

Musculoskeletal disorders: association with psychosocial risk factors at work

Literature review

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Executive summary

What did we find?

- **Psychosocial risk factors can combine with physical risk factors to cause MSDs.**

The review demonstrated that there is clear evidence that psychosocial risk factors play a causal role in the development of musculoskeletal disorders (MSDs) in the workplace. They do not act in isolation but their effect combines with (and often exacerbates) the effects of physical risk factors. The associations between psychosocial and physical risk factors and MSDs identified in the research literature are many and varied; however, it is not possible to identify consistent patterns in those associations. Thus, although factors such as high workload or a lack of social support can be shown to contribute to the development of MSDs, it is not possible to relate these or other particular psychosocial risk factors to specific MSDs.

There was no evidence to suggest that particular groups of workers were more susceptible to developing MSDs, although certain risks were more often encountered in specific sectors, placing those working in those sectors at greater risk from the influence of psychosocial factors.

Importantly, the negative association between psychosocial factors and MSDs can work both ways. Such factors can materially contribute to the causation of MSDs, but having an MSD can exacerbate or accentuate the perception of some psychosocial factors. This is of particular potential importance in influencing the chronic nature of some MSDs; it can be an important potential barrier to successfully rehabilitating those workers with an MSD and bringing them back into the workforce.

Furthermore, the effects of some psychosocial factors are not necessarily negative. Some factors can have a positive effect. For example, there is evidence that good job control can mitigate the otherwise negative effects of high job demands.

- **Many conceptual models of the relationships between workplace risks and MSDs have been developed.**

Many attempts have been made to present the complex relationships between workplace risk factors, the individual and MSDs in the form of conceptual models. An ideal model should incorporate both physical and psychosocial workplace risk factors and reflect the interactions between them. However, any such model should also acknowledge the potential influence of the external (non-work) environment. In the same way that individual physical fitness and related factors moderate the impact of workplace physical factors, an individual's external psychological milieu can moderate the impact of workplace psychosocial factors. Although detailed consideration of such elements arguably takes the model beyond the scope of the workplace, it is necessary to include some acknowledgement of the potential moderating contribution of 'individual susceptibility' in modelling all the elements influencing the impact of psychosocial factors on the onset of MSDs.

Any such model should also illustrate the potential two-way influence of some individual psychosocial factors. Thus, it should reflect the potential moderating effects of factors such as high levels of social support or of job control in reducing the impact of other factors such as high job demands.

It should also reflect the fact that the relationships and influences can be regarded as a 'dynamic equilibrium', with the factors acting on the worker and the responses to those feeding back to further moderate any relationship. This reflects the two-way nature of the relationship between MSDs and psychosocial factors, in which the emergence of MSD symptoms can contribute to the significance of psychosocial factors, such as the levels of job demand and job satisfaction. In this way, the experience of an MSD can feed back to the long-term response modulating the perception of the psychosocial environment by the individual.

So far, many of the models presented in the literature reflect mechanisms and pathways for the primary causation of MSDs. However, a considerable proportion of the negative impact of MSDs (on both workers and employers) arises not from MSDs primarily caused by workplace factors but from chronic MSDs in which both physical and psychosocial risk factors can provoke symptoms or possibly aggravate the underlying disorder. In such cases, MSD symptoms can persist and make it difficult for workers to either remain in work or return to work (rehabilitation). There is a need for some debate over the purpose

and function of such models. As part of this, consideration should be given to whether, in the interest of providing a complete picture, any model should incorporate the factors that influence chronicity and rehabilitation as well as primary causation.

- **The mechanism through which psychosocial risks exert their influence is not entirely clear.**

It is clear that psychosocial risk factors do contribute to both the primary causation of MSDs and the often persistent nature of their symptoms. What is currently unclear is the mechanism through which such effects are mediated. Although a number of biological pathways have been put forward, these have yet to be confirmed.

Possible explanatory mechanisms include:

- Psychosocial demands may produce increased muscle tension and exacerbate task-related biomechanical strain.
- Psychosocial demands may affect awareness and reporting of musculoskeletal symptoms and/or perceptions of their cause.
- Initial episodes of pain based on a physical insult may trigger a chronic nervous system dysfunction, physiological and psychological, which perpetuates a chronic pain process.
- Changes in psychosocial demands may be associated with changes in physical demands and biomechanical stresses, and thus associations between psychosocial demands and MSDs occur through either a causal or an effect-modifying relationship.

It has been suggested that neuroendocrine response mechanisms underlie several of these.

A number of them are not mutually exclusive and it is likely that the causal process is attributable to a combination of two or more of them acting in tandem. However, the fact that we do not yet understand exactly how psychosocial risk factors influence MSD risk should not present a barrier to taking action.

- **There are limitations to the research evidence available on psychosocial risk factors and MSDs.**

Although some psychosocial risk factors, such as psychological or sexual harassment and violence, can have readily discernible consequences, the current research evidence does not in general permit specific psychosocial risk factors to be associated with particular MSDs. This is not unusual in that similar considerations apply with physical risk factors, as it is seldom possible to isolate the extent of the contribution to overall risk of any individual physical risk factor. There is evidence from workplace investigations to suggest that adopting an undue focus on one particular factor (such as the weight of loads being handled) is less likely to be effective in reducing the risk of MSDs (or their consequences in the case of chronic MSDs) than the holistic approach advocated above. Thus, all psychosocial risk factors should be assessed and action taken to reduce those most prevalent, without seeking to relate these to specific MSD risks.

- **Workplace interventions should be developed to address the increased risk of MSDs due to psychosocial risks.**

To date, although there is guidance from the literature on what any workplace intervention should include, no reports have been found of formal evaluations of the effectiveness of any such interventions in practice. Although there are reports of interventions addressing MSDs, these have largely focused on physical risk factors. Similarly, interventions that address psychosocial risks have been identified, although the focus of these has been on the prevention of adverse psychological consequences.

It is clear from the literature that any workplace interventions addressing psychosocial risks and MSDs need to adopt a holistic approach, reflecting the multifactorial causality of such MSDs. Any such approach should address both psychosocial and physical risk factors. There is evidence to support adopting a participatory approach in any intervention, with all levels of the workforce committed to the need for action and to positively contributing to that action at all stages.

A recent discussion paper by the European Agency for Safety and Health at Work (EU-OSHA, 2021)¹ concluded that a participatory approach improves the identification of relevant risks and assists the workforce in assessing risks and finding solutions.

Especially when the intention of the intervention is rehabilitation rather than (or as well as) primary prevention, some attention should also be directed towards individual factors. This should aim to enhance the worker's physical and psychological resilience, again reflecting a holistic approach.

However, although the individual is important, any intervention strategy should avoid adopting an undue focus on individual workers. As with any workplace risk, removing or reducing any risk at source is, apart from a legal obligation, an option more likely to provide a successful outcome. Experience has shown that interventions that solely seek to enhance resilience without addressing the workplace risk factors are less likely to succeed.

- **A systematic intervention strategy to identify and reduce risks is required.**

In designing and implementing any intervention strategy, the first priority is to gain the positive commitment of those at all levels in the organisation, ranging from the workers through to supervisors, middle managers and senior managers. Although physical interventions can often be easily adopted at the workplace level, addressing psychosocial risk factors frequently entails organisational change, requiring recognition and commitment at all levels.

Reflecting the holistic approach to prevention, any intervention strategy needs the involvement and participation of all levels within the workforce. Participation should be an active process, with consultation and discussion at all stages of the risk prevention cycle. As noted above, successful interventions are more likely to arise through such active involvement than through a 'passive' imposition of change without such consultation and discussion.

Participation should continue throughout the process, engaging all levels of the workforce, not just in identifying risks but also in devising and then actively implementing appropriate solutions.

What guidance on interventions can we provide?

Although no formal evaluations of intervention strategies were identified, it was possible to use the available research evidence to determine what any such intervention should include. Building on established recognised good practice for effective workplace interventions in general, it was also possible to identify the key elements of a potentially effective strategy.

- **Commitment.** First, at all levels in the workplace there needs to be recognition of and commitment to a requirement to address both the physical and psychosocial risks of MSDs.
- **Holistic risk assessment adopting a participatory approach.** This should be followed by a systematic, holistic approach to risk assessment, covering both physical and psychosocial risks. As with physical risk factors, the assessment of psychosocial risk needs to adopt a comprehensive approach, taking a broad view to assess all potential risks and not seeking to focus on a selection. The risk assessment process requires management commitment and should actively involve the workforce, and it should ensure that actual work activities are assessed, not what is believed to happen.
- **Encourage and support an honest and open approach.** Because of the individual focus of many psychosocial risk assessment tools, adequately assessing psychosocial risk factors requires openness and honesty on the part of the workforce. Appropriate measures should be in place to safeguard and protect individual confidentiality. As part of this, assessing physical and psychosocial health and well-being will also be of value in identifying where action is most needed.

¹ EU-OSHA. (2021). *Participatory ergonomics and preventing musculoskeletal disorders in the workplace*. Discussion paper. Available at: <https://osha.europa.eu/en/publications/participatory-ergonomics-and-preventing-musculoskeletal-disorders-workplace/view>

- **Multiple effects.** It should be remembered that psychosocial risk factors can have a direct negative impact on psychological health and well-being and on MSDs. In addition, as well as contributing to the development of MSDs, psychosocial factors can create barriers to returning to work for those with chronic MSDs.
- **Risk prevention.** Risk assessment is a means to an end — not an end in itself — and requires the implementation of preventive and corrective measures. As with risk assessment, identifying and developing any follow-up actions should involve the workforce. Evidence suggests that solutions developed collaboratively are more likely to be successful. Furthermore, there is some evidence that a multifactorial approach to prevention is more effective than addressing single risk factors, both in primary prevention and in rehabilitation. Some psychosocial factors can work positively — especially positive support from co-workers and managers. Ideally such support should develop as part of an open and supportive culture. Where appropriate, it might be necessary to enshrine more formal support procedures into systems of work and, where necessary, ensure that supervisors and managers have the necessary training to understand and apply such systems. Some factors can work on both physical and psychosocial risks. For example, enabling greater individual freedom over scheduling work breaks (when possible) can act directly to reduce physical strain and provide a greater sense of personal control. This can lead to clear and comprehensive benefits. Addressing psychological and sexual harassment (where identified) should be a priority, as this can seriously affect both physical and psychosocial health.
- **Ongoing review.** Where changes in work and work systems are required, provisions should be made to ensure that such changes are introduced and maintained. Experience suggests that, without the necessary reinforcement, reversion to the status quo is often the norm. As part of this ongoing process, and in keeping with recognised good practice, workplace risks should be periodically reassessed, partly to confirm that any risk reduction measures are being correctly implemented and partly in recognition of the fact that many workplaces are dynamic places in which risks can change and new risks can emerge. In many instances, communication and collaboration and involvement are key, ensuring that change is explained and cascaded down within the workforce. Again, practical experience suggests that change introduced or enforced without such involvement can lead to resentment, a lack of commitment and cooperation and, eventually, system failure.
- **Rehabilitation, not just initial prevention.** The complexity of interacting factors with respect to rehabilitation and the prevention of recurrence (where individual psychological barriers to returning also have to be taken into account) can make such a multifactorial approach even more necessary, compared with initial prevention.

What further research is required?

Although it is possible to establish that psychosocial risk factors can materially contribute to the causation or exacerbation of MSDs in the workplace, there remains a clear need to explore this complex relationship further, in particular to understand the relative contribution of exposure to different risks and consequent responses.

At present there is no clear understanding of the biological mechanisms through which the influences of psychosocial risk factors are mediated. This is important, as it helps to establish the 'biological plausibility' of such effects. There is little evidence to suggest differential effects, whereby different psychosocial risks contribute more to some MSDs than others. This is an important consideration in exploring these causal mechanisms and should be examined further.

As with physical risk factors, not all psychosocial factors create a causal risk in all circumstances. In addition, as noted above, current research evidence suggests that these factors do not exert their influence in a manner that would enable individual factors to be associated with specific MSDs. Further research efforts would therefore be best directed towards identifying methods to quantify the overall

‘psychosocial load’ in a manner that best reflects the risk of MSD injury generated by that load, rather than any focus on individual risk factors.

Although causation and the causal mechanisms are not fully understood, this should not be regarded as a barrier to taking ameliorative action. At present, although many suggestions have been put forward to reflect strategic approaches to reduce the effect of psychosocial risks on MSDs, none have as yet been found to be adequately evaluated. There is a body of research to indicate the probable content of any course of action and further research-based evidence to guide any evaluation.

It is unlikely that significant differences will emerge in the relationship between workplace psychosocial risk factors and those MSDs considered to be caused by work, compared with those in which work factors exacerbate the ongoing development of underlying (perhaps degenerative) MSD problems. However, there are clearly further individual psychological factors that potentially affect the persistence of MSDs and their symptoms, together with the rehabilitation process. The role of such psychosocial factors in rehabilitating those with MSDs into the workplace (and retaining those still working in the case of rehabilitation and retention in particular) remains to be better understood. Understanding the psychological and the physical barriers to rehabilitation is vital, as there is clear evidence that ongoing MSDs present at least as great a burden to industry (and to the individual sufferer) as the initial occurrence of MSDs in the workplace.

Given the evidence that the assessment of physical factors alone is inadequate, there seems to be limited evidence of psychosocial factors being readily and widely assimilated into the MSD risk assessment process at present. There is therefore a clear need for the development of suitable tools or procedural approaches to facilitate holistic risk assessments and their widespread promotion and advocacy within industry.

What did we do to find this?

▪ Literature search methodology

The evidence and guidance summarised above was drawn from a careful examination and interpretation of the relevant research literature, following a rigid systematic review methodology. This process provided an extensive catalogue of literature, which was then screened, following an agreed template, to identify the most relevant papers. The study reflected a strong focus on material likely to provide an evidential basis for a causal role for psychosocial risk factors and MSDs. This therefore largely excluded cross-sectional studies, as such material provides evidence for ‘associations’ between the risk factors and outcomes of interest that are not necessarily causal. As a result of this process, 53 papers were retained for inclusion.

This database was supplemented by additional published material identified through a number of channels. Some additional material was derived from the literature identified through the searches (e.g. by reverting to the original source material presented in a review). In addition, some of the material accessed was added later, having not been published until after the main searches were conducted. In other instances, material was identified as being of relevance to the emerging issues covered during the review. The resultant review is therefore not limited to those studies identified through the formal search process.

In addition, although the main focus was on literature published in the peer-reviewed scientific domain, searches included ‘grey’ literature, derived from sources such as governmental or international bodies. This included material emanating from EU-OSHA, reflecting the strong focus on both MSDs and psychosocial risks (and their prevention) in recent years, related to the Healthy Workplaces Campaign ‘Lighten the Load’ (2020-22).²

The review focused on:

- the evidence for contributory risk factors for the association between psychosocial risk factors and MSDs;
- an overview of conceptual models explaining the relationship between psychosocial risks and MSDs;

² <https://healthy-workplaces.eu/>

- intervention strategies, including evidence for what would probably constitute an effective strategy and designing an effective strategy;
- good practice identified for preventing MSDs associated with psychosocial risks (and psychosocial risks associated with MSDs).

As part of this, the review considered what evidence there was for particular risks to be associated with different work sectors (including company size) or for particular groups of workers within those (or other) sectors.

1 Introduction

1.1 Psychosocial risks at work

Extensive research over many years has identified a variety of psychosocial factors potentially leading to risks to health or well-being in the workplace.

According to the European Agency for Safety and Health at Work (EU-OSHA),³ some examples of such psychosocial factors are excessive workloads; ineffective communication and a lack of support from management or colleagues, conflicting demands and a lack of influence over the way the job is done; and psychological and sexual harassment.

Often, these potentially causal factors combine and they might result in negative psychological, physical and social outcomes, for both the individual and their employer.

Research has shown that exposure to psychosocial hazards and stress may be associated with reactions such as sleep disturbance, changes in mood, fatigue, headaches and stomach irritability. Prolonged exposure to psychosocial hazards has been shown to be associated with a wide range of negative mental and physical health outcomes, including anxiety, depression, suicide attempts, back pain, chronic fatigue, digestive problems, autoimmune disease, poor immune function, cardiovascular disease, high blood pressure and peptic ulcers (EU-OSHA, 2014).

At an organisational level, the outcomes can include high staff turnover, reduced productivity and increased costs from compensation or health care.

Work-related stress is seldom the sole cause of such problems, but there is evidence that it can at times make a significant contribution.

As is explored later in this report, these workplace factors can not only contribute to the aetiology of musculoskeletal disorders (MSDs) but also influence their persistence, increasing the risk of them becoming chronic conditions. As a further overlay, individual factors such as innate anxiety or depressive tendencies can act as moderators (in the same way that individual joint flexibility, muscle strength, etc., can moderate the impact of physical factors). The mechanisms for these effects are complex, some of which are explored later in this report. Some are mediated through a complex series of physiological changes within the body that in themselves can have far-reaching physical and psychological effects. There are suggestions (e.g. van der Molen et al., 2017) that some forms of MSDs are more susceptible to the influence of psychosocial factors than others, possibly reflecting differences in the aetiology of the MSDs. This issue will be addressed later in this report.

1.2 Musculoskeletal disorders

MSDs cover any damage or disorder of the muscles, joints, tendons or other tissues (EU-OSHA, 2020a). Health problems arising from damage or disorder range from minor aches and pains to more serious medical conditions requiring time off or medical treatment. In more chronic cases, they can even lead to disability and the need to give up work. MSDs can affect any part of the body and cover any damage or disorder of the joints, tendons, muscles or other tissues. They can be characterised as specific, clinically defined disorders such as carpal tunnel syndrome or tenosynovitis; however, many individuals suffer from non-specific symptoms, especially (but not exclusively) non-specific back pain.

There are many potential causes of MSDs (EU-OSHA, 2021a).⁴ These can be classified into three categories:

1. Physical and biomechanical risk factors:
 - handling loads, especially when bending and twisting;
 - repetitive or forceful movements;
 - awkward and static postures;

³ <https://osha.europa.eu/en/themes/psychosocial-risks-and-stress>

⁴ <https://osha.europa.eu/en/themes/musculoskeletal-disorders>

- vibration, poor lighting or cold working environments;
 - fast-paced work;
 - prolonged sitting or standing in the same position.
2. Organisational and psychosocial risk factors:
- high work demands and low autonomy;
 - lack of breaks or opportunities to change working postures;
 - working at high speed, including as a consequence of introducing new technologies;
 - working long hours or in shifts;
 - bullying, harassment and discrimination in the workplace;
 - low level of job satisfaction.
3. Individual risk factors:
- prior medical history;
 - physical capacity;
 - lifestyle and habits (e.g. smoking, lack of exercise).

The inclusion of personal risk factors is important. It reflects a growing acknowledgement that, for health issues such as MSDs, it is not sufficient to focus solely on risk factors in the workplace, as MSDs are usually multifactorial in their origins, with numerous non-work factors playing a potentially significant role (EU-OSHA, 2020a).

Some MSDs result from underlying degenerative changes, possibly with a hereditary element (EU-OSHA, 2021b). For example, the hereditary condition osteoporosis can result in significant bone injury (such as spinal fractures) and pain. In other cases, work (or leisure) activities can lead to painful, largely soft-tissue, injuries that might lead to permanent degenerative change. Where there is an accepted association with work factors, the term 'work-related MSDs' might be applied. In some countries this term is reserved for those disorders for which there is formal recognition of the contribution of work factors to the development of the disorder. In others, it is applied more generally to MSDs for which there is an apparent association between work and the condition. In some instances the term 'work relevant' is informative and can be helpful (Burton et al., 2008). It is clearly 'relevant' to a worker or their employer if work causes them pain or makes it harder for them to do their work effectively (if at all). This applies when the work is actually causing a condition, making it worse or simply provoking symptoms of an underlying problem. Estimates of the extent to which work is a contributory factor are not straightforward because of variations in what constitutes work-relatedness. However, Tanaka et al. (2001) estimated that approximately 40 % of all upper extremity MSDs in the employed population in the United States were attributable to occupational exposures.

Naturally, if work is causing (or exacerbating) a condition, it is important to recognise that and to take steps to correct this and safeguard the health of those affected and their colleagues. Constant and sustained MSD pain can lead to many adverse consequences, both physical (they can make repetitive movements difficult) and psychological (stress, anxiety and depression), making it difficult for the affected employee to perform their job and maintain social contact (EU-OSHA, 2021b). Even if the pain and discomfort is due to an underlying condition (perhaps a historical injury) rather than being from a work-related injury, taking steps to avoid provoking symptoms will be beneficial to both the individual worker and their employer.

1.3 Psychosocial risks and MSDs

Many work factors can cause or exacerbate MSDs. Historically, much of the emphasis on reducing the risk of this occurring has been placed on physical work factors; this remains the case in many countries and for many employers. Thus, addressing physical factors such as lifting and handling heavy loads, repetitive or forceful movements or sustained awkward or static postures has been the focus of many efforts to reduce the risk.

The interaction between physical and psychosocial work factors and their impact on physical health has long been recognised. An early literature review on the issue (Bongers et al., 1993) could not identify conclusive evidence, although the authors did conclude that a number of such factors, including time pressure, low (level of) job control and a lack of social support, are related to MSDs.

In 1997, the authoritative National Institute for Occupational Safety and Health (NIOSH) review on MSDs and workplace factors included a chapter on work-related MSDs and psychosocial factors, in which the authors noted that '... there is increasing evidence that psychosocial factors related to the job and work environment play a role in the development of work-related MSDs of the upper extremity and back' (Bernard, 1997, p. 7-1).

At that time, Bernard and contributors summarised what they termed 'plausible types of explanation':

- Psychosocial demands may produce increased muscle tension and exacerbate task-related biomechanical strain.
- Psychosocial demands may affect awareness and reporting of musculoskeletal symptoms and/or perceptions of their cause.
- Initial episodes of pain based on a physical insult may trigger a chronic nervous system dysfunction, physiological as well as psychological, which perpetuates a chronic pain process.
- Changes in psychosocial demands may be associated with changes in physical demands and biomechanical stresses, and thus associations between psychosocial demands and MSDs occur through either a causal or effect-modifying relationship. (Bernard, 1997, p. 7-2)

Recent years have seen further research expanding on these possible explanations, in some cases providing detailed physiological pathways (such as evoking neuroendocrine system responses).

Growing concerns over the apparent failure of addressing physical work risk factors alone to reduce the workplace MSD burden significantly (EU-OSHA, 2020a) have reflected a more general awareness of the complexities of workplace MSDs and have renewed recognition of the potential role of psychosocial factors, both in their initial causation and, in some individuals, in their persistence. It is also important to recognise that, in addition to the contribution of psychosocial risk factors to the development of MSDs, the reverse can also occur whereby, for example, prolonged musculoskeletal pain, such as back pain, can lead to depressive disorders.

Based on an extensive examination of the research literature, Punnett and Wegman (2004) suggested that, for back disorders, physical risk factors predominated, while, for upper limb disorders, psychosocial factors played a proportionately greater role. The authors calculated a series of 'attributable fractions' (AFs) (defined as 'an estimate of the proportion of disease that would be reduced in the exposed population if the exposure were eliminated'; Punnett and Wegman, 2004). Although the AFs varied widely between different publications, they estimated that, among exposed populations, manual handling could account for up to 66 % of back disorders. For psychosocial risk factors, the estimates were described as 'generally lower', although low job satisfaction levels in particular could play a major role (AF of up to 69 %). For upper extremity disorders, the estimated AFs for physical factors tended to be higher, with the lower end of the estimated ranges generally exceeding 50 %. The authors also suggested a tendency towards a greater contribution from psychosocial risk factors, with estimates exceeding 50 % in some studies for all of the factors explored.

More recently, Nambiema et al. (2020) examined the causal factors for upper limb MSDs and calculated the relative contribution to the overall incidence of these factors, in the form of partial population-attributable fractions (PSFs) based on data from 1,275 French workers. Although the range of the estimates varied considerably, the authors found that 'low social support' and 'high psychological demand' make a substantial contribution to the overall risk among men, with approximately 14 % of total cases separately attributable to the two factors. The contribution of such factors to overall risk among women was less, although it was estimated that 'low social support' had a PSF of 10 %.

1.4 The scale of the problem

Self-reported data from the European Working Conditions Survey (EWCS) (Eurofound, 2015) shows that, in 2015, approximately three out of every five workers in the EU-28 (58 %) reported MSD complaints in the back, upper limbs (including neck and shoulders) and/or lower limbs. This figure had scarcely changed from the equivalent survey 5 years before (2010), when 60 % of workers questioned reported one or more MSD complaint, suggesting that MSDs remain an ongoing significant problem. Although the figures are higher among those in more manual occupations, such as agricultural, forestry and fishery workers (69 %), over half of clerical support workers and professionals (52 %) also reported problems, indicating the widespread nature of MSDs whatever the occupational sector. The same report indicated that, in a separate survey covering just neck and back disorders, 20 % of those questioned indicated that their disorder was considered chronic. An analysis of data from 2015 indicated that women (60 %) were slightly more likely than men (56 %) to report some form of MSD, although it is not apparent if this reflects differences in the sectors (and consequent risks) that they work in, rather than indicating any gender-specific susceptibility.

Further data from the EWCS show that more than two thirds (68 %) of workers questioned in the 2015 EWCS reported that work-related stress (arising from psychosocial risk factors) was a problem in their workplace. As with MSDs, this figure was unchanged from the equivalent survey in 2010, again showing that stress at work remains an ongoing significant problem.

More recent data, accessed through the EU-OSHA OSH Barometer, show the number of establishments in which exposure to various psychosocial risk factors is stated as occurring (<https://osha.europa.eu/en/facts-and-figures/data-visualisation/osh-barometer-data-visualisation-tool>). Headline figures from the 2019 European Survey of Enterprises on New and Emerging Risks (ESENER) show that one psychosocial risk factor alone, that of 'having to deal with difficult customers, patients, pupils, etc.', was reported as present by respondents from 60 % of workplaces. 'Time pressure' was recognised as present in 45 % of workplaces.

These ESENER statistics are obtained from questionnaires administered over the telephone to interviewees at establishments. In each case, a respondent 'who knows best about the way safety and health risks are managed at their workplace is interviewed' (https://oshwiki.eu/wiki/ESENER_2019_Methodology). They therefore reflect an overall view of that organisation. In contrast, EWCS data are collated from responses given by individual workers. In relation to two specific risk factors (influence over decisions and discrimination), in the 2015 EWCS survey, a total of 53 % of workers reported that they could either 'rarely or never' (27 %) or only 'sometimes' (26 %) influence decisions important for their work. A small but important proportion (7 %) of workers reported that they had been subjected to discrimination at work in the last 12 months.

The ESENER 2019 survey did not examine individual health problems such as MSDs. However, respondents from 65 % of workplaces reported that some work in their organisation involved repetitive hand or arm movements, 61 % reported the presence of sitting for long periods and 52 % reported that some of their work involved lifting or moving people or heavy loads. This demonstrates that workers in over half of workplaces remained exposed to potential MSD risk factors. Although the manner of data collection was radically different, these statistics provide an interesting comparison with the earlier (2015) EWCS in which workers were asked about some similar issues. The answers were collated for those workers who indicated that their work involved a certain activity 'almost all the time', and 'between 1/4 and 3/4 of the time'. Taking this, 58 % of workers reported that their work involved sitting and 42 % reported that their work involved either 'carrying or moving heavy loads' or 'lifting or moving people' (which can be regarded as a heavy load). A total of 61 % of workers indicated that their work involved 'repetitive hand or arm movements'.

No statistics are available to reflect the presence of combinations of physical and psychosocial risk factors in workplaces.

1.5 Context

It is clear that both MSDs and workplace stress continue to present major problems to workers and their employers, leading to significant personal, financial and social costs. Given the recognised relationship between the two, it seems likely that their interactions further exacerbate the problem. As noted in

section 1.4, there are many different estimates of the relative contribution to MSDs of psychosocial risks, with some suggesting that they play a substantial causal role (at least in some instances) (Punnett and Wegman, 2004).

Although traditionally there has been a tendency to associate MSDs with ‘heavy’ industries and obviously physical tasks, the statistics above demonstrate that this is not an entirely valid assumption. Thus, although the overall levels of MSDs are higher among the heavier industries, a breakdown by occupation shows that, even among professional workers and clerical and support workers, more than 50 % of workers report an MSD of some form (EU-OSHA, 2019). A report from EU-OSHA (2020a) suggests that, at least in part, the growth in such occupations in recent years, coupled with an increase in the extent of health and social care activities, has offset the widespread decline in ‘heavier’ industries. The authors expressed concerns that trends towards new ways of working, with an increase in digitalisation and an expansion in remote working, have further compounded this situation. Very recently, many such trends have been accelerated by the global Covid-19 pandemic, with marked increases in the extent of factors identified by this EU-OSHA report, such as e-commerce and home-working (EU-OSHA, 2020a).

Within this contextual framework, EU-OSHA has adopted the ongoing challenge of MSDs as the focus of the current Healthy Workplaces Campaign. Adopting a holistic approach to the management of MSDs in the workplace (covering prevention and also rehabilitation and return to work), the campaign aims to foster the prevention and management of workplace MSDs, including the provision of good practice examples and the development of practical resources. Embedded within this is the need to increase awareness and understanding of the association between psychosocial risk factors and MSD problems among policy-makers, those seeking to develop advice and guidance for employers, and the employers themselves.

The review presented here has been developed against this background. It seeks to provide research evidence for the interrelation between the issues and to identify effective approaches to workplace interventions aimed at preventing MSDs that could be caused or aggravated by the exposure to psychosocial risk factors.

2 Outline methodology and search results

2.1 Research questions

Three review research questions were formulated as a precursor to the searches and literature review reported here. These were:

- What factors are involved in the association between psychosocial risk factors at work and MSDs and MSD prevention? How do these differ by sector, company size and occupation and by individual factors such as gender and ethnic background?
- Are there any models available to explain the two-way relationship between psychosocial risks and MSDs? Which of these are the main models and how do they explain this relationship? What factors should any new model address?
- What are the main intervention strategies to address the combined effects of psychosocial and MSD risk factors? Is there any evidence for their effectiveness? Is there any evidence of the awareness of these strategies and their application at the workplace level?

As noted in section 1.5, a central focus of the research was the extent to which psychosocial risk factors could be regarded as causing (or aggravating) work-related MSDs.

2.2 Database searches

Following preliminary trial searches to allow the search scope to be refined, the agreed search scope (see Appendix 1) was used to inform the development of the search strings (see Appendix 2). The search strings were then run in Google Scholar, PubMed, Web of Science and Scopus. The search strings were modified when the results of the searches produced too many papers (e.g. Google Scholar

and Scopus) that at first review were not specific enough for this review (e.g. the shorter search string was therefore used in Google Scholar and Scopus). The database search results are presented in Table 1.

Table 1: Database search results

Database	Search results
PubMed	1,335
Web of Science	1,547
Google Scholar	992
Scopus	331
Additional sources	1
Total	4,206

The 4,206 references were then exported from the databases into RefWorks, after which they were imported into the DistillerSR (Eurofound, 2015) software. Following a duplicate check, 3,402 references remained for the first level of screening.

2.3 Screening

Two steps of screening were carried out: title screening and abstract screening. The numbers of articles included after each step are presented in Figure 1 in section 2.5.

Once the duplicates were removed, a title screening form was developed and, following pilot testing, established within the DistillerSR software. Following this, the reviewers began screening the references based on the reference title. The title screening questions are presented in Appendix 3.

When the reviewer selected to retain a reference it was taken forward to the next stage of the screening. When the reviewer selected to exclude the reference, the paper was excluded and not taken forward to the next stage of the review. When the reviewer identified that they could not tell if the reference should be included or excluded (based on title) a conservative approach was taken, and the reference was taken forward to the next stage, when the abstract could be screened for relevance. By performing this level of screening we were able to identify a large proportion of the references that were clearly not relevant and which could therefore be excluded from further consideration.

Once the references for retention at the title screening stage were identified, the next stage, that of screening the abstracts, was undertaken. As with the title screening, the abstract screening form was set up and piloted within the DistillerSR software. The abstract screening questions developed are presented in Appendix 3.

In a format similar to the title screening, when a reviewer selected to retain a reference, based on its abstract, it was taken forward to the next stage. References excluded based on an appraisal of the abstract were not taken forward for further consideration. As before, if a decision was not clear from the abstract (or if there was no abstract), a conservative approach was taken, and the paper was taken forward for consideration at the next stage.

2.4 Data extraction

Because of the high volume of papers included as a result of the abstract screening process (562, see Figure 1), before conducting the main data extraction, a preliminary extraction phase was conducted.

This additional process (preliminary extraction phase) involved working through the questions presented in Appendix 3. Firstly, this involved identifying each paper's relevance and whether the study focused

on psychosocial risks and MSDs. The aim of the preliminary extraction phase was to identify a few summary details and variables that could then be used to sort and filter papers before considering the full text extraction at the main data extraction stage. The criteria identified and recorded in the data extraction spreadsheet included the following:

- psychosocial risks covered in the study;
- MSDs covered in the study;
- study design (e.g. population details, countries involved, sectors, jobs, number of papers included in review);
- aim of the study;
- main results of the study;
- whether the study was about or covered an intervention or model (and details on this, e.g. whether or not this had been evaluated).

Following the preliminary data extraction, the summary results and variables were then used to focus and agree on refinements for the remaining papers (340, see Figure 1). The agreed refinements included focusing on the following for the full text data extraction:

- reviews and systematic reviews;
- longitudinal studies;
- studies with interventions;
- papers presenting conceptual models.

These papers were considered to include the most relevant information and were seen as the core body for analysis. Subsequently, additional articles not identified in the initial searches were identified and reviewed. These were considered to include complementary information, filling any gaps in information from the core body of publications or published after the main searches were completed.

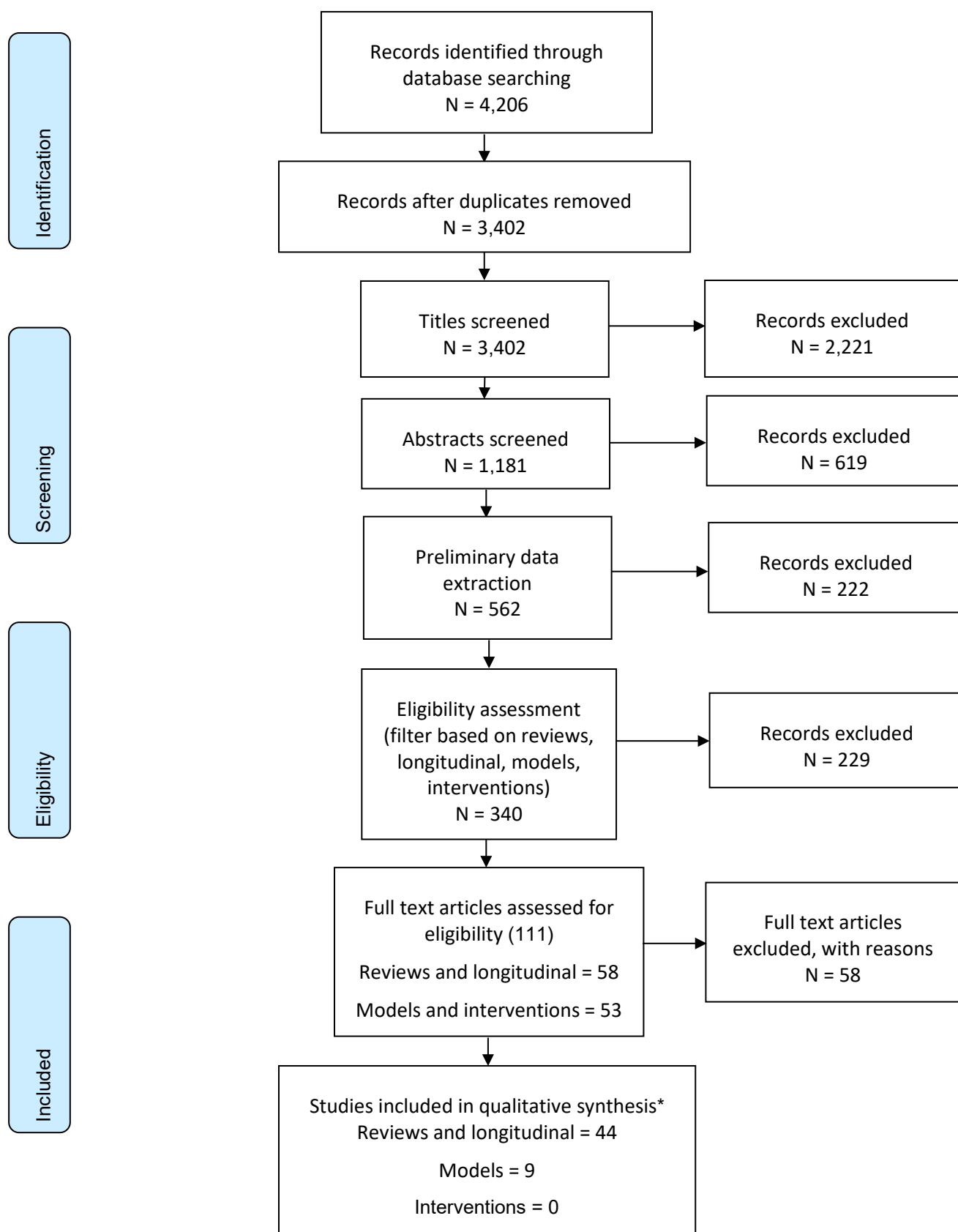
Once the references included at the preliminary data extraction stage that met the above criteria were identified (111, see Figure 1), the full text assessment and data extraction were undertaken in accordance with the data extraction template presented in Appendix 3. For the full text papers that were assessed to be included, the full data and information extraction process was undertaken. This involved extracting details on the study details, findings, intervention details (where relevant), model details (where relevant), quality assessment and additional information (see Appendix 3). For those full text papers that were assessed to be excluded, the reason for exclusion was recorded and no further data were extracted from them.

2.5 Initial summary results of the review process

After screening 3,402 papers, 111 papers were identified as the core body of available research. However, of these, 58 papers were excluded from the qualitative review for a variety of reasons. For example, some proved to be conference reports or opinion articles and did not present any original research, leaving 53 publications (24 longitudinal studies, 20 reviews, 9 models and 0 interventions) as a basis for the initial results described below. Reasons for exclusion include the focus of the paper not being on MSDs and psychosocial risks, lack of workplace context, reporting on old survey data (e.g. from the 1990s), limited power of the study and cultural differences. Figure 1 presents a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) diagram of the paper selection process (Moher et al., 2009).

As noted above, following the main literature searches, some additional papers not identified in the initial searches were identified and reviewed. Some of these were considered to include complementary information, filling any gaps in information from the core body of publications. Others were publications appearing in the literature more recently, enabling the review to be as up to date as possible. This included material relating to interventions to enable this aspect of the review to be explored.

Figure 1: PRISMA diagram of paper selection process*



*The reviews and longitudinal studies are listed together to avoid misleading duplication, as a number of papers presented work in both categories. No papers presenting formally evaluated interventions were identified.

3 Background evidence from the literature identified

3.1 Methodological challenges

One of the difficulties faced in trying to formulate coherent patterns from within the published literature is a lack of consistency between studies. This takes many forms, including many concerning estimates of exposure. Thus, some primary studies adopt direct measurement of physical variables such as load, frequency and posture; some use estimates by experts, while others rely on self-reporting by the workers taking part. Similar inconsistencies can be identified in terms of the psychosocial risk factors explored and the MSD outcome measures adopted. This issue is identified in a number of previously published systematic reviews. Although it could be argued, for example, that ‘decision latitude’ broadly reflects ‘job control’, such variations in terminology might introduce misleading variabilities in findings.

One paper (Bernal et al., 2014) illustrates this challenge, describing how studies identified variously measured psychosocial risk factors using the Karasek Job Content Questionnaire (Karasek et al., 1998), an adapted version of this, the Effort-Reward Imbalance (ERI) questionnaire (Siegrist, 1996) or the Copenhagen Psychosocial Questionnaire (Kristensen et al., 2005). Although common conceptual elements are used in framing these questionnaires, it is not always easy to determine when differences in findings might have stemmed from differences in questionnaire approach (or even wording) rather than something more fundamental. Even where some consistency in approach can be identified, some authors conflate question responses to frame the findings to reflect conceptual paradigms such as ‘demand-control’ while others present ‘demands’ and ‘control’ as separate entities. Some reviewers have chosen to address this by adopting a common terminology such as ‘job strain’. However, this composite term might mask the source or nature of that ‘strain’, which can sometimes be identified by retaining the basic risk factors.

Similar challenges arise with the outcome measures. Thus, one paper might report outcomes as ‘upper limb/wrist/hand’ (with ‘shoulder’ as a separate entity); a second might, less specifically, refer to the ‘upper limb’; and a third might choose to select a specific clinical diagnosis such as carpal tunnel syndrome (CTS) (affecting the wrist) to focus on as an outcome. Again, some reviewers have chosen to address this by combining individual (and often very different) musculoskeletal outcomes under an umbrella term such as musculoskeletal pain, regardless of the anatomical location or nature of that pain. In a further layer of complexity, studies vary considerably in the timescales over which they consider symptomatology. Thus, some take a broad perspective, such as any ‘pain over the last 12 months’, while others look for an index of chronic or persistent pain.

Some of the explanatory mechanisms presented in the scientific literature in respect of the causal relationship between psychosocial risks and MSDs are not necessarily compatible with the idea of different psychosocial influences on different MSD outcomes. Understanding the complexities of causation also requires a clear understanding of the nature and biological causation of the MSDs themselves. This challenge is addressed later in the report.

The findings presented below seek to draw common strands from such material, but differences are reflected on and acknowledged when they occur.

One theme that the review sought to explore was that of the possibility of differences between work sectors. From the extensive literature on workplace psychosocial risks (including cross-sectional studies) it is recognised that some risk factors are a particular feature of specific sectors (e.g. those that have to address a public interface) and it was considered possible that these might provide the strongest associations. Naturally, the most statistically robust outcomes are likely to emerge when there is the highest prevalence of a given risk factor among the target population. However, this may introduce a risk of bias with a possibly highly selected population for study. Some biases are readily identifiable (e.g. studies in working populations where one gender predominates) but others might be less obvious.

In practice, many of the papers sourced were review articles that tended to pool findings from multiple studies across multiple sectors. However, small clusters of studies were identified that researched specific sectors, most notably health care workers and office workers.

3.2 Risk factors contributing to the association between psychosocial risk factors and MSDs

3.2.1 The approach adopted

As noted in section 3.1, one of the challenges faced in seeking to identify consistent relationships between psychosocial risk factors and MSDs is the lack of consistency in the terminology used. This stems in part from the different phraseology adopted in the commonly used standard questionnaires. To overcome this challenge, the review grouped papers according to the more generic terms commonly adopted:

- demands;
- control;
- support (management/supervisory and co-workers);
- role conflict/lack of role clarity;
- job security;
- violence/bullying/harassment.

To these six terms the still more generic terms such as 'job strain' can be added (used here in the general sense of the term rather than the specific concept of job strain as adopted by Karasek (1979)).

The review of the evidence presented below is therefore formulated based on this grouping. Where relevant, each of these sections combines research material relating to all MSDs. The possibility of different findings emerging for different MSD outcomes was considered as part of this. However, although some occupational groups (such as office workers and health care workers) have come under more scrutiny than others (and individual papers have suggested a possible differential effect), it should be noted overall that no consistent evidence has emerged to connect different MSD outcomes with different psychosocial risk factors.

A further issue touched on, where appropriate, is the recognition that the relationship between psychosocial risks and MSDs is bidirectional. As well as psychosocial factors playing a role in the causation of MSDs, MSDs (and in particular the persistent pain and sometimes disability resulting from them) can also cause or exacerbate psychological problems such as anxiety and depression. However, although addressed at appropriate stages in this report, this latter relationship is not explored in detail.

3.2.2 Job demands

As expected, the terminology adopted in referring to 'job demands' varied between papers. While some, such as van der Molen et al. (2017), used the actual term, others referred specifically to 'mental job demands' (e.g. Bugajska et al., 2013) or 'emotional demands' (e.g. Madsen et al., 2018), or differentiated between 'cognitive demand' and 'sensory demand' (e.g. Janwantanakul et al., 2012). In total, 23 papers were identified in which a descriptive term suggestive of job demands was applied. Of these, approximately half (11) presented some form of systematic review. One feature of concern in at least one of these reviews (da Costa and Vieira, 2010) was that only papers reporting a statistically significant association were considered for inclusion, demonstrating a degree of selection bias. Thus, papers suggesting that any relationship was inconclusive would be excluded. However, this was not necessarily a positive bias, as the requirement was only for significance. Therefore, findings of a negative (protective) effect were potentially included. The concern is clearly that excluding inconclusive findings could suggest the existence of a stronger relationship than would otherwise be the case.

Not all of the reviews were comprehensive. Thus, some reviewers chose to restrict the scope of their review to a particular sector of work (e.g. Bernal et al., 2014 — nurses and aides) or to a specific MSD (e.g. Buruck et al., 2019 — low back pain).

The collected papers present a mixed picture. For example, following a review of three prospective studies on office workers, Janwantanakul et al. (2012) concluded that there was only limited evidence regarding any association between work demands (divided into cognitive, sensory and 'job' demands) and the onset of low back pain. The authors concluded that what evidence there was appeared to indicate no effect. In contrast, Keown and Tuchin (2018) concluded on the basis of their review relating

to computer users that there was significant evidence for a relationship between neck pain and two measures of job demand: time pressure and task difficulty. However, it should be noted that all but one of the papers included in their review were cross-sectional, with just a single prospective study. Interestingly, this one primary paper (Eltayeb et al., 2009), studying computer office workers, explored a variety of types of MSD (neck, shoulder). It used two subscales for what was considered to represent job demands, 'task difficulty' and 'job pressure'. From a series of multivariate analyses, task difficulty (but not job pressure) was found to be significantly associated with neck, shoulder and forearm/hand complaints. However, of the three, only the confidence interval for the odds ratio (OR) for neck complaints did not span values < 1.0 , suggesting a weaker relationship with symptoms in the other two body areas.

Probably the most comprehensive review is that of Hauke et al. (2011). Extending back earlier than the present review, this paper incorporated material from a total of 54 longitudinal studies from which material for meta-analyses was derived to investigate a potential causal relationship between psychosocial working conditions and the onset of MSDs. By analysing job demands across all body regions (43 papers), the authors determined a statistically significant positive association between high job demands and MSD symptoms. This association proved to be less certain when the data set was subdivided according to body regions. Thus, it persisted in the evidence for the low back (13 papers) and upper extremities (12 papers) but not for the neck/shoulder region (16 papers), this last finding contrasting with the positive finding for neck symptoms from Eltayeb et al. (2009) referred to above.

The extensive review by Hauke et al. (2011) was restricted to papers up to 2009. Since then, a further 11 prospective study findings have been published, although not all of these followed the convention of excluding those participants with symptoms at baseline (e.g. Dragioti et al. (2019) examined any change in the extent of symptoms rather than the emergence of new cases).

Between them, those 11 studies explored a number of different indices of psychological demand and a variety of MSD outcomes, some specific (e.g. CTS) and others more generalised. Possibly in part because of this variety, the collective picture emerging from these studies is unclear. Taking three studies that specifically studied risk of CTS as an outcome provides a good example of this. Harris-Adamson et al. (2016) reported an increase in CTS risk with an increase in 'job strain' (high demand/low control). In contrast, Petit et al. (2015) reported no significant effect of high psychological demands on CTS risk. A third paper, by Roquelaure et al. (2020), added to the complexity. These authors found no direct effect of psychological demands on CTS risk. However, such demands appeared to act as a modifier on biomechanical exposures where work pacing factors modulated psychological demands, which in turn had an impact on biomechanical constraints, although the effect was not significant.

Further demonstration of the complexity of any relationship can be found in the study by Warren et al. (2015). These authors demonstrated job-specific effects, with psychological demands having a significant effect on the intensity of upper extremity symptoms among manufacturing line workers but not correction officers (COs). This was the only significant relationship among eight comparisons of the prevalence and intensity of upper and lower extremity symptoms among these two groups of workers.

A recent longitudinal study, published since the literature searches were conducted for this report, is that of Nambiema et al. (2020); in this report risk factors for upper extremity MSDs (UEMSDs) were explored in a population sample. Although specific clinical diagnoses (e.g. CTS) were examined, the analysis is presented in terms of overall UEMSD risk. In an age-adjusted model, the results failed to show a significant association between high psychological demand and the risk of an UEMSD for the overall sample or for either gender analysed separately.

Overall, the evidence would suggest that psychological demands can have a causal effect on MSD symptoms, although it depends on how these demands are assessed and how MSD symptoms are assessed. It probably also suggests an occupation-specific effect, possibly depending on the extent of biomechanical hazards associated with a given occupation.

3.2.3 Job control

As with job demands, there is a marked variation in the nomenclature adopted, with some papers specifically referring to job control, while others refer to decision latitude, decision authority, autonomy or other terms, each of which could be interpreted as indicating a degree of personal control. In this instance, 25 papers were identified that included a job control dimension among their exposure variables, of which 10 were review articles. These reviews varied in their extent with one (Bernal et al., 2014) examining just three studies and that by Hauke et al. (2011) again being the largest, encompassing 54 studies in total (although individual analyses within this total frequently included far fewer sources). The majority of papers included a number of different occupations — often because they were based on population cohorts such as that by Roquelaure et al. (2020) — with just two occupations featured more than once.

The meta-analysis presented in the review by Hauke and co-workers found strong (and largely statistically significant) support for an adverse effect of low job control on most forms of MSDs. This was demonstrated for neck/shoulder problems, low back problems and ‘all body regions’. The exception was problems affecting the upper extremities where an adverse effect was identified but this narrowly failed to attain statistical significance. It is possible that this is, in part at least, a methodological (statistical) issue, as fewer individual estimates (five) were available for the derivation of this relationship, compared with those for other body parts (8-26 sources).

It is interesting to note that a second risk factor, low decision authority, which could be regarded as a reflection of low job control, showed a largely similar trend of significant positive relationships. In this instance, the effects for neck/shoulder, upper extremities and all body parts were statistically significant, with those for low back problems being positive but (narrowly) not significant. Most of the sample sizes were small (three or four for individual body parts) but still attained statistical significance in two out of three cases.

Bernal et al. (2014) reported on a systematic review and meta-analysis of papers studying nurses and nursing aides. This was supplemented by a paper by Lamy et al. (2014) on hospital workers. Bernal and co-workers identified 24 studies for inclusion, data from 17 of which were considered for meta-analysis. From these, data from three cohort studies were used in a meta-analysis of the association between low control (subsumed under the high demands-low control paradigm) and back pain. Each of the three studies showed a positive effect, although only two of these effects were statistically significant. Combining data from these three gave a statistically significant positive effect of high demand-low control on low back pain in the preceding 12 months.

In a slight methodological anomaly, Bernal and co-workers tabulated the ‘exposure variables’ for each of the papers cited, none of which appear to have actually included low job control as a variable. Thus, for Yip (2002) the variable cited is ‘relationship with colleagues’; for Smith et al. (2004) ‘high mental pressure’ and ‘low support’ are listed; and, according to the tabulation, Alexopoulos et al. (2003) included ‘high job demands’. It is therefore not immediately apparent where the relationship between job control and back pain was derived from.

Two reviews of studies of office workers by Janwantanakul et al. (2012) and Paksaichol et al. (2012) covered low back pain and neck pain respectively. A third paper identified (Eltayeb et al., 2009) included neck (but not back) pain and was included in the review by Paksaichol and co-workers.

The review by Janwantanakul et al. (2012), addressing low back pain, identified three prospective studies for review. However, of these only one presented findings relating to ‘influence at work’ and this paper presented limited evidence for no effect on low back pain.

The second review (Paksaichol et al., 2012) selected seven prospective studies (five scored as high quality, two as low quality) for inclusion, identifying four relevant terms: low influence at work, low decision authority, low skills discretion and low control. Each of these was only represented in one paper. Each paper presented what was regarded as limited evidence, usually for no effect of the selected parameter on the onset of neck pain. Thus, based on these limited studies, there would seem to be no evidence for an effect of low job control on the risk of either neck or low back pain among office workers.

However, according to the study characteristics of the source papers included by Janwantanakul et al. (2012), the one paper considered in reaching this conclusion did in fact identify a strong (and statistically

significant) relationship between postural risk factors and high job strain (the variable studied) and a risk of low back pain, although the effect was only apparent among female workers. This variable embraces high demands and low decision latitude (low control). Given that this is a composite variable, it is not actually possible to separate the influences of the two contributory factors.

Similarly, the conclusion of Paksaichol et al. (2012) on neck pain was based on one paper. It is interesting to note that in the paper by Eltayeb et al. (2009) job control was divided into decision authority and skill discretion, the same dimensions adopted by Hauke et al. (2011). In that latter review, low skill discretion similarly failed to attain statistical significance for neck/shoulder pain, so the two reviews are not contradictory.

The reliance of both the Janwantanakul et al. (2012) and the Paksaichol et al. (2012) reviews on just one paper suggests that their conclusions on office workers must be treated with caution.

The recent study reported by Nambiema et al. (2020) used 'low decision latitude' as a measure of job control. This failed to emerge as a significant risk factor in any of the analyses reported.

On balance, therefore, although there is an element of doubt in respect of some specific body areas, the overall conclusion remains from Hauke et al. (2011) that there can be a relationship between low job control and MSDs. The reliance of these reviews on longitudinal material allows the suggestion that this relationship is causal.

3.2.4 Support

Taking all forms of support together, in total 27 papers were identified from the literature that explored the role of workplace support in causing MSDs. The focus here was on support provided by others within the workplace (co-workers or managerial/supervisory staff) as opposed to any support that might be forthcoming from others, such as family members or friends.

Some of these papers differentiated between support provided by co-workers and that provided by managers or supervisors. However, other papers made no such distinction or used different terminology, such as the use of the term 'team spirit' by Oakman et al. (2016). Most papers, however, did make this distinction (although the exact terminology might vary), with some also presenting a combined parameter.

Twelve of the papers presented reviews, the most comprehensive of which was again that by Hauke et al. (2011), although the evaluations of specific body parts were based on fewer studies (13-20). Other large-scale reviews were those of Campbell et al. (2013) on low back pain (32 papers), Côté et al. (2008) on neck pain (27 papers), Lang et al. (2012) on various body parts (50 studies in total) and van der Molen et al. (2017) on soft tissue disorders (27 studies). Apart from that by Côté et al., the papers were more recent than that of Hauke et al. (2011) and worth examining.

Starting with the review of Côté et al. (2008), this paper adopts a very broad-brush approach to the area of neck pain at work, reporting a wide variety of parameters and not addressing any in much detail. Thus, without providing any additional detail or numerical data, the authors reported a 'preponderance' of evidence (four studies) for an association between low co-worker support and developing neck pain, although the authors do note two lesser quality papers that found no such association.

In clusters ranging in size from 13 to 20 studies, Hauke et al. (2011) found significant positive associations between neck/shoulder, upper extremity and low back pain and low social support, with the pooled data (51 studies) also showing such an effect.

The review by Lang et al. (2012) also presented findings separately for neck/shoulder, upper extremity and low back pain, additionally including lower extremity pain as a further outcome. In this paper, co-worker support and supervisor support are presented separately, with the pooled data also being provided. For neck/shoulder symptoms and low back symptoms both forms of support (and the pooled data) showed a positive effect, although, in each case, the low co-worker support parameter failed to attain statistical significance. For the upper and lower extremities only one measure (low social support) is presented, again showing a positive relationship (although that for upper extremity symptoms and low social support narrowly failed to attain significance).

A review by Campbell et al. (2013), solely on low back pain, did not present any form of meta-analysis, simply summarising the findings from each of the 20 papers selected for review. One point to note is that, despite the broad overlap in topic area, only approximately 50 % of the papers selected in this review were also included by Hauke et al. (2011) (despite falling within the time frame of that review). This review by Hauke et al. (2011) does not identify those papers included in their specific analyses for the different risk factors, but 11 studies from the Campbell review are not listed in the complete reference list and so are clearly not included.

Of the papers in the review by Hauke et al. (2011), the majority (16) are listed as providing 'no support' for a relationship between any form of workplace support and the risk of developing back pain. Of the remainder, three identified 'strong support', one 'moderate support' and two 'weak support'. One paper is identified as concluding that there was moderate support for a negative relationship. Looking at the source paper for this finding (Kerr et al., 2001), the authors found that workers who reported better co-worker support were 'somewhat more likely' to report low back pain, although this effect was not statistically significant in the final multivariate regression model. It is possible that this is, at least in part, a reporting issue with the more open working environment encouraging reporting, although this possibility was not explored in the paper.

Finally, in their review of risk factors for shoulder disorders, van der Molen et al. (2017) used data from three cohort studies to derive a meta-analysis. This provided a pooled OR very close to one (1.05), which was not statistically significant for any relationship between social support and what they termed subacromial pain syndrome (SAPS).

In this review, all three papers cited are relatively recent (2012, 2013, 2013) and were therefore not considered in the Hauke et al. (2011) review, with its cut-off year of 2009. In each case, there was no significant association between the measure of support adopted and the outcome measure. However, although referred to as a prospective study, one of the three papers included did not apparently directly follow up those involved in the baseline measurements and should perhaps be more correctly regarded as two linked cross-sectional studies (Bugajska et al., 2013). Thus, rather than report on the development (or worsening) of symptoms at a follow-up, compared with the baseline, the authors documented (and analysed) the prevalence of either clinically diagnosed upper limb disorders or complaints of musculoskeletal pain at the two measurement points. There was no consideration of individual baseline MSD status at baseline as a variable at follow-up.

One possibly important aspect of the review by van der Molen et al. (2017) is that, unlike the earlier review by Hauke et al. (2011), this review restricted the selection of studies to those in which the outcome measure (MSD) was clinically diagnosed. This feature was also a characteristic of the primary study by Nambima et al. (2020), referred to earlier. This population study also explored low social support as a risk factor for UEMSDs. In an age-adjusted model, analysing the results of the overall sample, low social support emerged as a significant risk factor for MSDs. Analysing the results by gender, low social support remained significant for men, but for women, although a positive relationship was identified, this did not reach statistical significance. In a more comprehensive multivariable model the positive relationship between UEMSD risk and low social support remained for the overall sample but not in the analyses by gender.

Despite the uncertainties over the inclusion/exclusion criteria for some of the studies included, it appears that there has been a slight weakening of the evidence summarised by Hauke et al. (2011), with this most recent paper illustrating the complexity of any relationship. It is possible that the restriction to clinically diagnosed disorders adopted by a number of these more recent studies was a factor here. As is discussed later, variability in the approaches adopted in different papers in respect both of exposure variables (both physical and psychosocial) and of outcome measures (MSDs) is undoubtedly a source of the variability in study findings. This issue will be further examined later in the present report.

The original evidence for a causal influence of poor support on the risk of MSDs is fairly substantial, being based on 13-51 studies depending on the body region. As the source papers used for this are not separately identified, it is not possible to recalculate the meta-analysis, but there does appear to have been a slight overall weakening of the accumulated evidence for a causal relationship between low workplace support and MSDs.

3.2.5 Role conflict and lack of clarity and job recognition

This category of psychosocial risk did not feature in the review of Hauke et al. (2011), nor in any of the longitudinal studies identified for review. Two papers identified included items that could be construed as indicating a degree of conflict between what an individual expected from their job and what they felt they were receiving. Thus, Lamy et al. (2014) analysed the themes from the ERI questionnaire (see section 3.2.10) from which the 'reward' element includes the theme 'perceived esteem and respect', which could be considered to reflect a mismatch between the respondents' expectations of what befitted their position and how they perceived they were regarded. In a second paper, Esquirol et al. (2017) included the term 'job recognition' (apparently addressed through a single question), which could again be seen as reflecting some form of job mismatch or conflict. In the discussion to this paper, the authors refer to the term as 'non-recognition of completed work', suggesting that it represented an equivalent concept to that of the ERI model.

The paper by Lamy et al. (2014) explored the emergence of shoulder pain among nurses and nursing auxiliaries over a 2-year period. In neither case did the perceived lack of esteem and respect demonstrate a significant difference from unity, indicating no significant difference.

In contrast, the paper by Esquirol et al. (2017), which studied workers from a variety of occupations, found a strong, positive causal relationship between a lack of job recognition and the development of chronic low back pain.

As these two studies were based on very different populations and considered different (but arguably related) terms for job recognition, it is inadvisable to draw any conclusions regarding the anatomical locations of their problems, as there are so many factors other than this that could account for differences between the two groups. Certainly, although the evidence base is not extensive, the one neutral and the one clearly positive finding can be construed in general terms as providing partial support for a potentially causal relationship between a lack of job recognition and MSDs.

3.2.6 Job security

In their review, Hauke et al. (2011) found few papers (four in total) on which to base their meta-analysis of the relationship between job security and MSDs. This was reflected in the searches for the current review in which four further papers published since their 2009 cut-off were identified. These were Lang et al. (2012) — providing a further review and meta-analysis; Bugajska et al. (2013) — presenting further original studies; Lamy et al. (2014) — presenting further original studies; and van der Molen et al. (2017) — presenting a further review and meta-analysis.

In their 2011 review, Hauke and co-workers found no papers for inclusion in respect of neck/shoulder or upper extremity problems, two for low back problems and four for all body regions. Neither of the meta-analyses conducted identified a significant relationship, with the computed effect size less than one in both cases. This is slightly at odds with the findings of an earlier review (Côté et al., 2008) that reported finding one study in which a small increased risk of neck pain was found to be associated with job insecurity. The cited paper is listed by Hauke et al. (2011) as a reference, possibly constituting the one paper they apparently identified.

Lang et al. (2012) identified data from eight papers reporting longitudinal studies for their review and analysis of the relationship between low job security and lower back symptoms. These yielded a pooled estimate of OR = 1.43, which was statistically significant.

In their multivariate analysis of data from their longitudinal study, Lamy et al. (2014) identified a positive relationship for perceived lack of job security and stability and a risk of developing shoulder pain among nurses and nursing auxiliaries, although only that relationship for nurses was statistically significant with that for nursing auxiliaries only weakly positive (OR = 1.04) and not significant.

Finally, a further review (van der Molen et al., 2017) cited one study (Bugajska et al., 2013) as demonstrating 'low quality evidence' for no increased incidence of SAPS (rotator cuff tendinitis in the paper cited) with low job security yielding a non-significant OR of 1.12.

Thus, there is at best weak evidence for a slight effect of low job security on any risk of MSDs, although the evidence is very weak and limited in scale.

3.2.7 Violence, bullying and harassment

Three papers were identified that reported on bullying or violence as potential psychosocial risk factors in respect of MSDs. The first of the two prospective studies (Kääriä et al., 2012) considered bullying as part of a study of the development of chronic neck pain among 'middle-aged' (40-60 years) municipal employees (encompassing over 200 different occupations). The initial sample was 5,277 employees who were free from chronic neck pain at baseline, with the follow-up 5-7 years later. Participants were asked about bullying 'now'; 'earlier at this workplace but not now' and 'earlier at a different workplace'. It is not clear whether a different workplace constituted a different employer or just a different place of work. All three measures demonstrated a significant positive effect of bullying on the development of chronic neck pain among women but not among men. The authors speculated that this gender difference might be explained by differences in occupational grouping, with men more likely to be in managerial and professional roles. No breakdown of the mix of occupations is presented. It is noted that, in the univariate analyses for men, bullying 'now' or 'earlier at a different workplace' did show ORs greater than 1.0, although the confidence intervals were very wide and the values not significant.

A second paper (Glambek et al., 2018) was a smaller scale study drawn from the general working population (1,003 participants). Unlike the earlier research this study did not exclude those with MSDs at baseline but explored the change in extent of back and neck pain over time (with a 6-month interval) and any association with bullying. In this case, bullying was the specific focus of the study, rather than being one of a number of psychosocial factors examined.

The authors found that exposure to workplace bullying behaviours reported at baseline 'contributed significantly' to subsequent MSD pain reports (covering the neck, low back and upper back). However, contrary to the authors' expectations (and in contrast to the previous paper), the effect was only shown among men. No data are presented to allow the extent of exposure to bullying to be assessed. The authors note that women appeared to report much higher levels of MSD pain at baseline, with the implication that this initially high level might have masked any effect due to bullying. As the study sample was drawn from the general working population, it was not possible to explore possible differences in work characteristics that might account for the difference.

In an apparent reversal of this pattern, a third paper (Madsen et al., 2018) found the risk of violence to be significantly associated with musculoskeletal pain in women but not in men. In this case violence was not the specific focus but just one of a number of parameters explored. Interestingly, the finding appeared to be relatively robust in that it was shown whether any risk was determined through individual reporting or through a job exposure matrix, in which a risk exposure was assigned to a particular job title by the researchers. As with the previous paper, the study cohort was again selected from a population sample but with a very differently defined MSD outcome measure.

With three very different papers it is difficult to draw any detailed conclusions. However, it appears that exposure to bullying can contribute to the development of MSD pain, although clearly the relationship is complex and the role of gender in particular is unclear.

3.2.8 Sector, company size and occupation

With most of the prospective studies being drawn from population-based samples, there was very little evidence on which to base firm conclusions regarding variations between different employment sectors, sizes of company or specific occupations. In the preceding sections, reference is made in some instances to the limited collation of material from some sectors/occupations, most notably office workers, computer users and nurses.

Warren et al. (2015) reported on a comparison of MSD symptoms between COs (prison staff) and manufacturing sector employees. The latter sample was drawn from 'manufacturing line' employees from three jet engine repair centres. Details of the nature of the work of the latter group are not provided and, given the description used of 'repair centres', it is possible that they were not engaged in primary manufacture. The study was conceived as a longitudinal study. However, as the manufacturing company withdrew before the longitudinal data could be collected, the results presented are drawn purely from the baseline data. Response rates were relatively low, with 39 % of COs and 30 % of manufacturing workers responding. Observational data on working postures indicated marked differences in exposure to adverse postures between the two groups, although no statistical analyses are presented. Although

the general outcome from the data were that MSD symptom levels were a function of both biomechanical and psychosocial factors, there was no consistent pattern to this between the two job types, other than the fact that job tenure for COs appeared to be a significant driver for both biomechanical and psychosocial exposures, leading to the conclusion that a career in the prison service can be quite costly to COs' physical and mental health.

No other longitudinal studies were found that presented any comparisons between sectors or occupations in this manner. Although some studies in single industries were identified, the absence of any comparators makes it impossible to derive a realistic picture of the relative risks in different sectors or occupations.

As noted previously, the nature of the type of study meant that those carried out in individual companies tended to be drawn from larger employers in order to provide an adequate sample size for any statistical analyses. Although some studies (e.g. Garg et al., 2012) were found in which the sample was drawn from a number of companies (in this case, 10 sites from seven employers, giving a total of 672 participants), company size did not feature in any analyses. In some cases, smaller companies were specifically excluded. For example, in the study reported by Lamy et al. (2014), workers were only included in the study if their work unit employed at least 20 nurses. Thus, it is not possible to derive any relationships between psychosocial risks and MSDs based on company size.

3.2.9 Impact of demographic and individual factors

▪ Gender

Section 3.2.7 presented a somewhat mixed picture of any relationship between gender and connections between the risk of bullying and MSDs, suggesting that there was no consistent pattern of susceptibility due to gender. A number of papers (e.g. da Costa and Vieira, 2010; McLean et al., 2010; Paksaichol et al., 2012), reported an influence of gender as a risk factor for specific MSDs but did not report on any gender specificity in any relationships between those MSDs and psychosocial risk factors.

One of the limitations of the inclusion of gender as a variable in some studies is that, especially where the study relates to a specific group of workers (as opposed to population studies), there might be a gender bias in the nature of the work undertaken. Thus, where hierarchical relationships occur within an organisation, any apparent gender differences might reflect this hierarchy rather than the gender variable.

Bearing in mind this potential limitation to any findings, some instances of gender-specific effects have been identified. A paper by Hooftman et al. (2009) specifically explored the possibility of a gender difference in the effect of psychosocial risk factors on MSDs. The participating cohort of workers was drawn from 34 companies. However, it should be noted that there were marked variations in the representation of female workers within these companies. Thus, approximately 60 % of the companies had less than 25 % of women in their workforce, while 25-30 % of companies had more than 75 % of women in their workforce (the balance falling between). In total, there were approximately two men per woman within the overall cohort.

The results from the study appeared to show that men were more susceptible to any risk of developing MSD symptoms from exposure to psychosocial risk factors. All of the psychosocial factors studied (psychological demands, skill discretion, co-worker support, supervisor support and job satisfaction) showed a significant positive relationship with the risk of low back symptoms, while for women such an effect was only apparent for supervisor support. Although the effects were less apparent for relationships with neck symptoms and shoulder symptoms, the pattern of stronger connections for men remained. No such patterns were apparent for arm/hand symptoms.

Studying just shoulder problems (defined as pain with or without a clinical diagnosis of rotator cuff syndrome — RCS) in a randomly selected population-based sample, Bodin et al. (2012) also found stronger effects for men than women, although the effects were usually not consistent across the two diagnostic categories. Thus, for men, high psychological demand and low skill discretion emerged as significant factors for shoulder pain with RCS, but low supervisor support was significantly associated with symptoms without RCS. For women, this last risk factor of low supervisor support was the only psychosocial risk to emerge as significant, but it was a significant factor for both diagnostic groups.

Herin et al. (2014) found gender to be a significant factor in the case of elbow, forearm or hand pain alone (but not for neck/shoulder pain, low back pain or hip, knee or foot pain), with female workers showing a significant association between this pain and the two psychosocial factors studied, namely psychological demand and decision latitude. No other significant associations were identified for women (and none for men). When the data on pain at individual sites were merged, a significant association was identified for females between both psychological factors and pain at three or four sites ('multisite pain'). As before, no other significant comparisons were made.

Unlike this paper, where there were indications that females were more susceptible than men to the influence of psychosocial risks on at least some MSD pain, Fanavoll et al. (2016) found that men display a greater susceptibility. Thus, work stress (but not poor job control) was positively associated with the risk of chronic neck/shoulder pain in both women and men, but the effect was greater in men than women. This study clustered the participants into four categories reflecting the extent of exposure to perceived work stress (not at all, rarely, a certain amount, almost all the time) and this analysis appeared to suggest a dose-response relationship, with the risk of developing musculoskeletal pain increasing with an increased extent of exposure.

In addition to the threat of violence in women reported earlier, Madsen et al. (2018) also reported gender to be a significant source of variation in the association between decision authority and musculoskeletal pain, but only for men (with an increase in such authority associated with a decreased level of pain).

In a similar vein, the results from a meta-analysis of studies reported by Buruck et al. (2019) suggested that the identified negative relationship between chronic low back pain and skill discretion (increases in skill discretion leading to a decrease in pain risk) was strengthened with increasing number of men in the samples.

Finally, in a recently published systematic review and meta-analysis of 21 longitudinal studies, Amiri and Behnezhad (2020) found job strain to be a significant risk factor for musculoskeletal pain, with the effect significant for both men and women but stronger among men.

On balance, the accumulated findings from these various studies would suggest that men were possibly more susceptible to an increased risk of MSDs arising from psychosocial risk factors than women, although the detailed results demonstrate a complexity of that relationship, suggesting the reality to be a complicated and complex picture.

▪ Age

Numerous studies have shown age to be a significant risk factor for a wide variety of MSDs and MSD symptoms. For example, Bodin et al. (2012) showed length of service to be a significant risk factor for shoulder pain with or without RCS, while Herin et al. (2014) found age to be a significant risk for pain in most (but not all) anatomical locations studied.

At least in part, this association is likely to be because many MSDs and their symptoms arise from age-related degeneration in muscles and associated structures (Graveling, 2019). However, in a work context it is not always possible (and certainly not easy) to separate the effects of the ageing process from time spent in the job with the increased exposure to both physical and psychosocial risk factors that usually entails. However, other factors such as selection bias in career progression and the well-established differences in the retention of female workers in the workforce (e.g. Brough and Frame, 2004) will often co-vary with age. Because of this recognised relationship, age is often controlled for in studies (e.g. Bugajska et al., 2013; Fanavoll et al., 2016), rather than being analysed as a variable.

A few exceptions can be identified, however. In a study especially designed to explore the contribution of age to risk, Oakman et al. (2016), while acknowledging the complexities of any apparent influence of age, found that the psychosocial factors that predicted MSD risk varied with different age groups. The study made some allowance for the potential influence of other age-related organisational factors by including a classification of subjects into blue- or white-collar job categories and including this as a covariable in the analyses. The study found that workplace culture was negatively associated with MSD risk among the youngest age group (20-35 years) but not in the older age groups (36-49 and over 50 years), with younger workers who perceived a poor workplace culture more likely to report increased MSD risk. For midlife employees, none of the psychosocial hazards were significantly related to MSD risk after taking into account other variables included in the study. For older workers, job satisfaction

was predictive of MSD risk, but not in the expected direction, with high job satisfaction associated with increased MSD risk. The authors point out that not all psychosocial factors were included in the study and that other factors (such as job demands) might act as moderators influencing some of these findings.

Published the following year, Oakman et al. (2017) analysed risks for the development of musculoskeletal pain (MSP) for four (smaller) age groups: 45-49, 50-54, 55-59 and 60-64 years. According to the authors, no clear age pattern of predictors emerged, with the exception of social support, which was associated with MSP in all age groups except the oldest. The authors suggest the existence of what could be regarded as a survivor population, with those over 60 years old less reliant on the support of others. This view was reinforced by the isolated relationship for low autonomy, which was a significant predictor of MSP only for this age group.

Finally, Buruck et al. (2019) addressed the question of whether or not the association between psychosocial factors and MSD changed with age in their meta-analysis of 18 papers. The authors analysed the impact of age (and other selected factors) as 'moderators' of the relationship between psychosocial risks and MSDs. Their analysis found that mean age did not significantly moderate any effect of workload, 'job control-combined' or 'job control-decision authority'.

As with many other factors, the impact of age on the causal relationship between psychosocial risk factors and MSDs appears to be complex and complicated. There is no consistent evidence for any influence of age on any relationship between workplace psychosocial factors and MSD risk, and it should not be assumed that older workers are any more (or less) resilient than their younger colleagues in this respect. Although in some instances there might be some form of 'survivorship', with those remaining in a job having developed individual coping mechanisms, this is pure speculation and there is little consistent evidence to support this.

▪ **Ethnicity and culture**

There appear to be cultural differences in the development of MSDs. In a major cross-sectional study across 18 countries, Coggon et al. (2013) found marked differences in the prevalence of two forms of MSD (disabling forearm and back pain) among workers carrying out apparently similar tasks that could not be fully explained by factors such as socioeconomic differences or workplace variables (including psychosocial factors).

Three primary longitudinal studies were identified for the present review in which ethnicity was identified among the study population. The remainder of the papers were predominantly conducted among European populations, presumably reflecting the ethnic mix within their respective populations. It is possible that ethnicity was reflected in specific job categories in some instances (where ethnic minorities might be expected to be over-represented) but this was not formally studied.

Of the three primary studies identified, two (both US based) reported ethnicity as a demographic variable but did not use it as a variable in any analysis (Warren et al., 2015; Harris-Adamson et al., 2016). The third study, by Jun et al. (2020), was deliberately constituted to examine cultural (ethnic) differences with the study encompassing office workers in Australia and South Korea. It was noted that the study was conducted against a background of increasing levels of depression and anxiety disorders in South Korea but a stable prevalence of such disorders in Australia. Workers identified as free from neck, shoulder or back pain were recruited. It was a requirement that they worked at least 30 hours a week and that more than 20 of those hours involved computer-intensive work.

A total of 220 workers were initially recruited (158 in Australia, 62 in South Korea). As a result of losses or incomplete data, 214 (156 in Australia, 58 in South Korea) remained for incidence analysis and slightly fewer (191 in total; 139 in Australia, 52 in South Korea) for risk factor analysis. A total of 39 MSD incident cases (27 in Australia) emerged in the 12-month follow-up.

An overall analysis (merging both subsets) found that high job strain and psychological stress were associated with an increased risk of developing neck pain. Higher levels of control, coping and social support had a moderating effect, countering these adverse influences. Although the level of job strain was higher and the level of physical activity was lower among the South Korea subgroup (both identified in the main analysis as influencing the incidence of neck pain), there was no difference in the incidence of emerging neck pain between the two groups. Thus, despite apparent differences in work and work

factors between the two cultures, the authors concluded that their findings appeared to be generalisable across the two cultures.

There were, of course, many differences between the two subgroups other than their ethnicity, reflecting differences between the South Korean and Australian social and work cultures. Nevertheless, this study provides at least preliminary indications that culture/ethnicity alone does not lead to any particular vulnerability to the influence of workplace factors (physical and psychosocial) on the development of neck pain.

3.2.10 Integrating constructs

In examining the relevant research literature, one factor to emerge is that researchers often applied integrating constructs to the evidence regarding exposure to psychosocial risks. There appears to be some evidence that such constructs can provide a stronger index of the influence of psychosocial factors on any risk of MSDs than the inclusion of the individual factors; this can sometimes present a somewhat confused picture.

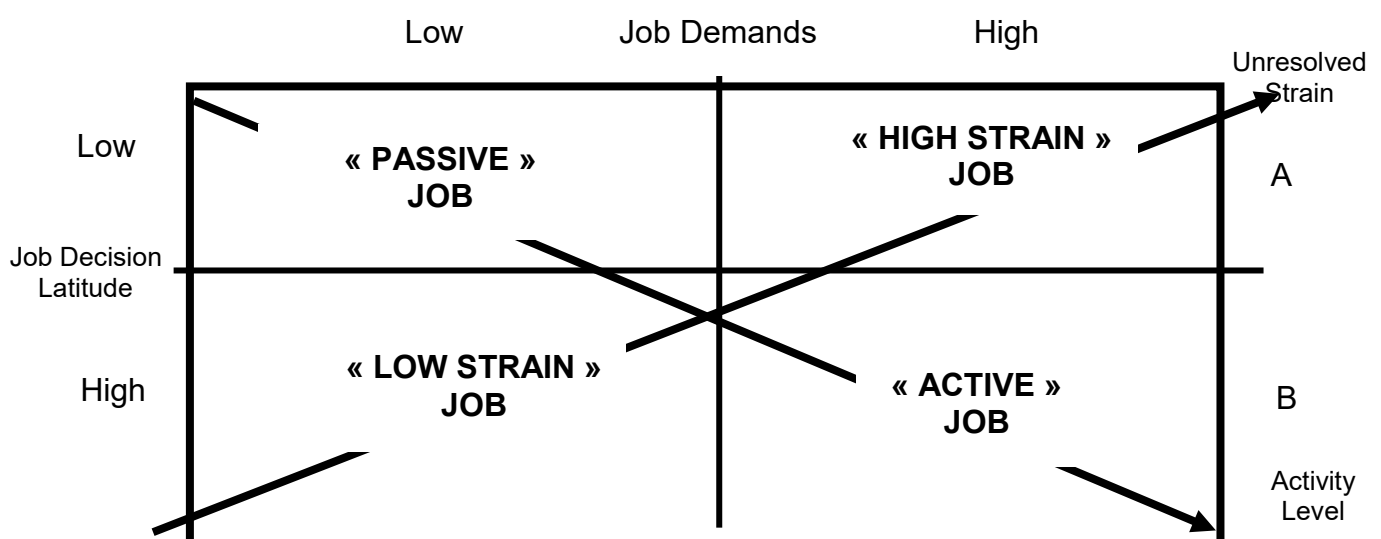
One likely reason for this is that, as noted earlier, there is evidence to suggest that some psychological factors at least can function in both a negative and a positive sense. Thus, for example, while inadequate support can add to the negative psychosocial burden, good support (from co-workers or managers) can have a positive influence. In this case this is not simply the absence of the negativity but a positive contribution to overall psychosocial well-being. Logically, it seems reasonable to suggest that, in the same way as how the overall risk presented by physical risk factors is a function of the integrated impact of those physical factors (such as force, frequency and posture), the net impact of psychosocial factors on well-being (both physical and psychological) will be a function of their integrated influences.

In studying the role of psychosocial factors on the risk of MSDs, some studies have accommodated these positive elements by including those factors as 'moderators'. More usually, however, as noted above, an integrating construct is applied by the researchers. The two most commonly used are the Demand-Control Model (DCM), first postulated by Karasek (1979), and the ERI model, presented by Siegrist (1996).

▪ Demand-Control Model

In presenting the DCM, Karasek drew attention to the apparent paradox whereby groups of workers could apparently be exposed to similar levels of what was termed 'job stress' or 'job demand', but those levels seemed to have a markedly different impact on aspects of their health and well-being. The author suggested that this could be explained by different levels of control, or 'job decision latitude', and presented data to support this suggestion. The relationship between demand and control was illustrated by a seemingly simple job strain model, presented in Figure 2.

Figure 2: Job strain model (from: Karasek, 1979, with permission).



The model reflects two axes, presenting job demands on the horizontal axis and job decision latitude on the vertical axis. This then divides into four quadrants reflected as low decision latitude and low job demands (characterised as a 'passive' job); high decision latitude and low job demands (a 'low strain' job); high decision latitude and high job demands (an 'active' job); and low decision latitude and high demand (a 'high strain' job). It will be seen that increasing both job demands and decision latitude lead to a highly active job but that increasing job demands while decreasing job latitude leads to what is termed 'unresolved strain'. Since this relationship was postulated, numerous studies have provided support, and it is now widely recognised that creating highly demanding jobs in which the worker has little control or decision latitude over how that job is performed often leads to adverse health impacts, while permitting workers greater control can often help to mitigate what would otherwise be regarded as highly demanding 'stressful' jobs.

Many of the papers referenced previously, in sections 3.2.2 and 3.2.3, used the DCM, often through the determination of the Job Strain Index (calculated by dividing the 'score' for job demand by that for job control). Frequently the variable scores are determined through the application of the Job Content Questionnaire (JCQ) (Karasek et al., 1998). As well as enabling the determination of the Job Strain Index (JSI) (through the decision latitude and psychological demands subscales), the JCQ incorporates a third subscale: social support, enabling the determination of a further potentially moderating influence on the overall impact of the psychosocial environment.

Not all papers that used the JCQ used it to calculate the JSI, with some (e.g. Nambiema et al., 2020) retaining the scores for the three subscales in their analysis. In contrast, Zamri et al. (2020) directly applied the model quadrants, presenting their analyses in terms of 'low job strain — high social support', etc. This latter study presented the results of an exploration of risk factors for low back pain among teachers. The sample population did not exclude those free from low back pain at baseline, although presence or absence of low back pain at baseline was included as a variable in some models. It was noted that the proportion of participants with low back pain at 'follow-up' (6 or 12 months) was higher among those who had low back pain at baseline. Interestingly, using these quadrant-based criteria, the study did not find any significant associations between any of those considered and low back pain at follow-up (although individual psychological aspects such as anxiety were significantly associated with low back pain at 12 months).

It is important to note, however, that, although the JSI is of value for analytical purposes, in analysing the JCQ in the workplace it is desirable to retain details of these individual parameters to understand those aspects of the psychosocial environment that are likely to be having the most impact on the JSI. This information can then be used in devising ameliorative action.

▪ **Effort-Reward Imbalance**

An alternative perspective to the DCM is provided by the ERI model developed by Siegrist (1996). A study by Lapointe et al. (2013) computed cross-correlations between components of these two models and concluded that they did appear to reflect different dimensions of the psychosocial work environment.

As the name suggests, the ERI seeks to reflect a balance between the perceived effort involved in engaging with a job and the perceived rewards from doing so. It is based on the hypothesis that the potentially negative impact of high job demands can, at least in part, be offset by a high level of perceived reward. In this context, 'reward' is not necessarily a tangible benefit such as financial remuneration but can also be derived from a sense that a job is valued and worthwhile. Some elements of job satisfaction probably also contribute to this sense of 'a job well done'.

The original version comprises 23 questions subdivided into three subscales, although some authors have used a 17-point version in which the six questions on the third scale (over-commitment) are not included, leaving 6 effort items and 11 reward items (these latter items can be further subdivided into 'esteem'; 'job promotion' and 'job security'). Although scores from the different dimensions can be used separately, a commonly used parameter is the effort-reward ratio through which the balance between these two aspects is assessed. Naturally, excessive effort for low rewards (resulting in a high ratio) would be regarded as adverse (with values being adopted as 'good' (> 1) or 'bad' (< 1)).

A systematic review specifically focused on studies that adopted the ERI model was published by Koch et al. (2014). The majority of studies selected for review in that paper were cross-sectional. However, three of them were prospective studies and their contents are summarised here.

Chronologically, the first of the three prospective studies identified by Koch et al. (2014) is that by Rugulies and Krause (2007), who used the ERI in a study of low back and neck injuries among San Francisco transit operators. Injuries were included when they had been accepted within the formal compensation process and assigned a valid disease code (ICD-9). For both low back and neck injuries such codes could be assigned for injuries as diverse as non-specific soft tissue injuries and discrete serious disorders such as vertebral disc damage. An ERI ratio was calculated as the ratio between the mean effort score and the mean reward score.

An increase in the ERI ratio (+1 SD, or standard deviation) was associated with a significant increase (13 %) in the risk of low back injury. This increase appears to have been mainly driven by the more severe injuries as, when the total injuries were divided into 'more' or 'less' severe, the relationship remained for the more severe injuries (23 %). Although an increase was also identified for the less severe injuries, this association was no longer statistically significant. For neck injuries a slightly different picture emerged. Total injuries and the less severe injuries demonstrated a significant relationship with ERI. However, the relationship between the more severe neck injuries and the ERI failed to attain statistical significance.

The authors postulate that this relationship could be explained by the effects of an increase in ERI generating an increase in hormonal activity and automatic nervous system activation leading, in turn, to an increase in muscle activity and tension, resulting in an increased risk of pain and injury. In a slight variation to this hypothesised mechanism, the authors also suggest that increased cortisol levels might increase muscle vulnerability (i.e. render them less tolerant of loading and therefore more susceptible to injury).

A second longitudinal study cited was that of Krause et al. (2010). Unlike the first study, which adopted onset of injury as its criterion, this study explored an increase in muscle pain (i.e. it did not restrict the study to those free from pain at baseline). This study also used a very different study group, namely call centre computer operators. In a further complication, the study participants also received one of four ergonomics interventions across the duration of the study (although a period of at least 8 weeks was left after the intervention period before 'post' measures were obtained).

The results showed no relationship between neck/shoulder pain and the ERI ratio. The ERI ratio did significantly predict change in right upper extremity pain, but failed to show any relationship with pain in the left upper extremity. Handedness was not explicitly documented in the tabulation of subject characteristics, although the text subsequently refers to 92 % being right dominant and 98 % using this as their mouse hand (although a few subjects (8 %) reported a discordance between handedness and mouse use).

Interestingly, these authors offer a different physiological mechanism to account for the associations identified, namely one of reduced oxygenation and interference with muscle relaxation. Importantly, the authors controlled for variations in physical characteristics of the work and the working environment.

The authors of the third prospective study (Lapointe et al., 2013) also carried out their research among computer users. Subjects were required to be symptom-free at baseline in the body region analysed, although this did not preclude them from having MSD symptoms elsewhere. The ERI ratio was used to define those considered 'high risk' (ERI > 1.0) and 'low risk' (ERI < 1.0). Interestingly, the authors also recorded parameters reflecting the DCM (demands and decision latitude) and social support. As noted previously, before detailed statistical analyses the ERI and demand-control construct data were analysed for cross-correlation and were found to have generally low correlations (except for those items reflecting effort/demand in both sets of data), suggesting that they generally reflect different aspects of the psychosocial environment.

The results showed a significant influence of ERI on the shoulder/neck and the upper limbs for women, but, although the results were suggestive of a relationship, the association between ERI and symptoms in the low back was not significant. No such relationship was found for men for any body part.

The authors do not present any particular hypothesis to account for this gender difference, although they note that gender-specific dissimilarities in susceptibility to different risk factors have been reported elsewhere. Interestingly, they cite an earlier study among the same cohort in whom demand-control variables were explored (Lapointe et al., 2009). In this earlier prospective study, interactions between physical and psychosocial factors were identified for both men and women. No major gross differences

in postural risk factors are apparent between men and women. However, on examination of the baseline characteristics, it is noted that, for men, roles in managerial or professional categories predominate, while women tend to be more represented as technicians or office workers. It is possible therefore that differences in job characteristics are making a contribution in some way, although this is pure speculation.

Whatever the detailed variations between the different studies, it appears that the effort-reward paradigm reflects a different dimension to that of demand-control and that both should ideally be considered in any exploration of psychosocial risk factors.

3.2.11 General comments

As noted above, there is clear evidence that psychosocial risk factors play a causal role in the development of MSDs in the workplace. However, it is equally clear that there is no consistent pattern to this relationship. The associations between psychosocial risk factors and MSDs identified in the research literature are many and varied, and it is not possible to identify more consistent patterns or to relate particular risk factors to specific MSDs. However, this is not unexpected and should not be regarded as undermining the strength of the general relationships that have been identified. With physical risk factors, such as the weight of objects, the frequency with which objects are handled and the postures adopted in handling some objects, not all factors apply at the time. An equivalent study of physical factors in, for example, the electronics assembly industry, would not be expected to identify the weight of the items being assembled as a significant risk of causing upper limb disorders. Logically, therefore, if 'control' does not emerge as a contributory psychosocial risk factor in a given workplace, this does not invalidate control as a potential risk in any workplace.

As acknowledged in papers such as that by Roquelaure et al. (2006), one of the key challenges in epidemiological studies lies with the quantification of exposure. The majority of the studies included in this review used self-reports of exposures to physical risk factors. Spielholz et al. (2001) reported on a systematic comparison of three approaches to exposure estimation for such factors: self-report, video observation and direct measurement. The study reported that self-estimation tended to overestimate physical exposures, although this variation was not consistent between different factors. A further complexity is that estimates of exposures tend to use a single parameter (e.g. perhaps classifying forces as 'high', 'medium' and 'low') and do not therefore reflect the complexity of exposure that might influence the extent of any injury risk. Finally, especially in respect of studies conducted within a specific workforce, the range of exposure might be relatively limited, meaning that studies often lack the sensitivity to differentiate any effects between different levels of exposure.

The picture is even more complicated in relation to psychosocial rather than physical factors because, in some instances, a psychosocial factor can in fact be protective. This idea is embodied within the well-established demand-control concept, which recognises that the potentially adverse effects of high demand can be offset by high levels of individual control. Similarly, it is widely recognised that strong positive support (from co-workers or managers) can potentially offset, or at least diminish, the otherwise adverse effects of other factors, such as high demand or role conflict.

As a further example, practical experience from unpublished fieldwork by the authors indicates that, to a large extent, the potentially stressful impact of a lack of control can be offset by worker expectations. If workers know (and therefore expect, and perhaps accept) that the role they play is subject to firm directions and control (e.g. with some call centre workers), then this has less of an adverse effect than might otherwise be expected. However, this apparently only applies where workers are able to exert freedom of choice over their employment. Where job opportunities are limited, workers can be forced to accept a greater degree of control by others than they consider acceptable; this serves to enhance the potentially adverse effect. Clearly, where there is little or no choice over employment options then, to use a metaphor, there are, of necessity, far more 'square pegs in round holes'. It could also be suggested that, when work is scarce, individuals are less likely to complain about aspects of their work.

This attitude can apply at a cultural level. For example, in some cultures the idea of a rigid working day is seen as the norm, with no expectations of flexibility or freedom. In such cases, the absence of personal control is therefore less likely to be regarded in a negative light.

There are some risk factors that are never acceptable. Violence (threatened or actual) and psychological or sexual harassment (bullying) are never acceptable, although, even here, their impact can be diminished (but never excused) by other factors such as strong support.

This overall situation creates a complex and what can sometimes be a confusing picture. However, this should not be regarded as an excuse for inaction. Chapter 5 of this report identifies the elements of a clear strategy that should enable employers to work together with their workers to identify any risk factors in their workplace and to take steps to remove or manage those factors to minimise the risk they pose to physical and mental health and well-being.

4 Conceptual models explaining the relationship between psychosocial risks and MSDs

4.1 Introduction

The relationship between physical, organisational, psychosocial and individual risk factors in the development of MSDs is complex. Much work has been undertaken to try to understand how these different risk factors relate to each other and to the development or reporting of MSDs. As has been explored in Chapter 3, the relationship between physical, organisational, psychosocial and individual factors has been examined in many studies, but the research varies widely in its scope, making the development of models that are generic and applicable to all occupational situations very difficult. Some of the main ways that these studies (and the models arising from them) vary relate to:

- **Definition of MSDs.** MSDs are usually quantified through subjective reporting of discomfort. As well as the scope for cultural and psychosocial factors affecting an individual's reporting of discomfort, studies also vary in their definitions of what constitutes an MSD (i.e. how significant does the pain/discomfort/impairment have to be before it is considered an MSD). Many definitions also vary in the duration over which the individual has experienced the symptom before it is classed as an MSD (typically somewhere between 4 weeks and 1 year). Some studies focus on a specific condition (e.g. CTS) while others focus on reports of discomfort, without requiring a specific diagnosis. There is also a range of ways that information on body discomfort is collected, although the Nordic Musculoskeletal Symptoms Questionnaire (Kuorinka et al., 1987) is most frequently used (often with some adjustment). In addition, studies vary in the body parts they focus on, with some focusing on only one body part and others on several.
- **Definition and scope of psychosocial risk factors.** As discussed in Chapter 3, studies vary in the psychosocial factors they focus on, making it harder to create generic models. In addition, various different tools (typically self-completed questionnaires) are normally used to measure psychosocial risk factors. Although standard tools are often used, some studies adapt these by adding an extra source of variation.
- **Physical risk factors.** Although some studies have adopted more objective approaches, the physical risk factors in many studies are usually quantified by self-report (i.e. a subjective report by the respondent of whether or not particular postures/forces are adopted in the workplace, and how frequently), and a value of physical risk is ascribed to this. Again, the reporting used is often not standardised between studies and, as discussed in section 3.2.11, this approach has recognised deficiencies.
- **Population.** The individuals recruited into these studies are also often restricted to a particular occupation, gender, geographical region or size of organisation, meaning that the findings may not be applicable to other populations.
- **Individual factors.** Studies vary in the individual factors that are reported (e.g. age, gender, body mass index — BMI, educational achievement, etc.). It is therefore difficult to take account of all of these in a model.

Many published studies are also cross-sectional, allowing associations to be made, but fewer are longitudinal, allowing causation to be considered.

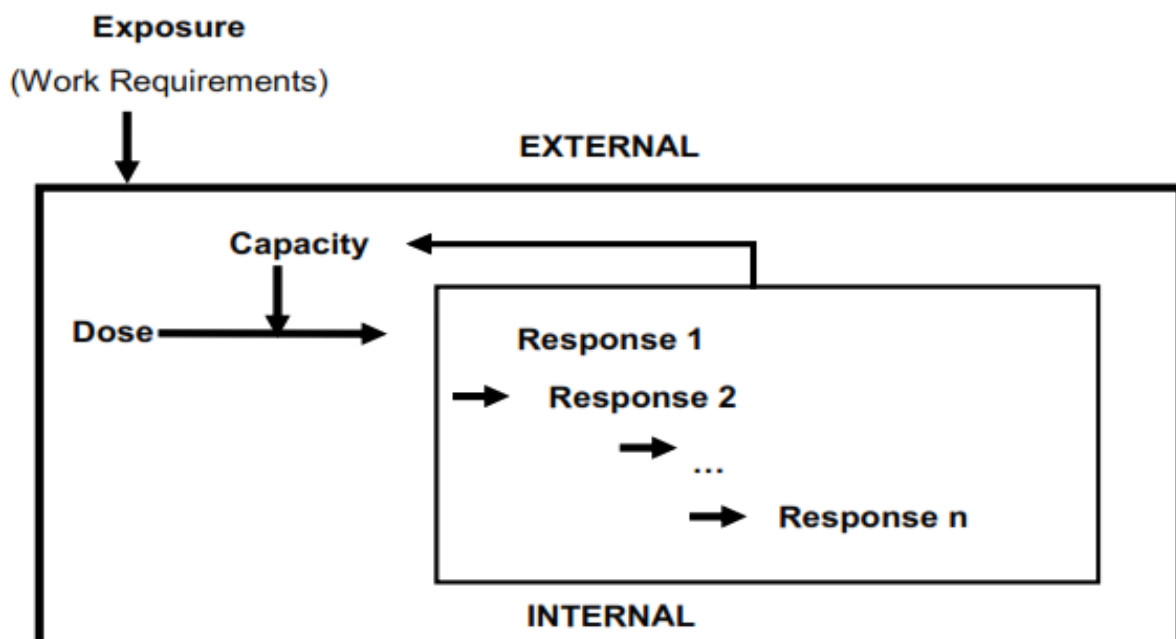
Against this background, and in an attempt to visualise the complexity of the relationships between physical and psychosocial risk factors, perhaps as a guide to understanding the mechanisms and causal pathways, a number of conceptual models have been developed. A number of these are presented below. This overview is not intended to present all published models but rather to present how the models have progressed and developed. It is not possible to present these as demonstrating a chronological progression of ideas and detailed interrelationships. Different research groups have largely acted independently, perhaps reflecting their own views and concepts regarding what is a complex area of science. However, some progressions of ideas can sometimes be seen within a group (e.g. in the research team that includes both Julie Bodin and Yves Roquelaure). One key distinction between some models is that not all include the two-way relationship between psychosocial factors and MSDs, whereby having an MSD can have psychological outcomes.

4.2 Overview of models

4.2.1 An important early model

One early high-level conceptual model, developed by an international group of researchers, is that presented by Armstrong et al. (1993), shown in Figure 3. This model does not present specific risk factors but introduces the important concept of the iterative nature of dose and response. Exposure to external work requirements leads to an effective 'dose' acting on the individual. Moderated by individual capacity, this leads to a response (response 1). One of the consequences of this response is that it feeds back to influence individual capacity, acting as a moderator for subsequent responses (response 2) and leading to an iterative cycle of continuing exposure, dose and response that is moderated by, and subsequently moderates, capacity. The authors propose that, in time, these cycles of responses can lead to impairment (diminished capacity to respond) or enhancement (increased capacity to respond).

Figure 3: Early conceptual model of the circular connectivity between dose and response (from: Armstrong et al., 1993, with permission).

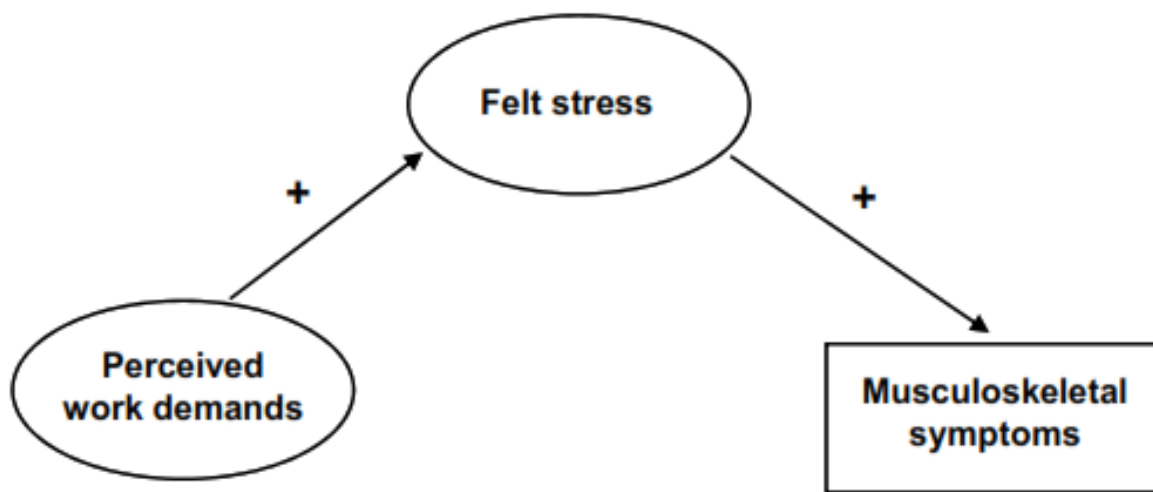


4.2.2 Psychosocial risk factors mediated through a stress response

Some models (e.g. Eatough, 2012; Golubovich, 2014; Maimaiti et al., 2019) propose that psychosocial risk factors (e.g. organisational factors) are mediated through a stress response in the individual, which contributes to MSDs.

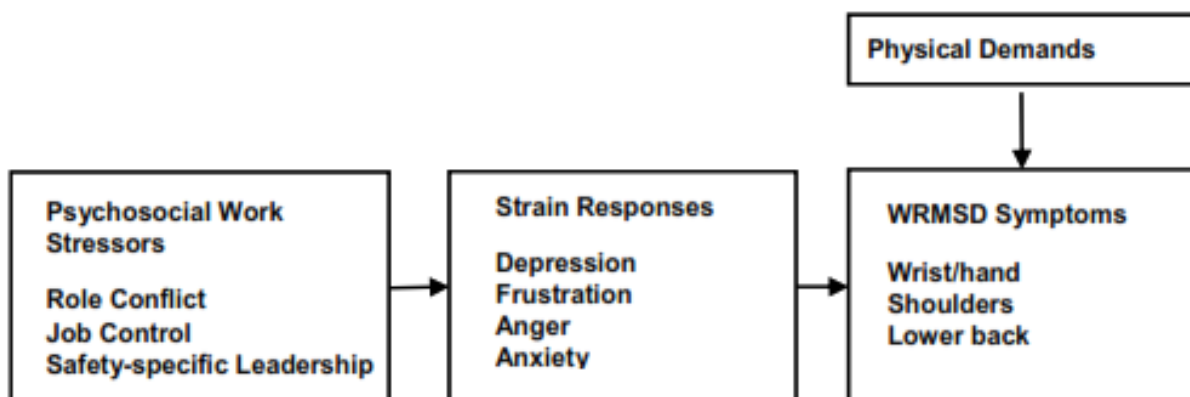
At their most basic (e.g. Larsman et al., 2006) these simply reflect this pathway with no cognisance of other risks or contributory factors (Figure 4).

Figure 4: Simple model of the connection between perceived work demands and MSDs (from: Larsman et al., 2006, with permission).



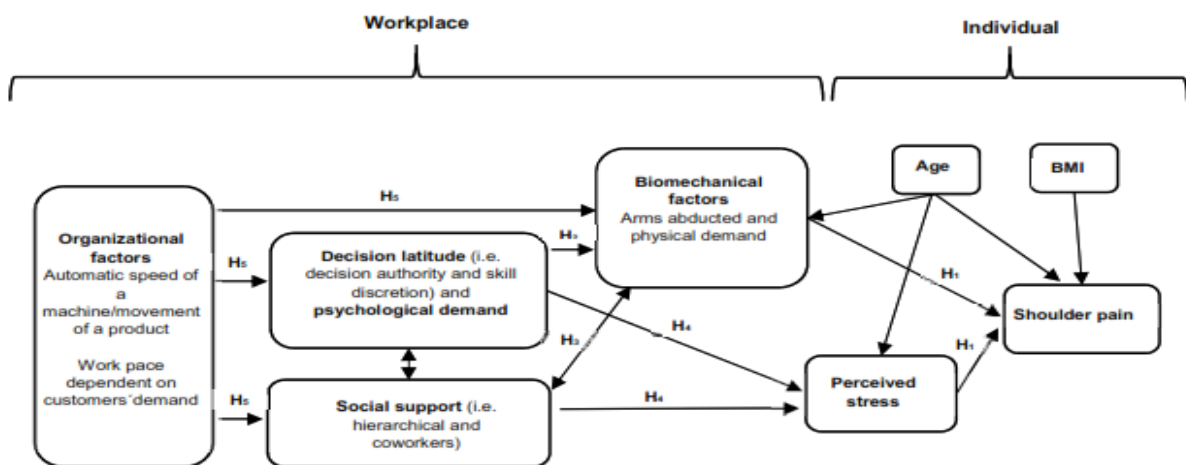
In most of these models, however, physical factors are shown as also contributing to MSDs, but are considered to be independent of the psychosocial risk factors (see, for example, Figure 5, which shows the psychosocial risk factors acting through a strain response). Individual risk factors are also considered to be independent of the physical and psychosocial risk factors, although these are not shown in all models.

Figure 5: Model itemising some psychosocial risks but showing physical risks as acting separately in causing MSDs (from Eatough et al., 2012, with permission).



A model by Bodin et al. (2020) (Figure 6) expanded on these simpler models to include how organisational factors affect psychosocial factors (decision latitude and psychological demand), as well as social support and biomechanical factors. It also included the mediation of some of these factors into a 'perceived stress' factor. Risk factors are shown as those relating to the workplace and those relating to the individual. The relationship between social support and biomechanical factors and social support and decision latitude/psychological demand is shown as a two-way relationship, as is the relationship between decision latitude/psychological demand and social support, while all others are shown as acting in one direction.

Figure 6: Development of more complex model showing both direct and indirect influence of psychosocial risks on MSDs (from: Bodin et al., 2020, with permission).

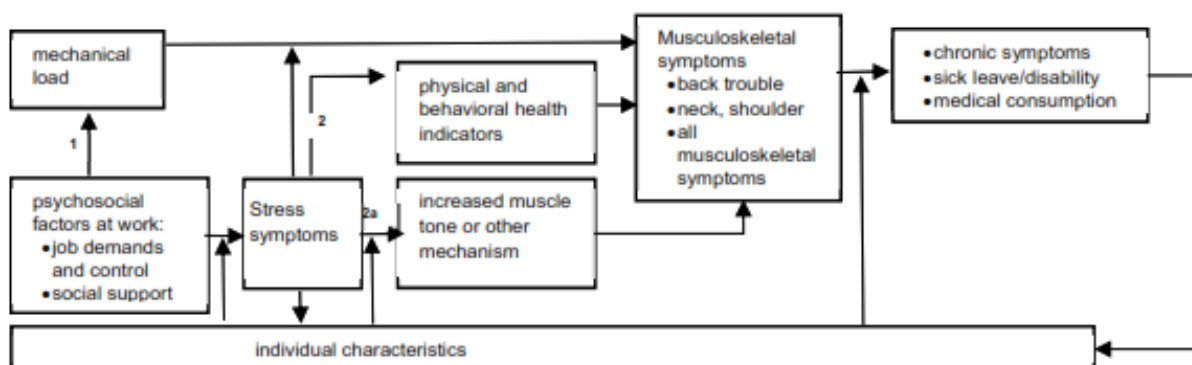


A similar model is presented by Roquelaure et al. (2020) for CTS (not shown) in which the groups of workplace factors are labelled as organisational, psychosocial and biomechanical.

4.2.3 Models recognising the two-way relationship between factors

As well as showing the interrelationships between risk factors, an early model by Bongers et al. (1993) (Figure 7) also seeks to integrate some awareness of causal mechanisms, in this case indicating how a stress response may contribute to musculoskeletal discomfort through increased muscle tone (or some other mechanism).

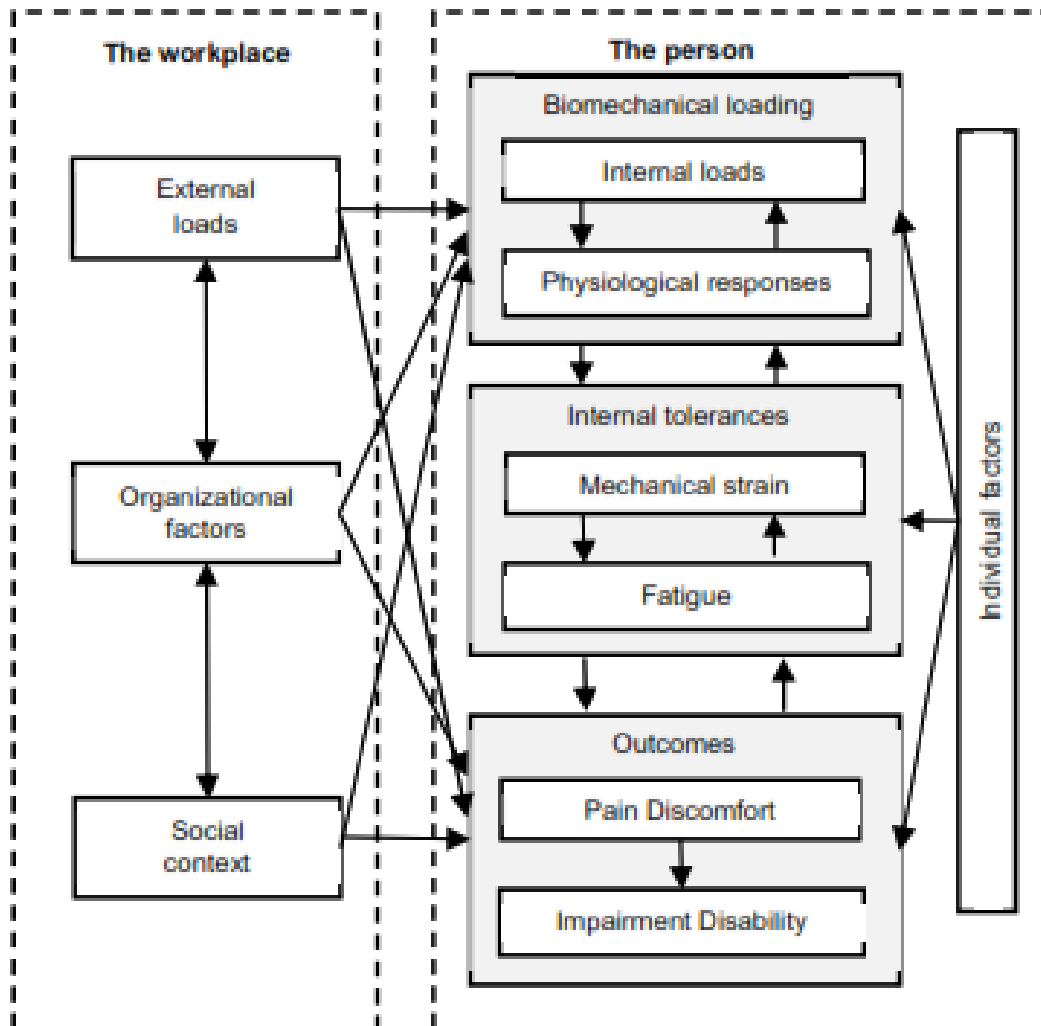
Figure 7: Model integrating some causal mechanisms into a causal pathway between psychosocial risks and MSDs (from: Bongers et al., 1993, with permission).



Roquelaure (2018) reproduces a model produced by the National Research Council (Institute of

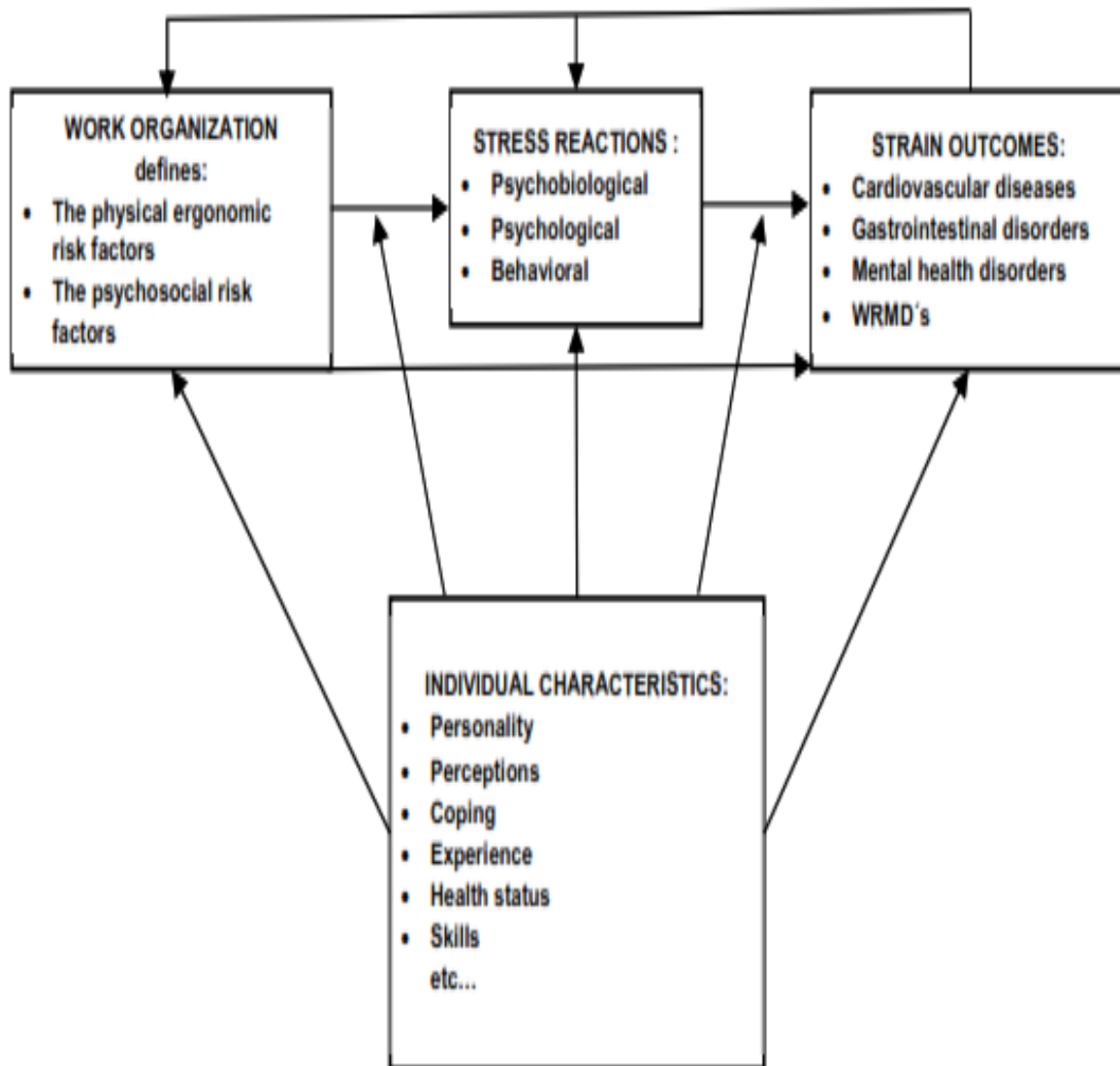
Medicine, 2001) (Figure 8). The author suggests that this is 'one of the first to take into consideration organisational factors while remaining focused on the individual' (Roquelaure, 2018, p. 35). However, in common with many such models, the author indicates that the model does not take account of individual psychological factors that are likely to be significant in the chronicity of MSDs. One point of note is that, although seemingly relatively basic, this model includes the dual pathway for organisational and social factors, acting directly on 'outcomes' but also acting through 'biomechanical loading'.

Figure 8: Relatively basic model introducing 'organisational factors' as a specific entity (from: Roquelaure, 2018, with permission).



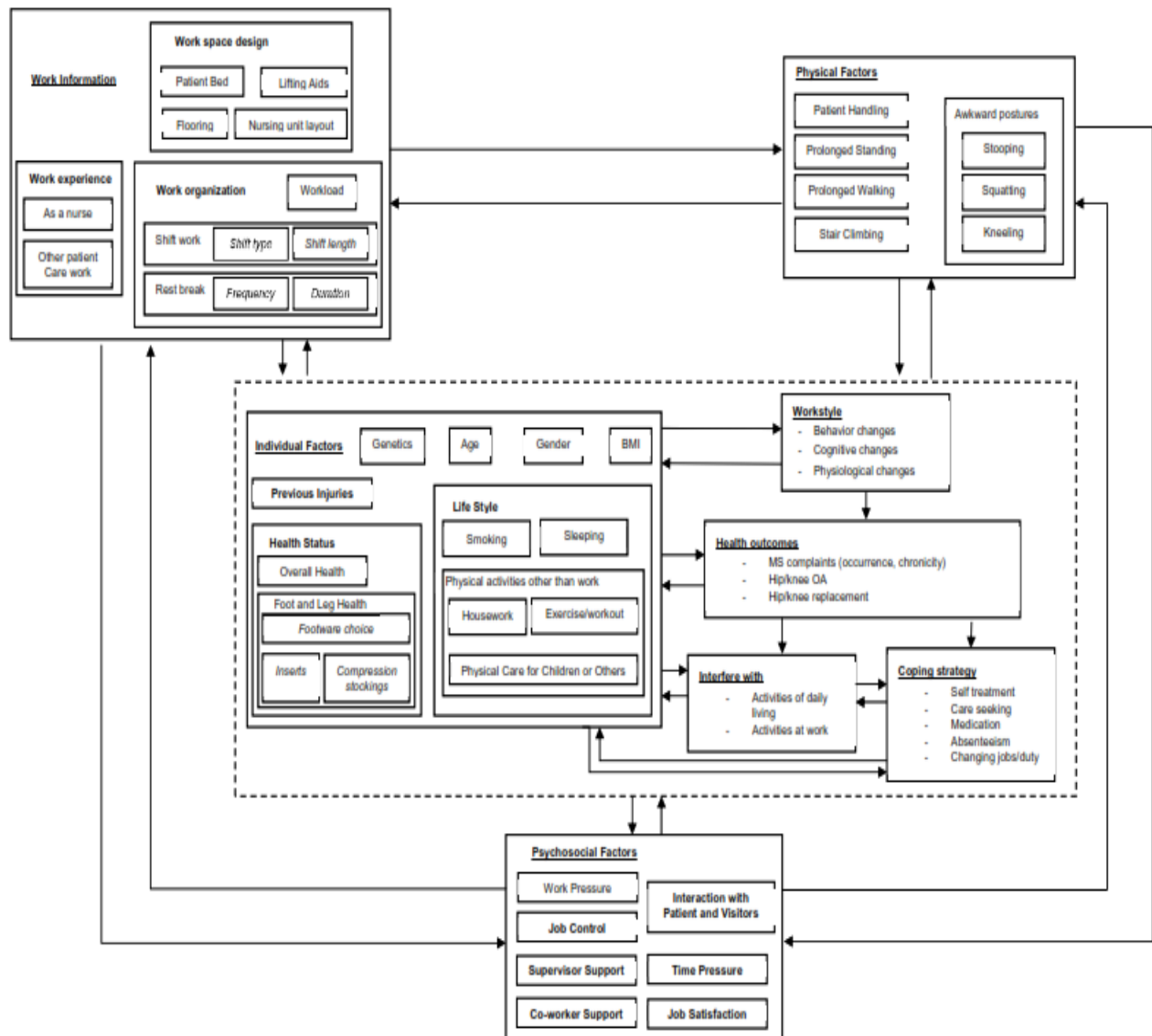
Roquelaure (2018) also reproduces an earlier model by Carayon et al. (1999) (Figure 9) and expands slightly the 'organisational factors' presented above into physical and psychosocial risk factors, although it does not present these in any detail. It does, however, expand on the 'individual characteristics', included (but not detailed) in the earlier model by Bongers et al. (1993). One notable feature of this model is the representation of 'individual factors' as influencing all stages in the process, acting on the factors themselves (boxes) and the consequences arising from those factors (connecting arrows).

Figure 9: Further relatively early model showing origins of physical and psychosocial risk factors within the work organisation (from: Carayon et al., 1999, with permission).



More detailed models consider the two-way relationship between many of these factors, for example the model of Li et al. (2020) (Figure 10). This model, which is focused on lower limb discomfort in nurses, shows the two-way relationship between factors external to the individual — ‘work information’ (work organisation, workplace design, etc.), physical factors and psychosocial factors — as well as the two-way relationship that each of these factors has on the individual. Factors relating to the individual are shown within the dashed box. This recognises the complexity of the relationship between many risk factors; it also recognises that the outcome for individuals may vary depending on their individual factors. This model also includes further work and work organisational details (work information), further illustrating the complexities of the relationship between workplace psychosocial risks and MSDs. One further feature of note in this model is the inclusion of individual factors including lifestyle aspects such as leisure physical activity.

Figure 10: More complex model showing further interrelationships between multiple factors and MSDs
(from: Li et al., 2020, with permission).

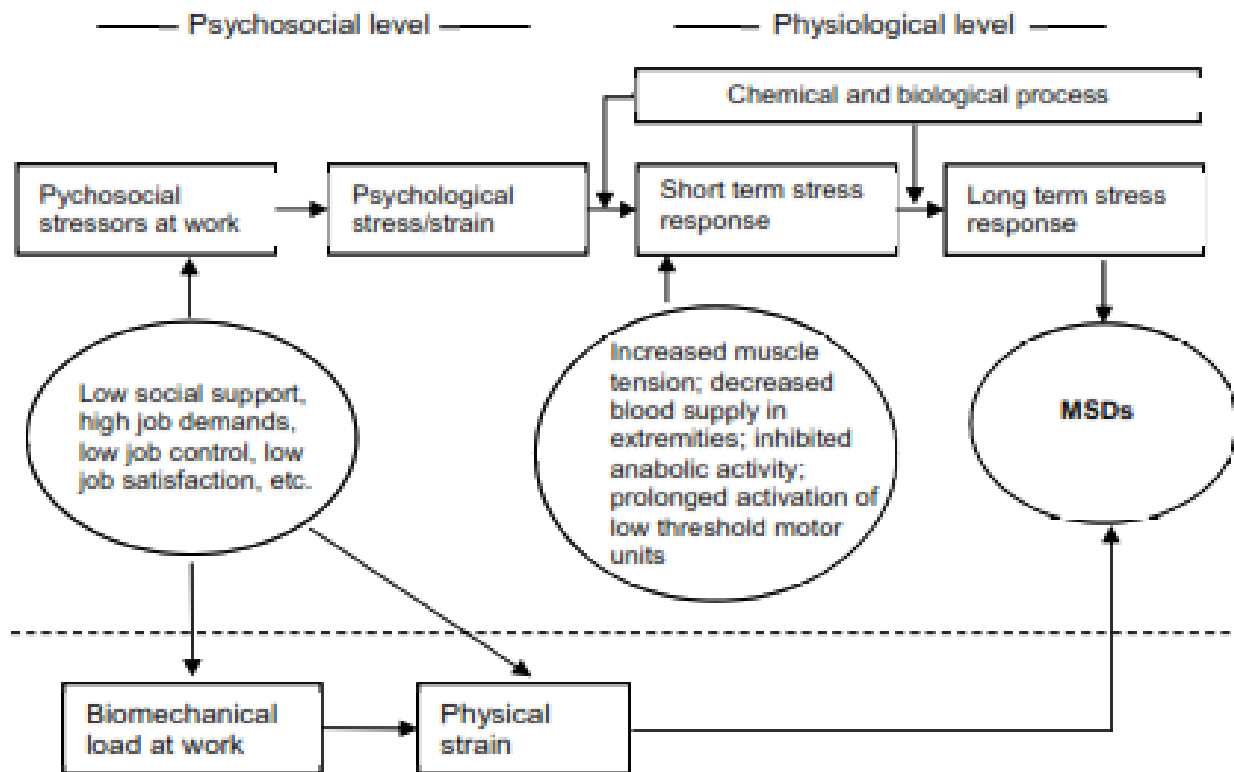


Although this model is specific to a nursing population, and musculoskeletal discomfort in a specific body part, the broad concepts can usefully be considered for other populations and MSDs. In particular, the recognition of two-way relationships between many risk factors and the separation of factors external to the individual and those intrinsic to the individual are helpful.

The model developed by Hauke et al. (2011) (Figure 11) separates psychosocial and physical risk factors, incorporates some of the possible physiological causal mechanisms and, importantly, appears to be one of the first to recognise that the effect of psychosocial factors can be mediated either through their impact on biomechanical load and physical strain or directly through a 'stress response'.

It does not, however, reflect the possible ameliorative effect of some psychosocial factors such as strong social support, although it could be argued that these are reflected in the net 'psychological stress/strain' included as an intermediate step in the pathway.

Figure 11: Model incorporating some of the physiological pathways that are considered to play a role in mediating the impact of psychosocial factors on MSDs (from: Hauke et al., 2011, with permission).



Although based on knowledge derived from the research literature, none of the preceding models were verified or refined through their application to research data. Bodin et al. (2020) took their model (shown in Figure 6) a stage further, using it as a vehicle for presenting the statistical outcomes from two studies on shoulder pain; one is a longitudinal study of a cohort of French workers and the other is a cross-sectional study from pharmaceutical manufacturing (shown in Figure 12). In these more complex models, social support is expanded to present supervisor and co-worker support separately, and different contributory factors to the biomechanical exposure are also incorporated. Interestingly, in a similar adaptation of the model presented by Roquelaure et al. (2020) for CTS, female gender — an established individual risk factor for CTS — is also added.

Although providing an interesting method for presenting the findings from statistical modelling, it is difficult to generalise from these presentations, as they reflect the findings from the different studies. Thus, in the model presented in Figure 12, psychosocial factors are shown as having effects mediated through the biomechanical factors and directly through 'perceived stress' while in the equivalent model for the longitudinal study only the indirect pathway through the biomechanical factors is significant. In a further application of this model, the version adapted by Roquelaure et al. (2020) for CTS does not include the 'perceived stress' element of the model.⁵ Apart from any other considerations, this variation serves to illustrate the complexities of the interrelationships and the concomitant difficulties in drawing any clear conclusions over the relationships between physical and psychosocial risk factors and MSDs.

⁵ It is understood from the lead author that this is due to technical aspects of the Cosali study protocol from which the data for the model were obtained.

Figure 12: Model applied to specific statistical data including the relative contributions of different work elements to the causation of MSDs (figure and legend from: Bodin et al., 2020, with permission).

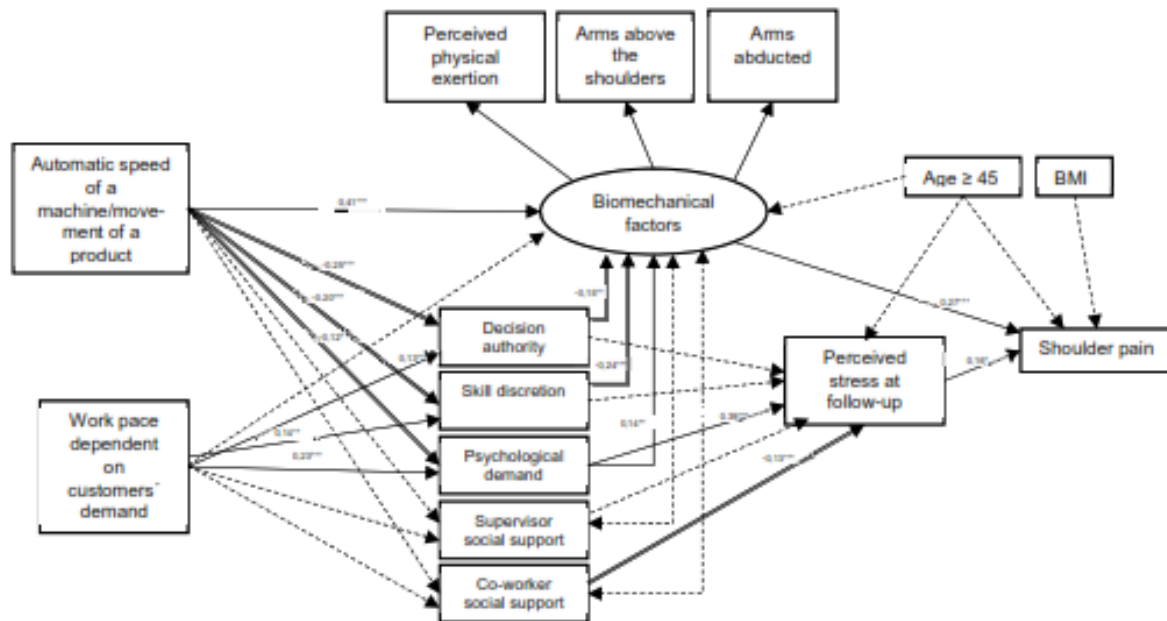


Fig.2. Structural equation model for a) Cosali survey ($n = 334$), b) Manufacturer of pharmaceutical preparations ($n = 487$). Ellipses = latent variables; boxes = observed variables. Significant ($P = 0,05$) positive direct paths are depicted as solid lines. Significant ($p < 0,05$) negative direct paths are depicted as double solid lines. Non-significant paths are depicted as dotted lines. * $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$. Correlations between psychosocial factors are not represented.

Note that this more detailed model presentation allows the inclusion of both negative and positive psychosocial influences. Thus, co-worker support is shown with a negative value, indicating that such support reduces the overall 'perceived stress'. Although not significant, by applying the specific data set used to verify the model, it retains the potential feedback pathway (dotted line) through which the biomechanical factors might affect the psychosocial elements.

One limitation of this model, however, is that it does not show any feedback from the shoulder pain (the iterative loops of the model by Armstrong et al. (1993) shown in Figure 3). Thus, it does not accommodate any impact of the pain on either ensuing physical capacity or the perception of psychosocial factors. To include such feedback might go some way to addressing the comment made by Roquelaure (2018) by including the role of different factors that might contribute to the chronicity of MSDs that are otherwise absent from the preceding models. As an adjunct to this, none attempted to include those psychosocial factors that might affect the effectiveness of the return to work process for a worker suffering from an MSD through pathways such as pain avoidance.

4.3 An ideal model?

It is apparent from the examples above that many attempts have been made to present the complex relationships between work, the individual and MSDs in the form of a conceptual model. One of the challenges faced in developing any such model is deciding the level of complexity to incorporate for any risk characteristic. For example, presenting the individual psychosocial risk factors as shown in Figure 12 is of value in visualising the findings from a specific study. However, as the interactive pathways are essentially the same, it is difficult to see at a conceptual level that this adds substantial benefit beyond the simpler representation in the model by Hauke et al. (2011) (Figure 11). By the same token, although varying in importance and relevance in applying any model to a specific work scenario, detailing individual physical work risks (frequency, duration, etc.) seems to add little at a higher conceptual level, as there is nothing to suggest that their influence on overall risk is mediated through different pathways or mechanisms.

It can be suggested from these comments that the model presented by Hauke et al. (2011) appears to strike the right level in terms of the detail provided. It shows the important double pathway between

psychosocial factors and MSDs (both directly and through affecting physical strain) and also incorporates the widely accepted intermediary of what might be regarded as a composite psychological strain factor. How, therefore, might this model be supplemented in creating an ideal?

One deficiency is that, as with the comment on the model by Bodin et al. (2020), it does not illustrate the two-way nature of the relationship between MSDs and psychosocial factors, in which the emergence of MSD symptoms can contribute to the significance of factors such as the levels of job demand and job satisfaction. Thus, in the model as illustrated (Figure 11) the experience of an MSD could feed back to the long-term stress response (for example), modulating the perception of stress by the individual.

Furthermore, although the positive and negative influences of various psychosocial factors are arguably implicit in the combined 'psychological stress/strain' element, it does not specifically illustrate the potential two-way influence of some individual psychosocial factors. Thus, it does not accommodate the potential moderating effects of high levels of social support or job control in reducing the impact of other factors such as high job demands.

A further deficiency is that it does not incorporate any influence of individual differences (such as age and possibly gender).

Should an ideal model seek to accommodate the criticism levelled by Roquelaure (2018) and include factors that influence the chronicity of MSDs or, in a further level of complexity, should it include those factors influencing the return to work or rehabilitation process? Ideally, such considerations would also extend to the fact that some MSD complaints are intermittent or episodic in nature and this might have an impact on any rehabilitation processes.

Although conceptually possible, it is likely that such a development would result in a degree of complexity that would diminish the clarity and usability of any resultant model. The physical and psychological influences on the return to work process are at least as complex as those contributing to the initial onset of MSDs. Illustrative conceptual models should serve to enhance the understanding of the various interrelationships between the factors illustrated. Any loss of clarity resulting from any such extension of the model would risk significantly undermining this function.

One omission from most of these models, including that by Hauke et al. (2011), is any significant consideration of the external (non-work) environment, although these are suggested to some extent in the 'individual characteristics' of Carayon et al. (1999) (Figure 9) or the 'individual factors' of Li et al. (2020) (Figure 11). Although the models are of value in presenting (to some degree or other) the contributions of various work-related factors, there is generally no reflection of the fact that workers do not exist at work in isolation from the influences of the external world. In the same way that individual physical fitness and related factors moderate the impact of workplace physical factors, an individual's external psychological milieu can also moderate the impact of workplace psychosocial factors. For example, experience has shown that the ability of an individual to 'cope' with the challenges of a mentally demanding job will differ when seen against a stable domestic background compared with one that presents its own demanding challenges. This concept is often reflected in the use of terms such as 'resilience'. Arguably, a complete model would include some acknowledgement of both physical and mental resilience as potential moderators of a number of the pathways and connections modelled. In the same way that some workers will be more capable of withstanding the physical demands of a given job, some will be less susceptible to its psychosocial demands and challenges. In seeking to adopt a holistic view of workers, their risk of injury and the scope for amelioration of that risk, much is made of the importance of influences such as healthy eating and 'lifestyle'. Much of this thinking tends to focus on what might be regarded as physical resilience, although the important moderating potential of mental resilience should not be neglected. Although detailed consideration of such elements arguably takes the model beyond the scope of the workplace, it is necessary to include within any such model at least some acknowledgement of the moderating contribution of 'individual susceptibility' in modelling all the elements influencing the impact of psychosocial factors on the onset of MSDs.

5 Intervention strategies

5.1 Review of research evidence for intervention effectiveness

As noted in Chapter 2, the literature searches and screening process identified no papers presenting formally evaluated interventions. This was almost certainly because the searches specifically focused on psychosocial interventions aimed at reducing the risk of MSDs. Explorations of the literature do identify intervention studies, but these address either physical workplace interventions to reduce MSD risk or psychosocial interventions to reduce the risk of stress-related ill health.

The searches identified a number of papers that made reference to some extent to psychosocial interventions and MSDs. However, in the majority of these, the reference was restricted to a few concluding remarks, usually suggesting that the findings of the paper (primarily relating to identifying associations between psychosocial risk factors and MSDs) should be used in designing subsequent interventions (e.g. Courvoisier et al., 2011; Golabadi et al., 2013; Govindu and Babski-Reeves, 2014).

One key factor to emerge from these, however, was the recognition of the need to adopt a holistic approach in designing interventions. Thus, Barzideh et al. (2014) concluded that ‘any interventional program should focus on reducing psychological and physical job demands and increasing decision latitude (control) in the workplace’ (p. 428).

It is worth noting that, in drawing this conclusion, the authors acknowledge the potential positive role to be played by some psychosocial factors (in this case job control-decision latitude).

In general, specific recommendations for the content of any workplace interventions reflected those psychosocial aspects identified in the specific study being reported. For example, in their study of MSDs among computer users, Kaliniene et al. (2016) advocated addressing high levels of responsibility and weak social support, while Back et al. (2018), in what they referred to as ‘emotional labourers’ (essentially those with a public-facing role), advocated an emphasis on job satisfaction (and, again, social support).

In an extension of the scope of any holistic approach, the paper by Govindu and Babski-Reeves (2014) advocated the inclusion of modifiable personal factors, again with an established relationship to MSD risk. In their particular study of low back pain, factors such as obesity (measured using BMI) and tobacco smoking emerged as making an identifiable contribution to low back pain risk.

Four relatively recent (2018 onwards) intervention review papers have been identified that reflect the current situation on workplace interventions. Three of the papers primarily addressed interventions aimed at rehabilitating those with MSDs into the workplace, while the fourth adopted a much wider brief, exploring all health promotion interventions. This last review (Pieper et al., 2019) was the only one to specifically address MSD prevention, rather than rehabilitation. However, given the lack of significant material on prevention, it was decided to include these recent reviews to hopefully provide some insight into relevant interventions. In addition to these review papers, a recent paper (Beemster et al., 2021) reported a primary study on rehabilitation that included some consideration of work processes.

An earlier review on rehabilitation (reduced sickness absence and job loss) was reported by Palmer et al. (2012). Although earlier than these recent reviews, it perhaps provides a useful starting point for widening the scope to include rehabilitation. Following an intensive screening process, the review included 54 reports, covering 42 studies in its detailed analysis. However, although psychological interventions were included, most of these were aimed at the individual level and were largely focused on behavioural or attitudinal change (e.g. cognitive behavioural therapy — CBT) such as fear-avoidance. Of the 42 studies, 17 included some form of workplace intervention, with 12 encompassing workplace-level activity. It appears that most of these addressed physical aspects of the work (e.g. exploring how well an exercise programme matched job demands or ergonomic changes to the physical environment). According to the review, some did, however, apparently include education and advice for managers, although these were not separately analysed or reported, so it is not possible to determine either their specific nature or their effectiveness. Overall, the review concluded that, taken collectively, ‘the benefits suggested are small and of uncertain cost-effectiveness’ (Palmer et al., 2012, p. 239).

Some insight into the challenges facing successful interventions in the prevention of MSDs can be found in the paper published the following year by Burdorf et al. (2013). This study specifically explored the

potential benefits of using mechanical lifting devices in place of the manual handling of patients. It estimated that what it termed a realistic scenario of implementation would result in little more than a 1 % reduction in low back pain prevalence, while complete elimination of the manual handling of patients was necessary to achieve a reduction in prevalence from 41.9 % to 31.4 %.

In the first more recent review (Oakman et al., 2018) the authors explored workplace interventions aimed at currently employed workers with the intention of improving their 'work ability'. This was defined as the degree to which an employee was mentally and physically capable of performing their current role. The importance of maintaining work ability was presented as being of importance, especially against the background of an ageing workforce. Interventions were categorised as either individual level (many of which were focused on physical activities in some form) or multilevel, where, again, physical activities played a major role. Of the 17 trials included, 12 were individually focused, with just five categorised as multilevel. Of these, four were listed as providing data for analysis. According to the summaries provided, in most cases, workplace intervention was limited to liaison between health professionals over the return to work process. One study was listed as including 'support for supervisors', and examination of the original paper showed this to include training for supervisors including 'how to present themselves as a source of support for the worker: not by taking over responsibilities but by strengthening the workers' autonomy' (Koolhaas et al., 2015). This particular study found a negative effect of the intervention, with workers in the intervention group having a significant reduction in work ability (although one of the psychosocial aspects, namely skill discretion, was significantly enhanced).

Overall, Oakman et al. (2018) considered the studies identified to provide only a moderate quality of evidence. This was mainly due to poor compliance with a high rate of attrition of subjects in the majority of studies. This introduces a risk of bias with the possibility that only those subjects who considered themselves to be benefiting from the intervention remained involved. The majority of studies found no effect on work ability, with a minority showing a modest positive effect and just one (multilevel) intervention (that by Koolhaas et al., 2015, referred to above) in which a negative effect was identified (in which work ability actually deteriorated in the intervention group compared with the control group).

Although physical work ability was a strong focus of this review, it was not specifically targeted at MSDs. A review by Cullen et al. (2018) explored the effectiveness of workplace interventions for return to work for those suffering from MSDs (or other pain-related conditions) or mental health conditions. Data extraction and evidence synthesis was only completed on those studies the authors considered to be of high or medium quality. Slightly more than half of the studies included (19/36) were randomised controlled trials and 26 of the total addressed MSD interventions (with 10 addressing mental health issues). Interventions were classified as health focused, service coordination or work modification. Those that covered at least two of these were regarded as multilevel. Workplace interventions either altered the organisation of work or introduced modified working conditions.

The reviewers identified a strong positive effect for comprehensive multidomain interventions to reduce lost time for both MSDs and mental health problems. Such interventions usually encompassed combining individual health-focused interventions with work modifications such as modified duties or ergonomics adjustments to the workplace. According to the authors, a number of the multilevel (multidomain) interventions included supervisor education/training, although no detail as to the nature of that training was provided, and it is not clear from the text whether these relate to mental health or MSD-related conditions. To investigate this a little further, the original texts for the three high-quality multilevel studies for MSDs were examined. In most cases, supervisor training mainly addressed understanding the nature of the MSD and how to manage the return to work process. In one study (Lambeek et al., 2010) the JCQ was administered at baseline (it showed that job control, job demands and social support did not differ between the intervention group and the usual care group). However, no details of any impact of the intervention on these measures was reported.

Although Cullen et al. (2018) recommended the implementation of a multidomain intervention (i.e. with health-focused, service coordination and work modification components), they commented that the actual content of such programmes was context dependent and did not make any specific recommendations over such content.

The primary study by Beemster et al. (2021) provided further support for the inclusion of work modifications into any rehabilitation programme. Their study of the efficacy of individual-oriented vocational rehabilitation in the return to work of those with chronic MSD pain found that, although

effective, the effectiveness of such programmes was enhanced by the inclusion of a work module, leading to a significant increase in the odds of work participation. This module explored barriers to (and facilitators of) work participation and included a workplace visit with possible advice for ergonomics adjustments to the workplace.

Another recent review (Sundstrup et al., 2020) also focused on interventions aimed at rehabilitating those with MSDs, in this case specifically into what was regarded as physically demanding work. The definition of MSDs adopted was very broad and encompassed those with both specific and non-specific MSD/musculoskeletal pain or discomfort. Interventions were grouped into five main categories: physical exercise, ergonomics, participatory ergonomics, multifaceted and stress management. The review found moderate evidence for a positive effect of physical exercise in general. Within this there was strong evidence specifically for strength training, limited evidence for a positive effect of aerobic training and mixed evidence for the effect of stretching exercises. There was limited evidence for either 'ergonomics' or 'participatory ergonomics' interventions being of no benefit, although, especially for the participatory cluster, the authors concluded that the studies were so varied in nature that it was difficult to cluster them together. A similar conclusion was reached for the 'multifaceted' category.

From the brief descriptions provided it appears that studies in the 'ergonomics' category focused on physical (biomechanical) ergonomics issues (as did many of the participatory ergonomics studies). From the brief details provided, two studies appeared to include organisational aspects, although examination of the original source for one of these (Eriksen et al., 2002) revealed that this aspect was not part of the randomised controlled trial. The second study (Haukka et al., 2008) reportedly included consideration of solutions aimed at reducing mental workload, although no specific solutions were described in the original source and psychosocial factors did not explicitly feature in any of the participatory workshops. However, the study found that job satisfaction improved significantly in the intervention group, both immediately at the end of the intervention and at the 1-year follow up. Despite this, no effect on musculoskeletal health was found.

On stress management, Sundstrup et al. (2020) concluded that there was strong evidence for no benefit, although this was based on just three (albeit high-quality) studies. However, it should be emphasised that this intervention category was aimed at the individual level and did not therefore constitute any form of intervention to address psychosocial risks at source.

A more general appraisal of workplace interventions, with a focus on health promotion, was reported in a 'systematic review of systematic reviews' by Pieper et al. (2019). The review adopted as a particular focus interventions for the prevention of musculoskeletal, psychological and behavioural disorders as well as interventions for older employees. An additional theme adopted was the exploration of evidence relating to the economic impact of such interventions in the workplace.

From their screening process, the authors identified 38 reviews of interventions aimed at preventing or improving mental disorders, of which 45 % were classified as low or very low quality and 50 % rated as moderate or high quality; 5 % were unclassified. The reviews encompassed over 1,000 individual papers that covered the effectiveness of topics such as resilience training programmes, mindfulness training, cognitive behavioural therapy, relaxation techniques and organisation-level workplace interventions. Of particular relevance to the present report, the authors found that organisational interventions including reduction of work impact and flexible work time seemed to lower stress and burnout symptoms. Two moderate-quality reviews found web-based health promotion programmes to be effective for the prevention of job stress-related mental disorders.

A total of 23 reviews were identified that addressed MSDs. The overall quality of these was slightly better, with 65 % rated as moderate or high quality and just 30 % rated as low or very low quality (5 % again unclassified). However, there was very little clear evidence for the effectiveness of many of the interventions explored with some conflicting material on approaches, for example individual ergonomics interventions such as sit-stand desks or job rotation. One review is cited as providing evidence for the effectiveness of workplace strength training. Overall, however, despite the total number of studies identified, there was little substantial evidence relating to any form of intervention and the authors concluded that the heterogeneity of the included studies precluded the development of any specific recommendations.

Of possibly greater relevance are the reviews that addressed the needs of older employees. Although only four were identified, they were all rated as moderate quality. Two of these were singled out for reference, both of which apparently recommended the adoption of multicomponent organisational interventions that involved changes in work environment, physical training and psychosocial support to promote the working capacity, health and well-being of older employees. However, examination of the original reviews shows that in neither case was any clear evidence identified regarding any specific intervention approach.

In a further development and in recognition of the multifactorial nature of contributing influences, Zhang et al. (2020) advocated the consideration of work-family conflict as a further area for intervention, in addition to workplace-specific elements such as job control and support.

Although the majority of the papers identified that referred to interventions were limited to using the findings of their reported study to draw inferences for any future interventions, two papers were identified that explored the issue of interventions and intervention strategies in more detail. The first of these was a discussion paper by Bongers et al. (2006) that explored studies on the effectiveness of preventive measures (for work-related MSDs).

The authors address both the issue of MSD prevention and obstacles for work resumption; however, in their introduction they note that 'empirical support of the effectiveness of measures... is largely absent'.

In broad terms, interventions can be classified as focusing on the individual, the organisation or the individual-organisation interface, while being classified as primary, secondary or tertiary. Although the exact definition of this latter classification varies between authors, they are often regarded as aiming to prevent the occurrence of the impact of ill health in the first place (primary), restricting the further development of an adverse impact (secondary) and enabling those suffering from such an impact to continue to function (tertiary). Murphy and Sauter (2004) present a useful illustration of this classification and the types of intervention they typically embody in the context of work organisation interventions.

Reflecting this classification, Bongers et al. (2006) discuss different interventions in five categories, with further subdivisions within each category:

- primary/secondary interventions aimed at the work organisation;
- primary/secondary interventions aimed at the individual;
- primary/secondary interventions combining different approaches;
- secondary/tertiary interventions aimed at the work organisation;
- secondary/tertiary interventions aimed at the individual.

Although isolated instances of a degree of success were identified, the overall outcome from each of the classes of intervention can be summarised as there being no conclusive evidence for their effectiveness in addressing the MSDs considered. Some evidence provided support for an effect at an intermediate level that could be regarded as beneficial. Thus, the authors cite a study that demonstrated an increase in social support or another where muscle tension was reduced, but in neither case did the anticipated reduction in musculoskeletal symptoms materialise.

In their final concluding remarks, Bongers et al. (2006) summarise the outcome of their extensive and thorough deliberations as follows:

... there is a great need for additional high quality trials before any conclusions on bio-behavioural interventions for reduction of neck and upper limb problems and return to work after these symptoms can be made. (p. 296)

Significantly, in terms of guidance for future interventions the authors also conclude that:

... the recent trials on effective return to work also seem to emphasise the importance of a participatory approach, i.e. early and structured involvement of the most relevant stakeholders (i.e. employer and employee). (Bongers et al., 2006, p. 296)

In a more recent paper, Stock et al. (2018) reported on a systematic review of the relevant literature on the effectiveness of work organisational interventions to prevent or reduce MSDs. The strongest evidence (classified as 'moderate') was for a beneficial effect of supplementary rest breaks. However,

it is not clear whether the impact was mediated through physical pathways or psychosocial pathways. To take an example, one paper cited as providing medium-quality evidence (McLean et al., 2001) found a reduction in neck discomfort with microbreaks among computer workers. Arguably, encouraging participants to stand up and walk away from their workstation during such breaks (which formed the intervention) would be expected to provide physical alleviation from the muscle movement over and above any benefit from the (assumed) break in mental activity.

Despite the time elapsed since the earlier reviews, the concluding remarks by Stock et al. (2018) suggested that there had been little advance in more recent years, with better quality studies still required before definitive conclusions could be drawn on the effectiveness of work organisational or psychosocial interventions to prevent or reduce work-related MSDs.

It would therefore seem that the quality of evidence relating to interventions is limited and does not allow any specific content to be formulated. More material appears to relate to the rehabilitation and return to work of those with existing problems than can be found regarding the initial prevention of problems. On rehabilitation, it is clear that the strongest evidence can be found to support a multifactorial approach. Such an approach is likely to include interventions aimed at treating residual symptoms, enhancing the work capabilities of the individual (through, for example, tailored exercise) and making adaptations to the workplace. However, it should be noted that the bulk of the material relating to such adaptations simply involve individual physical workplace changes. Most of the material relating to psychological issues focuses on individualised measures such as CBT and do not provide any evidence relating to accompanying measures to address relevant workplace psychosocial risks.

5.2 Designing interventions in the workplace

To date, based on both the research literature and evidence from the workplace (e.g. EU-OSHA, 2020b), it appears that most interventions aimed at addressing work-related MSDs have addressed physical risk factors. Similarly, interventions focusing on psychosocial risks have primarily sought to address psychosocial outcomes such as work-related stress. The evidence from the literature, summarised above, suggests that there have been comparatively few interventions aimed at addressing psychosocial risks in the context of MSDs and that those documented in the literature appear to be of relatively poor quality.

To some extent this is a reflection of the methodological challenges relating to evaluating interventions. In the preamble to their review of intervention studies, Bongers et al. (2006) suggest that evaluations of organisation-level interventions are relatively scarce because of the methodological challenges presented by this type of intervention.

In an earlier review of interventions aimed at promoting mental well-being in the workplace (Graveling et al., 2008), similar problems were encountered, with the better quality evidence being reserved for individual-level interventions (such as transcendental meditation), which are easier to design and evaluate than organisation-level interventions.

Individual-level interventions are often easier to implement. Thus, in developing guidelines for interventions aimed at reducing sickness absence due to MSDs, the biopsychosocial approach described by McCluskey et al. (2006) addresses individual psychosocial factors (referred to as yellow flags) such as somatisation tendencies and pain (fear-avoidance) beliefs, as described subsequently by Vargas-Prada and Coggon (2015), and workplace factors (blue flags) such as job dissatisfaction, stress, lack of perceived social support, job inflexibility and low perceived control. However, in the evaluation reported by Bongers et al. (2006) it appears that these were not addressed at the workplace but were instead incorporated into the individual-level coaching provided. Although 'modified work' was included as part of the plan, no details are provided about the nature of any such modifications. From the limited descriptions provided, it appears that this solely addressed physical changes to the workplace and perhaps some temporary organisational measures, such as reduced duties.

Many of the papers referred to above focus on optimising the methodology for evaluation interventions, rather than on the interventions themselves. Nevertheless, some valuable guidance can be drawn together to assist in the design of workplace interventions and these are discussed below.

5.2.1 Obtaining commitment

- **At all levels in the workplace there needs to be recognition of and commitment to a requirement to address both physical and psychosocial risks of MSDs.**

Among all the literature evaluated in preparing Chapter 3 of this report, and the numerous cross-sectional studies not included, data analyses have supported the view that both physical and psychosocial factors are important. No studies were identified that suggest a causal relationship between psychosocial risk factors and MSDs in isolation, with physical risk factors invariably contributing to the overall risk. Indeed, where studies computed effect sizes (e.g. Roquelaure et al., 2020) physical factors generally played a larger role in the development of MSDs (although psychosocial factors were shown to be relevant).

In describing the 'development' phase of an intervention framework, Brisson et al. (2020) identified focus groups with employees and meetings and follow-ups with managers and worker representatives or the intervention team as core features, reflecting this need for multilevel cooperation and collaboration.

- **This should be followed up by a systematic, holistic approach to risk assessment, covering both physical and psychosocial risks.**

The need for such an approach was a common theme in the conclusions of many of the papers summarised above, and in an earlier EU-OSHA report on the continuing problem of MSDs (EU-OSHA, 2020a).

There are many aids available for assessing the physical risks for MSDs. Similarly, aids and guidance are available for assessing psychosocial risks, albeit primarily in the context of psychological ill health. Conceptually, however, the nature of the adverse health outcome is immaterial to the assessment process and, although as yet there are few guides available to direct a comprehensive holistic assessment specific to MSD risks, this should not be a barrier to such an assessment, as all the required elements to carry out such assessments are in place and readily available.

As is apparent from the review of the evidence presented in section 5.1, it is not possible to associate specific psychosocial risk factors with particular MSDs. At present, therefore, the advice is to carry out the comprehensive assessment advocated and take steps to remove or reduce the risk factors identified (referred to by some as hazards) without seeking to establish their contribution to any MSD risk. As Oakman and Macdonald (2019) express it:

... in cases such as MSDs ... where risk results from the net effect of a large and variable set of hazards, some of which can interact with each other in affecting risk, effective management requires a broad, systems-based framework and more holistic assessment of risk from all relevant hazards together rather than in isolation from each other. (p. 2)

According to Macdonald and Oakman (2013), two authoritative international bodies — the International Ergonomics Association and the World Health Organisation (WHO) network of collaborating centres in occupational health — decided against formulating a specific risk assessment toolkit, concluding that no single toolkit would be appropriate for every situation. The organisations concluded that the priority was to ensure that any risk assessment procedure should focus on the underpinning principles and processes to be followed.

Based on this, the authors concluded that a multidisciplinary, holistic approach to assessing and controlling the risks identified in the particular workplace was necessary. In doing so, they emphasised the need for assessing the risk from the combined effects of the hazards identified, taking into account the additive and possibly interacting effects of both physical and psychosocial hazards and risks.

Subsequently, despite the decision noted above, Oakman and Macdonald (2019) developed a toolkit specifically aimed at jointly assessing both physical and psychosocial risks for workplace MSDs. This toolkit is unusual in that it seeks to integrate the assessment of both sources of risk. However, as at present there appears to be little evidence on which to base such integration, the advantages of such an approach compared with more conventional approaches that seek to assess the two sources separately (such as that advocated in the EU-OSHA guide; EU-OSHA, 2018) seem limited. Such tools, to assess either physical or psychosocial risks, are widely available. For physical risks, a useful summary of some of the available workplace observation methods freely available can be found in the

OSHWiki article on the assessment of physical workloads to prevent work-related MSDs (https://oshwiki.eu/wiki/Assessment_of_physical_workloads_to_prevent_work-related_MSDs), although many others are available.

For psychosocial risks there are many guides and tools available, including many that have been developed to reflect national attitudes and approaches. The OSHwiki page on psychosocial risks and work-related stress (risk assessment) (https://oshwiki.eu/wiki/Psychosocial_risks_and_work-related_stress_risk_assessment) provides a useful outline of the process, although it does not advocate any specific tools.

At present, the available research evidence does not permit the ready identification of the interactive effects between physical and psychosocial MSD risks, and further work to elucidate these remains a research need.

5.2.2 Involvement and participation

- **Risk assessment should actively involve the workforce and should ensure that actual work activities are assessed, not what is believed to happen.**

Examples have been seen in which the assessment process has been largely a ‘desktop’ exercise, considering written procedures rather than examining those that actually take place. Strambi et al. (2012) outline a ‘feedback’ method to improve ergonomic design that incorporates the process of assessing actual work activities. Advocating the establishment of working groups as part of this process, it relies strongly on commitment from all levels to ensure its effectiveness.

Approaches such as hazard mapping (see the OSHwiki article on the topic; https://oshwiki.eu/wiki/Hazard_mapping_and_MSDs) can be used to provide the basis for worker participation in the risk assessment process.

- **To encourage the necessary openness and honesty on the part of the workforce, it is essential to ensure that measures are in place to safeguard and protect individual confidentiality.**

Although physical risk factors can be explored by observing processes and discussing them with the workforce, assessing psychosocial factors entails a more individualised, personal process. Workers need to be confident that concerns and experiences they share will not be regarded as individual weakness or susceptibility and this requires assurances of confidentiality. Many organisations will have the resources to provide such assurances in house, although others might find it helpful to secure the assistance of external agencies or consultants to help provide that confidence to their workforce and ensure individual anonymity.

- **In addition to identifying and assessing hazards and risks in the workplace, it can also therefore be of value to assess the physical and psychosocial health and well-being of the workforce as an aid to identifying where action is most needed.**

As a guide to identifying priorities for action (see below) it is often helpful to obtain supporting data regarding the extent and nature of problems among the workforce. Carrying out formal systematic surveys of the physical and psychosocial health and well-being of the workforce can provide such data. In theory, any sickness records maintained by the employer might provide some insight, although practical experience suggests that they are often not sufficiently comprehensive and that individual data protection requirements might limit their utility.

Again, standardised health survey instruments are available to support this process, covering both physical and psychological health and well-being but, as with the risk assessment tools, no single instrument is suitable for all workplaces. For MSD symptoms, simple approaches such as body mapping (EU-OSHA, 2020c) and the Nordic Musculoskeletal Symptoms Questionnaire (Kuorinka et al., 1987) offer simple, easy-to-administer tools. For psychological health and well-being, the General Health Questionnaire-12 (GHQ-12) (Goldberg and Williams, 1988) or the even shorter WHO Five Well-being Index (WHO-5) (e.g. Schütte et al., 2014) have been translated into and validated in a variety of different languages. Alternatively, tools such as the Copenhagen Psychosocial Questionnaire (COPSOQ) enable the evaluation of both the environment and well-being in a single instrument (Burr et al., 2019).

5.2.3 Taking action

As with the risk assessment process, a holistic approach should also be adopted in taking action.

- **In addition to their role in contributing to the development of MSDs, psychosocial risk factors can have a direct, negative impact on psychological health and well-being.**

Any course of action identified in respect of psychosocial risks should not only focus on musculoskeletal health but also consider the psychological health and well-being of the workforce, reflecting this need for a holistic approach.

- **It should also be recognised that, as well as their role in causing MSDs, physical and psychosocial factors can create barriers for those returning to work.**

These barriers can be imposed for both those seeking to return after an acute MSD episode or those who have developed a chronic MSD problem and are seeking to remain in work or obtain employment. Section 5.1 identified a need for a multifactorial approach to that return to work process, yet again reflecting the need for a holistic approach, in this case addressing both individual work ability and workplace barriers.

- **It should be recognised that risk assessment is only an intermediate step in the process of preventing or reducing the risk of MSDs. Information gathered from the risk assessment process should be used to develop preventive and corrective measures.**

Evidence from practitioners suggests that, in many workplaces, too much emphasis is placed on risk assessment (often bolstered by strategic-level actions that focus on such assessments) and that insufficient attention is placed on subsequent risk prevention action (EU-OSHA, 2020d). EU-OSHA guidance on MSD prevention summarises the well-established hierarchy of prevention in which, if possible, avoidance of risks and combating risks at source should take priority over secondary measures such as training in handling techniques (EU-OSHA, 2020e).

- **Identifying and developing follow-up actions should involve the workforce.**

There is evidence to suggest that a participatory approach, involving the workforce in the development of solutions, is more likely to succeed in reducing MSDs and that it will help with the implementation process (EU-OSHA, 2021c).

Practical experience suggests that solutions developed in conjunction with those who will implement and apply them are more likely to gain acceptance from the workers, thus enhancing their probability of success.

Even if the focus of the intervention is primarily on physical risks, the involvement of the workforce will make a notable positive contribution to workplace psychosocial factors such as communication and involvement in decision-making.

- **There is some evidence that a multifactorial approach is more effective.**

Winkel and Westgaard (2019) advocate a systems approach to the development of interventions, arguing that solutions that focus on the detailed workplace level without considering broader organisational factors are less likely to succeed. This can be seen as supporting the recommendations of Pieper et al. (2019), who advocate a participative approach, engaging employees, employers and management structures. An EU-OSHA case study report (EU-OSHA, 2020f) describes the successful application of this approach in reducing MSD risk, and this and other case studies on this topic are summarised in the OSHwiki guide on carrying out participatory ergonomics (https://oshwiki.eu/wiki/Carrying_out_participatory_ergonomics). Furthermore, more general guidance on worker participation can be found in the EU-OSHA practical guide (EU-OSHA, 2011).

Winkel and Westgaard (2019) indicate that interventions in the workplace often involve new approaches entailing organisational change. It is therefore clearly essential that those involved at an organisational level are engaged in this process. The EU-OSHA (2020f) case study report describes the involvement of all levels in the target organisation (including decision-makers), in this case to facilitate physical workplace improvements. This requirement was also emphasised by Nielsen et al. (2010), who discussed occupational health interventions (with a particular focus on psychological health and well-

being). They suggested that a lack of management support for any interventions impaired the impact of the interventions, and the authors emphasised the benefits of the involvement of middle management in implementing organisational-level initiatives.

Support for this need for an organisational approach can be found in examples such as the study reported by Haukka et al. (2008). The authors reported on a participatory ergonomics intervention that appeared to show no effect on musculoskeletal health. They commented that the interventions were limited in their scope to specific design changes that did not entail redesigning work processes (and were restricted by workplace design characteristics). In a further complication, simultaneous organisational changes outside the scope of the intervention might have negated any positive effect. The authors concluded that a more comprehensive redesign of work organisation and processes was needed.

A widely known example of this necessity can be drawn from the numerous accounts of apparent failures in the implementation of patient-handling devices in health care settings. Introducing such devices without the necessary changes in infrastructure and organisational procedures frequently leads to a lack of their acceptance and 'failure' in their implementation. For example, Evanoff et al. (2003) found that, although there was evidence for the effectiveness of patient hoists in reducing MSDs, only one fifth of workers questioned indicated that they used a mechanical lift themselves. Reasons given for their non-use included perceived lack of need for lifts (25 %), insufficient training in lift use (14 %) and the perception that using the hoists was too time consuming (13%). As noted earlier in this report, Burdorf et al. (2013) found that a realistic scenario of implementing such lifts would result in little more than a 1 % reduction in low back pain prevalence; complete elimination of the manual handling of patients would still only achieve a 25 % reduction in prevalence.

Similar findings were reported by Li et al. (2004), who reported usage levels falling to one tenth of the expected rate after they had been in place for a few months. Such findings clearly indicate a need for a multifaceted approach to interventions. In this case it suggests a requirement for awareness training (attitudes) and technical training (skills); these need to be implemented together with the organisational measures necessary to ensure their availability, and there should be sufficient time for their use (procedures).

A more recent study (Jakobsen et al., 2019) provided somewhat contradictory findings. Data collected during their intervention study found an increase in what was termed the 'general use' of assistive devices for patient handling but no change in the extent of 'necessary use'. As a consequence there was no change in the incidence of pain in the low back, neck or shoulder or of back injuries. As with the earlier study, however, the intervention does not appear to have extended to any organisational changes. The authors comment that implementing the planned solutions 'requires that healthcare workers and, in particular, management need to prioritise time for this' (p. 154), suggesting that busy schedules may, in part, explain the lack of improvement in the extent of necessary use.

- **In developing action it should be remembered that, as well as possibly contributing to the problem, psychosocial factors can also provide part of the solution.**

There is considerable evidence from the literature that positive support from co-workers and managers can help to offset the adverse effect of other factors (such as periods of high demand). Furthermore, some factors can work on both physical and psychosocial risks. For example, enabling greater individual freedom over scheduling work breaks (when possible) can act directly to reduce physical strain and can also provide a greater sense of personal control.

- **In identifying and developing intervention strategies, priority should be given to addressing psychological and sexual harassment (where identified), as this can seriously affect both physical and psychosocial health.**

This has been recognised in a number of European countries in which legislative measures have been adopted specifically to address this issue. In 2007, the European social partners signed the framework agreement on harassment and violence at work (European Commission, 2007), which aimed to 'provide employers, workers and their representatives at all levels with an action-oriented framework to identify, prevent and manage problems of harassment and violence at work' (p. 5). An EU-OSHA report on workplace violence and harassment (EU-OSHA, 2010) identified that work-related violence was a serious health and safety issue that has both physical and psychological consequences.

6 Discussion

6.1 Considerations for different groups

6.1.1 General considerations

Establishing the reasons for any increase in risk based on categorisation by work sector, gender or other groupings is not straightforward because of the complex interrelationships between factors. For example, an EU-OSHA report on workforce diversity (EU-OSHA, 2020g) found that migrant workers were more exposed to psychosocial risk factors. However, the same report also commented that they tended to work in jobs and sectors with poor psychosocial conditions. Determining which of these factors can be regarded as dominant therefore becomes problematic. Are groups of workers such as women or migrant workers working in the same job more or less exposed to psychosocial risks than, for example, their male or non-migrant colleagues?

As an example of the complexities surrounding such considerations, a brief report by Arici et al. (2016) found that, within the same organisation, migrant workers were less likely to be in relatively senior or leadership roles. However, compared with their non-migrant colleagues, they reported significantly greater job satisfaction and, contrary to what might be expected, did not report any difference in the perception of discrimination at work.

Separate, but related to this issue, is the question of whether or not particular groups are more vulnerable to any adverse effects of psychosocial factors when exposed to the same extent? The limited evidence relating to these questions is explored below.

6.1.2 Sector or occupation

Many of the cohort studies conducted are based on population samples and do not allow any analyses to be made of the influence of working in different industrial sectors or specific occupations. Among the papers evaluated as part of the review, just three named occupations were specifically identified in more than one paper: nurses and other health care workers, computer/office workers and manufacturing workers. In each case, the papers included data from only a single occupation, and there was therefore no cross-analysis of comparative risks across the different groups.

One paper (Bodin et al., 2020) did include data from two separate groups. However, only one of these was drawn from a specific population (pharmaceutical manufacturers), the other being derived from a population cohort. Additionally, the data presented were derived from very different studies: one cross-sectional and the other longitudinal. Although the paper did comment on the different psychosocial factors that emerged as significant in the two groups, any further comparison between groups would be problematic.

The studies on office workers were very different in their approach and scope and there were no attempts to make comparisons with other groups.

It would not be possible to derive any statements regarding greater or lesser susceptibility between the various groups, as exposure variables were not determined in the same way, and no particular significance can be drawn from the emergence of specific risk factors as having a significant causal effect in one group but not in another. It is certainly not possible to suggest that any one group differed markedly in vulnerability from other specific groups or population samples. In addition, even within a group of, for example, pharmaceutical manufacturers, there may well be a wide range of exposure to different risk factors, depending on the individuals' roles. A report by Eurofound and EU-OSHA (2014) suggests that an individual's role within a company is of possible significance in influencing the nature and extent of specific risks. Thus, workers at a lower level in the organisational structure are possibly more likely to be engaged in repetitive (possibly monotonous) tasks while those at a higher level might have greater task complexity.

In the same manner as such occupational groups differ in their exposure to a given physical risk factor, it is reasonable to surmise that there would be differences between groups in their relative exposures to some specific psychosocial risk factors. Thus, those working in public-facing roles might well be expected to be more likely to be exposed to the risk of third-party violence than those employed in office occupations or others with no public-facing role. Similarly, the Eurofound and EU-OSHA (2014) report

found that there was a small proportion of workers in most sectors who reported not knowing what was expected of them at work 'at least sometimes' but that this occurred most commonly in financial services, agriculture and construction. However, the differences between sectors were not large in absolute terms, suggesting that sector would not be a major influence on exposure to this factor.

6.1.3 Company size

No studies were identified in which company size had been explored as a specific variable. The nature of the studies reported meant that those conducted among specific occupational groups tended to be within larger organisations to provide a sufficiently large sample for the study. Undoubtedly a proportion of the workers studied in population cohorts would have worked for smaller organisations but no study was identified in which this was explored as a specific element.

6.1.4 Gender

In most instances, the studies adjusted for gender in their statistical analyses, so it was not possible to derive any analyses based on this as a variable. A few of the papers studied analysed their results by gender, either as a main focus or as a secondary consideration. These showed mixed results in terms of any possible causal associations between psychosocial factors and MSDs, with some reporting significant associations among women but not men (and vice versa). In some instances, the authors were able to explain this in terms of differences in job roles between the gender groups, with men more likely to be in managerial and professional roles (and women in what were termed technical roles).

The overall impression is that there is no clear gender susceptibility, although, on balance, there was perhaps a slight suggestion that men were possibly more susceptible than women to an increased risk of MSDs arising from psychosocial risk factors. However, the varied and detailed results from those studies that did report the influence of gender as a variable demonstrate the complexity of that relationship, suggesting the reality to be a complicated and complex picture.

One exception to this overall picture is probably that female workers are more likely to experience psychological harassment (bullying) than their male counterparts. Even here, however, the picture is complex, as it is difficult to distinguish the fact that women are apparently more likely to be harassed from any suggestion that women are any more (or less) susceptible to the effect of that harassment when it occurs.

6.1.5 Ethnicity and culture

Although some studies reported ethnicity in the demographic details of their study sample, this was often apparently for the sake of completeness of information, and this was not analysed as a variable. In very few cases, study results appear to suggest that cultural differences (rather than ethnicity) might lead to different impacts of psychosocial risk factors on MSDs. This view is reinforced by experience in working within different cultures where it is apparent that different expectations exist within the workforce regarding what might be considered 'normal' expectations. It appears plausible to suggest that differences in cultural norms regarding a specific factor (such as control over work) are likely to be reflected in the extent of any impact of that factor on MSD risk.

6.2 Associations between MSDs and psychosocial risks

Section 3.2 summarised the evidence for causal relationships between a number of psychosocial risk factors and MSDs. Although these relationships are complex and not always straightforward, the balance of evidence does seem to support the existence of such relationships. Section 3.2 also suggested that a better reflection of the likely impact in any working situation might well be derived from the adoption of integrating measures, such as the DCM (sometimes extended to demand-control-support) and the ERI model. Using such models allows the accommodation of the fact that some psychosocial factors can have a positive influence (such as a high level of job control offsetting the potentially negative impact of high job demands).

A key factor to consider is the undoubted fact that associations between psychosocial factors and MSDs can work both ways. In general terms, psychosocial factors can contribute to the causation of MSDs but having an MSD can have negative consequences, including poor psychological health. It is not always easy, however, to determine the extent of such interactions. For example, although there is little question

that constant pain (from an MSD or other cause) can be depressing, the associated sequelae of such pain, such as the inability to work and enforced social isolation, can also have similar effects, and it is hard to differentiate the relative contribution of each of these (and other) factors to the overall problem.

Examining the associations between psychosocial risks and MSDs in more detail, it is not possible to establish specific associations between different types of MSDs and different types of psychosocial risk.

Parallels can be drawn with physical risk factors where, although a generic complex of causal factors can be described, the relative role and contribution of each of the factors differs between different MSDs (through mechanisms summarised for a number of common upper limb disorders by Graveling (2019)). For example, for some upper limb MSDs, such as tenosynovitis, the primary physiological/biomechanical causal mechanism appears to be excessive (or sustained) tension in tendons and other structures, while in others, such as CTS, excessive compression or entrapment is cited as a mechanism.

A number of different causal mechanisms have been put forward to account for the contribution of psychosocial factors to the causation of MSDs. If just one of these played a major role in causation, then there might be some justification for expecting differential effects between different psychosocial risks and specific MSDs consistent with that mechanism. However, it appears to be the consensus that the effects of psychosocial risks are mediated through a common mechanism. If this is the case, then this would not generally suggest the likelihood of such differential effects over such a diverse range of MSDs. It must be remembered that the term MSD is a convenient umbrella term for a variety of specific clinical conditions (together with some that, to date, do not have an agreed underlying pathology). The diverse conditions that the term represents do not necessarily share a common causal mechanistic pathway, whether the causal influences are physical or psychosocial.

As noted above, there is evidence to suggest that creating a composite index of overall psychosocial load (sometimes referred to as a 'strain index') generates a stronger prediction of MSD risk than considering each source of psychosocial risk individually. One partial explanation for this is the observation that psychosocial factors are not always negative. For example, good support (from co-workers or managers) can offset the negative effects of factors such as high job demands. Carefully constructed, a 'strain index' can accommodate these positive influences where they occur, allowing the overall collective influence of psychosocial risk factors to be accommodated. Parallels for this approach can be drawn with the various tools for collectively quantifying physical risk, such as the hand activity level, strain index and occupational repetitive action composite measures used by Garg et al. (2012).

Established psychological tools such as those applying the ERI measure or the demand-control concept enable such collective assessments to be applied to the psychosocial risk domain, and there is evidence to suggest that they provide valuable insights into the relationship between psychosocial risks and MSDs.

6.3 Main intervention strategies

Although many suggestions have been put forward to reflect strategic approaches to reduce the effect of psychosocial risks on MSDs, none have, as yet, been found to be adequately evaluated. Most of the recommendations for interventions identified in the literature are limited to a suggested focus on the need for a holistic approach to risk assessment that considers both physical and psychosocial risks.

Within the multifactorial approaches that have been promoted and, to some extent, investigated, those elements aimed at the individual appear to offer the strongest evidence. However, experience from other, related, disciplines (e.g. Graveling et al., 2008) strongly support the view that much of the reason for that relative strength lies in methodological factors, as it is easier (and more efficient) to design and conduct a statistically strong investigation of an individual-level intervention than an organisation-level one. This has resulted in some authors (e.g. Oakman et al., 2018; Sundstrup et al., 2020; Westgaard, 2010) questioning the conventional reliance on studies such as randomised controlled trials as the gold standard benchmark in evidential reviews of this nature.

Section 7.2 presents some guidance for an intervention strategy to prevent MSDs and covers both physical and psychosocial risks based on previous research and existing recognised good practice.

There is, as yet, little evidence that the adoption of risk reduction strategies in the workplace that address both physical and psychosocial risks is widespread. Section 5.2.1 refers to a number of tools readily available for separately assessing physical and psychosocial risks in the workplace.

There does, however, seem to be a growing awareness of the need for integrated strategies and there would seem to be some merit in developing further tools harnessing approaches that employers and industries are already familiar with (such as the Online Interactive Risk Assessment — OIRA tool; <https://oiraproject.eu/en>).

7 Research gaps and recommendations for prevention

7.1 Research gaps on the association between psychosocial risk factors and MSDs

One fundamental potential research need depends on the extent of acceptance of a causal role for psychosocial risks and MSDs. Once that relationship is generally accepted, then there appears to be little value in expending research resources solely on reinforcing that relationship. However, there will be an ongoing need to further develop that knowledge, in particular to understand the relative contribution of exposure to different risks and consequent responses.

The overall body of research evidence clearly suggests that not all psychosocial factors create a causal risk in all circumstances. This is not unexpected, given that a similar variance can be established for physical risk factors. For example, although repetitive work has clearly been established as a risk factor, not all repetition is necessarily harmful. The nature of what is being repeated, in terms of forces or postures, interact with that repetition to create an overall influential ‘physical load’ that characterises the extent of any risk of injury. Efforts would be better directed towards developing methods to quantify the overall ‘psychosocial load’ in a manner that best reflects the risk of MSD injury generated by that load.

As discussed above, at present there is no clear understanding of the exact biological mechanisms through which the influences of psychosocial risk factors are mediated. As noted earlier, a number of potential mechanisms have been hypothesised and it is possible that several of these act in unison. Establishing a causal mechanism (or mechanisms) is important, as it would be valuable in helping to establish the ‘biological plausibility’ of such effects. At present there is little evidence to suggest differential effects, whereby different psychosocial risks contribute more to some MSDs than to others. This is an important consideration in exploring these causal mechanisms and should be examined further.

Although causation and the causal mechanisms are not fully understood, this should not be regarded as a barrier to taking ameliorative action. At present, although many suggestions have been put forward to reflect strategic approaches to reduce the effect of psychosocial risks on MSDs, none have as yet been found to be adequately evaluated.

Much of the emphasis in the literature explored was on the fundamental initial causal connections between psychosocial risks and MSDs. It is unlikely that significant differences will emerge in the relationship between workplace psychosocial risk factors and those MSDs considered to be caused by work, compared with those in which work factors exacerbate the ongoing development of underlying (perhaps degenerative) MSD problems.

Some evidence-based guidance is available on aspects of psychosocial influences on MSDs and their persistence (e.g. Waddell et al., 2008, on vocational rehabilitation). However, compared with the impact of physical factors and barriers, it appears that less research effort has been expended on understanding the influence of psychosocial factors on the persistence of MSDs (chronic MSDs). Similarly, the role of psychosocial factors in rehabilitating those with MSDs into the workplace (and retaining those still working in the case of rehabilitation and retention in particular) remains to be better understood. Understanding the psychological as well as the physical barriers to rehabilitation is vital, as there is clear evidence that ongoing MSDs present as least as great a burden to industry (and to the individual sufferer) as the initial causation of MSDs in the workplace (EU-OSHA, 2021b).

Given the evidence that the assessment of physical factors alone is inadequate (EU-OSHA, 2020d), there seems to be limited evidence of psychosocial factors being readily and widely assimilated into the risk assessment process at present. There is therefore a clear need for the development of suitable tools or procedural approaches to facilitate holistic risk assessments and their widespread promotion and advocacy within industry. Previous EU-OSHA research has generated a catalogue of different strategic approaches to the prevention of MSDs (EU-OSHA, 2020b), and these could readily be adapted and refined as required to accommodate psychosocial risk factors.

7.2 Good practice for preventing MSDs associated with psychosocial risks and psychosocial risks associated with MSDs

A number of key elements of a potentially effective strategy can be identified, combining the findings from the review above with recognised good practice in assessing and reducing workplace risks.

- At all levels in the workplace there needs to be recognition of and commitment to a requirement to address both physical and psychosocial risks of MSDs.
- This should be followed by a systematic, holistic approach to risk assessment, covering both physical and psychosocial risks. There are many aids for assessment available.
- As with physical risk factors, the assessment needs to adopt a comprehensive approach, taking a broad view to assess all potential psychosocial risks and not focusing on a selection of those risks.
- Risk assessment requires management commitment and should actively involve the workforce, and it should ensure that actual work activities are assessed, not what is believed to happen.
- Because of the individual focus of many psychosocial risk assessment tools, adequately assessing psychosocial risk factors requires openness and honesty on the part of the workforce. Appropriate measures should be in place to safeguard and protect individual confidentiality.
- Assessing physical and psychosocial health and well-being will also be of value in identifying where action is most needed.
- It should be remembered that psychosocial risk factors can have a direct negative impact on psychological health and well-being and on MSDs.
- As well as contributing to the development of MSDs, psychosocial factors can create barriers to returning to work for those with chronic MSDs.
- Risk assessment is a means to an end — not an end in itself — and requires preventive and corrective measures to be identified and implemented.
- As with risk assessment, identifying and developing any follow-up actions should involve the workforce.
- Evidence suggests that solutions developed collaboratively are more likely to be successful.
- In keeping with recognised good practice, workplace risks should be periodically reassessed to confirm that any risk reduction measures are being correctly implemented and in recognition of the fact that many workplaces are dynamic places where risks can change and new risks can emerge.
- There is some evidence that a multifactorial approach to prevention is more effective than addressing single risk factors, both in primary prevention and in rehabilitation.
- The complexity of interacting factors in respect of rehabilitation and the prevention of recurrence, where individual psychological barriers to returning also need to be taken into account, can make such a multifactorial approach even more necessary, compared with initial prevention.
- Some psychosocial factors can work positively — especially positive support from co-workers and managers. Ideally such support should develop as part of an open and supportive culture.

- Where appropriate, it may be necessary to enshrine more formal support procedures into systems of work and, where necessary, to ensure that supervisors and managers have the necessary training to understand and apply such systems.
- Where a change to work and work systems is required, provisions should be made to ensure that such changes are introduced and maintained (see note above on reassessment). Experience suggests that, without the necessary reinforcement, reversion to the status quo is often the norm.
- In many instances, communication and collaboration and involvement is key, ensuring that change is explained and cascaded down within the workforce. Again, practical experience suggests that change introduced or enforced without such involvement can lead to resentment, a lack of commitment and co-operation and, eventually, system failure.
- Some factors can work on both physical and psychosocial risks. For example, enabling greater individual freedom over scheduling work breaks (when possible) can act directly to reduce physical strain and can also provide a greater sense of personal control. This can lead to clear and comprehensive benefits.
- Addressing psychological and sexual harassment (where identified) should be a priority, as this can seriously affect both physical and psychosocial health.

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Appendix 1: Search scope

The search terms and scope are presented in Table 2. Note that, for brevity, some terms are presented as clusters of terms, although, as shown in the search strings below, they were included as individual aspects in searches.

Table 2: Search terms and scope

Criterion	Description
Population	Employees
	Workers
	Age > 16 or 18
	Ageing worker; older worker; younger worker
Intervention/impact	Risk assessment
	Guidance
	Prevention
	Toolkits
Context	Work
	Workplace
	Organisational factors
	- Ways of working including: <ul style="list-style-type: none"> ▪ new ways and forms of work; teleworking; gig economy; flexible working; agile working; lean management; piece work; temporary work; home-based work; remote work; digitalisation
	- Work load factors including: <ul style="list-style-type: none"> ▪ high work load; high work pace; regular overwork
	- Job content
	- Lack of control
	- Role ambiguity AND role conflicts
	- Inflexible work schedules
	- Lack of career prospects
	- Equal/unequal pay
	Psychosocial factors
	- Interpersonal relationships at work; conflicts
	- Harassment; bullying; discrimination
	- Work design; work organisation; work management
	- Job insecurity
	- Low social support
	- Isolated work
	- Blurring boundaries between work and life/work-life conflict
	- Burnout; fatigue
	- Low job control

Criterion	Description
	<ul style="list-style-type: none"> - Individual psychological factors - Pain perception; fear of movement - Motivation
Outcome	<p>Musculoskeletal disorders; MSDs</p> <p>Neck pain; shoulder pain; upper limb disorders; back pain; lower limb disorders</p> <p>Chronic pain</p> <p>Stress; technostress</p> <p>Fatigue</p> <p>Sleep problems</p>
Types of studies	<p>Epidemiological</p> <p>Cross-sectional</p> <p>Case control</p> <p>Systematic reviews for extracting unpublished data and/or checking cross-references</p> <p>Guidance on interventions</p> <p>Case studies</p>
Inclusion criteria	<p>Relevance — the publication informs the review research questions</p> <p>Reputation — the publication is from a reputable source</p> <p>Robustness — the publication research methods are robust and fulfilled (according to the quality assessment; detailed below)</p> <p>Publication date — 2006* onwards (based on the publication date of a previous comprehensive review on the topic)</p> <p>Geographical scope — international literature and publications</p> <p>Language — all</p>
Exclusion criteria	<p>Publication date — pre-2006*</p> <p>Duplicate studies</p>

*This parameter, limiting the publication dates selected, will not be included when searching for grey literature, which was not covered by the selected core review.

Appendix 2: Search strings applied in the databases

PubMed

(workers OR “flexible working” OR “teleworking” OR “gig economy” OR “agile working” OR digitalisation OR “lean management” OR “piece work” OR “temporary work” OR “home-based work” OR “remote work*” OR “job content” OR “high work” OR (pace AND (“work load*” OR workload*)) OR (regular AND overwork*) OR “lack of control” OR “role ambiguity” OR “role conflicts” OR “inflexible work schedules” OR (“career prospects” AND lack*) OR “equal pay” OR “unequal pay”) AND ((psychosocial AND risk) OR (“interpersonal relationships” AND work*) OR conflicts OR harassment OR bullying OR discrimination OR “work design” OR “job design” OR “work organisation” OR “work management” OR “job insecurity” OR (work AND human AND isolation) OR (people AND burnout) OR (people AND fatigue) OR (work-life AND (conflict OR balance OR boundaries)) OR (perception AND pain) OR “fear of movement” OR motivation) AND (“musculoskeletal disorders” OR MSDs OR “neck pain” OR “shoulder pain” OR fatigue OR (sleep* AND problems) OR “upper limb disorders” OR (stress AND human) OR techno-stress OR technostress OR “techno stress” OR (chronic AND pain))

= 1,335 results (imported to DistillerSR)

Web of Science

(workers OR “flexible working” OR “teleworking” OR “gig economy” OR “agile working” OR digitalisation OR “lean management” OR “piece work” OR “temporary work” OR “home-based work” OR “remote work*” OR “job content” OR “high work” OR (pace AND (“work load*” OR workload*)) OR (regular AND overwork*) OR “lack of control” OR “role ambiguity” OR “role conflicts” OR “inflexible work schedules” OR (“career prospects” AND lack*) OR “equal pay” OR “unequal pay”) AND ((psychosocial AND risk) OR (“interpersonal relationships” AND work*) OR conflicts OR harassment OR bullying OR discrimination OR “work design” OR “job design” OR “work organisation” OR “work management” OR “job insecurity” OR (work AND human AND isolation) OR (people AND burnout) OR (people AND fatigue) OR (work-life AND (conflict OR balance OR boundaries)) OR (perception AND pain) OR “fear of movement” OR motivation) AND (“musculoskeletal disorders” OR MSDs OR “neck pain” OR “shoulder pain” OR fatigue OR (sleep* AND problems) OR “upper limb disorders” OR (stress AND human) OR techno-stress OR technostress OR “techno stress” OR (chronic AND pain))

= 1,547 results (imported to DistillerSR)

Google Scholar

(“psychosocial risk” AND “musculoskeletal disorders” AND workers AND adults AND (prevention OR occurrence) AND study)

= c. 1,900 results (when reviewing results pages, 992 results were presented; therefore, the 992 were imported to DistillerSR)

Scopus

(psychosocial AND risk) AND “musculoskeletal disorders” AND worker*

= 331 document results

Appendix 3

Title screening questions

The screening question applied is presented in Table 3.

Table 3: Title screening questions

Question text	Type	Answer text
Is this reference potentially relevant to our review on psychosocial risks and MSDs?	Radio (select one response from list of answers)	Yes (include) No (exclude) Can't tell (include)

Abstract screening questions

Abstract screening involved reviewing the abstracts based on the questions in Table 4.

Table 4: Abstract screening questions

Question text	Type	Answer text
Does the publication cover the association between psychosocial risk factors and MSDs? Here we are determining if the study is of relevance to the review on psychosocial risks (e.g. organisational factors, individual factors) and MSDs (e.g. neck pain, shoulder pain, upper limb disorders).	Radio	Yes (include) No (exclude) Can't tell (include)
Does the publication cover work environments/employees? Here we are determining if the study population is of relevance.	Radio	Yes (include) No (exclude) Can't tell (include)
Is there an abstract?	Radio	Yes No
Does the paper explain/consider two-way relationship between psychosocial risks and MSDs?	Radio	Yes (include) No (exclude) Can't tell (include)

Preliminary data extraction questions

Preliminary data extraction involved extracting data available based on the questions in Table 5.

Table 5: Preliminary data extraction questions

Question text	Type	Question header
Reviewer initials	Text	
Unclear/not sure/discussion needed (insert brief comment below explaining why you are not sure/why it is unclear) (insert n/a if you can complete the form below)	Text	

Question text	Type	Question header
<p>If the study is still relevant, select 'study is relevant and included'. If the study is not relevant, select one of the following excluding factors and select submit form. If selected, then there is no need to extract information in the following questions. If there is a new excluding factor, add this to the list.</p>	Checkbox	<p>Study is relevant and included</p> <p>Limited focus or evidence on psychosocial risks</p> <p>Stress is an outcome of the study</p> <p>It is a thesis</p> <p>It is a conference paper</p> <p>It is a book/chapter</p> <p>Duplicate</p> <p>Population is patients (not workers)</p> <p>Not focused on MSDs</p> <p>Return to work or rehabilitation as the outcome</p> <p>Review papers pre-2006</p> <p>Population is students</p> <p>Study protocol</p> <p>Injury claim</p> <p>Focus is sick leave</p> <p>Somatisation</p> <p>No abstract</p> <p>Effects of physical exercise</p>
<p>What types of psychosocial risks are covered?</p>	Checkbox	<p>Psychosocial risks</p> <p>Interpersonal relationships at work</p> <p>Harassment</p> <p>Bullying</p> <p>Discrimination</p> <p>Work design</p> <p>Work organisation</p> <p>Work management</p> <p>Job insecurity</p> <p>Low social support</p> <p>Low job control</p> <p>Isolated work</p> <p>Work-life balance/work-life conflict</p> <p>Burnout</p> <p>Fatigue</p> <p>Demands</p> <p>Management</p> <p>Workload</p> <p>Job strain</p> <p>Stress</p> <p>Effort/reward imbalance</p> <p>Support</p> <p>Decision latitude</p> <p>Job satisfaction</p> <p>Absorption</p>

Question text	Type	Question header
What types of MSDs are covered?	Checkbox	Musculoskeletal disorders Neck pain Shoulder pain Upper limb disorders Back pain Lower limb disorders Chronic pain Low back pain Elbow pain Wrist Arm Hand Rotator cuff syndrome
What is the study design?	Checkbox	Cross-sectional Case-control Systematic review Review Guidance Case study Longitudinal Qualitative Cohort Meta-analysis Randomised controlled trial Cluster randomised controlled trial Quasi-experimental Prospective Personal monitoring
Population details — sample size (if not available insert n/a in text box)	Text	
Confounders/modifiers considered (if not available insert n/a in text box)	Text	
Population details — age/gender (if not available insert n/a in text box)	Text	
How many papers were included in the review?	Text	
How many papers were included in the systematic review?	Text	
What is the aim of the study? (copy from abstract)	Text	
Which countries are involved? (if not available insert n/a in text box)	Text	
Which sectors are covered? (if not available insert n/a in text box)	Text	

Question text	Type	Question header
Which jobs are involved? (if not available insert n/a in text box)	Text	
Is the study about an intervention or model?	Checkbox	Intervention Model No Can't tell
Has the intervention been evaluated?	Radio	Yes No Can't tell
What type of intervention is it?	Text	
Info on the model (name, type)	Text	
What are the main (relevant) results? (with effect size and statistical significance where relevant)	Text	
Additional notes	Text	

Data extraction questions

Data extraction involved extracting the details presented in Table 6 for the studies included when studies were excluded, a reason for exclusion was provided.

Table 6: Data extraction questions/criteria

Categories	Data extraction questions/criteria to be extracted
	RefID
	Bibliography
Assessment of full text	Based on full text review, is the publication included or excluded? (include/exclude/not sure) (no further data extraction required if excluded, just a reason for exclusion in column D)
	If excluded, what is the reason for exclusion?
	What research question(s) does the study address?
Study details	What is the aim of the study?
	What type of publication/study is it?
	What types of psychosocial risks are covered?
	What types of MSDs are covered?
	Which countries are involved?
	Which sectors are covered?

Categories	Data extraction questions/criteria to be extracted
Intervention details	Which occupations/jobs are involved?
	Are case studies detailed in the paper? (yes/no)
	Population details — sample size (if relevant)
	Population details — age/gender (if relevant)
	How many papers were included in the review? (if relevant)
	Is the study about an intervention or theoretical model? (intervention/model/no/not sure) (if yes, complete relevant questions sections/questions below on interventions/models)
	What was the name of the intervention?
	What was the aim of the intervention?
	How does the intervention work?
	Who is the target population of the intervention?
	Has the intervention been implemented?
	What were the results of the intervention?
	What type of intervention is it?
	What were the results of the intervention?
Model details	Info on the theoretical model (name, type)
	Provide a brief description of the model
Results	What are the main (relevant) results? (with effect size and statistical significance where relevant)
	How do the findings inform the review?
	Confounders/modifiers considered (if relevant)
Stakeholders	What stakeholders were involved/included in the study? (e.g. policy-makers, OSH community, trade unions)
Quality	What is the NICE quality appraisal score? ('++', '+', '-')
Additional information	Are any evidence gaps identified? (if so, please state)
	Additional notes

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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