred to as a EU Member State.

- Previously high prevalence in one sector may move to a different sector. For example, shorter stays in hospital increase home recovery time, and patient handling then moves from the healthcare to the home care setting, thus shifting the exposure.
- The effect of changing workplace policies such as no-lift policies shifts the exposure site from the back to the shoulders, or just-in-time manufacturing increases the speed of working and level of repetition without ergonomic assessment, leading to an increase in reported MSDs.
- Unhealthy lifestyles, physical inactivity and rising obesity rates may result in increased musculoskeletal problems.
- The impact of changing workforce demographics mean an older workforce with an increased likelihood of musculoskeletal problems (whether arising from work or age) as well as a younger workforce coming to work with pre-existing musculoskeletal problems.
- The importance of psychosocial risks is increasing.
- A growing proportion of sedentary jobs results in increased occupational sedentary exposure and musculoskeletal complaints.
- Failure to reduce physical workplace hazards, including heavy physical work, excessive repetition, awkward postures and heavy lifting, results in continued exposure.
- Different socio-economic contexts, classifications of industrial diseases, support structures and insurance arrangements in each EU Member State have an impact on MSD reporting.
- A lack of adequate work organisation and/or work design results in increased exposures to MSD risks.
- There are gaps in risk assessment and prevention practices.

- **Work**

There are known associations between work factors, including poor and awkward postures, high levels of repetition and the need for high levels of force, with the prevalence of MSDs. However, there appears to have been little change in exposure to MSD hazards since 2005. The continuing high prevalence cannot be explained by physical work factors alone and other issues need to be considered.

- **Sectoral change**

In the last two decades, the EU has undergone a shift in its economy in which workers have moved from manufacturing industries to service and construction industries. This has resulted in a change in the nature of the MSD hazards to which workers are exposed, including patient handling in health and social care, poor posture, high levels of repetition in service work, and sedentary work in office environments. Postural risk scores are high in many remaining sectors.

- **Changing ways of working**

Work is changing in both how and where we carry it out. Digitalisation has resulted in the use of new technologies potentially allowing access to work at all times. Simultaneously, online platform working has increased whereby the relationship between employer and worker is changing and more people are either self-employed or on casual contracts in which the necessary OSH regulations might not be in followed.

This increase in digitalisation has also changed consumer behaviour and e-retail is consistently increasing. Consequently, more people are employed in this sector in picking warehouses and as delivery drivers. Although automation is being used by some organisations, there is still a need for humans for quality assurance, more complex picking tasks and at times more menial tasks. These workers can be subject to both high physical and mental demands when working under time pressure. There is little evidence at the moment that OSH hazards are being addressed.

New ways of working also include changes in work processes such as lean manufacturing processes in the manufacturing sector. Although the research is ambivalent about the impacts of lean processes on MSD hazards, it is clear that implementing change using job design and ergonomics can reduce exposure. Within healthcare using sliding rather than lifting and recuperation at home has changed the nature of the exposure. Although the home environment is good for the patient, it is less controlled and less likely to have lifting aids for the carer.

While fixed robots have been in the workplace for a few decades, the extent of automation and autonomous robots is predicted to increase in the coming years. What is clear is that, while automation can reduce exposure to MSD hazards, this is not always properly evaluated and workers may end up working in machine-paced roles. More positively, autonomous robots may reduce workers' exposure to dirty and highly repetitive work. There has been limited applied research examining how humans and robots will work side by side and the OSH issues that might be encountered.

Finally, more of us are spending our working lives sitting down. This has recognised adverse health effects, but sedentary work is also associated with MSDs, again with a number of identifiable risk factors. Job design needs to be considered to ensure that people can get up and move at work (and are encouraged to do so). In addition, ensuring that changing facilities and showers are available for people who want to take exercise during breaks can also be beneficial. Guidance for protecting sedentary workers' safety and health has been provided.

- **Health behaviours**

Although this exploratory review is focused on work-relevant factors in relation to the prevalence of MSDs, there are recognised associations between health behaviours and MSDs, in particular obesity, physical inactivity and tobacco smoking. Workplace health promotion could have a beneficial impact by reducing these behaviours and thus reducing the prevalence of MSDs.

- **Age and gender**

In relation to age, the prevalence of MSDs increases in older workers. Whether this is due to extended duration of exposure and/or reduced capacity with increasing age is still being debated. On examining exposure to MSD risks in older workers (usually defined as workers over 50 years) compared with those under 35 years old, it was found that exposure to repetitive arm movements and moving and handling loads was reduced, whereas exposure to painful and tiring positions was increased. These data suggest that older workers are still being exposed to considerable risks at work. As a corollary, there is also evidence to indicate that, when injuries occur, recovery time is longer.

The data also highlighted that younger workers were also reporting high levels of MSDs. Further research is required to establish whether this is due to starting work with problems or quickly developing MSDs after starting work. It is essential that prevention measures are made available throughout people's working lives.

Generally, men report more MSDs than women. However, the nature of their MSDs differs, with men more likely to report back problems and women neck, shoulder, hand or arm problems. When exposures to MSD hazards are examined, for specific hazards including repetitive movements and sitting for long periods, women and men report being exposed to the same extent. For lifting people, 6 % of women report carrying this out all the time (versus 2 % of men) and 9 % of women reporting lifting people for a quarter to three quarters of the time (vs 4 % of men). This implies that horizontal segregation has an impact, with more women in health and social care work. However, vertical segregation also plays a part, with more women in part-time roles that may expose them to MSD hazards. However, the impact of the dual role of women as workers with domestic responsibilities should not be ignored, as such work can both cause and prevent MSD risks. When examining age and gender, although women over 50 years old report more symptoms than men, this is the age group that has seen the largest increase in employment in the last decade.

- **Health beliefs and somatisation**

Health beliefs influence how we think about ill health, and somatisation is the manifestation of physical symptoms arising from psychological distress. Self-perceived poor health has been associated with an increase in the prevalence of MSDs. Individuals can bring positive or negative health beliefs to work, but negative beliefs can be associated with symptoms. In the work reported, negative beliefs on work-related health issues, prognosis and having heard of RSIs (repetitive strain injuries) was associated with symptoms. There appears to be a lack of knowledge of the symptoms of, prognosis for and likely recovery from MSDs, and increasing the amount and accurate of our knowledge may help in both prevention and recovery.

- **Psychosocial factors**

There is growing acknowledgement that psychosocial factors also have an impact on the prevalence of MSDs. Various pathways have been hypothesised, including high mental workload increasing muscle tension, exposure to stress not allowing recovery and stress causing changes in the immune or inflammatory system. The review identified that reducing exposure to burnout may have the potential to reduce musculoskeletal pain. Fatigue might also be a factor, and individuals with MSDs reporting getting less sleep. Psychosocial factors including poor social support, low levels of job control and work-life conflict have all been found to be associated with MSDs. Managing psychosocial risks may reduce musculoskeletal problems. There is a concern that this is not happening widely, partly because many employers are unaware of this connection and partly because psychosocial risks are not categorised as a specific risk (being bundled into the Framework Directive with no differentiation between them and other workplace hazards). Where psychosocial risks are assessed, this is often done 'in a silo', i.e. focusing purely on the consequences of 'stress' for mental health, an approach that makes no linkage between psychosocial and other workplace risks.

- **Socio-economic differences**

Socio-economic differences between Member States and national differences in methods of reporting MSDs do have an impact on their prevalence. At present, this is perceived as being affected by changes in the reporting of industrial diseases and by awareness campaigns about such changes increasing reporting. However, the review also showed that the reporting of back pain has increased in countries where there are higher levels of social protection and social inclusion. It was suggested that this was due to income protection and support mechanisms being more readily available.

- **Gaps in risk assessment and prevention practices**

Although provisions for the prevention of MSDs are laid down in the Manual Handling and Display Screen Equipment Directives, these do not cover all MSD risks. There are a large number of tools available for risk assessment, but few have been thoroughly evaluated. Why do we still have a large number of people reporting MSDs? Our focus on aetiology rather than epidemiology may be holding the research back, as we need to develop and report intervention studies. We do not know how many organisations are implementing workplace changes or how effective these are. Thus, planning, designing and implementing intervention research over a reasonable timescale has to be the way forward. The review also identified barriers and facilitators to implementing strategies for MSD prevention. Recently, evaluating the impact of OSH legislation and enforcement revealed that there is a large gap in both musculoskeletal and psychological research. There is a clear need to evaluate both musculoskeletal and psychosocial risks in a joined-up way, and research from Australia shows how this could be achieved.

A number of guidance documents are available in which prevention of MSDs must be seen as a long-term commitment as part of general OSH management and must involve the participation of the workforce. Lack of knowledge can be a barrier to prevention, so training and awareness raising is also essential. The need to think about psychosocial risks as part of prevention has also been emphasised. We need a broader framework involving the regulator, organisations (employers and workers) and researchers.

In relation to our new ways of working, further guidance has been provided on sedentary work to increase opportunities for moving while at work. There remains a large area of research on automation and robotics that we need to consider in relation to the interface between the human and the machine.

Discussion and conclusions

This exploratory review has examined various hypotheses on why there is still a high prevalence of MSDs. The review investigated changes in the sectors where people are employed and changes in the way people work as a result of technological and process changes. What is clear is that exposure to MSD hazards is not reducing. Although there is the potential to reduce exposure, there is little evidence that this happening in workplaces and exposure may actually be reduced by the casualisation of work.

There is certainly a requirement for a better understanding of the interface between the human, the workplace and work equipment in new technologies.

There is still a need for workplace health promotion to improve the level of health we bring to work. Our understanding of health beliefs might give us an opportunity to share accurate knowledge about MSDs and their occurrence, prognosis and prevention to help us understand the issues. Demographic change and an increasingly older workforce creates a group of workers more at risk; surprisingly, younger workers also appear to be starting work with MSDs.

The recognition of psychosocial factors and their influence on the prevalence of MSDs has not been linked into the risk assessment process in any real way. Research from Australia does make recommendations on how this can be done, but this has not been yet evaluated.

There is a clear need to take new approaches to preventing MSDs, including designing workplace intervention studies that take a more holistic approach covering both physical and psychosocial risks. Furthermore, educating the public about MSDs is essential to increase awareness and knowledge of their impact and help bring about change.

This exploratory review has identified a clear need to do the following:

- Understand differences between countries and, where countries have reduced the prevalence of MSDs, find out what works and why.
- Adapt risk assessment tools and risk reduction measures to be able to assess both MSDs and psychosocial risks in one assessment.
- Increase awareness and understanding of the work relevance of MSDs and their identification, prognosis and prevention in the workforce.
- Carry out intervention studies to help identify what is effective and just as importantly what does not work.
- Ensure that workplace health promotion activities focus on MSD prevention as well as health behaviours that affect MSDs.
- Identify current practices to improve the prevention of the impact on MSD caused by the digital integration of an individual's work-life commitments and platform working.
- Update legislation to cover new technologies, including examining the implementation of the existing legislation to determine:
    - Does the legislation cover the correct risks?
    - Are employers adequately assessing these risks?
    - Are employers implementing appropriate controls?

1 Introduction

This exploratory review is the starting point of the project 'Review of research, policy and practice on prevention of work-related MSDs', which aims to do the following:

- to improve knowledge of new and emerging risks and trends in relation to factors that contribute to work-related musculoskeletal disorders (MSDs) and to identify the related challenges;
- to identify gaps in current strategies for tackling work-related MSDs at both policy and workplace levels;
- to investigate the effectiveness and quality of workplace interventions and risk assessment approaches; and
- to identify new approaches for more effective prevention of MSDs.

The project consisted of desk research, comprising the current literature review and an overview of policies, strategies and programmes, followed by qualitative research encompassing interviews and focus groups involving experts, intermediaries and other relevant stakeholders in six selected countries (Belgium, Germany, France, Austria, Sweden, United Kingdom).

More specifically,

- The research literature was reviewed with a focus on the factors that potentially contribute to the persistently high prevalence of work-related MSDs.
- Policies, strategies, programmes, actions and initiatives aimed at tackling MSDs in selected European countries were identified, described and analysed, including success factors and barriers to implementation.
- Qualitative research was carried out to investigate risk assessment practices and prevention strategies in relation to MSDs and to understand the gaps between research and practice on the one hand and policies and practice on the other hand.

The aim of this exploratory review, undertaken as task 1 of the project was to examine the literature with a focus on the factors that potentially contribute to the persistently high prevalence of work-related MSDs, including the evidence in relation to prevention, to gain a better understanding of the possible reasons for their high prevalence.

The review also aimed to examine the evidence for what works (or not) in preventing MSDs and to explore new risk assessment and prevention approaches.

1.1 Musculoskeletal disorders, prevalence and trends

MSDs is an umbrella term for pain and discomfort in the muscles of the body, in this case focused on the back and upper and lower limbs. For the purpose of this exploratory review, and based on the European Agency for Safety and Health at Work's (EU-OSHA's) 2007 Healthy Workplaces Campaign, the following definition of work-related MSDs was used:

> *work-related MSDs were defined as impairments of bodily structures such as muscles, joints, tendons, ligaments, nerves, bones or a localised blood circulation system that are caused or aggravated primarily by the performance of work and by the effects of the immediate environment where the work is carried out (EU OSHA, 2008).*

Often MSDs are broken down by the site of pain and discomfort. For example:

- back pain (which can be low back pain, upper back pain or neck pain) in which the source of problems is around the spine and supporting muscles and ligaments;
- upper limb disorders, usually including the shoulders, upper arms, forearms, hand or wrist; and
- lower limb pain, including the hips, legs, knees, ankles and feet.

Upper limb disorders are often misleadingly called repetitive strain injuries. There are many suggested causes of upper limb disorders. Although repetition is one of these, it is by no means the only one and often not a causative factor at all.

Confusingly, the site of pain or discomfort is not always the site of the disorder. Thus, back disorders can lead to sciatic (leg) pain, and neck problems frequently result in pain and other symptoms down one or both arms.

According to the EU Labour Force Survey (LFS) ad hoc modules (2007 and 2013), reported rates of MSDs across the EU generally increased from 54.2 % to 60.1 % between 2007 and 2013. However, this increase is not consistent across all EU countries. Table 1 shows the data for the 28 Member States of the EU (EU-28). From this it can be seen that 14 countries have experienced an increase in MSDs (shown in bold/red) over this period and the rest a decrease.

Table 1 Reported rates of MSDs (%) in the EU-28, 2007 and 2013

Member State	2007 (%)	2013 (%)	Difference (% points)
European Union (current composition)	54.2	**60.1**	+5.9
Belgium	57.5	56.7	-0.8
Bulgaria	37.3	**42.8**	+5.5
Czechia	44.5	**69.7**	+25.2
Denmark	59.0	57.9	-1.1
Germany	74.9	64.5	-10.4
Estonia	54.7	**66.0**	+11.3
Ireland	55.2	49.2	-6.0
Greece	54.7	**59.3**	+4.6
Spain	62.1	62.3	+0.2
France	47.3	**57.7**	+10.4
Croatia	55.1	54.8	-0.3
Italy	49.7	**59.2**	+9.5
Cyprus	56.4	**68.7**	+12.3
Latvia	61.6	54.1	-7.5
Lithuania	44.0	**61.4**	+17.4
Luxembourg	62.2	40.4	-21.8
Hungary	61.5	44.2	-17.3
Malta	56.7	**64.9**	+8.2
Netherlands	56.2	-	-

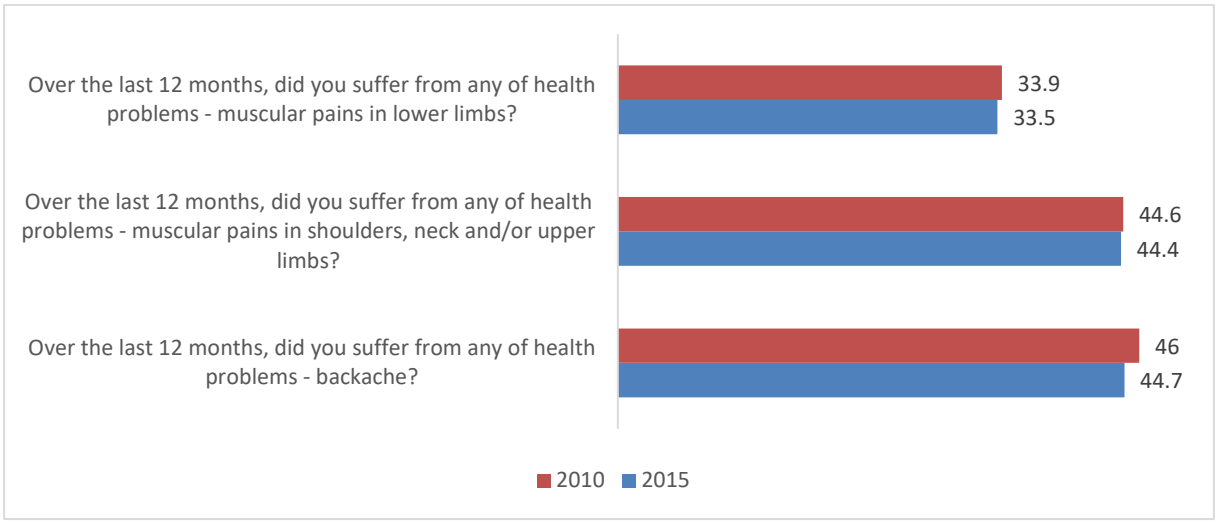
Member State	2007 (%)	2013 (%)	Difference (% points)
Austria	66.3	66.6	+0.3
Poland	63.2	69.2	+6.0
Portugal	55.3	51.8	-3.5
Romania	39.7	42.6	+2.9
Slovenia	58.2	57.1	-1.1
Slovakia	61.0	65.7	+4.7
Finland	67.8	70.3	+2.5
Sweden	58.7	53.1	-5.6
United Kingdom	50.5	40.5	-10.0

Source: Eurostat, Labour Force Survey ad-hoc modules 2005 and 2013

The prevalence of MSDs remains high in all countries, despite EU-wide policies and prevention and risk reduction measures being a major part of the approach to occupational safety and health (OSH) and having been so for more than two decades in many Member States.

Figure 1 presents data from the European Working Conditions Survey (EWCS) in 2010 and 2015. These data show that there has been no real reduction in the reported prevalence of MSDs affecting the back, shoulders, neck or upper or lower limbs in the period between the surveys.

Figure 1 Percentage of individuals reporting specific types of MSDs in the EU, 2010 and 2015



Source: European Working Conditions Survey, Eurofound

There is a lack of comparable data on MSDs at EU level. More specific and recent data is in some instances available at national level, providing an indication of trends in the prevalence of MSDs by type and sector.

For instance, the UK Health and Safety Executive (HSE, 2017) examined the prevalence of self-reported ill health across various sectors using data from the UK Labour Force Survey data for periods of one year, three years and five years The sectors that reported the highest prevalence of MSDs were skilled trades occupations, caring, leisure and other service occupations and process plant and machine operatives.

The MSD data were split into different categories including MSDs mainly affecting the upper limbs and neck and MSDs mainly affecting the back. MSDs affecting the upper limbs and neck were most frequently seen in skilled trades occupations. When examined across all sectors, there had been no reduction in MSDs affecting the upper limbs and neck during the preceding three or five years. When investigating trends, upper limb and neck symptoms were lower for the one-year period than for the preceding three- and five-year data points in human health and social work activities.

Sectors with the highest prevalence of MSDs mainly affecting the back included skilled trades occupations, caring, leisure and other services and process plant and machine operatives. Looking at different sectors within these data, the following sectors reported a higher than average prevalence of MSDs: agriculture forestry and fishing; construction; transport and storage; public administration and defence; compulsory social security; and human health and social work activities. What was evident from the longitudinal data was a reduction across all sectors but especially caring, leisure and other occupations.

Further analysis of back symptoms in those working in human health and social work activities found that they were higher than the overall industry average. For all other sectors, back symptoms were less common overall for the preceding three and five years. Thus, we can see symptoms increasing in some sectors and, in the case of health and social work activities, a sector increasing in size.

The UK LFS data have also been analysed to look how self-reported MSDs are attributed to or made worse by work. In these data, estimated rates of MSDs were highest for manual handling (lifting, carrying, pushing, pulling), awkward or tiring postures, keyboard work or repetitive actions (repeating a series of movements), a workplace accident or work-related stress. However, there are no data for trends in relation to changes in attribution over time.

Within the EU, workplace hazards should already be adequately controlled by the extensive OSH legislation transposed into national law. However, the possibility that some workplace hazards are not adequately controlled was raised as part of the ex-post evaluation of the 24 OSH directives including the Manual Handling Directive (Directive 90/269/EEC) (European Commission, 2015a). Although the changing demography of the workforce and the changing nature of work are important in understanding why prevalence remains high, workplace factors still need to be considered. In a similar vein, the equivalent report on the Display Screen Equipment (DSE) Directive (Directive 90/270/EC), as well as pointing out the failure of the directive to reflect modern computing technologies, cited evidence to suggest that actual compliance with the regulatory requirements was less than might be suggested by awareness surveys (European Commission, 2015b).

In summary, while there have been a number of strategies and policies at both EU and national levels, there appears to have been little impact in some countries of trying to reduce the incidence and prevalence of MSDs. The following review will address some of the hypotheses proposed with a view to better understanding what drives the continuing high prevalence of MSDs.

2 Methods

The approach taken to the review was to identify research papers that examine causes of the high prevalence of MSDs and from this propose working hypotheses to be further explored.

The exploratory review started with the question 'Why does there continue to be a high prevalence of work-related MSDs?'. From this question, a number of hypotheses were identified and examined through focused searching. Thus, this is not a systematic review but the scoping searches and focused searching were carried out systematically and recorded. The research questions addressed in this exploratory review were as follows:

- Why is there a continuing high prevalence of work-related MSDs?
  - What are the changes in the world of work that potentially contribute to high prevalence?
  - What is the impact of demographic change?
  - What is the impact of individual risk factors?
  - What are the gaps in current prevention and risk assessment approaches?

2.1 Searches

Although these are very broad questions, the process followed to identify relevant research was to carry out initial focused searches on studies that examined the prevalence of MSDs. These were based on the search strategy presented in Appendix A. From the papers initially identified, we developed hypotheses on the potential reasons for the continuing high prevalence of MSDs. The hypotheses (Table 2) were then used to direct further focused searches on each topic.

2.2 Data extraction

Although this is an exploratory review, there was still a need for a simple yet systematic approach to collating and summarising the information and knowledge identified. A data extraction table was developed and is presented in Appendix B. This table was created as an Excel spreadsheet, which was trialled with three papers. Data were then extracted from the papers included into the spreadsheet. Summary information from each of the papers included is presented in an annotated bibliography in Appendix C.

All papers were stored in a RefWorks database to allow ease of access by the research team.

3 Results

3.1 Hypotheses for the continuing high prevalence of MSDs

To inform more focused searches, scoping searches were carried out to identify publications that examined the prevalence or continued high prevalence of MSDs. The author-generated hypotheses for the continued high prevalence of MSDs, derived from these preliminary papers, are presented in Table 2.

Table 2 Hypotheses for the continuing high prevalence of MSDs

Hypothesis
The impact of digitalisation on the nature and organisation of work may expose individuals to new or increased MSD hazards.
The increasing use of information technology, including mobile devices, both at work and in leisure time has an impact on MSD hazards.
Changes in contractual arrangements including the gig economy have the potential to reduce the level of protection of the workforce, leading to increased musculoskeletal problems.
Previously high prevalence in one sector may move to a different sector, for example from manufacturing to the service sector, or patient handling moving from healthcare to home care, thus shifting the exposure.
The effect of changing workplace policies such as no-lift policies shifts the exposure site from the back to the shoulders, or just-in-time manufacturing increases the speed of working and levels of repetition without ergonomic assessment, leading to an increase in reported MSDs.
An increase in poor lifestyle choices lead to increased obesity and reduced physical activity, resulting in increased musculoskeletal problems.
The impact of changing workforce demographics mean an older workforce with an increased likelihood of musculoskeletal problems (whether arising from work or age) as well as a younger workforce coming to work with pre-existing musculoskeletal problems.
The influence of psychosocial risk factors is increasing because of work intensification, new production methods or dysfunctional work organisation, resulting in increased MSD risks.
An increasing proportion of workers is involved in sedentary occupations and insufficient physical activity results in increased musculoskeletal symptoms.
Continuing exposure to physical workplace hazards, including heavy physical work, excessive repetition, awkward postures and heavy lifting, keeps the prevalence of MSDs high.
Different socio-economic contexts, classifications of occupational diseases, support structures and insurance arrangements in each EU Member State have an impact on MSD reporting.
A lack of adequate work organisation and/or work design results in increased exposures to MSD risks.
There are gaps in risk assessment and prevention practices.

3.2 Work

The aim of this section is to examine the impact of work on MSDs and to understand how the changing world of work, including new contractual arrangements, new technology, automation and new work processes might have an effect on the prevalence of MSDs.

3.2.1 Risk factors and exposures

It is recognised that workplace causes of MSDs include high physical demands, highly repetitive work, work that needs high levels of force or poor posture and psychosocial factors. Table 3 shows that, although there is reasonable evidence for an association between some work, lifestyle and individual factors, the range of associations is varied. It should also be recognised that many of these factors have disorder-specific relationships. Thus, for example, there is strong evidence for a positive relationship between female gender and the incidence of one upper limb disorder (carpal tunnel syndrome) but no such evidence for another (epicondylitis) (Graveling, 2018).

Table 3 Levels of evidence for associations between work, individual factors and MSDs

Body area	Strong evidence	Reasonable evidence	Insufficient evidence
Back and neck	None	Psychosocial factors Smoking Gender Posture Co-morbidity	Heavy physical work Lifting Sedentarism Older age High BMI*
Lower back	None	Awkward postures Heavy physical work Lifting Psychosocial factors Younger age High BMI	Gender Smoking Co-morbidity
Upper limbs — shoulder	None	Heavy physical work Psychosocial factors	Repetitive work Older age High BMI* Sedentarism
Upper limbs — elbow/forearm	None	Awkward postures Co-morbidity Repetitive work Older age	Repetitive work Older age High BMI* Sedentarism
Upper limbs — wrist/hand	None	Prolonged computer work Heavy physical work High BMI Older age Female gender Awkward posture Repetitive work	Smoking Co-morbidity Psychosocial factors
Lower limbs — non-specific lower limb MSDs	None	None	Co-morbidity Psychosocial factors Smoking High BMI*
Lower limbs — hip	None	Lifting Heavy physical work	Repetitive work
Lower limbs — knee	None	Awkward postures	Psychological distress

Body area	Strong evidence	Reasonable evidence	Insufficient evidence
		Lifting Repetition Co-morbidity	Smoking Heavy physical work High BMI*
Non-specified MSDs	None	Co-morbidity	Psychosocial factors (fear avoidance) Older age Smoking

*BMI, body mass index.

In more recent work, Coggon et al. (2013) reported on an international study examining disabling low back pain and disabling hand and wrist pain in 18 countries over 47 different occupational groups. Despite the large number of different groups, the majority of participants were nurses and office workers and few EU countries were included. Thus, the research includes other socio-economic influences from countries and regions including Japan, the Middle East and South America. Using a standardised interview or survey, the results from 12,426 participants identified positive associations between lifting weights of more than 25 kg and disabling low back pain (proportional reporting ratio, PRR = 1.16, 95 % confidence interval, CI, 1.06-1.26) and between working for more than four hours per day at a computer or other repetitive task and disabling wrist/hand pain (PRR = 1.63, 95 % CI 1.40-1.90). However, it should be noted that this was a cross-sectional survey, and it cannot be assumed that the relationships were causal for any underlying injury (although they might well reflect provocation of pain).

Work-related risk factors for MSDs with reasonable evidence for a causal relationship include heavy physical work, excessive repetition, awkward postures and high psychosocial work demands (da Costa & Viera, 2010). In a study in Portugal, in which participants were split into blue-collar and white-collar workers, Silva et al. (2016) identified that back pain was associated with exposure to vibration, high work demands, feeling exploited and a perceived loss of dignity at work. The analysis identified that, for white-collar workers, back pain was associated with awkward postures, sedentary work, exposure to physical aggression and having to be awake before 05.00. The authors suggest that this may be related to timetabling and shift work organisation in manufacturing and service industries.

The papers above summarise knowledge at the time of the review with work-related physical risk factors for MSDs. Although there is more research available, in general this highlights the same associations between work-related factors and the prevalence of MSDs. As regards trends in exposure to MSD risk factors, data from the EWCSs suggest that that exposure to physical risk factors, although reduced, has not been removed from the workplace (Eurofound, 2017). The data from EWCSs show (Table 4) that there is still a high proportion of workers exposed to those risk factors. Although exposure to tiring or painful positions, carrying or moving heavy loads, and repetitive hand or arm movements show decreasing trends, exposure to lifting or moving people is increasing.

Table 4 Proportion (%) of workers across the EU-28 exposed to risk factors for at least a quarter of their working time

Factor	2005	2010	2015
Tiring or painful positions	46	46	43
Lifting or moving people	8	9	10
Carrying or moving heavy loads	35	34	32
Repetitive hand or arm movements	62	63	61

Source: European Working Conditions Survey, Eurofound

In summary, there are known associations between work factors, individual factors and the prevalence of MSDs. Although physical factors are recognised as contributing to MSDs, there has been little change in exposure to physical MSD hazards since 2005.

The impact of physical factors has been highly researched, but there is a growing acknowledgement that psychosocial factors also contribute to the development of MSDs. This section examines those factors for which research has identified an association between psychosocial risks and the prevalence of MSDs in the context of changing ways of working over the last 10 years.

The literature shows that highly demanding jobs are associated with an increased risk of MSDs, especially when combined with limited latitude in decision-making and poor social support, as illustrated by the demand-control model of occupational stress (Karasek, 1979) and the effort-reward imbalance model (Siegriest, 1996).

The following sectors all report above-average levels of work intensity in the EU: health sector, construction, industry, financial services, and commerce and hospitality, with the health sector presenting the greatest intensity (Eurofound, 2017).

Data from the EWCS (Eurofound, 2017) suggest that high work intensity is quite prevalent in Europe, with 36 % of workers in the EU reporting working to tight deadlines and 33 % reporting working at high speed 'around three quarters of the time', with 1 in 10 (10 %) (men and women) reporting 'never' or 'rarely' having time to do their jobs. Workers in the health sector are exposed to the highest levels of work intensity.

Considering work intensity over time, the EWCS work intensity index ([2]) shows there has been a slight intensification of work since 2010 — reflected in a one-point increase in the index — but a small decrease overall since 2005 (Eurofound, 2017).

In a cross-sectional study of hospital workers, Magnavita et al. (2011) found a strong interaction between the physical and psychosocial factors affecting MSDs. Their results build on the findings of previous studies, as they show that the risk from exposure to both sets of factors is greater than the risk from high exposure to only one of the factors (either factor). In particular, Magnavita et al. (2011) found that problems in the upper limbs (as opposed to low back pain) were more strongly influenced by the combined effects of physical and psychosocial risk factors.

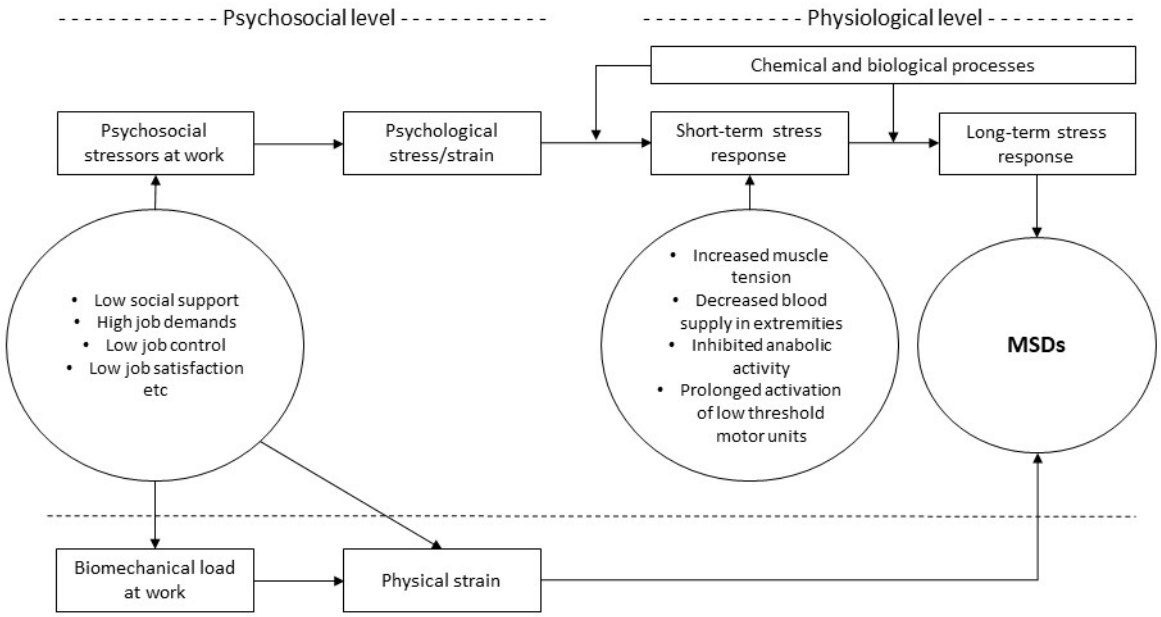
There are various suggested mediating mechanisms linking psychosocial issues and musculoskeletal pain, as identified in the reviews cited by Armon et al. (2010), Bongers et al. (2002) and Elfering et al. (2008):

- high mental loads and job demands increasing muscle tension and decreasing micropauses in muscle activity;
- work-related exposure to stresses affecting an individual's ability to unwind and reduce physical activity during breaks at work and non-working hours;
- stress-induced adverse changes in the immune/inflammatory system; and
- activation of the sympathetic-adrenal medullary system in response to stress, leading to secretion of noradrenaline, which increases muscle activity.

These are summarised Figure 2.

([2]) This index measures the level of work demands in the job: for instance, working at high speed and under time pressure and experiencing emotional demands, such as dealing with angry clients. The trend version of the work intensity index includes a smaller set of indicators because not all questions were measured in previous rounds of the EWCS.

Figure 2 Explanatory model of the impact of psychosocial factors on MSDs



Source: Hauke et al., 2011Burnout

Burnout has been identified as different from depression and anxiety. Burnout is context specific, as it refers to 'the depletion of individuals' energetic resources at work' (Armon et al., 2010).

From a prospective cohort study of 1,704 healthy participants in Tel Aviv, Armon et al. (2010) concluded that burnout could be a risk factor in the development of musculoskeletal pain. Furthermore, such a risk remained even after controlling for anxiety and depression, reinforcing the significance of burnout as a risk factor for the onset of musculoskeletal pain (and the distinction between this and anxiety and depression). Furthermore, the findings of the study did not support the potential for reverse causation, i.e. of musculoskeletal pain predicting elevated levels of burnout (Armon et al., 2010). From the implications identified, the authors suggested that, given the stability of burnout over time, it seems that measures taken to either prevent or alleviate burnout may reduce the risk of debilitating, costly and prevalent musculoskeletal pain (Armon et al., 2010).

Long working hours have been associated with negative health and well-being outcomes such as musculoskeletal disorders (Trinkoff et al., 2006 cited in Eurofound, 2017). According to the sixth EWCS, 16 % of workers in the EU-28 usually work long hours (48 hours or more per week): 21 % of men and 9 % of women (Eurofound, 2017). The trend is decreasing: in 2005 the proportion was 19 %, in 2010 it was 17%, and in 2015 16 % (Eurofound, 2017).

- **Poor social support**

Research has shown an association between poor social support and MSDs. This includes muscle-related pain at all sites as well as specifically pain and problems in the lower back, neck and shoulders.

In an epidemiological cohort study, Clays et al. (2007) studied a sample of 2,556 middle-aged men and women. For men, the prevalence of low back pain was significantly related to poor social support.

This association was also found in a systematic review (24 articles) and meta-analysis (17 of the 24 articles) of hospital nurses and nursing assistants by Bernal et al. (2015), in which poor social support was associated with MSDs at all pain sites. In addition, Hauke et al. (2011) in a systematic review of 54

articles identified significant associations between poor social support and musculoskeletal problems in the following sites: neck/shoulder problems, upper extremities and low back. These findings are reflected in the cross-sectional study of Swedish commercial pilots by Runeson-Broberg, Lindgren & Norback (2014), in which it was found that poor social support and also poor supervisor support was associated with neck, shoulder and low back problems.

- **Low level of job control**

In the literature, there are findings that support an association between low levels of job control and pain in the back, neck, shoulders, wrists, elbows, hips/thighs and knees.

In the systematic review and meta-analysis of nurses and nursing assistants, Bernal et al. (2015) found an association between high psychosocial demands and low levels of job control with pain in the back, neck, shoulder and knee. These findings support those of Runeson-Broberg, Lindgren & Norback (2014), who found associations between high work demands and neck, shoulder, elbow and low back pain symptoms in pilots. Significant associations between high job demands and upper extremity and low back pain and between low levels of job control and neck/shoulder and low back pain were also identified in the systematic review by Hauke et al. (2011). This is further supported by Collins & O'Sullivan (2010), who found that for men high job demands were associated with MSD problems in the shoulders, elbows, wrists/hands, upper back, lower back and hips/thighs, with a greater number of associations in younger men. Collins & O'Sullivan (2010) also found that in women there was a greater number of significant associations between psychosocial factors and MSDs. These factors include job demands, work environment and job content.

Hauke et al. (2011) also found an association between:

- lack of decision-making authority and MSDs in the neck/shoulder and upper extremities;
- lack of discretion to use skills and low back pain;
- poor job satisfaction and upper extremities and low back pain;
- high levels of job strain and neck/shoulder and low back pain; and
- psychological distress and pain in upper extremities.

Along with the association between lack of decision-making authority suggested by Hauke et al. (2011), the study by Clays et al. (2007) identified that for men the prevalence of low back pain was significantly related to baseline limited latitude in decision-making. The authors also found that for men low back pain was not significantly related to high levels of job strain, low wages and lack of job satisfaction, feeling stressed at work and feeling depressed. However, for women, they found that high levels of job insecurity, feeling stressed at work and feeling depressed did not significantly increase the relative risks for low back pain.

- **Work-life conflict**

Working in non-working time impacts the work-life balance and in some cases can result in work-life conflict. According to the sixth EWCS, one in five workers (22 %) is working in their free time several times a month, and 2 % of all workers reported working daily in their free time to meet work demands; this is most common in managers (7 %), agricultural workers (7 %) and professionals (5 %) (Eurofound, 2017). There is literature that shows an association between work life conflict and MSDs.

In a survey of 6,091 service sector employees in Switzerland, Hämmig et al. (2011) found that work-life conflict is significantly and quite strongly associated with MSDs even when various control variables (gender, age, education, physical activity) and other covariates (physical strain at work, time pressure at work, workload, job autonomy, general stress) are adjusted for. This is also supported by the findings of Clays et al. (2007), who found that both work and non-work-related psychosocial factors constitute non-negligible risks for developing low back pain.

As suggested by Kim et al. (2013), there are several explanations for pathways linking work-family conflict and MSDs. One of the factors could be that, when experiencing this conflict, workers may be distracted by non-work duties while working, which has an impact on job demands and could influence musculoskeletal pain. Another possible factor is stress as this could be caused by work-life conflict, which may result in increased muscle tension, which may then lead to musculoskeletal pain.

- **Adverse social behaviours**

Most research on the impact of psychosocial factors on MSDs has focused on job demands and job control. Other psychosocial factors, related to the quality of relationships at work, have not been studied in detail. The results of a study by Vignoli et al. (2015) confirm that exposure to bullying is linked to MSDs (in the low back, upper back and neck regions). The authors suggest that there is a direct effect of bullying and an indirect effect mediated by psychological stress. The authors argue that as bullying is associated with strong feelings of anxiety and anxiety is one of the strong mediators between psychosocial factors and MSDs, there is a reason to assume that psychological stress generated by bullying has an even more important role in the occurrence of MSDs than demonstrated in the study. They suggest that more research is needed in this area.

3.3 Changes in sectoral employment

Structural changes in the economy, consisting of a fall in agriculture and manufacturing and a large increase in services, result in shifts in sectoral employment and consequently changing patterns of exposure to workplace hazards. According to Eurostat Labour Force Survey data, in total there were 34.6 million people employed in manufacturing in 2007 across the EU . This had fallen to 32.6 million in 2017. Within public administration, defence, education, human health and social work the size of the workforce increased from 51.4 million in 2007 to 55.5 million in 2017. Finally, in wholesale and retail trade, transport, accommodation and food services the numbers employed increased from 56.5 million in 2007 to 58.4 million in 2017.

Eurostat data also show that the number of people employed in agriculture, forestry and fishing was 10.3 million in 2008 and had fallen to 8.6 million in 2017 . In construction, the numbers fell from 18.4 million in 2008 to 15 million workers in 2017. Over the same period, the number of workers in human health and social work activities increased from 20.9 million to 24.2 million, and the numbers in the accommodation and food sector increased from 9.2 million in 2008 to 10.7 million in 2017.

In 2016, nearly half of all employment in the EU was concentrated in two economic activities: wholesale and retail trade, transport, accommodation and food services (24.7 %) and public administration, defence, education, human health and social work activities (23.7 %) ([3]). These shifts in employment towards the service sector result in an increasing number of workers being exposed to emotional demands at work, a psychosocial risk factor. In fact, according to data from the EWCS, the indicator ‘handling angry clients, customers, patients, pupils’ (one of the indicators for emotional demands), has been increasing since 2010, and the proportion of workers handling angry clients all or almost of all the time nearly doubled between 2010 and 2015. The greatest increases are seen in education, followed by the health sector and commerce and hospitality, the sectors where workers have to deal more often with third parties. According to EWCS data (Eurofound, 2017), those sectors are also the most exposed to adverse social behaviours. Service and sales workers report more often than average being subjected to unwanted sexual attention (4 %) and sexual harassment (2 %), and they are also considerably more often victims of verbal abuse (16 %), humiliating behaviour (8 %) and threats (7 %). As much as 5 % of workers from this group report having been subjected to physical violence at work in the previous 12 months and around 6 % to bullying/harassment. The health sector reported the highest percentage of workers subjected to all of the adverse social behaviours, with the exception of workplace threats, which was found most common in public administration (11 %).

There have also been increases in the numbers of workers involved in sedentary and office based work, again with recognised associations with MSDs. Although the work tasks have changed and the exposure patterns change, the MSD risk factors are not necessarily removed.

Eurofound (2017) constructed three indices to examine risks in different occupational groups. This included posture-related risk, based on exposure to vibrations, tiring positions, lifting people, carrying heavy loads and repetitive movements. Additional indices include exposure to biological and chemical

([3]) https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20171024-1

risks (including inhaling smoke, toxic vapours and handling chemical products and infectious materials) and ambient risks including vibration, noise and temperature extremes.

Using these risk indices, in Eurofound (2017) the rates in different occupational groups were examined. These data are presented in Table 5.

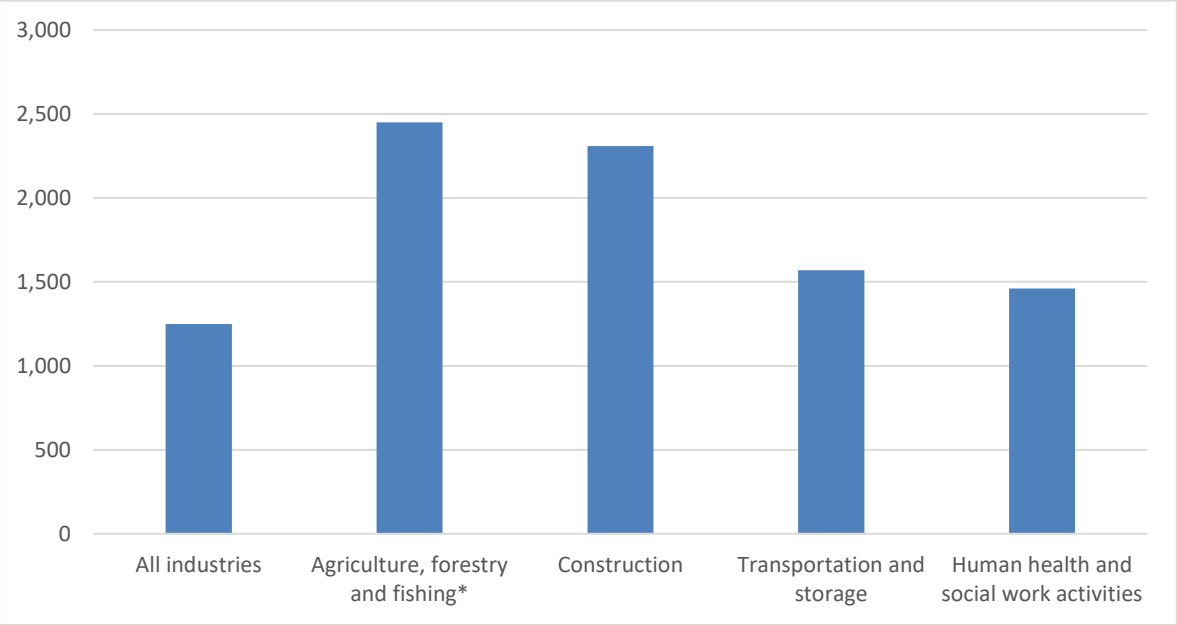
Table 5 Posture-related risks by occupation in the EU-28

Occupational group	Posture-related risk score	Ambient risks
Managers	16	11
Professionals	16	10
Technicians	18	11
Clerks	16	8
Service and sales workers	24	14
Agricultural workers	31	30
Craft workers	37	31
Plant and machinery operators	34	27
Elementary occupations	30	20
EU-28 average	24	16

Source: European Working Conditions Survey, Eurofound

Taking the United Kingdom as an example, the UK LFS data for 2017/18 show that the highest work-related MSD levels were reported in the sectors agriculture, forestry and fisheries; construction; transportation and storage; public administration and defence; and human health and social work activities (HSE, 2017). Agricultural workers had an estimated prevalence of self-reported MSDs of 2,450 per 100,000 workers and construction workers had a prevalence of 2,310 per 100,000 workers compared with public administration and defence and transportation and storage with an estimated prevalence of 1,570 per 100,000 workers. Health and social care activities had an estimated rate of 1,460 MSDs per 100,000 workers' These figures are illustrated in Figure 3.

Figure 3 Estimated prevalence of self-reported work-related MSDs from the UK LFS for people working in the last 12 months, by selected industries, averaged over 2014/15 to 2016/17. Rate per 100,000 workers



* Rate based on fewer than 30 sample

Source: HSE, 2017

Changes in the proportion of people in the employment sectors would reduce the number of people being exposed to physical MSDs hazards. However, the shifting of the workforce into health and social work activities and accommodation and food is not likely to have lessened the risks, as both of these sectors incur exposure not only to physical MSDs but also to psychosocial hazards. Furthermore, when examining the percentage of workers reporting exposure to risk factors that can adversely affect work-related health and mental well-being, the results in Table 6 show that these remain high across all sectors.

Table 6 Percentage of workers reporting health problems and exposure to psychosocial risks, 2013

NACE Code/sector	Percentage of workers reporting a work-related health problem	Percentage of workers reporting exposure to risk factors that can adversely affect mental well-being
A/Agriculture, fisheries farming	7.3	18.4
B-E	7.3	25.1
F/Construction	8.5	24.7
G-J	7.0	26.9
K-U	8.0	31.5

NACE, a European industry standard classification system for economic activities.

Source: Eurostat, Labour Force Survey ad-hoc module 2013

In summary, while the EU has undergone a shift in the sectors that people are employed in, this does not necessarily mean a reduction in exposure to either physical or psychosocial risks. For example, the number of people working in health and social care has increased, and in this sector there are exposures to both physical (patient handling) and psychosocial (emotional demands) risks. Although the main focus of prevention remains on physical work tasks, the pathways for the impact of psychosocial risks on the development of MSDs suggested by Hauke et al. (2011) may indicate a secondary route for prevention. In addition, there is evidence of a strong interaction between work-related environmental and psychosocial factors affecting MSDs and the risk of exposure to both sets of factors is greater than the risk of high exposure to only one of the factors (see above, Magnavita et al. (2011)). Therefore, it is unlikely that the shift from sectors traditionally considered high risk, such as agriculture and construction, to service and health care sectors would reduce the prevalence of MSDs.

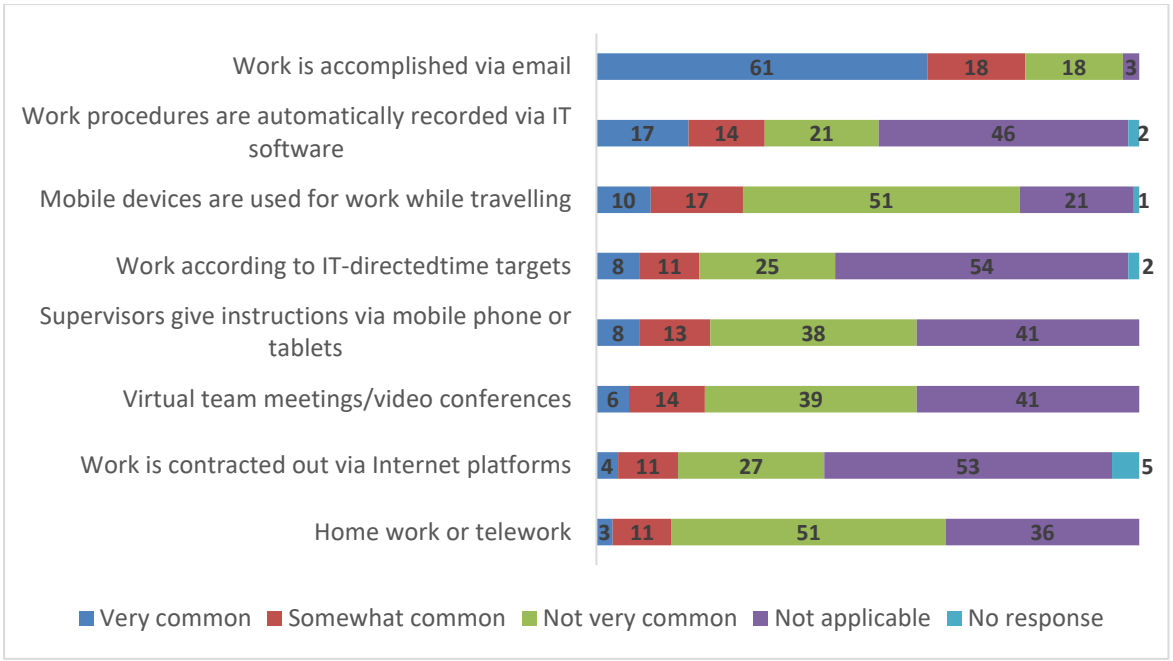
3.4 Changing exposures/changing ways of working

This section examines changes in the workplace and work processes as a result of the increased use of technology including digitalisation in the workplace, changing work processes, automation and robotics. It is clear that, while technology has the potential to improve work or remove the need for human exposure to hazardous work, this is not always reflected in its implementation.

- **Digitalisation of work**

Technology changes are often seen as a means of increasing productivity. As a result, more tasks have been digitalised. This has been seen across all sectors, not just in high-technology working environments. The extent of the digitalisation of work was examined in Germany by Ahlers (2016). Figure 4 shows the extent of this change across all industries, not limited to the obvious sector of information and communications technology (ICT). While such innovations give the workforce the opportunity to work more flexibly in relation to where and when they work, Popma (2013) suggests that there can be a blurring of boundaries between work and home life (leading to a potential increase in psychosocial risks).

Figure 4 Extent of digital working practices, Works Council Survey responses (percentages)



Source: WSI Works Council Surveys 2016 in Ahlers, 2016

Valenduc & Vendremin (2016) highlighted a number of changes in the world of work due to digital technologies such as cloud computing, big data, automation and robotics. These include changes in employment patterns, an increase in the casualisation of work and an increase to 7 % in the numbers of workers who are remote and/or mobile workers across the EU. Figure 5 presents this change and shows a shift from being employed to being self-employed and from casual to collaborative work. The consequences of this change is that more people may become self-employed or work casually; this may be without the necessary OSH protection in place.

Eurofound and the International Labour Organisation (2017) estimated that 17 % of employees in the EU are working in telework or mobile work using ICT. It is difficult to estimate the number of people involved in more casual working arrangements. However, we can look at how business is adjusting to using technology ([4]). For businesses, 95 % have access to the internet (through both fixed and mobile broadband). In 2016, half of all EU businesses provided internet access for staff. In this 2017 report, 69 % of businesses reported providing mobile devices for their staff. There is an increasing provision of access and equipment at work, as well as increased use of technology at home. The number of businesses becoming involved in e-commerce through websites has also increased, giving them new access to information on products, advertising jobs, accepting online applications, and ordering and making reservations and bookings online; overall 80 % of businesses have a website but not all involve e-commerce.

Eltayeb et al., (2007) found that 54 % of Dutch computer workers reported at least one MSD symptom in the arm, neck or shoulder. The annual prevalence of shoulder symptoms was 31 % and of neck symptoms 33%. Griffiths, Mackey & Adamson (2007) in their review of the impact of computerised work on MSDs found that professionals were encouraged to carry out work with high mental demands for long hours with inadequate breaks. It was suggested that this impacted on work pace resulting in increased muscle tension.

While we have seen changes in technology including increased ICT use, there have also been changes in the types of equipment used. Griffiths et al. (2007) highlighted the risk factors associated with computer use, and this is discussed further in the section on changes in work processes.

New types of technology, including smartphone use, was examined by Etivipart, Viriyarojanakul & Redhead (2017). This systematic review examining 11 papers found that, due to neck flexion when using smartphones, muscle activity in the muscle groups supporting the neck (erector spinae, upper trapezius and neck extensor muscles) was increased. There also appeared to be increased neck flexion when users were sitting down. The authors conclude that smartphone use may contribute to MSDs.

Gustafsson et al. (2012) examined the impact of texting on MSDs in a cohort of young people aged 20-25 years over a five-year period. The study identified positive associations between texting and neck and shoulder pain. Examining those who had been symptom free at the start of the study, significant associations were found between texting and new cases of hand and finger symptoms. For those with symptoms at baseline, neck and upper back symptoms continued to occur. This study highlights the speed at which MSDs can occur within a younger population during exposure to new technology.

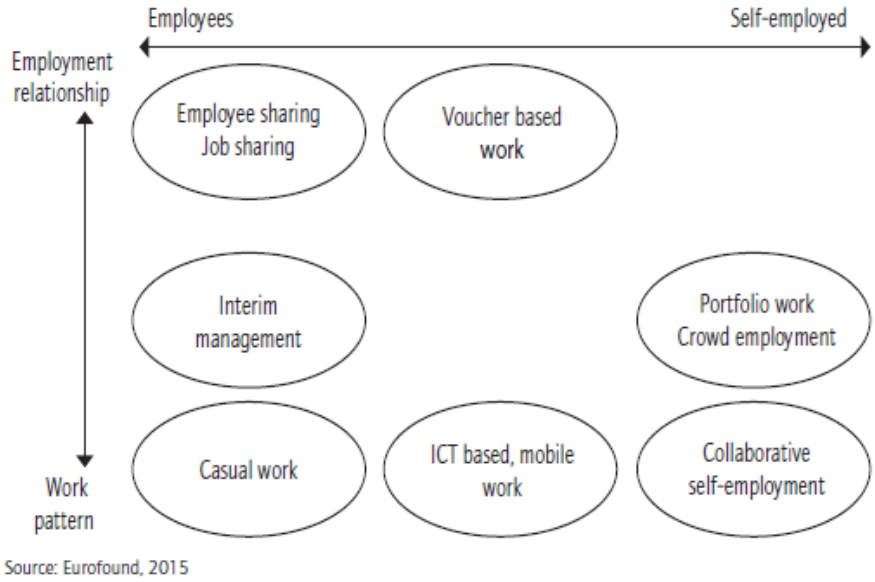
Although new technology offers opportunities for more flexible working, there is a need to evaluate its use in relation to possible MSD risks arising from poor posture.

- **New forms of contract**

The changes in technology do give individuals more flexibility in where and when they work. Valenduc & Vendramin (2016) describe these new ways in Figure 5.

([4]) Digital economy & society in the EU, 2018: https://ec.europa.eu/eurostat/cache/infographs/ict/bloc-1a.html

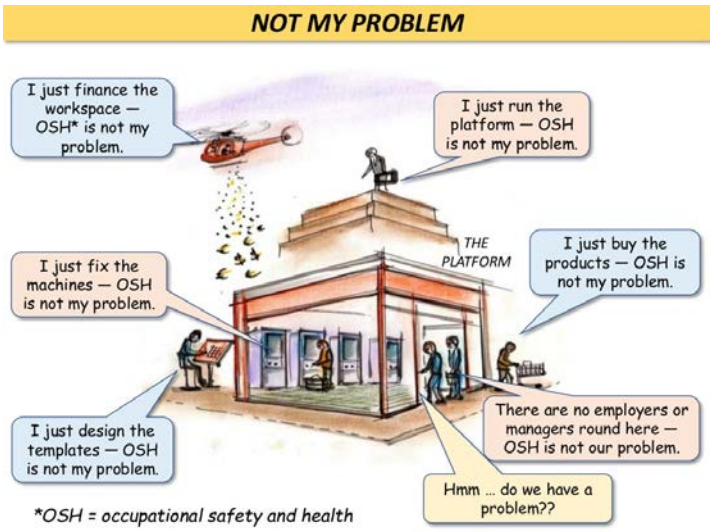
Figure 5 New forms of employment



Source: Eurofound, 2015 reported in Valenduc & Vendramin, 2016

EU-OSHA (2017) highlights that the concern about online platform working is not only the employer/employee relationship, and the fact that individuals are often seen as self-employed, but also what this means in relation to OSH regulation. There are different applications of the law depending on the nature of the employment. The perception is that, like agency and temporary workers, who we know have higher injury rates, online platform workers may also be at increased risk. Although this type of work does give the worker additional flexibility, there are still many concerns with regard to the lack of OSH protection. Because such workers often work in isolation, social dialogue and other supporting mechanisms are not commonly available either.

Figure 6 Not my problem



https://www.slideshare.net/euosha/foresight-on-new-and-emerging-osh-risks-related-to-digitalisation-by-2025

Source EU-OSHA, 2018

We are also seeing a change in the relationship between the employer and the worker and between the customer and the worker. The use of apps to contract out work does increase workers' autonomy. However, there is concern that the lack of a common workplace or of a standard employment relationship puts these workers at risk.

Apart from any psychosocial risks, such changes in employment, including the push to casualisation of work and self-employment, has the potential to expose individuals to increased hazards through a lack of OSH protection. For example, is the individual working on their computer at home subjected to the same level of scrutiny as their office-based colleagues in respect of the national regulations derived from the DSE Directive? As a further complication, Valenduc & Vendramin (2016) point out that there may also be risks from working under high pressure or there not being enough work for those on zero-hours contracts (perhaps making them more reluctant to complain or more likely to tolerate poor working conditions).

- **E-retail**

Digitalisation has also impacted the retail sector, and EU OSHA (2018) has summarised some of the OSH issues around e-retail and internet retail. Online sales in the EU reached EUR 232.60 billion in 2016, an increase of 15.6 % on the preceding year. This change in consumer behaviour has led to an increasing demand for cheaper products and faster delivery; this may not result in the best job designs in environments where costs are tightly controlled.

There has been an increase in employment in fulfilment distribution centres where orders are picked from storage, packed then delivered. While there has been some media coverage of the impact of different picking systems and the speeds required and demands made of the workforce, the job itself already has known musculoskeletal risks including (EU OSHA, 2018; Webster et al., 2014):

- frequent repetitious picking;
- rates of work imposed by a process;
- awkward and static postures (handling from high or low shelving, lifting objects out of or putting them into cramped spaces, bending or twisting the torso while lifting or holding heavy items);
- prolonged pushing and pulling of trolleys or roll cages; and
- heavy lifting:
    - heavy lifting done with one hand or without the assistance of mechanical devices;
    - heavy lifting while bending over, reaching above shoulder height or twisting.

Although in larger scale operations there has been an increase in mechanisation, this is not likely to be the case in smaller retail outlets where loads will still have to be manually handled, the level of automation is often dependent on the size of the parent company and there is a trade-off between the costs of automation versus the cost of human workers (Webster et al., 2014), in some cases employing agency staff and so bypassing some of the employer's responsibilities.

The EU OSHA (2018) report also highlights the impact of monitoring, including countdown systems, increasing both physical and psychosocial demands. Although automation decreases the load on the human, workers may be exposed to increased repetitive work, including quality assurance and packing of products.

The increase in e-retail also needs an increase in the number of delivery drivers, often individuals using private vehicles working as part of the gig economy. Driving is known to increase reported MSDs, and EU-OSHA identified the following as additional risk factors:

- provision of less manual handling equipment;
- compromised employer terms and conditions for 'gig economy' drivers, such as reduced pay and employer support, for example no paid holidays and no paid sickness absence;
- long working hours, often linked to performance-related pay ('pay per drop'), possibly resulting in driver fatigue and thereby contributing to an increase in road traffic incidents;
- increased performance demands (linked to fast delivery and specific delivery times); and
- increased performance monitoring of drivers, resulting in potential risk of stress for some.

Although larger retail companies have invested in ergonomic design of delivery vehicles to reduce manual handling and musculoskeletal risks, this is not evident for other delivery drivers.

- **Changes in work processes**

Manufacturing is one sector in which production has changed to lean production environments using systems such as just-in-time, Six Sigma or agile manufacturing processes. Westgaard & Winkel (2011) carried out a systematic review evaluating the impact of lean practices as part of workplace rationalisation. From the 34 studies identified, approximately half reported negative impacts on safety and health, including increases in both work volume and intensification. These resulted in increased stress and a mismatch between demands and resources. More positively, there was an increase in the scope of the job, quality and work enrichment. However, without proper evaluation of the impacts on humans, the authors perceive that workers with the most routine jobs will be put more at risk. Brännmark & Håkansson (2012), in their review of lean manufacturing and MSD risk, evaluated 23 papers. Their findings emphasised a lack of consistency and quality within the published literature. However, it was suggested that not using ergonomists in the work design process tended to result in the risks of MSDs being increased.

In a cross-sectional comparative analysis, Womack, Armstrong & Liker (2009) compared 56 similar jobs in two plants, one that had implemented lean manufacturing and one that was still using traditional methods, by assessing repetition, force and posture. Productivity was increased and waiting times reduced but exposure to repetitive work was increased within the lean manufacturing plant. In comparison, threshold values for risks from repetition and force were lower in the lean production plant.

Koukoulaki (2014) examined the impact of lean production techniques on MSDs and psychosocial risks over a 20-year period. This study identified that, in the early days of lean production, the level of MSD reporting increased within the automotive industries. This was thought to be because of rigid implementation processes, an increased speed of production and a lack of recovery time. However, although the risks of developing MSDs were present, this did not always result in an increase in the prevalence of symptoms. The authors suggest that, perhaps due to peer pressure within the working environment, symptoms were not always reported. This study also examined psychosocial risks and found that these were also more evident in lean production environments and that their impact was likely to be greater where there was no social support from co-workers or line managers.

There are mixed messages about the impact of lean production environments on exposure to MSD hazards including force, repetition and poor posture However, the literature reviewed here does stress the importance of considering ergonomic risks, psychosocial risks and participation from the workforce in redesigning work processes.

Looking at the healthcare environment, Davis & Kotowski (2015) highlight the impact of MSDs in nurses and nursing assistants in their review, which included 132 studies. The review highlights low back pain in nurses as one of the main injuries reported, but the authors do question whether the focus on low back pain has caused researchers to miss other areas, including shoulder and neck pain. With the change in workplace policies towards ‘no-lifting’ of patients strategy, but using other means including sliding patients or using lifting aids, the risks and consequent pain and discomfort may have moved to other areas of the body including the shoulders and neck. The situation is exacerbated by increasing numbers of obese patients. Furthermore, changes in treatment and convalescence patterns mean that more people are convalescing at home, resulting in the burden of handling patients being moved to other carers. For those involved in domestic care work, this means going into people’s homes, where there is little control over the work environment and usually less access to lifting aids.

Managing the risks from computer work, including the pace of work and work demands, is important.

- **Automation and robotics**

While the automation of work tasks has been a continuing evolution in many work environments, the impact of this has been concern about increasing levels of unemployment. In addition to this, automation in the workplace may result in increased machine pacing of humans, increasing both physical and psychosocial risks to workers.

Alongside this is the debate about the increased use of robots and autonomous robots in all sectors. At the current time, this debate is in its infancy but groups including EU-OSHA and the US National Institute for Occupational Safety and Health (NIOSH) have started discussions around this. In an EU-OSHA (2015) discussion paper, the use of robots is seen as both an opportunity and a challenge. Robots could reduce exposure to repetitive work and high-hazard environments. However, many workers have never experienced working with robots and their increased use in autonomous systems within workplaces needs to be further examined.

In its discussion paper on e-retail, EU-OSHA (2018) discussed the most likely next development in this sector, which includes the use of collaborative robots for picking tasks. However, humans will still be part of this working system for tasks that require dexterity, quality assurance and potentially repetitive tasks including repackaging or waste removal. Although some risks can be removed by automation, it is not clear that it will eliminate all musculoskeletal risks.

- **Sedentary work**

The impact of sedentary work and lack of physical activity in the workplace is now seen as a major health risk, including for MSDs. Data from the EWCS suggest that 25 % of men and 31 % of women are sitting all or most of the time (Eurofound, 2017). A further one third (29 % of women and 31 % of men) were sitting between 25 % and 75 % of the time. The German Federal Institute for Safety and Health estimates that an office worker can spend up to 80,000 hours of their working life seated. Straker & Mathiassen (2009) highlight that, from an ergonomics perspective, less physical workload has historically been seen as better. Thresholds were set in the 1960s for maximal physical activity (50 % of maximal oxygen uptake for an 8-hour shift). This was at a time when jobs were physically demanding. However, the rise of the information economy resulted in an exponential increase in jobs and tasks involving prolonged sitting at a computer. Straker & Mathiassen (2009) suggest that there needs to be a paradigm shift in ergonomics to encourage more physical activity and design work not only to avoid ill health but to improve health and physical capacity. Within its Total Worker Health programme NIOSH (2017) focuses on the health impacts of sedentary work including non-communicable diseases as well as MSDs. There is a clear need to focus on how work can be designed to increase movement by improving control over work, ensuring that facilities such as lockers or changing rooms are available for people who want to exercise during the working day and thinking about how work is designed to enable appropriate movement.

3.5 Health behaviours

Although the focus of this review is on work-related risk factors for MSDs, poor health behaviours have also been associated with the occurrence of MSDs. This section aims to briefly look at those factors, as they can be influenced by workplace health promotion. However, health behaviours are influenced by numerous factors, and a number of studies show associations between workplace stress and shift work and unhealthy behaviours including smoking and poor eating habits.

3.5.1 Body mass index

One of the factors increasing the risk of MSDs is obesity. The worldwide prevalence of obesity nearly doubled between 1980 and 2008 ([5]). Across the EU, 51.5 % of the population was considered overweight in 2014. Within this group, 35.7 % were pre-obese (body mass index, or BMI, of between 25 and 30) and 15.9 % were obese (BMI greater than 30) ([6]). This was an increase compared with 2008 when 50 % were obese. Higher BMI has been found to be associated with MSDs in several studies (da Costa & Vieira, 2010; Faghri & Momeni, 2014; Sethi, Sandhu & Imbanathan, 2011; Viester et al., 2013). The study by Viester et al. (2013) based on the Netherlands Working Conditions Survey found, using normal weight as a reference point, that musculoskeletal symptoms, including back problems and neck

([5]) http://www.euro.who.int/en/health-topics/noncommunicable-diseases/obesity/data-and-statistics
([6]) https://ec.europa.eu/eurostat/documents/2995521/7700898/3-20102016-BP-EN.pdf/c26b037b-d5f3-4c05-89c1-00bf0b98d646

and shoulder problems, were associated with being obese and that upper and lower extremity problems were significantly associated with being both overweight and obese. Problems in the lower extremities may not be a surprise because of the additional biomechanical stress put on the lower limbs by being overweight. The study by Viester et al. (2013) also examined the impact of high workloads. Overall reporting of MSDs was higher for those with higher BMI (including those who were obese) and higher workloads. Recovery from injury was also assessed in this study: those with a higher BMI took longer to recover.

It is likely, however, that the influence of obesity varies for the different MSDs. For example, Graveling (2018) reported an association between obesity and increased risk of carpal tunnel syndrome but not of epicondylitis (both leading to upper limb pain and other symptoms).

3.5.2 Physical inactivity

It is recommended that adults take 150 minutes of physical activity (outside work) each week (WHO, 2018). In 2014, it was estimated that 48.8 % of adults were taking no exercise ([7]).

The effect of physical inactivity on MSDs was investigated by Nilsen, Holtermann & Mork (2007), who examined BMI and physical activity in the general adult population. The authors concluded that high levels of inactivity and higher BMI both lead to increased risk of chronic pain in the low back and neck/shoulders. Andorsen et al. (2014) also found that lower rates of physical activity were associated with increased reporting of musculoskeletal symptoms.

Kristensen et al. (2014) examined aerobic fitness in men at conscription age in Norway (18/19 years) and followed them up for musculoskeletal symptoms 5-15 years later. This study identified a moderate association between higher levels of aerobic fitness and reduced risk of MSDs in later life. The authors state that confounding was an issue in this study, as both intellectual capacity and parental education levels had more of an effect on the occurrence of MSDs than aerobic fitness.

3.5.3 Smoking

According to the World Health Organisation (WHO, 2018) ([8]), current rates of tobacco smoking in the EU are 28 %, although there are many international and national policies aimed at smoking reduction. Smoking has also been found to be associated with MSDs by other authors (e.g. Andorsen et al., 2014; da Costa & Vieira, 2010). Andorsen et al. (2014) found that current smoking was significantly associated with musculoskeletal symptoms among both men and women but showed a stronger effect in women (men odds ratio, OR = 1.25, 95 % CI 1.02-1.52; women OR = 1.60, 95 % CI 1.30-1.96). As a result, the authors suggest that smoking cessation may benefit women more than men.

In summary, with regard to the health that people bring to work, there is still a need for health promotion and improved health behaviours, including losing weight, increasing physical activity and stopping smoking. Fahgri & Momeni (2014) highlight the importance that workplace-based weight management programmes can have and identified reduced reporting of MSDs as one of the outcomes in their study.

3.6 Demographic change

3.6.1 Age

The rates of MSDs vary with age, and increasing rates are reported across the population but specifically in the older and youngest populations (see Figure 7). There has been much discussion about the reasons for this increase and whether it is down to duration of exposure (older workers may have been exposed to workplace risk factors for longer) or whether they are more at risk because of the

([7]) https://ec.europa.eu/eurostat/web/products-datasets/-/hlth_ehis_pe2e
([8]) http://www.euro.who.int/en/health-topics/disease-prevention/tobacco/data-and-statistics

physiological changes associated with age (such as reductions in muscle strength or joint flexibility). Coggon et al. (2013), in their study of disabling low back pain and disabling wrist or hand pain, identified an increasing risk with age associated with both disabling low back pain and disabling hand or wrist pain. Whatever the source of this increase in prevalence of MSDs with age, we are currently promoting the extension of working lives. Palmer & Goodson (2015), in their review of ageing, musculoskeletal health and work, corroborated the fact that musculoskeletal problems are more common in older workers. However, this does raise the question of whether individuals should continue working and possibly exacerbate their symptoms or leave the workplace. Their review highlights the trade-off that exists between work being positive for maintained muscle strength, mobility and good psychological health, on the one hand, and older workers perhaps struggling with the demands of work, on the other. They also identified a number of evidence gaps in their research including the lack of follow-up for patients returning to work with health problems. Palmer & Goodson (2014) draw the following conclusions in relation to older workers musculoskeletal problems, and work:

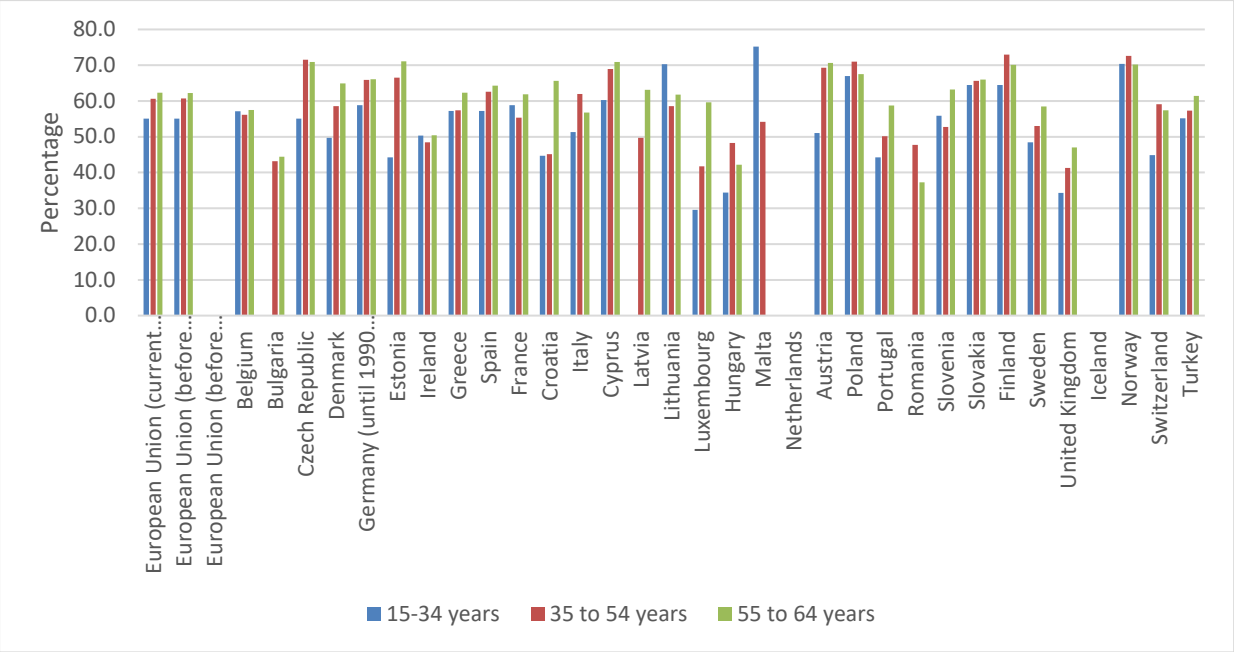
- MSDs are very common; their prevalence generally rises in older people.
- At older ages MSDs have a considerable impact on people's employment prospects.
- Factors that influence job retention in older people include the type of MSD, its severity and treatment, the presence of comorbidity, people's attitudes to work and retirement, and the work environment's demands.
- Interventions to optimise symptom control and provide a more flexible and adaptive work environment can substantially improve older people's prospects of remaining in work.
- Based on the present evidence, far more needs to be done in these areas if individuals with MSDs are to realise the possibility of extending their working lives.

The results of the 2015 EWCS showed that exposure to painful and tiring positions and repetitive hand or arm movements for at least a quarter of the time was reported by 43 % and 61 % of respondents, respectively. When this was examined by age, comparing those under 35 years old with those over 50 years old, exposure to both repetitive arm movements (63 % vs 58 %) and moving and lifting heavy loads (35 % vs 29 %) was reduced. However, for exposure to painful and tiring positions, slightly more over-50s reported being exposed (43 %, compared with 42 % in the under 35-year-old group). For patient handling slightly fewer over-50s again reported being exposed (9 %, compared with 10 % in the under 35-year-old group). Despite these generally minor changes (which could be within the error sampling of the survey), these data indicate that workers are still reporting being exposed to considerable postural risks over the age of 50.

However, returning to Figure 7, we can see that MSD reporting is also high in the youngest age group, which suggests that young people are either starting their working lives with problems or quickly developing musculoskeletal problems. A literature review by the Organisation for Economic Co-operation and Development (OECD) pointed out that musculoskeletal discomfort associated with children's computer use has been noted in a number of studies as well as the postural risks associated with using devices such as computers and tablets. The review also refers to recent findings suggesting an increase in neck symptoms related to television, phone and tablet use and in visual symptoms related to increased use of phones and tablets in particular.

Because of demographic change and the push to extend working lives, the increase in the number of older workers is likely to be contributing to the continued high prevalence of MSDs. Although there does appear to be a duration of exposure effect for MSDs, this is often confounded, as those with longer duration of exposure are part of an older workforce.

Figure 7 Prevalence (%) of MSDs by age group



Source: Eurostat Labour Force Survey ad-hoc module 2013

One of the main issues around age and the prevalence of MSDs is that there is not a clear cause-effect relationship between age and MSD occurrence. The review by Okunribido & Wynn (2010) identified that there are age-related physiological/physical changes, including a reduction in joint mobility, a reduction in muscle strength and a slowing of movement. These are also influenced by other factors including level of habitual physical activity and the physical demands of the individual's work (which clearly affect their habitual levels of activity). Older workers may need to work closer to the limits of their capabilities, which does increase the risk of sustaining an MSD (Okunribido & Wynn, 2010). Davis et al. (2014) found that the frequency and costs of MSDs increases with age but that is also influenced by job-specific risk factors. These authors also make the point that the impact of age alone on MSDs cannot be calculated, because of the confounding factors of lifestyle, health behaviours and other risks. Andorsen et al. (2014) examined the prevalence of MSDs in Norwegian women and suggested that positive associations between age and the prevalence of MSDs may be explained by both longer duration of exposure and changes in lifestyle variables over time.

While we are attempting to extend working lives, there is evidence to show that the prevalence of MSDs increases with age. Areas for recommended future research have been identified, but large evidence gaps remain at the moment, including the answer to the question of whether it is better to continue working with symptoms.

3.6.2 Gender

The Eurostat data, broken down into gender differences for MSD reporting, shows a variety of patterns across the EU-28 (see Table 7). Generally, men report more MSD symptoms than women, although there are differences depending on MSD. Thus, men are more likely to report back problems but more women report neck, shoulder, arm or hand problems (EU OSHA, 2016b). In their study across 18 countries, Coggon et al. (2013) identified female gender as being significantly associated with disabling low back pain (PRR = 1.31, 95 % CI 1.16-1.47) and disabling wrist or hand pain (PRR = 1.56, 95 % CI 1.37-1.78).

Table 7 MSD reporting by gender across the EU-28, 2007 and 2013

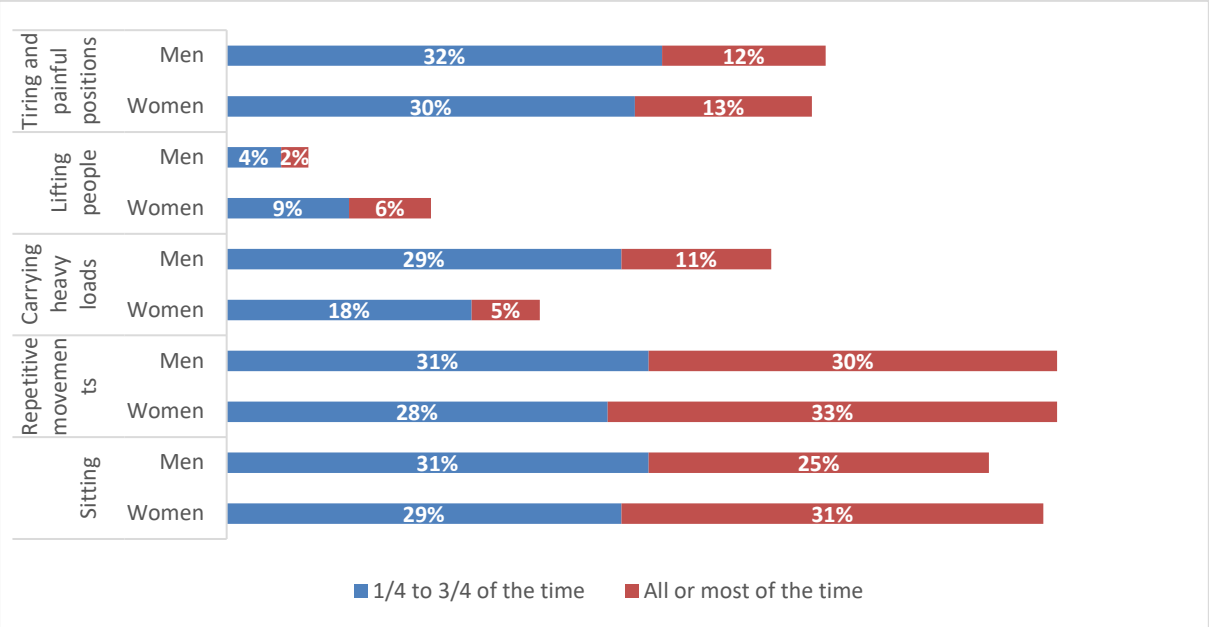
Country or region	2007 Men	Women	2013 Men	Women
European Union (28 countries, including United Kingdom)	54.6	53.7	60.7	59.6
European Union (before the accession of Croatia)	54.6	53.7	60.8	59.5
European Union (before the accession of Croatia) except France (26 countries)	60.0	59.3	-	-
Belgium	58.1	56.7	55.9	57.5
Bulgaria	40.0	34.9	40.8	44.9
Czechia	48.4	40.9	70.7	68.7
Denmark	61.3	57.3	63.0	53.8
Germany	74.9	75.0	64.4	64.5
Estonia	57.5	52.0	65.5	66.5
Ireland	57.5	52.0	55.4	43.1
Greece	54.5	55.0	55.7	63.8
Spain	61.0	63.3	58.3	66.2
France	47.9	46.6	59.2	56.4
Croatia	53.8	57.1	50.0	61.2
Italy	51.1	47.8	57.9	60.9
Cyprus	58.8	53.7	67.1	70.2
Latvia	:	70.8	58.7	50.2
Lithuania	43.5	44.5	66.3	54.2
Luxembourg	64.6	59.1	41.8	39.1
Hungary	61.6	61.4	47.6	40.6
Malta	59.0	-	67.7	-
Netherlands	57.4	54.8	-	-
Austria	68.0	64.4	67.7	65.4
Poland	63.5	62.9	69.4	68.9
Portugal	49.6	59.0	52.1	51.7
Romania	40.6	38.8	50.5	33.9
Slovenia	57.9	58.5	57.8	56.4
Slovakia	59.6	62.4	67.4	63.8
Finland	65.7	69.4	71.7	69.3
Sweden	60.1	57.7	58.2	49.6
United Kingdom	50.6	50.4	41.4	39.5
Iceland	67.3	73.2	-	-
Norway	67.7	67.3	72.0	71.0
Switzerland	-	-	55.0	54.8
Turkey	-	-	56.1	59.2

- data not available/not recorded.

Source: Eurostat Labour Force Survey ad-hoc module 2007 and 2013

Examining exposure to posture-related risks, Eurofound (2017) reported that, for specific hazards including repetitive movements and sitting for long periods, women reported being exposed to the same extent as men (see Figure 8).

Figure 8 Reported exposure (%) to various posture-related risks, by gender, EU-28, 2015



Source: European Working Conditions Survey, Eurofound

Andorsen et al. (2014) found that being female increased the risk of having a chronic MSD by 66 %. Collins & O'Sullivan (2010) in a cross-sectional study found that women reported more MSDs than men. The authors suggested that this was due to exposure to both physical and psychosocial risks.

Gender differences in MSD reporting reflect horizontal and vertical segregation in the labour market and within the workplace resulting in different exposure to risks. As an example of horizontal segregation, more women are employed in health and social care and thus have a greater exposure to risks such as lifting and handling people. As a result of vertical segregation, there is evidence that, because of women's reduced workplace mobility, they are more likely to remain in tasks that result in greater exposure to repetitive movements (EU OSHA, 2016b). Sadeghian et al. (2014) examined MSDs in laboratory workers in a cross-sectional study. The authors found that being female was a significant risk factor for back pain (OR = 2.537, 95 % CI 1.006-6.399), shoulder pain (OR = 5.353, 95 % CI 1.690-6.955) and hand/wrist pain (OR = 4.282, 95 % CI 10.760-17.036). This study also examined heavy workloads at home as an additional risk factor and this was considered significant for hand/wrist pain. This dual role of female workers may therefore increase their overall risks of developing at least some types of MSDs.

When considering age and gender, women over 55 years old report more musculoskeletal symptoms than men (64.3 % vs 60.3 %) ([9]). Disorders including carpal tunnel syndrome and tenosynovitis are reported more frequently by women, as are self-reported neck, shoulder, arm or hand problems. This is thought to be because of the influence of both horizontal and vertical segregation in the workforce. As the number of women workers has increased across the EU and with the extension of working lives, without appropriate intervention, this is likely to be a major source of the increasing prevalence of MSDs and, with current trends in employment, is likely to increase in future years. When we look at data on shifts in demographics in the workplace, the largest increase in numbers has been observed in women over 50 years old.

([9]) http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

3.7 Health beliefs/somatisation

The impact of health beliefs on ill health occurrence has been researched for many decades. Research in this context has focused on somatisation (the manifestation of physical symptoms from psychological distress) as well as beliefs about what makes us ill. Although it is difficult to quantify is how many individuals are affected by this, the pathways from beliefs to symptoms have been well researched, including the belief that work will make you ill.

When examining health beliefs and somatisation Andorsen et al. (2014) found that self-perceived poor health was related to an increased likelihood of reporting MSDs. However, the authors also point out that a high burden of MSDs leads to a poor self-perceived health status but not vice versa. In their study across 18 different countries, Coggon et al. (2013) used the Brief Symptom Inventory to evaluate somatisation. This study identified that, as the number of distressing somatic symptoms increased in the previous week from zero to one, then two or more, there was a significantly increased risk of disabling low back pain and disabling wrist or hand pain. Although such an association is not necessarily indicative of causation, it does highlight an interplay between physical and somatic symptoms. Farioli et al. (2014) also found this association between somatising symptoms and back pain and (separately) neck and upper limb pain across the EU.

People also bring health beliefs to work and these can influence health in both positive and negative ways. When examining health beliefs around MSDs, Coggon et al., (2013) found that, for disabling low back pain and disabling wrist or hand pain, having adverse beliefs around how they might relate to work, prognosis and (for disabling wrist or hand pain) having 'heard of [repetitive strain injuries] or equivalent' were each found to be significantly associated with symptom occurrence. However, a cross-sectional study can neither determine that these are causal relationships nor the directions of the associations. Nevertheless, the authors consider that the findings are consistent with the hypothesis that awareness of musculoskeletal pain and adverse beliefs about it increase its reporting in the workplace. This may be only a small effect overall.

Hoe et al. (2012b) examined nurses in Australia in relation to MSDs, somatisation and health beliefs. Using the Fear Avoidance Beliefs questionnaire, the study found that, where two symptoms out of seven were reported as distressing (somatisation tendency), this was associated with neck pain, shoulder pain and neck and shoulder pain. Work causation beliefs were found to be associated with both neck and shoulder pain but not with neck or shoulder pain.

There appears to be a lack of information available on symptoms and recovery in relation to low back pain and wrist and hand pain. The impact of health beliefs should be examined further, as beliefs around recovery time and causation may be incorrect and having accurate information may influence occurrence and recovery.

3.8 Socio-economic differences

Farioli et al. (2014) analysed data across the EU from the fifth EWCS. In total, they included 35,550 participants in their analysis. They identified wide variations in MSDs reported by country, including a prevalence of reported back pain of 63.8 % in Portugal versus 25.7 % in Ireland and of upper limb pain of 67.7 % in Finland versus 26.6 % in Ireland. Further analyses were carried out to examine socio-economic differences between countries, and back pain was associated with higher levels of expenditure on social protection. Conversely, the prevalence of pain was found to be lower in countries with higher rates of social exclusion and more people at risk of poverty. The authors are cautious in their interpretation of these results because of the nature of the step-wise analysis carried out. However, they suggest that the increase in back pain in countries with increased social protection may be psychological and attributable to easier access to income support and protection from poverty.

Eurogip (2016), reviewed MSD reporting and the recognition of MSDs as occupational diseases in 10 European countries. Examining data on trends collected between 2007 and 2014, Sweden, Switzerland and Finland report continuing decreases in the number of reported and recognised MSDs. Denmark and Spain showed a gradual decline over the same period, and Italy, Belgium and France showed an

increasing trend, although it decreased in France after 2012. When looking at these data in more depth, there are also a number of other changes that occurred simultaneously. In Italy, in 2008 MSDs were added to the list of occupational diseases; in Belgium, the increased rates in 2013 relate to the addition of tendinopathies to the list of occupational diseases in 2012; and, in France, rates started to reduce in 2012 after the criteria for the recognition of shoulder and elbow MSDs were changed. This report also highlights that, until 2011, information campaigns were carried out in both Italy and France, which may have led to increased reporting of MSDs. This study also serves to highlight that comparisons between countries are difficult because of differences between countries in what MSDs are recognised as occupational diseases.

Socio-economic differences and changes in reporting are shown to have an impact on MSD reporting. At the current time, this is perceived as being affected by changes in reporting requirements and the availability of social and other support. The study by Eurogip emphasises the impact that changes in reporting systems have on recorded rates of MSDs, specifically those that are added to the list of industrial diseases.

4 What are the gaps in risk assessment and prevention practices?

The aim of this section is to examine the gaps in risk assessment and prevention practices. This includes coverage of risk assessment requirements as well as the barriers to and facilitators of intervening to prevent MSDs.

4.1 Why are musculoskeletal disorders still a problem?

Provisions for the prevention of MSDs are included in the Manual Handling Directive and the DSE Directive. However these two directives do not cover all MSD risks and, in particular, those risks associated with many repetitive or forceful industrial tasks are not covered by either directive. These are only covered by the non-specific provisions of the Framework Directive, although the Work Equipment Directive does require consideration of ergonomic factors.

In the last four decades, a large number of tools and sources of guidance on risk assessment and implementing risk reduction have been developed and made available. However, in the light of this, Wells (2009) posed the question: Why have we not solved the MSD problem? This was with the intention of trying to identify which aspects of management and prevention were ineffective. Wells does this by asking the following questions:

1. How well do we understand MSDs and their burdens?
2. How good are our risk factors at predicting MSDs?
3. How effective and informative are our current workplace approaches to MSD assessment?
4. How effective are the recommended interventions in actually reducing MSDs in the workplace?
5. How thoroughly and widely implemented are workplace interventions to prevent MSDs?
6. How well are we improving disability outcomes for MSDs?

Discussing each of these questions, Wells (2009) attempts to summarise the current state of knowledge, highlight the gaps and emphasise the need for ‘MSD prevention strategies that are feasible, socially acceptable, affordable, scalable and sustainable, have good coverage for substantial parts of the working population’, and, ideally, also ‘result in measurable MSD improvements within a reasonable time-frame’.

Reflections on each of the questions above are summarised below:

1. Although our understanding of the aetiology of MSDs has greatly improved, understanding the mechanisms of injury gives us more insight. However, we now need to move on to intervention studies and the epidemiology of MSDs.

2. There appears to be a disconnect in our current knowledge in that interventions to prevent specific risk factors does not reduce the prevalence of MSDs. Poorly characterised risk factors will not improve prevention and, at the current time, these are focused on physical hazards.
3. Although there is a large variety of tools available for MSD prevention, little work has been carried out to evaluate the effectiveness of these tools ([10]).
4. Although there is good practice in intervention research, this does not always feed through into workplace prevention if the impact on health is not actually measured. In choosing an intervention, it is important to know that the intervention addresses the risk factors, it is implemented widely, the type of intervention is known to work, and the impact must apply to a large number of individuals exposed to MSD hazards to see a reduction in exposure.
5. There is little information available about how many organisations are implementing workplace interventions to prevent MSDs.
6. Individuals who have had an MSD are more likely to have another incident. Thus, the question is how well support for receiving medical help, rehabilitation and return to work is organised. This includes social support from colleagues and managers as well as having workplace policies and procedures in place.

Wells (2009) points out that, while there is a large amount of aetiologically based research, the lack of good-quality intervention studies does not help in implementing change. Bearing this in mind, there is a real need to carry out intervention studies over longer periods to evaluate the impact of different strategies. Although different sectors have taken particular approaches, these are often seen as not transferable to other sectors.

4.2 Barriers to and facilitators of preventing musculoskeletal disorders

Yazdani & Wells (2018) examined barriers to and facilitators of preventing MSDs. In their scoping review, in which a thematic analysis was carried out, various barriers to and facilitators of MSD prevention were identified; these are listed in Table 8.

Table 8 Barriers to and facilitators of MSD prevention

Barriers	Facilitators
Lack of time	Training, knowledge and ergonomist support
Lack of resources	Communication, participation and support
Lack of communication	Effective implementation process
Lack of management support, commitment and participation	
Lack of knowledge and training	
Resistance to change	
Changing work environment	
Scope of activities (e.g. one workstation or a whole plant)	
Lack of trust, fear of job loss or loss of authority	
Process deficiencies	

Source: Yazdani & Wells, 2018

([10]) The possible exception to this is the provision of manual handling training for which there has been evidence of its ineffectiveness for many years (e.g. Graveling, 1986), especially the generic training frequently provided.

According to Yazdani & Wells (2018), barriers include lack of time made available to staff for training or for addressing relevant factors. This is strongly linked to lack of resources (money, equipment or staff), and the authors highlight that this can be due to shortage of money to intervene, poor resource management, lack of interest and/or having a short-term mind set. Lack of communication among all the relevant stakeholders is also seen as a barrier. The authors point out that a lack of continued communication between the workers and management can cause a prevention intervention to fail. They also highlight that commitment, support and participation were all required for a successful intervention. Lack of knowledge on MSDs and their potential work-relatedness may be a barrier. Resistance to change may also be a barrier if individuals are reluctant to change the way they work. There are reports of new ergonomic tools not being used because they are difficult to use or there has not been enough time to learn how to use them efficiently. The workplace culture will affect the adoption of new ways of working. Without consideration of the work culture, interventions are likely to fail. Changes in the work environment have also been identified as a potential barrier; these can be changes in management, whereby MSD prevention is stopped, or changes in employment, whereby more temporary workers are employed. Access to prevention measures may be different for temporary workers and their relative lack of training has been widely identified as a concern.

The scope of activity was also seen as a barrier by Yazdani & Wells (2018). What they mean by this is whether this is one workplace change, a whole plant changing or an international corporate change. The outcome will be influenced by culture as well as the fact that interventions may not work in different sections of a business or on different continents. Awareness of cultural differences may improve this.

Lack of trust, fear of job loss or loss of authority and the general climate within an organisation can also influence the success of an intervention.

Process deficiencies are also seen as having a negative impact on MSD prevention. Yazdani & Wells (2018) identified a number of factors that can be barriers, including the prevention programme not fitting with the current norms and practices within the business or the intervention not being sustained over time. The final barrier identified by Yazdani & Wells (2018) was that of the difficulty of implementing controls. Their paper reports examples such as alternative equipment being difficult to use, the solution not being designed for all workers or the focus being on changing behaviour rather than engineering controls.

Yazdani & Wells (2018) identified facilitators for successful interventions for MSD prevention, although these were less numerous than the barriers. Training, knowledge and ergonomist support were all seen as having a positive effect as well as communication and a participatory approach. Finally, their paper highlights the importance of an effective implementation process.

Andersen et al. (2018), carried out a systematic review of the effect of OSH interventions in the workplace. Their review included 61 papers that examined the impact of legislation, inspection/enforcement activity, training and campaigns and the introduction of technical devices. They found that the introduction of legislation and associated enforcement activity had a positive impact by reducing injuries and fatalities. However, there is still a knowledge gap in relation to MSDs due to the lack of good-quality intervention research.

In relation to what levels of intervention are effective there have been two Cochrane reviews examining interventions to prevent MSDs. Verbeek et al. (2011) carried out a Cochrane review of nine randomised controlled studies and nine cohort studies on the prevention of back pain. The results showed that those employees who received training for manual handling reported similar levels of back pain to those that had not. While the review found that there was an increase in knowledge in relation to manual handling risks, this did not translate into a change in behaviour to adopt better manual handling processes. The authors conclude that there is a moderate amount of evidence that training on manual handling is ineffective. As a result of such evidence, the UK HSE ([11]) is currently campaigning to reduce risks from manual handling by redesigning jobs rather than by training alone, emphasising that changing the way the work is carried out is a better way to manage risks than training.

([11]) http://www.hse.gov.uk/aboutus/strategiesandplans/health-and-work-strategy/health-and-work-strategy.pdf

Hoe et al. (2012a) examined ergonomic interventions and equipment used to reduce upper limb and neck pain. In their review of 13 randomised controlled trials, they found moderate evidence for reducing neck/shoulder disorders by using an alternative mouse and an arm support; however, this did not reduce right hand MSDs more generally in right-handed people. The authors found that there was very low-quality evidence that ergonomics did not reduce upper limb disorders. However, the research used in this review was very varied in quality and outcomes. This would suggest a need for better controlled studies to be carried out to clarify this issue.

Van Eerd et al. (2015) updated a review examining the use of interventions to reduce MSDs. The review included the 35 original papers plus a further 26 added as part of the update. The study identified strong evidence for resistance training and moderate evidence for the benefits of stretching, vibration feedback and forearm supports in reducing MSDs (see Table 9). The authors again highlight that, while none of the studies showed an increase in MSD symptoms, the study quality for some interventions that were included was not good enough to support any recommendations.

Table 9 Evidence of effectiveness of various interventions

Level of evidence (direction of effect)	Intervention (number of studies)	Message
Strong (positive)	Resistance training (7)	Implementing a workplace-based resistance training exercise programme, policy or practice can help manage and prevent upper extremity MSD symptoms and disabilities
Moderate (positive)	Stretching exercise programmes (includes upper extremity component) (6) Vibration feedback on static mouse use (3) Forearm supports (workstation) (3)	Consider implementing in practice if applicable to the work context
Limited (positive)	Aerobic exercise programmes (3) Alternative keyboard (force profile) (1) Trackball pointing device (± arm supports) (1) Rest breaks (5) Postural exercise programme (1) Specialised exercise programme (Feldenkrais) (1) Curved seat pan chair (non-office) (1) Lighter/wider dental tools (1) Neuromuscular exercise (non-office) (1)	Not enough evidence from the scientific literature to guide current policies/practices
Limited (no effect)	Work redesign to minimise shoulder load (non-office) (4) Joystick pointing device (± arm supports) (1) Neck school programme (1) individualised exercise programme (± stress management) (1)	Not enough evidence from the scientific literature to guide current policies/practices
Mixed	Ergonomics training + workstation adjustment (8) Low-intensity participatory ergonomics programmes (4) Cognitive-behavioural training programme (2) Ergonomics training (2)	Not enough evidence from the scientific literature to guide current policies/practices
Insufficient	Rest breaks plus exercise (1) Reduced hours (1) Alternative keyboard (split) (1)	Not enough evidence from the scientific literature to guide current policies/practices

Level of evidence (direction of effect)	Intervention (number of studies)	Message
	Individual interventions (office) (1) Patient handling programme (1) OSH training (2-3 h) and/or ergonomic advice/change and/or exercise and/or medical examination (1)	

Source: van Eerd et al., 2015

Comper et al. (2017) examined job rotation as a means of reducing MSDs in the textile industry. In this randomised controlled trial of 266 workers in the intervention group and 225 in the control group, a job rotation group was set up to review the work process and redesign the work. All participants were given some ergonomic training before job rotation was implemented. Participants were followed up at four time intervals: 3 months, 6 months, 9 months and 12 months. The analysis found that job rotation did not have a positive impact on any of the measures including time lost through sickness absence, musculoskeletal symptoms or improved perception of pain. The study may highlight one of the major issues with job rotation in modern manufacturing, in that there is unlikely to be a change in the muscle groups used, as there is little variety in the jobs available; thus, redesigning the workplace rather than rotating employees within it may have more of an impact.

4.3 Little consideration given to psychosocial risk factors

Many of the research papers examining the interaction between psychosocial risks and MSDs highlight the importance of assessing physical, biomechanical and psychosocial risks in the workplace.

Considering the prevalence of MSDs, Macdonald & Oakman (2015) suggest that workplace risk management procedures do not reflect current evidence concerning MSDs' work-related causes and that inadequate attention is given to assessing and controlling risks from psychosocial hazards, with the conventional risk management paradigm focusing too narrowly on risks from individual hazards. Instead there should be promotion of a more holistic approach to managing the combined effects of all relevant hazards. This is supported by Hauke et al. (2011), as they suggest that organisations need to be aware that efforts to prevent MSDs should not only be limited to the physical work environment, such as technical equipment and training in lifting techniques, but should also involve improvements in the psychosocial work environment.

Often the means to do this is not available as a 'joined-up' risk assessment process, and MSD and psychosocial risks are assessed separately. The study by Oakman et al. (2016) showed that risk management of MSDs generally only covered physical risk factors but, taking a more holistic approach, risk assessment should be aimed at both MSDs and mental health risk factors. As part of the research aiming to develop an MSD risk management toolkit, interviews and policy analysis were carried out to find out about attitudes to and beliefs about MSD occurrence and current prevention practices and to gain stakeholders' feedback on the new toolkit. The results showed that there is a need for a broader risk management framework that encompasses both MSD and psychosocial risk factors.

5 Recommendations for new approaches to preventing musculoskeletal disorders

Alongside examining barriers to MSD prevention, Yazdani & Wells (2018) also provide some recommendations for a successful implementation of interventions to prevent MSDs.

Box 1 Recommendations for prevention

- MSD prevention and implementation processes should be approached as part of a long-term commitment to workers' safety and the company's success.
- MSD prevention should be incorporated into other management and OSH processes.
- Management's commitment should be demonstrated by allocating adequate time and resources to MSD prevention activities.
- Participation of workers, communicating their opinions and suggestions for improvements in ergonomic programmes, must be included.
- Lack of information as a barrier can be overcome by comprehensive training coupled, ideally, with implementing ergonomic interventions.
- For individual implementations to be accepted and utilised, they must be culturally relevant and easy to integrate into workers' current work practices and the organisation's procedures.

Source: Yazdani & Wells, 2018

This absence of firm evidence for what works does not mean that we should do nothing to try to prevent MSDs, but much of the research that exists is not well controlled and has been carried out in complex environments where randomised controlled trials are difficult to implement. We also see from the push by the UK HSE that we need to go further than training – designing work and workplaces to reduce risks at the design stage. This includes reducing physical risks and considering how we can build movement into the working lives of those in sedentary occupations.

5.1 Psychosocial risk management as part of a holistic approach

In a 'sounding board paper', Wells (2009) reports that the relationship between mechanical factors (e.g. repetition), work organisational factors and individual factors have been demonstrated in many types of work. Wells also suggested that the interaction of multiple factors means that there is an argument for the use of a bio-psychosocial rather than a biomedical model. In support of the multiple factors approach, Oakman & Kinsman (2016) argue that, while there is a strong body of evidence demonstrating that work-related psychosocial hazards and the psychosocial environment have an impact on MSD risks and workers health and well-being, there is anecdotal evidence that the management of psychosocial hazards is rarely a consideration in MSD risk management. Macdonald & Oakman (2015) state that it is evident that to focus workplace risk management strategies only on workstation design and physical actions while performing tasks is not the optimal way to reduce MSD risks.

Oakman & Kinsman (2016) suggest that more holistic approaches are required to address all relevant types of hazards. Macdonald & Oakman (2015) suggest that, to achieve a change in the paradigm towards a more holistic approach, new MSD risk management tools and better integration of the roles of OSH personnel with those of line managers are needed. Alongside this Oakman & Kinsman (2016) suggest that line managers and supervisors need to be educated about their roles in managing these risks, as they often play a key role in generating both physical and psychosocial hazards.

It seems clear that the need to think about psychosocial risks as part of prevention is essential. At the current time, the work by MacDonald & Oakman (2015) on developing a toolkit is one of very few

attempts taking an integrated risk assessment approach. Their research shows that there is a need for a broader risk management framework that encompasses both MSDs and psychosocial factors. They present recommendations for the various stakeholder groups (Box 2).

Box 2 A risk management framework that encompasses physical and psychosocial risks

Regulator

- Develop web-based tools that integrate risk assessments for MSDs and mental health disorders
- Promote educational programmes to highlight the impact of psychosocial hazards on workers' physical and mental health
- Develop and disseminate best practice case studies
- Promote consultation and participation in risk assessments

Organisations

- Ensure that managers receive evidence-based training on how their actions can influence MSDs and mental health issues
- Reduce organisational silos by having risks managed by OSH professionals, human resources and the workforce
- Ensure that at-risk employees take part in the risk assessment process
- Develop open communication between senior management and the workforce

Researchers

- Ensure that the language used in materials fits a range of literacy levels
- Develop simpler cost-benefit analysis approaches
- Implement and evaluate the risk management toolkit
- Ensure that tools are readily available to the workforce

Source: MacDonald & Oakman, 2015

In addition both work and non-work psychosocial factors need to be considered (Clays et al., 2007), including work-life conflict as a stressor (Hämmig et al., 2011) and organisational aspects of the work environment (Bernal et al., 2015).

6 Discussion

Although MSD reporting rates vary between countries, and some countries seem to have reduced them, the prevalence of work-related MSDs remains high across Europe. The aim of this exploratory review was to understand better the reasons behind the continuing high prevalence of reported MSDs in the working population. As an exploratory review, research papers were limited to those that examined the causes of the high prevalence and focused searches based on the hypotheses identified; thus, it does not completely cover the published research. As part of the review, a number of hypotheses were identified from the research, as presented in Table 2.

6.1 Limitations of the report

This was an exploratory review to examine the hypotheses on why there is a continuing high prevalence of MSDs across the EU. Therefore, it focused on papers in which hypotheses had been generated, and from this a question-mapping approach was taken for each of the hypotheses. Although the authors made their searches as wide as possible, it was not a systematic review.

The hypotheses cover a broad range of potential causes of the continuing high prevalence of MSDs. These include sectoral change, new ways of working, lifestyle behaviours, demographic change, health beliefs and somatisation, psychosocial factors and socio-economic differences, as well as the gaps in risk management and prevention practices not reflecting the complexity of the causal factors for MSDs, including the lack of consideration of psychosocial risk factors. Each of these is discussed below.

6.1.1 Sectoral change

Structural changes in the economy result in shifts in sectoral employment and consequently changing patterns of exposure to workplace hazards. Although this change is happening, there is little evidence of a reduction in exposure to physical MSD hazards when the prevalence of MSDs and postural exposure are examined. In fact, with more people working in health and social care, their exposure to handling patients has increased. While sectoral change may bring different types of work, there is little evidence of reduced exposure to MSD hazards.

6.1.2 The impact of digitalisation on the world of work

Work itself and where and how people work is constantly changing. Technology change should allow us to work better and remove the need for exposure to highly demanding or highly repetitive work. The research findings reviewed highlight that digitalisation in some form is part of most jobs nowadays, be that the provision of a smartphone or the use of workplace apps for time recording. Alongside this, digitalisation of the online platform, temporary contracts and fixed term contracts have increased the casualisation of work, with more workers having different types of contractual arrangements, including being self-employed or employed on a temporary basis. Although we know that temporary and agency staff are more at risk of accidents, there is concern that the casualisation process may be leading to a reduction in those workers' OSH protection. Platform working may give the individual flexibility in approaching their working day, but there is concern that this flexibility may be exploited with no redress for the worker. The impact of working in non-traditional workplaces, such as at home or driving one's own vehicle, also leaves room for a lack of scrutiny in relation to OSH, MSDs and psychosocial risks. With such changes in working boundaries, the potential for burnout, isolation and the psychosocial impact of work as a result of the 'always on' mentality suggests enhanced risks for MSDs that require increased focus.

As online retail (or e-retail) spreads, increasing numbers of people are employed in distribution centres as pickers or as delivery drivers, where again individuals may be working as agency workers rather than as full-time employees. This work is often highly pressured and pick rates are set by the employing company. There is little evidence that the ergonomic needs of this workforce have been addressed, and

often when manual and automated work collide the human is left with monotonous and repetitive work. This lack of protection for the e-retail workforce has been highlighted in the press. At the current time, it can be concluded that the lack of thought with regard to ergonomics and psychosocial risks in this working environment is contributing to higher levels of MSDs.

Changing work processes were also identified in the review, including the impact of lean manufacturing. MSD reporting may be increased because of the unintended consequences of changes in processes or tasks. Although productivity may increase with lean manufacturing, this may be to the detriment of musculoskeletal health if ergonomics and psychosocial risks are not considered in the redesign of work; several papers included in the review point this out. In the health care sector lifting aids were introduced many years ago in hospital environments; however, more patients are now cared for at home where lifting aids are not available and there is little control over the working environment.

Robotics and automation are also increasing in industry. Fixed robots have been used for several decades in manufacturing, but new autonomous robots may be bringing new risks to the workplace. Autonomous robots may be useful in reducing exposure to MSD hazards, such as work that is repetitive or needs high levels of force or dirty environments, but there has been little work done to examine the interface between the human and the robot and the unpredictable nature of humans. Increased use of automation is also evolving in many workplaces. This can potentially result in an increased number of machine-paced roles or in carrying out highly repetitive work that cannot be automated.

Work in some areas is also becoming less active, bringing with it new risks to the workforce through inactivity. Sedentary work has been associated with musculoskeletal problems and other non-communicable diseases. There needs to be thought given to how to change work to make it more active and how to encourage movement in the workplace. Although the DSE Directive does have requirements for breaks, this is difficult to implement in some working environments. Considering job design and work tasks may help increase opportunities for movement throughout the working day. As Straker & Mathiassen (2009) point out, this is a paradigm shift for ergonomics: traditionally its role has been to reduce exposure to physical demands, but we now need to think about how to increase physical activity to reduce MSD and other health risks.

6.1.3 Lifestyle behaviours

Although this review has focused on work-relevant factors in MSDs, the impact of the individual factors on the development of MSDs cannot be ignored. The three areas examined were that of higher body mass index, physical inactivity and tobacco smoking, all of which are associated with increased prevalence of MSDs. While body mass indexes have increased, smoking has reduced but physical inactivity is still a problem for 48 % of the EU population. Improving workers' health behaviours is likely to have a positive impact on the prevalence of MSDs. The workplace can be used as an arena for raising awareness and carrying out workplace health promotion to improve health in general. This perhaps needs to be part of general raising awareness of the impact of health behaviours on MSDs and how to maintain health when working lives are being extended.

6.1.4 Demographic change

When the data were examined in relation to age and reported MSD, it was clear that older workers report more MSDs; however, there were high rates of reporting in the younger age group too. Previous work by EU-OSHA (2016a) has highlighted the issue of increasing reporting of MSDs with increasing age, although there is still much debate over whether this is due to age-related change, duration of exposure or both. The relatively high rates of MSD reporting in younger workers is also concerning, especially in the context of the general trend towards extending working lives. It is not clear whether young people are starting their working lives with existing MSDs or the problems occur soon after starting work.

Women generally report more MSD symptoms, although the findings varied in some studies in which men reported more back pain and women more neck, shoulder, hand or arm symptoms. When we

examine exposure based on gender, women report more lifting and handling of people and similar rates of exposure to tiring and painful positions, repetitive movements and sitting. We need to understand better why it is that, with similar levels of exposure, women report more symptoms. Collins & O'Sullivan (2010) suggest that this is due to responses to both physical and psychosocial hazards. Does this mean that women respond differently to the same types of exposure? If this is the case, risk assessment may need to take that into consideration. However, when we examine where women are working and the age at which they return to the workforce after time away, we see an intersection between age and gender, as more women over 50 years old have joined the workforce. The changing structure of the workforce is likely to be impacting the prevalence of MSDs: more older women are working and they are more at risk of MSDs.

6.1.5 Health beliefs and somatisation

What we believe affects our health, including how MSDs are related to our work and the time taken to recover. There is a need to share accurate and realistic knowledge and information about MSD risks, injuries and recovery times among the workforce through education. The campaign in Scotland 'Don't take back pain lying down' (Waddell et al., 2007) is an example of an attempt to modify people's behaviour during an episode of back pain. The health and health behaviours that people bring to work is also a factor in the occurrence of MSDs, so taking a workplace health promotion route to education may have the potential to influence health behaviours and persuade people to improve their own health. This also presents the opportunity to improve understanding of the impact and duration of symptoms.

6.1.6 Psychosocial factors

Psychosocial factors have long been implicated in developing MSDs. The pathways for this have also been discussed, for example, in the work of Hauke et al. (2011). The interaction between physical health and psychosocial factors has been extensively researched, and positive associations between burnout, poor social support, low levels of job control, work-life conflict and MSDs have been identified. However, little has been done at the current time to take a holistic approach to prevention, rather than just addressing physical hazards. Taking a 'silo approach' means that risk assessments are carried out separately for musculoskeletal problems and for psychosocial risks. Macdonald & Oakman's (2015) work in Australia provides guidance on how to develop combined risk assessments for both MSDs and psychosocial risks.

6.1.7 Socio-economic differences

The analysis of socio-economic differences showed that they contribute to the wide variation in reported levels of MSDs across the EU-28. Some studies suggest that, where there is social support and no poverty, people report more MSDs. It is not clear if this is down to the provision (or lack of provision) of particular support or insurance systems. However, examining trends, it is apparent that the list of MSDs recognised as occupational diseases, the criteria for their recognition and compensation practices in particular countries have an impact on the levels of reporting. For example, in Belgium, France and Italy, increased levels of reporting between 2007 and 2012 was down to the addition of specific tendinopathies to the list of general MSDs, as well as information campaigns to highlight this, both of which might have increased levels of reporting. Taking this as it stands with a number of caveats on methodology, this suggests that MSDs are reported more frequently where there are support systems in place with higher rates of social protection. Whether this is due to workers being comfortable reporting MSDs in those countries, or fearing losing their jobs in areas with lower levels of social protection, requires further analysis.

6.2 Prevention

Although there are many tools available MSD risk assessment, many of those have not been evaluated nor has their impact been measured. As highlighted in this review, much prevention is based on the evidence relating to physical hazards associated with the development of MSDs, rather than what works in preventing MSDs, for which the evidence is still lacking. Furthermore, while we know that psychosocial factors are linked to the development of MSDs, there has been little progress in translating that knowledge into the workplace to try to avoid the silo approach and bridge the gap between MSD and psychosocial risk assessment. The research identified in this review suggests ways of integrating the two.

However, as there is a need to build the evidence base for MSD prevention, there is a push to take new approaches to prevention, including carrying out intervention studies in the workplace. It is clear that these require design, implementation over long periods and adequate evaluation to identify what works. The studies identified also recommend including raising awareness of and transferring knowledge about MSDs as part of an overall preventive strategy. This should cover their causes, their impact and how they are best prevented. Health beliefs are likely to affect how people perceive their disorder, so having accurate information about occurrence, causes, impact and prevention is essential, as is having ergonomist support. The latter was one of the facilitators identified by Yazdani & Wells (2018).

As with many intervention studies, barriers to prevention are likely to include lack of time, resources, management support, resistance to change and the changing work environment. In developing prevention interventions it is important to identify the relevant stakeholders, ensure participation at all company levels, gain support from management and have a good communication plan. Training for line managers on integrating OSH into everyday practice is also perceived as positive.

While we are still building a knowledge base of what works in prevention, taking a more holistic approach to prevention is advisable. This is especially true in a changing work environment where we are not always aware of the consequences of change such as the impact of automation and robots or how to reduce sedentary work. As both areas are currently being researched, organisations including EU-OSHA and NIOSH are already identifying good practice for the workplace.

7 Conclusions

This exploratory review examined research carried out since 2008 that can help to explain why the prevalence of MSDs remains high. The literature on the causes and prevalence of work-related MSDs refers to ageing of the workforce, effects of new forms of work, interaction of psychosocial and physical exposures, and shortcomings in risk assessment and prevention practices and in implementing interventions in companies. The review of the relevant literature seems to confirm the hypotheses derived from the preliminary research.

There is a whole range of interactions that are likely to contribute to the continuing prevalence of MSDs including demographic change, changing work and workplaces, gender, age and the lack of inclusion of psychosocial risks as part of risk assessment. EU data also confirm that there is little reduction in exposure to physical risk factors for MSDs across the workforce.

There is a growing body of research linking IT technology use/overuse, including mobile devices and during both professional and leisure time, to musculoskeletal complaints. In addition to rapid changes in the technologies used at work, the equally rapid developments in IT and entertainment technology drives changes in the nature of work, business structures, employment status, hierarchies and relationships; the combined impact of these changes could challenge existing mechanisms for managing and regulating OSH.

Although there are many tools available to assess MSD risks, there has been little work on evaluating their impact.

Demographic change leading to an increasingly older workforce results in a group of workers more at risk of MSDs. The relatively high proportion of younger workers also affected gives rise to concern.

The recognition of psychosocial factors and their influence on prevalence of MSDs has not been linked into the risk assessment process in any real way.

There is a clear need to take new approaches to preventing MSDs, including creating workplace intervention studies, which will need to take a more holistic approach covering both physical and psychosocial risks. Furthermore, raising awareness of MSDs and their prevention is essential to bring about change.

The causes of the continuing high prevalence of MSDs are complex and include the impact of new forms of work, continuing high levels of exposure to physical risks, new types of exposure, the ageing of the workforce, and shortcomings in risk assessment and prevention practices, among others. To achieve a sustained reduction in the societal burden of MSDs all these issues need to be addressed, requiring an interplay between measures taken in all of these areas, including research, awareness raising and public education, legislation, OSH and public health policy.

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9 Appendix A - Search strategy

Scope/criteria	Relevant terms/description
Population	Employees Workers
Intervention	Risk assessment Guidance Prevention Tool kits
Outcomes	Musculoskeletal disorders MSDs Upper limb disorders Back pain Lower limb disorders
Context	Work ICT New technology Precarious work Psychosocial risks Sedentary work Health
Sectors	Manufacturing Services industries HORECA Health and social care/nursing Telecommunications
Types of studies/publications	Epidemiological Cross-sectional Case-control Systematic reviews Guidance Case studies
Inclusion criteria	Study informs on musculoskeletal disorders including back pain, upper limb disorders and lower limb disorders Study informs on new risks for MSDs Published post 2007
Exclusion criteria	Published pre-2007 Not published in English, German, French or Spanish

Scope/criteria	Relevant terms/description
Search databases	Incidence and Prevalence Database
	SciSearch
	Social SciSearch
	Embase
	MEDLINE
	Open Grey
Websites	EU-OSHA
	CORDIS
	NIOSH
	HSE
	BAuA
	Worksafe BC/Ontario
	Safe Work Australia
	WSH Institute Singapore
	INRS
	IFA-DGUV

10 Appendix B - Data extraction table

Data extraction assessment criteria	Populated fields
Screening	RefWorks ID number Reference Reviewer name Inclusion or exclusion Reason for exclusion (if excluded then the publication will not have the following data extracted)
Publication type	Sector Outcome (MSDs, upper limb disorders, back pain, lower limb disorders) Type of publication Research (e.g. primary research, secondary research) Non-research/intervention (e.g. guidance, toolkit)
Research	Type of research study (e.g. epidemiological, cross-sectional, case-control, systematic review, case study) What were the research questions? What was the research methodology? How does this research help you answer your key question? What were the main findings of the study?
Non-research	Type of non-research publication/intervention (e.g. risk assessment, guidance, prevention, toolkit) What was the aim of the resource? How does this resource help you answer your key question? What does the content cover? Has the publication/intervention been evaluated?
Assessment of publication	Does the study address an appropriate and clearly focused question? A description of the methodology, search strategy, inclusion/exclusion criteria and quality assessment is included Is the literature search broad enough to identify all relevant studies, i.e. not just MEDLINE but including other search engines and the Cochrane Library Has a study quality assessment of included papers been carried out? Are there enough similarities between the studies selected to make combining them reasonable? Overall assessment of publication or resource: ++, all or most criteria have been fulfilled; +, some of the criteria have been fulfilled; -, few or no criteria fulfilled
Additional information	Any evidence gaps identified Any additional notes and comments

11 Appendix C - Table of included research papers

Ahlers, E., 2016, 'Flexible and remote work in the context of digitization and occupational health', International Journal of Labour Research, 8(1/2), 85.	This EU review investigates flexible and remote work in a digitised environment. The findings highlight the extent of digital working and how work is changing. It highlights the issues around working time and the 'always on' culture. The review also examines OSH in this context and the fact that the nature of stress has changed.
Andersen, J.H., Malmros, P., Ebbehoej, N.E., Flachs, E.M., Bengsten, E., Bonde. J.. 2018, 'Systematic literature review on the effects of occupational safety and health (OSH) interventions at the workplace', Scandinavian Journal of Work, Environment & Health, 45(2), pp. 103-113. doi:10.5271/sjweh.3775.	A systematic review of OSH interventions in the workplace including the impact of legislation and follow-up inspections on injury, training, campaigns and new devices. In total 61 papers were included in the review. The review finds that legislation and regulatory policy reduce injuries and fatalities. However, for MSDs, the three included papers on the use of devices (lifting aids) showed that they did reduce injuries. However, the paper highlights a lack of research in approaches targeting MSDs or psychological processes.
Andorsen, O.F., Ahmed, L.A., Emaus, N., Klouman, E., 2014, 'High prevalence of chronic musculoskeletal complaints among women in a Norwegian general population: the Tromsø study', BMC Research Notes, 7(1), 506.	This cohort study in Norway investigates the prevalence of MSDs in the general population. The findings suggest that women report more musculoskeletal problems than men (general prevalence 63.4 % vs men 52.9 %). Significant associations identified with smoking, high BMI, lower education level and moderate physical activity.
Armon, G., Melamed, S., Shirom, A., Shapira, I., 2010, 'Elevated burnout predicts the onset of musculoskeletal pain among apparently healthy employees', Journal of Occupational Health Psychology, 15(4), 399.	This prospective cohort study in Israel investigates the extent to which changes in the levels of burnout over time predict new cases of musculoskeletal pain in 1,704 healthy employees (men and women). The findings suggest that burnout might be a risk factor in the development of musculoskeletal pain in healthy individuals. Increased levels of burnout over a period of 18 months were associated with an increased risk (2.09-fold) of developing musculoskeletal pain during the subsequent 18 months of follow-up. There was no support for the possibility of reverse causation, i.e. that musculoskeletal pain predicts subsequent elevation of burnout levels.
Bernal, D., Campos-Serna, J., Tobias, A., Vargas-Prada, S., Benavides, F.G., Serra, C., 2015, 'Work-related psychosocial risk factors and musculoskeletal disorders in hospital nurses and nursing aides: a systematic review and meta-analysis', International Journal of Nursing Studies, 52(2), pp. 635-648.	This systematic review and meta-analysis of 24 studies of healthcare nurses and nursing aides aims to evaluate and quantify psychosocial risks and MSDs in the healthcare setting among nurses. The findings suggest that there is a significant association between demand/control and back pain, neck pain, shoulder pain and knee pain. Poor social support was associated with all pain sites as was effort-reward imbalance. The study concludes that there is an association between psychosocial risks and MSDs even when physical demands are adjusted for.

Bongers PM, Kremer AM, ter Laak J (2002) Are psychosocial factors risk factors for symptoms and signs of the shoulder, elbow, or hand/wrist?: a review of the epidemiological literature. Am J Ind Med 41:315–342	This review shows, that high - perceived job stress was consistently associated with all upper extremity problems (UEP) in high and lower quality studies. Although not often studied, non - work - related stress was also consistently associated with UEP. In addition, there was some evidence for a relationship between high job demands and UEP, although the results did not meet the pre - set criterion for consistency
Brännmark, M., Håkansson, M., 2012, 'Lean production and work-related musculoskeletal disorders: overviews of international and Swedish studies.' Work, 41(Suppl. 1), pp. 2321-2328.	This review of 23 papers in Sweden investigates the impact of lean manufacturing on MSD risk. The review points to the lack of consistency and quality across the published literature. It highlights that lean manufacturing may increase exposure to MSDs and risk factors for MSDs if ergonomists are not involved in the change process.
Bridger, R.S., Brasher, K., Bennett, A., 2013, 'Sustaining person-environment fit with a changing workforce', Ergonomics, 56(3), pp. 565-577.	This longitudinal cohort study in the UK military investigates the identification of predictors of health risks between 2007 and 2011 in naval officers. The findings suggest that higher BMI was associated with MSDs and back pain.
Clays, E., De Bacquer, D., Leynen, F., Kornitzer, M., Kittel, F., De Backer, G., 2007, 'The impact of psychosocial factors on low back pain: longitudinal results from the Belstress study', Spine, 32(2), pp. 262-268.	This Belstress study in Belgium investigated the impact of psychosocial factors, both work and non-work-related, on the prevalence of lower back pain after 6.6 years on average in 2,556 workers (1,729 men, 827 women). The findings suggest that, after adjustment for individual and physical risks, including occasional back pain at baseline, the prevalence of low back pain in men is significantly related to baseline low decision latitude and poor social support at work and non-significantly to high job strain, low wage and job satisfaction, feeling stressed at work and feeling depressed. High job insecurity, feeling stressed at work and feeling depressed did not significantly increase the relative risks for low back pain in women.
Coggon, D., Ntani, G., Palmer, K.T., Felli, V.E., Harari, R., Barrero, L.H., Felknor, S.A., Gimeno, D., Cattrell, A., Serra, C., Bonzini, M., 2013, 'Disabling musculoskeletal pain in working populations: is it the job, the person, or the culture?', Pain, 154(6), pp. 856-863.	This international cohort study of healthcare and office work explores cultural and belief systems on MSDs of 12,426 nurses and office workers in 18 countries. The findings suggest that low back pain was associated with being female, an ex-smoker and smoking, lifting weights of over 25 kg, working over 50 hours per week, job insecurity, two or more somatic symptoms in the preceding week, intermediate or poor mental health and beliefs including the work-relatedness of and prognosis for MSDs. Disabling wrist or arm pain was associated with being female, increasing age, being a current smoker, using a keyboard, time pressure at work, lack of support at work, lack of job control, one or more somatic symptoms in the past week, poor mental health and adverse beliefs including the work-relatedness of MSDs.
Collins, J., O'Sullivan, L., 2010, 'Psychosocial risk exposures and musculoskeletal disorders across working-age males and females', Human Factors and Ergonomics in Manufacturing & Service Industries, 20(4), pp. 272-286.	This cross-sectional study in Ireland investigates the prevalence of MSDs and trends with psychosocial risks, across age and gender in 332 workers (200 women, 132 men). The findings suggest that the most prevalent symptoms of MSDs were in the low back, shoulder and neck regions. Age and gender differences in prevalence were evident for these regions with a general trend towards increasing prevalence with age.

Comper, M.L.C., Dennerlein, J.T., Evangelista, G.D.S., Rodrigues da Silva, P., Padula, R.S., 2017, 'Effectiveness of job rotation for preventing work-related musculoskeletal diseases: a cluster randomised controlled trial', Occupational and Environmental Medicine, 74, pp. 545-552.	This randomised controlled trial in the US textiles industry investigates the prevention MSDs using job rotation as a control measure. The findings suggest that job rotation and ergonomics training did not have an impact on measures including sickness absence, symptoms or pain perception. However, the paper highlights that job rotation is difficult in modern manufacturing, as there are no changes in the muscle groups used.
da Costa, B.R., Vieira, E.R., 2010, 'Risk factors for work-related musculoskeletal disorders: a systematic review of recent longitudinal studies', American Journal of Industrial Medicine, 53(3), pp. 285-323.	This international systematic review of longitudinal studies investigates factors associated with MSDs after the Bernard review, including work and individual factors. The review findings suggest that both work and personal factors are associated with the occurrence of MSDs.
Davis, K., Dunning, K., Jewell, G., Lockey, J., 2014, 'Cost and disability trends of work-related musculoskeletal disorders in Ohio', Occupational Medicine, 64(8), pp. 608-615.	This cross-sectional study in Ohio, United States, investigates the costs and spread of MSDs based on insurance claims. The findings suggest that the claim costs of MSDs increased until the age of 64 years then levelled off.
Davis, K.G., Kotowski, S.E., 2015, 'Prevalence of musculoskeletal disorders for nurses in hospitals, long-term care facilities, and home health care: a comprehensive review', Human Factors, 57(5), pp. 754-792.	This review in the nursing sector investigates the prevalence of MSD pain and reported injuries for nurses and nursing aides. The findings suggest that the prevalence of MSD pain for nurses and nursing aides was highest in the low back, followed by the shoulders and neck. The review highlights that, as patients live longer with more chronic diseases, obese patients, early mobility requirements and those who want to live at home during sickness can result in MSDs shifting to different populations, e.g. home healthcare workers, long-term care workers and physical therapists. In addition, it was also suggested that because of this there is likely to be a shift to different body regions affected, such as shoulders and upper extremities.
Elfering A., Grebner S., Gerber H. and Semmer NK., Workplace observation of work Stressors, catecholamines and musculoskeletal pain among male employees Scandinavian Journal of Work, Environment & Health Vol. 34, No. 5 (October 2008), pp. 337-344	This field study tested whether a high level of work Stressors is associated with musculoskeletal pain and higher urinary norepinephrine excretion rates at work, after work, and on Sundays. Methods Altogether 32 male employees working in adult education took part in a three-phase repeated-measures field study including workplace observation, self-report of musculoskeletal pain, and measurement of urinary catecholamine at work, in the evening after work, and at corresponding times on Sundays. Conclusions High levels of work Stressors turned out to be associated with musculoskeletal pain and norepinephrine concentration in male employees. Increased activity of the sympathetic-adrenal medullary system seems to play an important role in work-related musculoskeletal pain.

Eltayeb, S., Staal, J.B., Kennes, J., Lamberts, P.H., de Bie, R.A., 2007, 'Prevalence of complaints of arm, neck and shoulder among computer office workers and psychometric evaluation of a risk factor questionnaire', BMC Musculoskeletal Disorders, 8(1), 68.	This cross-sectional study in the Netherlands of office workers investigates the occurrence of MSDs, including a breakdown based on gender. The findings suggest that neck and shoulder problems are more prevalent in workers and that women reported more symptoms for the same job grade.
Eitivipart, A.C., Viriyarojanakul, S., Redhead, L., 2018, 'Musculoskeletal disorder and pain associated with smartphone use: A systematic review of biomechanical evidence', Hong Kong Physiotherapy Journal, 38(2), pp. 77-90.	A systematic review that included 11 papers within the analysis. The results showed that head flexion was associated with smartphone use and through this increased activity in the upper trapezius, erector spine and neck extensor muscles. Neck extension was increased when participants were in a seated posture.
EU-OSHA, 2018, The future of the (E-)retail sector from an occupational safety and health point of view, Discussion Paper. EU-OSHA, Bilbao.	This review investigates the impact of e-retail on those employed in distribution centres and found that increased risks of MSDs are related to work rate and increased psychosocial risks. The review highlights current and future risk factors in e-retail in distribution centres where loads are handled, work is fast and there are concerns about exposure to ergonomic risks.
EU-OSHA, 2017, Protecting workers in the online platform economy: An overview of regulatory and policy developments in the EU, European Risk Observatory Discussion Paper. Publications Office of the European Union, Luxembourg.	This review addresses the loss of protection for workers who may not be on full contracts or may be temporary or self-employed. The review also defines digitalisation and the online economy and how OSH considerations need to be taken into account.
EU-OSHA, 2016, The ageing workforce: Implications for occupational safety and health. A research review. Publications Office of the European Union, Luxembourg.	This EU review investigates different impacts in relation to age, work and safety and health.
EU-OSHA, 2016, Women and the ageing workforce. Implications for occupational safety and health: a research review. Publications Office of the European Union, Luxembourg.	This EU review investigates the various impacts of work and age on women in the context of OSH.
EU-OSHA, 2015, A review on the future of work: Robotics. A discussion paper. EU-OSHA, Bilbao	This EU discussion paper investigates the impact of robotics in relation to OSH. The findings suggest that robots can improve work, but we also need to consider the possible unintended consequences and safety issues around such equipment.

Eurofound, 2017, Sixth European Working Conditions Survey: Overview report (2017 update). Publications Office of the European Union, Luxembourg.	This Eurofound report aims to evaluate working conditions across the EU and identifies how many people are exposed to poor working conditions.
Eurogip, 2016, Musculoskeletal disorders: What recognition as occupational diseases? A study on 10 European countries. Eurogip, Paris.	This epidemiology study across 10 EU countries investigates MSD trends in reporting in relation to listings of occupational diseases.
Farioli, A., Mattioli, S., Quaglieri, A., Curti, S., Violante, F.S., Coggon, D., 2014, 'Musculoskeletal pain in Europe: role of personal, occupational and social risk factors', Scandinavian Journal of Work, Environment & Health, 40(1), 36.	This EU cross-sectional study using data from the fifth European Working Conditions Survey investigates the role of personal, occupational and social factors on the development of MSDs. The findings suggest that the one-year prevalence of back pain was 46 % and for neck/upper limb pain it was 44.6 %. The strongest personal predictor was somatisation. The highest prevalence was in agriculture and fisheries and among labourers, the smallest in teaching. Data were broken down by gender and by country. Different rates were identified by country, with Ireland being the lowest and Portugal the highest for back pain and with neck/upper limb pain lowest in Ireland and highest in Finland. The authors hypothesise that the different rates could be explained by socio-economics: countries that are richer and have more social support have a higher prevalence of MSDs.
Graveling, R., ed., 2018, Ergonomics and musculoskeletal disorders (MSDs) in the workplace. A forensic and epidemiological analysis. CRC Press, London.	Examination of the role of work in causing commonly occurring MSDs, with an up-to-date focus on the scientific evidence, and of the causal factors, including the impact of psychosocial factors.
Griffiths, K.L., Mackey, M.G., Adamson, B.J., 2007, 'The impact of a computerized work environment on professional occupational groups and behavioural and physiological risk factors for musculoskeletal symptoms: a literature review', Journal of Occupational Rehabilitation, 17(4), pp. 743-765.	This international review of computer workers investigates the potential risks to musculoskeletal health with the computerisation of work. The findings suggest potential risk factors including extended working hours, fast-paced work and lack of breaks.
Gustafsson, E., Thomée, S., Grimby-Ekman, A., Hagberg, M., 2017, 'Texting on mobile phones and musculoskeletal disorders in young adults: a five-year cohort study', Applied Ergonomics, 58, pp. 208-214.	The study was a five-year cohort study examining musculoskeletal symptoms in young adults (20-24 years). Self-reported symptoms were collected and the results identified a positive association between text messaging and upper extremity pain. For those without symptoms at baseline, a positive association was found between hand and finger symptoms and texting. For those with symptoms at baseline, a positive association was found between ongoing pain in the neck and upper back.

Hämmig, O., Knecht, M., Läubli, T., Bauer, G.F., 2011, 'Work-life conflict and musculoskeletal disorders: a cross-sectional study of an unexplored association', BMC Musculoskeletal Disorders, 12(1), 60.	This cross-sectional study in Switzerland investigates work-life conflict and MSDs in 6,091 employees (57.1 % men, 42.9 % women) in four companies (insurance = 1,696; banking = 3,127; transport = 766; health care = 502). The findings suggest that work-life conflict is significantly and quite strongly associated with MSDs even when adjusting for various control variables (gender, age, education, physical activity) and other covariates (physical strain at work, time pressure at work, workload, job autonomy, general stress).
Harcombe, H., McBride, D., Derrett, S. and Gray, A., 2009, 'Prevalence and impact of musculoskeletal disorders in New Zealand nurses, postal workers and office workers', Australian and New Zealand Journal of Public Health, 33(5), pp. 437-441.	This cohort study in New Zealand of nurses, postal and office workers investigates the 12-month prevalence of MSDs from all causes in the low back, neck, shoulder, elbow, wrist/hand and knee. The findings show that 88 % reported at least one MSD lasting longer than a day; 72 % reported a MSD lasting longer than seven days. Postal workers reported a higher percentage of elbow, wrist/hand symptoms than the other two groups. Nurses and postal workers reported more knee problems than office workers.
Hauke, A., Flintrop, J., Brun, E., Rugulies, R., 2011, 'The impact of work-related psychosocial stressors on the onset of musculoskeletal disorders in specific body regions: a review and meta-analysis of 54 longitudinal studies', Work & Stress, 25(3), pp. 243-256.	This international systematic review of 54 studies investigates longitudinal studies relating MSDs to psychosocial risks. The findings suggest significant associations between poor social support and neck/shoulder problems, upper extremities and low back pain. Significant associations were identified for high job demands and upper extremity and low back pain; low job control and neck/shoulder and low back pain; low decision-making authority and neck/shoulder and upper extremity pain; low skill discretion and low back pain; low job satisfaction and upper extremity and lower back pain; high job strain and neck/shoulder and low back pain; and psychological distress and upper extremity pain.
Hoe, V.C., Kelsall, H.L., Urquhart, D.M., Sim, M.R., 2012, 'Risk factors for musculoskeletal symptoms of the neck or shoulder alone or neck and shoulder among hospital nurses', Occupational and Environmental Medicine, 69(3), pp. 198-204.	This cross-sectional study in Australia investigates the relationship between sociodemographic, individual and workplace factors and neck pain alone, shoulder pain alone, and neck and shoulder pain among 1,111 nurses (91 % women) working across three public hospitals. The findings suggest that employment and work-related psychosocial factors were not associated with neck pain alone or shoulder pain alone or neck and shoulder pain combined. Work-related physical factors, mental and physical health and well-being, health beliefs and somatisation tendency were consistently associated with neck and shoulder pain. Neck pain alone was more consistently associated with sociodemographic factors and physical health and well-being, shoulder pain alone was associated with fear avoidance beliefs and physical health and well-being. Strategies to control work-related MSDs of the neck and shoulder should take account of the difference in risk factors for neck or shoulder pain alone and for neck and shoulder pain combined.
HSE 2017, Work-related musculoskeletal disorders (WRMSDs) statistics in Great Britain 2017. HSE, London.	This UK report provides summary data to highlight the number of cases of MSDs in the United Kingdom and the rates in different sectors.

Karasek RA., Jr Job demands, job decision latitude, and mental strain: Implications for job redesign. Adm Sci Q. 1979;24:285–308.	This review shows, that a stress-management model predicts that mental strain results from the interaction of job demands and job decision latitude. The consistent finding is that it is the combination of low decision latitude and heavy job demands which is associated with mental strain.
Koukoulaki, T., 2014, 'The impact of lean production on musculoskeletal and psychosocial risks: an examination of sociotechnical trends over 20 years', Applied Ergonomics, 45(2), pp. 198-212.	This international review of 36 papers of production environments and manufacturing investigates what lean manufacturing techniques lead to positive or negative health and safety outcomes. The findings suggest that in the earlier studies reviewed lean production was associated with the development of MSDs. Increased MSD symptom reporting was associated with increases in work pace and reduced recovery time associated with just-in-time manufacturing.
Lachowski, S., Choina, P., Florek-Łuszczki, M., Goździewska, M., Jezior, J., Jurkiewicz, A., Buczaj, A., 2017, 'Dissatisfaction with work as a risk factor of musculoskeletal complaints among foresters in Poland', Annals of Agricultural and Environmental Medicine, 24(4), pp. 706-711.	This cross-sectional study in Poland of forestry workers investigates the relationship between job satisfaction and musculoskeletal symptoms. The findings show that in total 399 participants (86 % male) 85 % reported having some MSD. The most frequent complaint was low back pain with over 70 % reporting this. Fifty-one per cent reported knee pain and 37 % of the sample reported shoulder pain. Associations between job satisfaction and MSDs found that, the lower the levels of job satisfaction, the greater were MSD complaints. Improving job satisfaction may contribute to reducing MSDs.
Macdonald, W. and Oakman, J., 2015. Requirements for more effective prevention of work-related musculoskeletal disorders. BMC musculoskeletal disorders, 16(1), p.293.	This debate paper aims to identify some major barriers that are hindering both communication of the need for changes and workplace implementation of changes for MSDs. The paper suggests that workplace risk management procedures do not reflect current evidence concerning their work-related causes. Inadequate attention is given to assessing and controlling risk from psychosocial hazards, and the conventional risk management paradigm focuses too narrowly on risk from individual hazards rather than promoting the more holistic approach needed to manage the combined effects of all relevant hazards. Achievement of such changes requires new MSD risk management tools and better integration of the roles of OHS personnel with those of line managers.
Magnavita, N., Elovainio, M., De Nardis, I., Heponiemi, T., Bergamaschi, A., 2011, 'Environmental discomfort and musculoskeletal disorders', Occupational Medicine, 61(3), pp. 196-201.	This cross-sectional study in Italy investigates whether environmental factors at work are associated with MSDs in 1,744 hospital workers (nurses (60 %), physicians (18 %),technicians and biologists (8 %), white collar workers (11 %) and blue collar workers (3 %)) (767 men, 977 women) to investigate potential interactions between environmental and psychosocial risk factors in the workplace associated with MSDs. The findings suggest that physical environmental factors in the workplace were related to MSDs. In addition, a there was a strong interaction between environmental and psychosocial risk factors affecting MSDs. Problems in the upper limbs seemed to be more strongly affected by environmental and psychosocial factors than low back pain. To prevent MSDs, a multi-level approach is needed, including environmental measures and interventions directed at both psychosocial and organisational factors.

Mehlum, I.S., Kristensen, P., Kjuus, H., Wergeland, E., 2008, 'Are occupational factors important determinants of socioeconomic inequalities in musculoskeletal pain?', Scandinavian Journal of Work, Environment & Health, 34(4), pp. 250-259.	This cohort study in Norway investigates the quantification of socio-economic differences in reporting low back pain, neck and shoulder pain and arm pain. The findings suggest that for men there was a steep gradient for low back pain and occupational grade and for those where handling and lifting were involved and high physical demands were reported. This was observed for arm pain too. For women, the slope was not as steep, but there was a significant association between low back pain and socio-economic group and for jobs involving lifting and handling. Arm pain was associated with sedentary work and jobs involving lifting and high physical demands.
Miranda, H., Punnett, L., Gore, R., Boyer, J., 2011, 'Violence at the workplace increases the risk of musculoskeletal pain among nursing home workers', Occupational and Environmental Medicine, 68(1), pp. 52-57.	This cross-sectional study in the United States in health and social care investigates the association between physical assaults and musculoskeletal pain in care home workers. The findings suggest that 26 % had been assaulted once or twice in the preceding three months. Younger workers were more exposed to physical assaults. Being exposed to one or two assaults was associated with low back pain, knee pain, wrist/hand pain and widespread pain. Being exposed to three or more assaults was significantly associated with all types of pain. The authors suggest that this may be related to stress and delayed healing in the participants.
Mozafari, A., Vahedian, M., Mohebi, S., Najafi, M., 2015, 'Work-related musculoskeletal disorders in truck drivers and official workers,' Acta Medica Iranica, 53(7), pp. 432-438.	This case-control study in Iran of truck drivers and official workers investigates the prevalence of MSDs in truck drivers and official workers (173 drivers and 173 official workers). The findings suggest that the prevalence of pain in the most commonly involved body regions within one year were neck (27.2 %), lumbar (24.3 %), back (15.6 %), shoulder (14.5 %) and knee (19.1 %) in drivers and knee (36.4 %), lumbar (12.1 %) and ankle (9.8 %)in official workers. Drivers reported more back and shoulder pain ($P < 0.05$), knee disorders were significantly more often reported in official workers ($P < 0.001$).
Nilsen, T.I.L., Holtermann, A., Mork, P.J., 2011, 'Physical exercise, body mass index, and risk of chronic pain in the low back and neck/shoulders: longitudinal data from the Nord-Trøndelag Health Study', American Journal of Epidemiology, 174(3), pp. 267-273.	This longitudinal study in Norway investigates the associations between BMI, physical activity and musculoskeletal symptoms. The findings suggest that increased levels of leisure time physical activity were associated with fewer musculoskeletal symptoms. Those who were obese were at a 20 % increased risk of back pain and neck and shoulder pain.
NIOSH, 2017, Using total worker health concepts to reduce the health risks from sedentary work. DHHS, NIOSH, Cincinnati, USA.	This report from the United States provides information on reducing the amount of sitting time at work and methods of improving movement and physical activity.
Okunribido O., Wynn, T., 2010, Ageing and work-related musculoskeletal disorders a review of the recent literature. HSE, Buxton, UK.	This international review is a scoping review to develop policy in relation to MSDs and age and work. The findings suggest that MSDs are a problem for young and old workers. Employers are now realising that older employees can be an asset to a company but the implementation of measures to protect older workers from MSDs is slow.

Osborne, A., Blake, C., Fullen, B.M., Meredith, D., Phelan, J., McNamara, J., Cunningham, C., 2012, 'Prevalence of musculoskeletal disorders among farmers: a systematic review', American Journal of Industrial Medicine, 55(2), pp. 143-158.	This international systematic review of 24 papers on farming investigates the establishment of MSD prevalence and trends in farmers. The findings suggest that lifetime prevalence among farmers is 90.6 %. The most common complaint was low back pain with a lifetime prevalence of 75 %. There is a lack of agreement on diagnostic criteria for other MSDs.
Popma J., 2013, The Janus face of the 'new ways of work': Rise, risks and regulation of nomadic work. European Trade Union Institute, Brussels.	This EU review investigates the impact of digitalisation on workers. The findings suggest that new ways of working highlight some of the potential issues around 'techno-stress'. It covers issues around the home-work interface as well as looking at OSH requirements in this context. The review also suggests things to consider in risk assessment including ergonomic design of equipment, information and training, working time, evaluation of health and evaluation of the efficiency and costs of new ways of working.
Runeson-Broberg, R., Lindgren, T., Norbäck, D., 2014, 'Musculoskeletal symptoms and psychosocial work environment among Swedish commercial pilots', International Archives of Occupational and Environmental Health, 87(7), pp. 685-693.	This cross-sectional study in Sweden in the transport sector investigates the prevalence of MSDs among commercial pilots by examining flight length and psychosocial work conditions. The findings suggest that women reported more hand symptoms and pilots generally on long-haul flights had fewer elbow symptoms. High work demands were associated with neck, shoulder, elbow and low back pain symptoms. Poor social support was associated with neck, shoulder and low back pain. Finally, low supervisor support was associated with neck, shoulder and low back pain.
Sadeghian, F., Kasaeian, A., Noroozi, P., Vatani, J., Hassan Taiebi, S., 2014, 'Psychosocial and individual characteristics and musculoskeletal complaints among clinical laboratory workers', International Journal of Occupational Safety and Ergonomics, 20(2), pp. 355-361.	This cross-sectional study in Iran investigates the prevalence of MSDs in laboratory workers and the interaction with personal characteristics and psychosocial factors. The findings identify that of 156 employees (53 % women) 72.4 % reported at least one MSD in the previous 12 months. The significant risk factor for low back pain, shoulder pain, hand/wrist pain and leg pain was gender (being female). In further analysis using multiple logistic regression, after adjustment, both increasing age and being female were associated with MSDs.
Sethi, J., Sandhu, J.S., Imbanathan, V., 2011, 'Effect of body mass index on work related musculoskeletal discomfort and occupational stress of computer workers in a developed ergonomic setup', Sports Medicine, Arthroscopy, Rehabilitation, Therapy & Technology, 3(1), 22.	This descriptive cross-sectional study of computer workers in India investigates the effect of BMI on stress and MSDs. The findings suggest that 64 % of the sample were overweight. Higher BMI was associated with increased MSD reporting ($P < 0.001$) and Occupational Stress Indicator score ($P < 0.001$).

Siegrist, J. (1996). Adverse health effects of high-effort/low-reward conditions. Journal of Occupational Health Psychology, 1(1), 27–41	This study discuss the relevant issues concerning the link between psychosocial occupational stress and health. It is discussed 2 theoretical models, the person-environment fit and the demand–control models, are reviewed to help analytically define those components. A 3rd theoretical concept is introduced: the model of effort–reward imbalance at work. Results of 2 social epidemiologic and psychophysiological studies of men are provided to examine the adverse cardiovascular and other health effects of chronically stressful experience in terms of high effort and low reward.
Silva, C., Barros, C., Cunha, L., Carnide, F., Santos, M., 2016' 'Prevalence of back pain problems in relation to occupational group', International Journal of Industrial Ergonomics, 52, pp. 52-58.	This cross-sectional study in Portugal of blue and white collar workers investigates work-related physical and psychosocial factors in relation to back pain problems. The findings suggest that the occurrence of back pain was for blue collar workers associated with exposure to vibration, high work demands, feeling exploited and a loss of dignity. For white collar workers associations were with awkward postures, sedentary work, being awake before 05.00 and physical aggression.
Trinkoff, A. M., Le, R., Geiger-Brown, J., Lipscomb, J. and Lang, G. (2006), 'Longitudinal relationship of work hours, mandatory overtime, and on-call to musculoskeletal problems in nurses', American Journal of Industrial Medicine, Vol. 49, No. 11, pp. 964–971.	The purpose of this study was to examine the relationship of extended work schedules in nurses to MSD. Nurses are at very high risk for work‐related musculoskeletal injury/disorders (MSD) with low back pain/injury being the most frequently occurring MSD. Schedule characteristics increasing MSD risk included 13+ hour/days, off‐shifts, weekend work, work during time off (while sick, on days off, without breaks), and overtime/on‐call. These increases in risk were not explained by psychological demands, but were largely explained by physical demands.
Valenduc, G., Vendramin, P., 2016, Work in the digital economy: Sorting the old from the new. European Trade Union Institute, Brussels.	This EU review investigates digitalisation in relation to occupational health.
van Eerd, D., Munhall, C., Irvin, E., Rempel, D., Brewer, S., Van Der Beek, A.J., Dennerlein, J.T., Tullar, J., Skivington, K., Pinion, C., Amick, B., 2016, 'Effectiveness of workplace interventions in the prevention of upper extremity musculoskeletal disorders and symptoms: an update of the evidence', Occupational and Environmental Medicine, 73(1), pp. 62-70.	This international systematic review of 61 papers investigates the effectiveness of workplace-based interventions for MSDs. The findings suggest that the strongest evidence was for resistance training within the workplace. There was moderate evidence for stretching programmes, forearm support and vibration feedback on a static mouse. For other topics there was insufficient evidence to guide current practice or policy.

Verbeek, J.H., Martimo, K., Karppinen, J., Kuijer, P.P.F., Viikari-Juntura, E., Takala, E., 2011, 'Manual material handling advice and assistive devices for preventing and treating back pain in workers', Cochrane Database of Systematic Reviews, 6.	This systematic review investigates prevention measures in reducing back pain from manual handling. The findings suggest that there is moderate evidence that training is ineffective in reducing manual handling risks.
Viester, L., Verhagen, E.A., Hengel, K.M.O., Koppes, L.L., van der Beek, A.J. and Bongers, P.M., 2013', 'The relation between body mass index and musculoskeletal symptoms in the working population', BMC Musculoskeletal Disorders, 14(1), 238.	This epidemiology cohort study in the Netherlands investigates the relation between body mass index and musculoskeletal symptoms in the working population. The findings suggest that being overweight was significantly associated with upper and lower extremity pain in adjusted data. Obesity was associated with neck/shoulder, upper extremity, back and lower extremity pain. For those with high physical workloads, obesity was significantly associated with lower extremity pain. For individuals with low physical workload, being both overweight and obese were associated with lower extremity pain.
Webster, J., Dalby, M., Fox, D., Pinder A., 2014, Factors in the design of order picking systems that influence manual handling practices. HSE Books, Norwich, UK.	This review (and stakeholder interviews) investigates how the design of picking systems impacts on manual handling. The findings highlight the interface between different picking systems and manual handling. While more systems have been automated, the complexity in different order types results in humans being used to pick products. There are often trade-offs between the costs of automation and the costs of human pickers. Levels of activity are often seasonal in warehouses so without additional pickers physical and mental work demands increase. Guidance on positioning of goods is also provided in this report. Control measures include better workplace design, knowing the weights of products and team lifting. However, poor manual handling practice can be seen in warehouses where the demands on the pickers are high.
Wells, R., 2009, 'Why have we not solved the MSD problem?', Work, 34(1), pp. 117-121.	This review attempts to address six questions on why we have not solved the MSD problem. The questions include: 7. How well do we understand MSDs and their burdens? 8. How good are our MSD risk factors? 9. How effective and informative are current workplace MSD assessment approaches? 10. How effective are the recommended interventions in actually reducing MSDs in the workplace? 11. How intensely and widely implemented are workplace interventions to prevent MSDs? 12. How well are we improving disability outcomes for MSDs? The review highlights where we have knowledge and the importance of future interventions that are scalable, affordable and sustainable.

Westgaard, R.H., Winkel, J., 2011, 'Occupational musculoskeletal and mental health: significance of rationalization and opportunities to create sustainable production systems — a systematic review', Applied Ergonomics, 42(2), pp. 261-296.	This systematic review of 34 papers investigates the impact of lean manufacturing on musculoskeletal symptoms. The findings suggest that almost half of the papers reported a negative impact on health and risk factors. There was an increase in work volume and work intensification but also change introduced without considering the environment or worker involvement. Positive aspects of change were job enlargement, quality and enrichment. Negative impacts included increased stress and workload with a mismatch between resources and demands. The review highlights that workers with routine jobs are most at risk.
Womack, S.K., Armstrong, T.J, Liker, J.K., 2009, 'Lean job design and musculoskeletal disorder risk: a two plant comparison', Human Factors and Ergonomics in Manufacturing & Service Industries,19(4), pp. 279-293.	This cross-sectional study investigates the impact of lean manufacturing compared with traditional manufacturing on MSD risks. Repetition, force and posture were assessed in 56 jobs in both plants. The findings suggest that the differences identified included greater productivity, less waiting and less walking in the lean production site but greater exposure to repetition. The lean production site had fewer hand force requirements and, examining repetition and force together, threshold values for risk were lower in the lean production environment. The paper also highlights the importance of having participation from ergonomists and other OSH professionals in developing lean manufacturing.
WHO, 2018, Physical activity factsheet. WHO, Geneva. Available online: https://www.who.int/news-room/fact-sheets/detail/physical-activity	Factsheet on recommended levels of physical activity in adults and children.
Yazdani, A., Wells, R., 2018, 'Barriers for implementation of successful change to prevent musculoskeletal disorders and how to systematically address them', Applied Ergonomics, 73, pp. 122-140.	This scoping review identifies 11 barriers and three facilitators for MSD prevention. Barriers include issues around lack of time, lack of resources, lack of communication, lack of management support, commitment and participation, lack of knowledge and training, resistance to change and lack of trust. Facilitators include training, knowledge and ergonomic support, communication and an effective implementation process.

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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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