RESEARCH AND EVALUATION

Work-related musculoskeletal disorders

LITERATURE OVERVIEW

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Te Kāwanatanga o Aotearoa
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WORKSAFE
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AUTHORSHIP

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EXECUTIVE SUMMARY

This review summarises two separate literatures: the New Zealand and international literature on the risk factors for WRMSDs and the literature on interventions to reduce harm from WRMSDs.

The key findings from the risk factor literature were that:

- the risk factors for MSDs are complex and interrelated
- there is a need to focus on organisational and wider systemic risk factors for WRMSDs, beyond a narrow focus on worker demographics and task design
- psychosocial risk factors need to be addressed
- workplace culture is a key underlying risk factor for WRMSDs
- the different demands and drivers for workers' and managers' behaviour are important considerations and underlying risk factors for WRMSDs.

All of these findings should be used to strengthen conventional approaches to WRMSDs that focus on workstation design, task design, manual handling loading and personal features of individual workers. Doing so will provide a holistic understanding of what causes WRMSDs. Risk factors at the higher level of the socio-technical system can also be incorporated into the WRMSDs literature, although this should be done with due caution.

Oakman *et al.*'s (2016) recommendations for regulators are useful starting points for intervention design. These were:

- change the advice focus from secondary and tertiary prevention to primary prevention and highlight the need for employers to focus on organisational and psychosocial hazards
- promote educational programs on psychosocial hazards targeting managers and supervisors
- develop and promulgate best-practice case studies in managing psychosocial hazards
- promote more holistic risk management tools
- promote the need for paid worker consultation and participation in risk assessment and control procedures
- promote the need for senior managers to develop and maintain a detailed understanding and valuing of OHS issues and receiving feedback from staff
- review existing information and advice to ensure relevance.

Expert recommendations suggest that successful interventions will be ones that:

- are systems-based or use a macro-ergonomics approach that addresses the wider context that work occurs within
- address psychosocial risk factors for WRMSDs and the causes of psychosocial harm
- are participatory ergonomics that promote deep and meaningful worker engagement and organisational changes
- result in changes in managerial and cultural changes both within an organisation and between organisations
- are properly targeted and tailored to the specific organisational and work context within which MSDs harms occur.

These recommendations highlight the need to avoid prescriptive recommendations for interventions, but instead stress the need for regulators to tailor their interventions to particular contexts and to involve workers, managers and organisations in the development of interventions. Overall though, the review of the intervention literature found much research to be of dubious applicability to WorkSafe, with most studies finding little to no effect or lacking adequate assessment of context or causality to establish why interventions are or are not effective. However academics with significant experience in addressing WRMSDs have provided guidance on key features of effective interventions.

In order to ensure that the findings here are theoretically robust, the research programme was guided by socio-technical systems theory, in particular the work of Jens Rasmussen. From this initial starting point it was determined that a realist methodology would be appropriate for the literature review. This approach allows for the products of different research disciplines to be incorporated into a single assessment. Adopting a realist methodology helps researchers avoid falling into the trap of exclusively addressing the often repetitive and not insightful, but prolific, epidemiological literature on WRMSDs. Instead it allowed for an inclusive approach to the literature from a broader range of disciplines.

CONTENTS

appendices

tables

figures

1.0
Introduction

This report summarises the risk factors for, and interventions to address work-related musculoskeletal disorders (WRMSDs), from a theoretical and methodologically robust perspective.

This review summarises two separate literatures: the New Zealand and international literature on the risk factors for WRMSDs and the literature on interventions to reduce harm from WRMSDs. Further evidence was collected using WorkSafe's survey programme, StatsNZ and ACC's data and internal interviews with WorkSafe staff. These data are covered in other documents.

There were two tranches in the risk factor literature, the epidemiological and the qualitative literature. The epidemiological literature is large but is almost exclusively focused on re-confirming known physical hazards and individual risk factors for MSDs (such as demographic features). The qualitative literature is smaller but also addresses a broader range of risk factors, particularly organisational, relational and structural factors. Some of the findings from both of these literatures were that:

- the risk factors for MSDs are complex and interrelated
- there is a need to focus on organisational and wider systemic risk factors for WRMSDs, beyond a narrow focus on worker demographics and task design
- psychosocial risk factors need to be addressed
- workplace culture is a key underlying risk factor for WRMSDs
- the different demands and drivers for workers and managers are important considerations and underlying risk factors for WRMSDs.

These findings should be incorporated into conventional approaches to WRMSDs which primarily address workstation design, task design, manual handling, loading and personal features of individual workers. Risk factors at the higher level of the socio-technical system can also be incorporated into the WRMSDs literature, although this should be done with due caution.

The qualitative literature highlights how many WRMSDs are delegitimised by employers and government agencies. This delegitimization adds further strain to workers and may discourage reporting and prevent early interventions to address emerging chronic MSDs. Lastly qualitative studies also demonstrate the complex nature of many risk factors, with significant variations in the relationships between factors such as teamwork or management styles and WRMSDs.

The review of the intervention literature found much research to be of dubious applicability to WorkSafe, with most studies finding little to no effect or lacking adequate assessment of context or causality to establish why interventions are or are not effective. However, academics with significant experience in addressing WRMSDs have provided guidance on key features of interventions. Oakman *et al.*'s (2016) recommendations for regulators are useful starting points. These were:

- change the advice focus from secondary and tertiary prevention to primary prevention and highlight the need for employers to focus on organisational and psychosocial hazards
- promote educational programs on psychosocial hazards targeting managers and supervisors
- develop and promulgate best-practice case studies in managing psychosocial hazards
- promote more holistic risk management tools
- promote the need for paid worker consultation and participation in risk assessment and control procedures
- promote the need for senior managers to develop and maintain a detailed understanding and valuing of OHS issues and receiving feedback from staff
- review existing information and advice to ensure relevance.

These recommendations highlight the need to avoid prescriptive recommendations for interventions, but instead for the need for regulators to tailor their interventions to particular contexts and to involve workers, managers and organisations in the development of interventions.

The lack of intervention literature also emphasises the need for more evaluations of interventions, a need that becomes more signficant given the complex nature of WRMSDs. The importance of context meaning that interventions cannot be simply transferred from one context to another adds additional importance to evaluating interventions to provide greater insight into what intervention features are effective, where and for whom.

In order to ensure that the findings here are theoretically robust, the research programme was guided by socio-technical systems theory, in particular the work of Jens Rasmussen. From this initial starting point it was determined that a realist methodology would be appropriate for the literature review. This approach allows for the products of different research disciplines to be incorporated into a single assessment. Adopting a realist methodology helps researchers avoid falling into the trap of exclusively addressing the often repetitive and not insightful, but prolific, epidemiological literature on WRMSDs. Instead it allowed for an inclusive approach to the literature.

2.0 Theory and background

IN THIS SECTION:

1.1 Systems theory

This section provides a brief overview of socio-technical systems theory (systems theory). Systems theory shifts focus from the immediate features of an accident, such as the 'mechanism' of injury or the injured party's behaviour, toward the wider interplay between people, organisations and technology that provide the preconditions that allow accidents to occur. Subsequent chapters will discuss how systems theory will be applied to WRMSDs data through a discussion of realist methodology.

Sociotechnical systems theory provides a robust theoretical explanation for harm causation based on a model of human behaviour as an emergent property of system relations. There are a range of models and tools that have been developed to put the findings of systems theory into practice such as the AcciMap (Goode *et al*., 2016; Salmon *et al*., 2012; Waterson *et al*., 2015) or Leveson's STAMP (Salmon *et al*., 2012).

A theoretically robust model of behaviour is central to intervention design in part because of large gaps in the epidemiological evidence, but also because the insights gained from theories organise empirical evidence into a model and help to understand why people and organisations act in particular ways. Consequently:

> "In order to choose the interventions likely to be most effective, it makes sense to start with a model of behaviour. This model should capture the range of mechanisms that may be involved in change, including those that are internal and those that involve changes to the external environment" (Michie *et al*., 2011, p. 44).

Intervention designers make implicit and explicit assumptions about human behaviour. This can be problematic if these assumptions of behaviour are inaccurate. An empirically robust theory of behaviour can help illuminate and guide the assumptions made by intervention designers and correct inaccurate assumptions.

The next section discusses behaviour as an emergent property of a system, and how it differs from individualistic and structural approaches to behaviour. The section after that outlines how systems theory has been used in relation to health and safety. The final section outlines the ACCIMAP model and safety system, as developed by the prominent human factors and safety science theorist Jens Rasmussen.

Models of human behaviour

This section discusses behaviour as an emergent property of system interactions, as opposed to either the result of individual decision-making or pre-determined structural actions. The debates around what drives human behaviour are too complex to adequately address in this document, however, and are not necessary in order to apply theory to the literature reviewed here. Consequently this section provides a cursory overview of the challenges to conventional, individualistic models of behaviour, and briefly outlines why an environmental model is ultimately more suitable for WorkSafe to achieve its goals.

In general human behaviour has traditionally been explained as resulting from structural determinants, individual choices or a combination of the two. Throughout the 20th century individual choices had primacy as the main determinant of human behaviour in psychology, economics and politics. Individuals were seen primarily as self-interested rationally choosing beings who were goal oriented and made and enacted decisions based on those goals.

More recent individualistic paradigms have acknowledged some environmental factors such as education or mutual reciprocity, but these were generally a secondary consideration seen as only useful in helping to explain an individual's rational decisions (such as by them having subjective values or imperfect information) (for instance Becker, 1996). This discourse was increasingly challenged during the 20th century, as empirical observations of human behaviours contradicted expectations of what a self-interested rational individual would do in a given situation (see Archer, 1995 for a detailed discussion).

The common alternative for much of the 20th century were structural theories. These theories, commonly referred to as 'structural deterministic', located human action as part of social structures that determine how people will act, and their actions' outcomes. Structural theories have their own issues, however, and human agency is often lost in favour of teleological social structures, as evident in the work of Parsons, and others. Such an explanation presupposes the existence of particular social structures, and then seeks evidence for structures and develops tools to explain away contradictory evidence or activity. These make human action irrelevant and usually resort to circuitous arguments.

The limitations and issues with these two traditional approaches have resulted in researchers looking for alternative models of human behaviour. Some such as structuration theory or habitus theory failed to provide adequate alternatives by seeking a mid-ground between structure and agency. More successful recent approaches have focused on systems of networks and relations between actors. From such a perspective:

> "actors respond and reply to one another. Their actions are not effects of antecedent causes. At the same time, however they do stimulate, arouse, provide and otherwise exert a causal influence upon one another" (Crossley, 2011, p. 17).

Consequently, society is constructed of networks of actors, both human and non-human that impact on and interact with other actors in ways that are both complex and common enough to be mundane. Systems of networks are more than the sum of their parts; the interactions between networks are also seen as both irreducible to the actors involved, and producing properties independent from the actors themselves (Crossley, 2011; Latour, 1991; Wilson, 2014).

The actions and properties of a system and actors within it emerge from the networks of interactions between components (people, machinery, laws, and knowledge) of a system. Consequently, safety is an emergent property of a system – it is not the feature of one component (such as a safely behaving worker, a safe tool etc.), but rather it emerges from the interactions between different components (Carayon, Hancock, *et al*., 2015; Dekker, 2011).

Another consequence of such an approach is that both humans and objects are, to a similar degree 'actors' within these networks. The notion of objects as actors is also implicit in the human factors literature. To understand what is meant by objects as actors in the same way as humans relies on a distinction between action and agency. In this distinction agency refers to the intent to act possessed by humans (even if this purpose is driven by external factors). Action then refers to the impact an object/human has on other objects/humans in a network, and does not require intent.

Theorists are not always clear what they mean by 'system'. Wilson (2014) proposes the following comprehensive definition that a system is:

> "a set of inter-related or coupled activities or entities (hardware, software, buildings, spaces, communities and people), with a joint purpose, links between the entities which may be of state, form, function and causation, and which changes and modifies its state and the interactions within it given circumstances and events, and which is conceptualised as existing within a boundary; it has inputs and outputs which may connect in many-to-many mappings; and [...] the whole is usually greater than the sum of the parts" (Wilson, 2014, p. 6).

In contrast Dekker (2013) provides the following features of complex systems:

- complex systems are open systems
- complex system components are unaware of the behaviour of the system as a whole, and do not know the effects of constituent actors' actions on the system as a whole
- complexity is a system property not of the components of the system
- they are never static or in equilibrium and are constantly morphing and changing
- they have a history and this directs future behaviour
- interactions in a complex system are non-equivalent; a seemingly small input may have significant effects and vice versa.

Furthermore there is a need to remember that the behaviours of individuals, organisations and other components are emergent properties of the system.

Systems of networks are not static, or predetermined **structures**. Instead the performance of a system "emerges from the pattern of dynamic activities within and between its social and technical components" (Crossley, 2011; Kleiner *et al*., 2015). This is commonly referred to as the 'emergent properties' of a system. It means that a system is both more than the sum of its parts, because the relationships between those parts are just as important as the parts. It also means that system behaviour can be difficult to precisely predict since behaviours emerge from often unpredictable interactions (Dekker, 2011).

Behavioural explanations in occupational health and safety

Despite the recognition of the environmental determinants of social action in other spheres, most models of occupational health and safety management still retain both an individual focus, and an assumption that injuries are caused by localised, rather than systemic failures (Carayon, Kianfar, *et al*., 2015; Dekker, 2011).

It is important to shift toward a sociotechnical systems approach (referred to as a systems approach in this document), that recognises behaviour is emergent from systems (Carayon, Hancock, *et al*., 2015; Le Coze, 2015a; Underwood & Waterson, 2014; Waterson *et al*., 2015) and identifies system failures, as opposed to looking for 'broken components' (Dekker, 2011). This redirects our focus beyond identifying who acted in what way to explaining **why** they acted in such a way.

As noted by Rasmussen and others (Le Coze, 2015b; Leveson, 2012; Leveson *et al*., 2010; Rasmussen, 1997; Svedung & Rasmussen, 2002), there are many demands on workers, employers and managers, and many of these compete with best practice behaviours. Whilst perfectly safe and healthy behaviour is ideal, in practice the presence of other demands on workers, management, employers and safety professionals means that this is rarely attainable. Instead people balance and manage the different demands on them, meaning that behaviour generally

migrates or drifts toward the boundaries of safe behaviour (see below for a graphical representation) (Dekker, 2011; Rasmussen, 1997). Boundary behaviours are not explicitly unsafe, but are not perfectly safe either involving things like, cutting corners, or working in ways that increase the risk of injury, as unlikely as those risks may be.

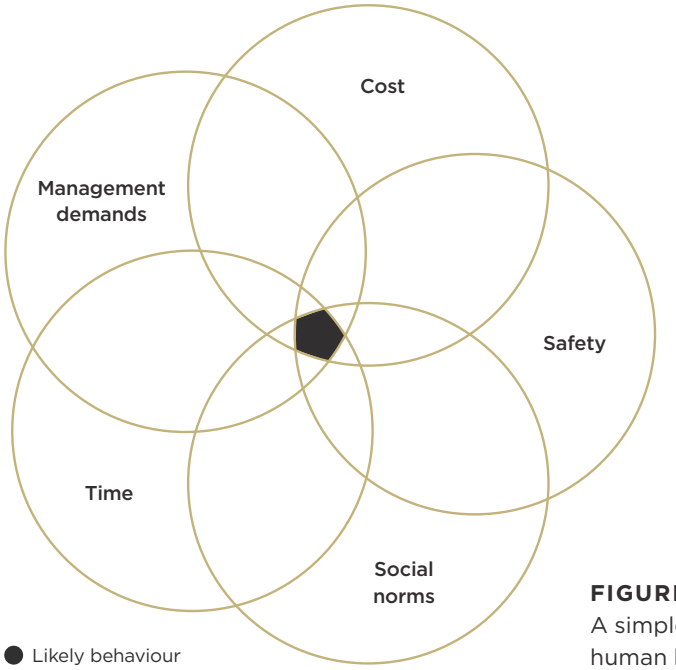

FIGURE 1:
A simple model of human behaviour

The most significant consequence of this is that behaviour rarely, if ever aligns to prescribed rules, contracts and regulations and, more importantly, that there are unavoidable reasons for this divergence (Dekker, 2011). Work practices cannot be prescribed in full, and "it is not possible to organise and obtain [improved] results based only on deterministic rules", rather behaviour is an emergent property of the system (Carayon, Kianfar, *et al*., 2015, p. 554). This means that systems are often characterised by a high degree of uncertainty and recognising this uncertainty is central to any intervention to be effective. Furthermore, in complex systems (like New Zealand's national health and safety system), the controllers' understanding of how the system acts, rarely, if ever aligns to how behaviour actually occurs. This has significant implications for WorkSafe, as there is a need to recognise that our understanding of health and safety requires constant and substantial feedback from every element (workers, PCBUs, inspectors, stakeholders, health and safety advisors/specialists) to remain even close to the actual state of the system, which can be provided by a properly applied systems-theory approach (Carayon, Hancock, *et al*., 2015; Leveson, 2012).

Health and safety in systems theory

The shift in focus to emergent systems is already occurring in the accident causation literature, which has traditionally been focused on identifying the causal 'fault' leading to a linear series of accidents, resulting in an accident (see for example Dekker, 2011; Reason, 2000; Salmon *et al*., 2012).

Linear models have been the traditional way of understanding accident causation. The first of these was Heinrich's 'Domino Theory' developed in the 1930s (Dekker, 2011; Larouzee & Le Coze, 2020; Reason, 2008). These linear models of behaviour assume there is a cause of an accident, a falling domino, which knocks over

another domino and so on until an accident occurs. From this perspective finding the cause of an accident involves tracing the line of fallen dominos and preventing future accident means removing one of the dominos. A similar linearity can be seen in Reason's Swiss Cheese model, however he argues that "'Swiss cheese' is primarily about how unsafe acts and latent conditions combine to breach the barriers and safeguards", and sees it as a systems-perspective (broadly defined) (Reason, 2008 ch. 5).

Generally the cause identified in linear models is human error since the non-adherence to prescribed practices is usually the most obvious and most expected 'failing' and also fulfils the illusion that people have free will (Reason, 2008). Whilst this simplicity is appealing, these models have repeatedly shown to be inadequate in explaining and modelling the cause of accidents in complex systems (Dekker & Pruchnicki, 2014). Their appeal comes because they individualise the cause of accidents thereby exempting larger organisations such as the employer or insurance companies from financial loss (particularly in the USA, see Baram, 2007), rather than providing an ability to adequately explain accident causation (Dekker, 2013).

As Winge *et al*. put it, it is increasingly acknowledged "that 'human error' is largely a result of the system humans are part of and symptomatic of trouble deeper within a system" (Winge *et al*., 2019, p. 137). While this change is increasingly accepted in academic circles, it faces difficulty in legal or business discourses where the search for an at-fault party, and the desire not to be held accountable for worker injuries result in a preference to identify an individual as responsible for an accident.

Human actions cannot be separated from the context in which they occur and, more importantly that context determines what is understood to be the 'correct' behaviour from the perspective of the actor (Leveson, 2004; Rasmussen, 1997; Svedung & Rasmussen, 2002). Thus system failure prevention approaches can become "focused not on human error and violation of rules, but on the mechanisms generating behaviour in the actual dynamic context" (Leveson, 2012, p. 46).

Summary

This section has provided a brief discussion of systems and behavioural theory to ground the subsequent sections. It has discussed how behaviour can be seen as an emergent property of a system, and has highlighted the often overlooked interactions between components. It has also noted how there are multiple demands on human behaviour that emerge from these system interactions, and has emphasised the importance of addressing these demands in order to achieve significant and long lasting improvements. The remaining sections will discuss ways of operationalising these findings, providing tools and graphical representations of the concepts that can be applied by intervention designers.

2.2 Applying systems theory: The AcciMap

This section moves toward outlining a practical application of systems theory. In particular it will discuss the AcciMap model developed by Jens Rasmussen and applied by other authors. The AcciMap is intended to provide a framework for which a realist review of the work-related musculoskeletal disorder literature outlined in the next section can be represented and aligned with systems theory.

Rasmussen developed the AcciMap model of accident causation in the 1990s to aid preventative risk-management (Rasmussen, 1997; Svedung & Rasmussen, 2002). The model draws on a series of empirical studies of accidents, to provide an approach to health and safety that in turn drew on a range of academic disciplines including engineering, sociology, political science, human factors/ergonomics and law.

For Rasmussen:

> "[...] the AcciMap was one part of a broader process for generalising from a series of accidents to define the conditions for safe operation in a particular type of system, so that risk management strategies could be devised" (Branford *et al*., 2009).

It thus had a practical component, both in its development and in its intent, and has been tested using case studies of serious accidents (Branford *et al*., 2009; Goode *et al*., 2016; Leveson *et al*., 2010; Salmon *et al*., 2012; Salmon *et al*., 2017).

The model avoids overly simplified or linear explanations of accident causation provided by accident-chain models and allows investigators to map the complex interactions between elements of the safety system that impact on health and safety. This complexity can make AcciMaps difficult to approach and 'messy' such as with Salmon, Cornelissen and Trotter's (2012) model of the Mangatepopo Gorge accident map shown in figure 2. However, these difficulties are unavoidable outcomes of addressing a complex system.

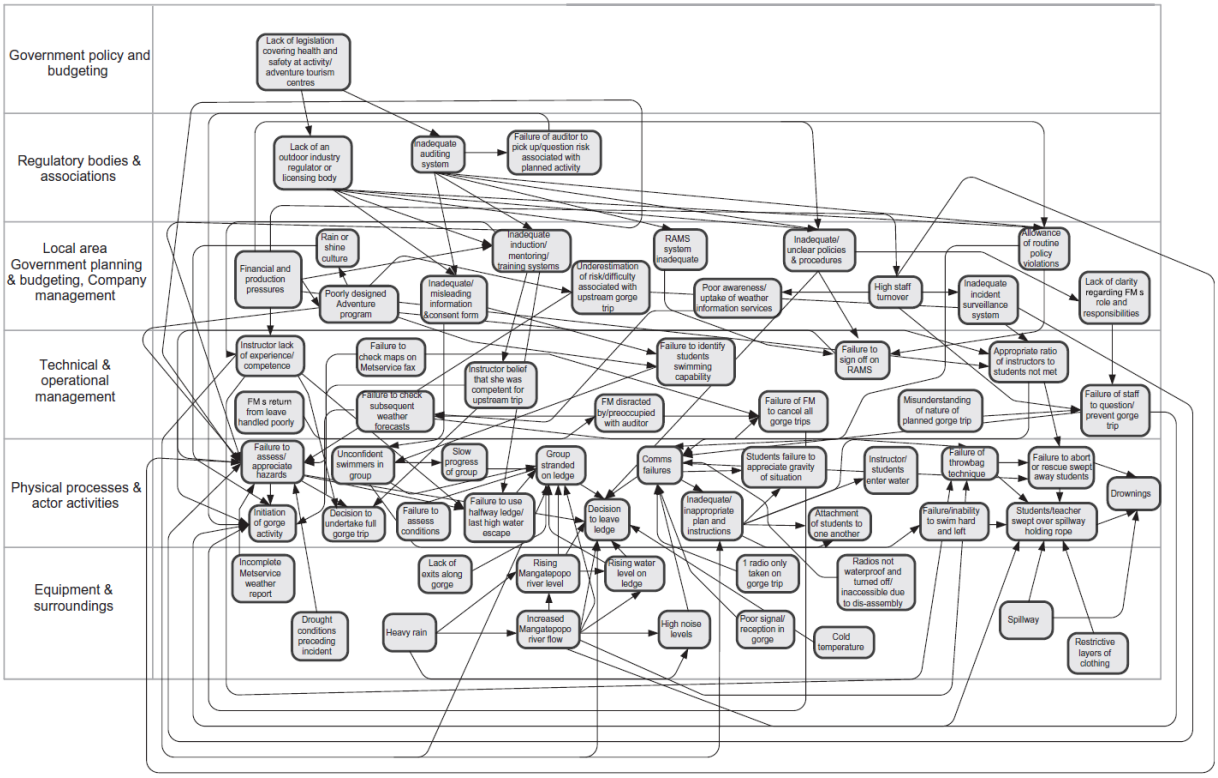

FIGURE 2: Mangatepopo accident map in Salmon *et al*. (2012)

A focus on the interrelationships between components is central because in complex systems, accidents often emerge from the interaction between perfectly functioning components, not from their failure. Decisions made at each instance may follow prescribed procedures but taken together result in an accident, and it is the role of the health and safety system to manage such misalignments (Leveson *et al*., 2010). 'Tightly woven' systems may lead to significant failures due to the high level of interrelations between them (Perrow, 1999). In some cases safe behaviour from the perspective of the actor may actually contribute to an accident – a building contractor may reorganise a site in a way that is safe for their workers, but then contributes to an accident for another contractor

who was unaware of the reorganisation. From this perspective understanding an accident does not end with the observation that, for instance, the worker was tired and so slipped, but rather explores what demands the worker was responding to that made them work when tired or being tired in the first place, the floor being slippery, and so on.

Systems are varied, constantly changing and are made up of many ever changing interrelations and actors. Whilst such models are useful in producing a 'mental map' it is important to remember that they are abstractions, not accurate representations of the complexity of networked systems. They do however provide a useful, roughly accurate 'common language' to conceptualise a health and safety system. Context-specific mapping of accident causation based on primary research and other forms of system feedback can help to provide more accurate mental maps.

Rasmussen's safety system model aligns with his AcciMap model (as can be been in Salmon *et al*.'s analysis shown earlier), to provide a framework for understanding accident causation, and for understanding how the safety system can function to address accidents. However, for elements of a control system to be effective it must have an accurate and up-to-date understanding of the system it aims to control. Furthermore, the different elements of the control system must also understand their role in the system and how that relates to other elements of the system. At a high level this may be clarification of the boundaries between WorkSafe and other regulators, at a lower level this may be different PCBUs understanding their responsibilities and having a clear understanding of where other PCBUs' responsibilities end.

Work-process in practice

Authors in both human factors/ergonomics and systems theory have stated the importance of analysing process documents such as regulation, company manuals and good practice guides etcetera. These authors also emphasise that work practices do not match intended processes, and that this is not something that can always simply be overcome through education or communicating these intended processes. Instead what is needed is for system controllers, such as regulators, to learn why processes are not followed and what are the barriers or demands that compete with safe processes. This is the most direct consequence of the focus on the determinants and context of behaviour.

An example of this is the finding that many long-haul drivers and machinery operators do not wear seatbelts. This is not due to either a lack of awareness of the presence of or need to wear seatbelts. Instead the issue is not one of education or awareness, but of other demands (comfort) made to conflict with safe behaviour (uncomfortable seatbelts) exacerbated by particular processes (long work hours) (Bohm & Harris, 2010; Mooren & Williamson, 2013). Elements of a human-technology interaction, coupled with other demands on workers lead to poorer health and safety outcomes, despite the immediate behaviours being explicitly prohibited by legislation.

Keeping mental models up-to-date: the importance of feedback

The limitations of top down interventions has also been noted in the accident causation literature, with discussions of different 'mental models' held by different actors (Dekker, 2011; Vaughan, 1996). Leveson (2012) in particular has noted that the further away from the accident environment someone is the more simplified, inaccurate and slower to change is their mental model. That is to say operators and workers on the ground likely have up-to-date and accurate models of what is going on, whereas their supervisors are slightly less so, and so on, with regulators and government workers having detached and outdated models of what action is occurring at lower levels of the system. The divergence of different mental models makes systems failure more likely to occur, however changes

should be driven from the bottom-up as much as possible because on-site operators and workers have the most up-to-date and accurate mental models of their working environments. The divergence of mental models may also be exacerbated by organisational memory loss when expertise are lost through staff turnover, particularly at the regulator or industry level. Although the issues faced by regulators cannot be fully overcome, they can be mitigated by being open to and facilitating feedback from all levels of the system, and not exclusively that of stakeholders or selected focus groups.

The above points are connected by the need for intervention designers to avoid preconceptions about causation. Systems work in unpredictable ways, are complex and mental models and beliefs of those 'up' the system are all reasons why it is important for intervention designers to avoid drawing on their preconceptions or to assume that their knowledge of working environments is accurate or sufficient.

2.3 Summary

The previous two sections have outlined systems theory and the AcciMap that will be used to provide the theoretical basis and framework for the literature review. The section has emphasised the construction of behaviour and accidents as emergent properties of system interactions and the complex, open and context specific nature of systems. It has also emphasised the need for multi-faceted interventions.

The next section will discuss the methodology of realist literature reviews that will be used to populate an AcciMap with evidence of the risk factors and potential interventions relevant to work-related musculoskeletal disorders. As will be discussed in more detail in the next section, a systems theory approach aligns well with a realist ontology and consequently from methodologies that have emerged from it.

3.0 Methodology: a realist review, ‘what works for whom, under what circumstances, how and why?’

IN THIS SECTION:

This document aims to review existing literature of:

1. the risk factors for work related musculoskeletal disorders (and their prevalence), and
2. evaluations of interventions addressing those risk factors.

Given the complex nature of both musculoskeletal disorders and the socio-technical system they occur within, a multidisciplinary approach, informed by a realist theory was taken in reviewing the literature. A realist review assesses various types of evidence according to the standards of each study's methodology. It then attempts to synthesise the different types of evidence identified without omitting or ignoring the conflicts between different research methodologies (Pawson, 2006). Due to their shared focuses on complex context and multidisciplinary research, systems theory is compatible with a realist approach both methodologically and in their underlying understanding of social relations (Westhorp, 2012).[1]

Realism occupies the middle ground between positivist and social constructivist social theories (Archer, 1995; Pawson, 2006).[2] Like positivism it accepts that there is a reality but like social constructivism it accepts that this reality cannot be measured directly. Insights into reality can be assessed indirectly through a variety of different types of empirical (and theoretical) evidence. Realism also rejects the crude empiricism of positivism and allows for multiple types of evidence to be treated equivalently and according to the standards of their own discipline (Dunn, 2012). The use of realist approaches to reviewing evidence for policy programmes has been outlined by Pawson (2006) and procedures for such reviews have also been built (Greenhalgh *et al*., 2011; Wong *et al*., 2013).

Multidisciplinary work produces difficulties primarily because "different disciplines and different social groups have different conceptions of evidence that they deem persuasive in guiding policy and practice" (Cole *et al*., 2003). This issue has been noted of epidemiology where, despite increased recognition of qualitative studies, the discipline remains positivist and views qualitative research as a secondary 'soft' science that merely supplements quantitative research (Dunn, 2012; Pawson, 2006; Silva & Fraga, 2012). This positivist approach is unproductive because it assesses social interventions according to medical standards, leading to the exclusion of context. It also leads to existing occupational health and safety research being negatively assessed for not fitting the standards of controlled trials. However, randomised control trials are impractical and undesirable in policy analyses, due to both the impossibility of developing counterfactuals in complex systems and the inability for RCTs to address context (beyond controlling for it) (Hawkins, 2016). Similarly, the effective interventions in controlled or laboratory conditions are frequently ineffective in field studies because they do not attend to context (Cole *et al*., 2003).

As Pawson notes social systems cannot be 'closed' nor standardised, thus interventions cannot be 'controlled' for. Furthermore the importance of context in determining the outcomes of social interventions means that, unlike in medical treatment variation in intervention effectiveness cannot be seen as happenstance. Instead:

> "[s]ocial interventions are active; they work through the interpretations of their providers and subjects. These responses take the programme along different courses; the active ingredient differs in the minds of different subjects. These interpretations are not irritating contingencies; the subjects' reactions are the programme lever" (Pawson, 2006).

[1] There is also significant common ground between the two and complexity theory Westhorp, G. (2012). Using complexity-consistent theory for evaluating complex systems. Evaluation, 18(4), 405–420.

[2] In addition to being a mid-range theory in the Mertonian sense of existing between grand theory and practical/applied theory.

The importance of context in determining the outcomes of social interventions also means that the outcomes of interventions are not necessarily reproducible neither do they have effects that can be pooled or averaged (Pawson, 2006). This lack of averaging or reproducibility is because humans do not act according to laws; human behaviour does still show certain patterns, which realism refers to as 'demi-regularities' (Archer, 1995; Westhorp, 2012). The aim of reviewers then is to identify 'demi-regularities' and patterns of outcomes and to identify likely mechanisms by which contextual conditions and intervention programmes produce these outcomes. Consequently the approach taken in the review is to assess the quality, limitations and potential generalisability of intervention evaluations on a case-by-case basis, and according to their merits within their own field of study (that is, is it a 'good' example of the type of evaluation it is assessing) and to judge the relevance of insights to the New Zealand context similarly on a case-by-case basis.[3]

Instead of looking for fixed affect sizes of interactions, realist reviews ask "what works for whom under what circumstances, how and why?" (Pawson, 2006; Wong *et al*., 2013). Reviewers producing a realist review should identify the **contextual influences** that have triggered **relevant mechanisms** which have produced the **outcomes** of interest (Greenhalgh *et al*., 2011; Pawson, 2006; Wong *et al*., 2013). This approach aims to "help make sense of heterogeneous evidence about complex interventions applied in diverse contexts in a way that informs policy" (Greenhalgh *et al*., 2011, p. 116). As has been noted, the nature of work-related MSDs necessitates an open, realist approach to reviewing evaluations (Greenhalgh *et al*., 2011; Pawson, 2006; Wong *et al*., 2013). Consequently, unlike positivism which aims to produce 'truth' and universal laws, realism aims to produce practically adequate, or instrumental knowledge that is revised and refined over time (Dunn, 2012).

In addition to incorporating qualitative evidence, conceptual and theoretical risk factors will also be addressed. This may result in some definitional issues (see Tsilipakos, 2015); it is also necessary to recognise that not all causal factors can or have been empirically observed (Archer, 1995). In the case of occupational health and safety, this recognition is clear with regards to safety culture (an ontologically real, but not directly observable phenomenon that has a significant impact on health and safety outcomes) and the related safety climate (the empirically collected perceptions of members of an organisation that are taken as indicative of the safety culture at a single point in time) (Guldenmund, 2000). The importance of conceptual and theoretical evidence for causal factors becomes more important at the higher levels of the safety system where empirical evidence is often unattainable.

Despite the limitations discussed above, there remains a space for epidemiological studies and meta-analyses in identifying risk factors. These studies not only constitute the bulk of harm-related research, but they can provide some insights into **what** mechanisms to look at, even if they are deficient in explaining why they operate as they do. Realism has been incorporated into epidemiological frameworks, such as the Cochrane framework, in which some authors have recently stated the need to review research "methods consistent with each tradition before integration takes place using a common framework" (Harden *et al*., 2018).

Finally it is important to briefly emphasise that this review makes no claim toward completeness or objectivity. Such claims are counter-productive because they ignore that:

> "Complexity makes it impossible for researchers to claim that they can produce a model that would embrace all experienced phenomena. Models remain therefore forever limited and inadequate, from certain specific angles, for their users" (Le Coze, 2013, p. 207).

[3] As Pawson notes, bad research can still produce good and relevant insights.

Rather, the adoption of a socio-technical systems theory and the inclusive approach to collecting and incorporating evidence is designed to capture and analyse as much data as possible within this unavoidable limitation. Inevitably by translating texts from diverse streams of literature and incorporating them into a methodological realist position means that the meaning of those texts will change. This is acknowledged, but also unavoidable.

3.1 Summary

This brief chapter has outlined the methodological approach that is adopted in this review and highlighted how this methodology will be put into practice. In short by adopting a realist methodology this review aims to assess knowledge according to its own terms rather than **a priori** rules of assessment. Doing so facilitates the weaving of many different types of knowledge to provide insights into the context of work-related MSDs and determines the success of interventions to address them.

4.0 Methods

IN THIS SECTION:

4.1 Introduction

The projects this review aims to support rely on weaving distinct types of knowledge together, in order to provide evidence on the risk factors and interventions for work related musculoskeletal disorders (WRMSDs).

Consequently there are several different methods employed to collect evidence on:

- the risk factors for WRMSDs
- the prevalence of risk factors for WRMSDs
- WorkSafe's current interventions to address WRMSDs
- evaluations of other interventions to address WRMSDs that may be applicable to WorkSafe.

Each of these methods aims to use existing literature and evidence to produce practically applicable knowledge in line with both realist theory and systems theory approaches to occupational health and safety.

4.2 Risk factor evidence

Due to workload commitments and the need to incorporate LEED data into the knowledge model, the risk factor evidence was collected before the prevalence and intervention evidence. Goode *et al*. (2016) provided the starting point for the inclusion of epidemiological data, identifying a number of risk factors and some evidence for intervention effectiveness. Unsurprisingly, they found that the focus of epidemiologists is on the lower level of the socio-technical system, with most risk factors identified being at the work, staff or immediate work organisational (management) levels and little evidence for the impact of context (Goode *et al*., 2016). Given the proliferation of meta-analyses and systematic reviews on MSDs in recent years as well as a number of omissions from their review, the epidemiological literature was re-reviewed. While a systematic review was preferable, time restrictions meant that a non-systematic approach was taken:

- The first stage reviewed meta-analyses and systematic reviews directly assessing risk factors for musculoskeletal disorders (either as a whole, or for specific disorders) across industry and occupation. Where possible the impact of a risk factor was recorded, as was the type of studies reviewed and the population targeted (typically odds ratios or relative risk).
- The second stage broadened the review to meta-analyses and systematic reviews assessing risk factors for work-related injuries. Given the believed prevalence of MSDs as a form of work-related injury this was deemed a suitable proxy where no direct reviews of MSDs were found. The procedure of data-recording used in stage 1 was followed.
- The third stage included recent high-quality cohort and longitudinal studies that explored risk factors for work-related MSDs. While the focus was on recent studies, it is possible that some of these studies were included in already reviewed meta-analyses and systematic reviews. However, this was deemed acceptable as these studies were intended to fill gaps in the coverage of meta-analyses and systematic reviews. The procedure of data-recording used in stage 1 was followed.

After the epidemiological review was completed a review of qualitative research was begun. As with the epidemiological review, a non-systematic approach was taken but aim was to be as comprehensive as possible. The initial focus was on qualitative studies directly researching the link between risk factors and work-related musculoskeletal disorders. However there appeared to be a lack of evidence directly assessing this relationship. Consequently the focus was

broadened to qualitative studies that addressed the risk factors and context around work-related injury and ill-health in general. Such a broad approach would capture relevant data for work-related MSDs, but requires subject matter expertise to assess its suitability. The qualitative data reviewed included interviews, observational studies and case-studies.

The purpose of this review was two-fold. The primary goal was to produce a realist synthesis of the evidence of risk factors to provide the context for interventions into musculoskeletal disorders. Following a realist synthesis this aims to provide recommendations for important considerations for the intervention developers, and also to help guide the synthesis of the intervention evidence.

4.3 Prevalence of risk factors

Members of WorkSafe's Research and Evaluation team reviewed the list of risk factors compiled in the risk factor section and considered potential sources of prevalence information for each. Due to budgetary constraints, only existing data sources were considered; it was not feasible to commission new studies to measure specific risk factor prevalence in the New Zealand context. Both publicly available and internal sources available to WorkSafe were considered, including research and administrative data.

None of the administrative data sources considered were deemed able to provide robust prevalence information for the risk factors of interest.

Ultimately, three usable sources were identified from this process:

- a representative survey of workers from WorkSafe's Workforce Segmentation and Insights Programme (WSIP) (Colmar Brunton, 2019)
- the Worker Exposure Survey, conducted by Massey University's Centre for Public Health Research (Eng *et al*., 2018)
- the Stats NZ Survey of Working Life (StatsNZ, 2019).

Within each data source, the researchers identified the survey questions and measures that corresponded with the risk factors of interest. They then independently assessed each question or measure based on its suitability, considering the extent to which it aligned with the definition of the corresponding risk factor given in the literature. The ratings were reconciled and a list of usable questions and measures was agreed.

The prevalence statistics from the Worker Exposure Survey and Survey of Working Life were extracted directly from the respective research reports and entered into an Excel spreadsheet. Depending on availability, prevalence statistics were entered for the total population of workers as well as demographic factors of interest, including: sex, age group, ethnicity, occupation (ANZSCO), and industry (ANZSIC).

The researchers assigned a subjective 'confidence rating' to each prevalence statistic entered in the spreadsheet on a scale of '1 – very low confidence' up to '5 – very high confidence'. In assigning the ratings, the researchers considered the robustness of the survey methodologies, the sample size from which the statistic was obtained, and the alignment of the survey question or measure to the risk factor definition.

For the survey of workers from the Workforce Segmentation and Insights Programme, respondent-level data was available, allowing the researchers to extract the relevant raw survey variables from the SPSS survey data file. These were appended to the spreadsheet in raw, individual-response format. Confidence ratings, as described above, were entered in a separate table for this data.

4.4 Intervention evidence

Data were collected:

- non-systematically
- using key word searches on Google Scholar ("intervention to address work related musculoskeletal disorders" "evaluation musculoskeletal disorders")
- after this there was a process of snowballing from citations identified in the literature search to find further evaluations

As this review is targeted primarily at WorkSafe intervention designers, evidence on intervention evaluations was collected from this perspective. This means that certain technical aspects of intervention design (such as specific task design) have not been discussed. The evidence was collected using Pawson's (2006 ch. 4) six stage guide for conducting a realist review of intervention evaluations:

Stage 1: Refining the review question

Refining the (pre-established) review question goes beyond the clarification of key terms. It is instead an ongoing and time-consuming affair and involves creating a series of interlinked hypotheses.

Stage 2: Searching for primary studies

Searching for primary studies is a messy and ongoing process. It roughly involves a background search, a tracking of programme theories, then the search for empirical evidence to test theories and a final search to fine-tune the synthesis. The aim is to reach theoretical saturation rather than reviewing all articles from a defined set of databases.

Stage 3: Quality appraisal

"The reviewer should [...] appraise the contribution that each one makes to the developing synthesis. That contribution is unlikely to stem from the entirety of a study" (Pawson, 2006, p. 87). Assessment of rigor is not based on pre-formed checklists but instead the precise usage of each fragment of evidence within the review.

Stage 4: Extracting data

Pawson recommends three stages in extracting data, annotation, collation and reportage. Annotation involves scouring documents for relevant passages, ideas, approaches or insights. These are then combined to begin forming a model. Collation then uses this early model to draw out inferences to test current hypotheses and refine the model. Reportage involves developing ways of ensuring that the approach taken (and the criteria for including and excluding texts) is transparent, understandable and relevant to decision-makers. It also involves the continued refining of the model to clarify and prepare it for testing.

Stage 5: Synthesizing the data

Data synthesis is not undertaken to make summative verdicts, but instead to refine theory and ensuring the findings are relevant to the real world of intervention formation. It involves questioning programme theory integrity, adjudicating between rival theories, considering the theory in different, comparable settings, comparison of expectations with actual practice.

Stage 6: Disseminate findings

For reviews to be relevant in the implementation world, the work of researchers needs to continue beyond the submission of a final report. Instead there needs to be an ongoing interplay between intervention designers and reviewers. There is also a need for researchers to ensure that their findings are disseminated in useful ways. Instead of an abstract claim toward intervention effectiveness, there is a need for the review to provide recommendations for intervention designers such as 'remember A', 'beware of B', 'address C', 'little is known about D, E, F' and so on.

These six stages were adopted in the assessment of MSDs intervention evaluations, with a particular focus in broadening the literature beyond epidemiology to assess intervention evaluations according to their own methodological approach. Obviously, this document constitutes phases 5 and 6 of Pawson's approach. The goal of this approach was to move beyond epidemiological studies to explore the insights that can be gained from other literatures.

5.0 Risk factors for work-related musculoskeletal disorders

IN THIS SECTION:

5.1 Introduction

This section outlines the literature on risk factors for work related musculoskeletal disorders (WRMSDs). Given the nature of the literature it is divided into three sections the first outlining the quantitative/epidemiological literature, the second the qualitative literature and the third outlining potential additional risk factors for WRMSDs that are discussed in the safety literature more broadly.

The epidemiological literature is focused on a small number of risk factors at the lower levels of the socio-technical system. The methods employed by epidemiology attempts to isolate these risk factors in surveys in order to assess their individual impact on WRMSDs rates. However, there is also some literature that attempts to assess the relationships between these risk factors.

The qualitative literature sees risk factors as inseparable from both one another and the wider context. Its use of semi-structured interviews identifies interrelated themes and explores the meanings of these themes in greater detail than the quantitative literature. The emphasis on contextualisation of themes allows qualitative research to identify and discuss risk factors higher up in the social system. However, the small sample sizes and nuances of specific contexts mean that qualitative researchers are often reluctant to generalise their findings.

As will be discussed at the end of this chapter, there is significant overlap between findings from the two literatures. This suggests that despite their different understandings of risk factors, the two literatures provide different but complementary lenses on the risk factors for WRMSDs.

The third section outlines some potential other risk factors for WRMSDs. These factors are based on a wider reading of the non-MSDs specific OHS literature and expert assessment by the authors as to their validity as risk factors for WRMSDs. Consequently they should only be considered expert opinion. However, the lack of direct evidence for underlying risk factors, such as organisational or structural factors, for WRMSDs makes reliance on expert evidence necessary.

5.2 Quantitative risk factors

The majority of the literature on work-related musculoskeletal disorders (WRMSDs) has been produced by epidemiologists and is quantitative in nature. The epidemiological literature, with its adoption of medical standards of research quality and methods provides a coherent body of knowledge on a number of risk factors associated with work-related MSDs. The proliferation of epidemiological studies into WRMSDs has reached saturation, with numerous studies exploring the same correlations and finding similar responses. A number of meta-analyses and systematic reviews have confirmed this saturation, but have also highlighted how many studies find only marginal significance at the 95% confidence interval (CI), with many more finding no significant difference in outcomes for exposed and unexposed populations.

As highlighted in the methods section, the review of the epidemiological systematic reviews and meta-analyses were the focus of the review of the epidemiological literature. These systematic reviews and meta-analyses were supplemented by cohort studies and New Zealand surveys where there was a lack of information on a particular risk factor.

Despite the coherence of the methods used and topic studied, there is little consistency in how risk factors are defined or the survey questions used to measure them. Given the lack of consistency this review has grouped questions that are similar, resulting in the following list of risk factors:

- poor workstation design
- vibration
- low temperature

- poor equipment design
- working with computers/visual display units
- high repetition and task invariability
- posture-related risks
- physical loading/manual handling
- High BMI
- exposure duration
- experience of discrimination
- lack of training
- demographic factors
- working under time pressures
- harassment/bullying/violence
- gender-based division of work
- inadequate job design
- lack of recovery time
- inadequate resource provision
- lack of job control
- monotonous and repetitive task design/task invariability
- psychosocial risk factors
- inadequate leadership
- precarious employment
- poor safety climate (and underlying culture)

Definitions of these risk factors are given in Appendix 3

Detail of the risk factors for MSDs according to the epidemiological literature is given below. The location or specific type of MSDs the risk factor was assessed for is also given, as is a summary of the ratio type used, with unlabelled ratios being odds ratios (OR). The risk factors for WRMSDs that were significant at the 95% confidence interval were:

DOCUMENT	FACTOR	LOCATION/ MSDs DIAGNOSIS	RATIO (OR if not stated)	LOWER 95% CI	UPPER 95% CI
Coenen *et al*. (2018)	standing	low back	1.31	1.10	1.56
Azizpour *et al*. (2017)	female gender	low back	2.44	1.89	3.14
Azizpour *et al*. (2017)	>7 years experience vs <7 years	low back	2.61	2.02	3.37
Azizpour *et al*. (2017)	night shifts vs day shifts	low back	1.84	1.43	2.37
Azizpour *et al*. (2017)	low satisfaction with environment	neck	RR 1.28	1.07	1.55
Azizpour *et al*. (2017)	close keyboard position	neck	RR 1.46	1.07	1.99
Azizpour *et al*. (2017)	low task variation	neck	RR 1.27	1.08	1.50
Azizpour *et al*. (2017)	muscular tension	neck	RR 2.75	1.60	4.72
Azizpour *et al*. (2017)	poor psychosocial health	shoulder	1.12	1.01	1.25
Azizpour *et al*. (2017)	job control	shoulder	1.22	1.00	1.50
Azizpour *et al*. (2017)	hand-arm force exertion	shoulder	1.53	1.25	1.87
Azizpour *et al*. (2017)	hands above shoulder	shoulder	1.91	1.47	2.47
Azizpour *et al*. (2017)	hand arm vibration	shoulder	1.34	1.01	1.77

DOCUMENT	FACTOR	LOCATION/ MSDs DIAGNOSIS	RATIO (OR if not stated)	LOWER 95% CI	UPPER 95% CI
Bernal *et al*. (2015)	force	carpal tunnel syndrome	4.23	1.53	11.68
Bernal *et al*. (2015)	repetition	carpal tunnel syndrome	2.26	1.73	2.94
Bernal *et al*. (2015)	force x repetition interface	carpal tunnel syndrome	2.03	1.43	2.89
Bernal *et al*. (2015)	hand arm vibration	carpal tunnel syndrome	5.40	3.14	9.31
Bernal *et al*. (2015)	lack of social support	back	1.82	1.43	2.32
Bernal *et al*. (2015)	high job demands	back	1.52	1.14	2.01
Bernal *et al*. (2015)	high job demands	shoulder	1.89	1.53	2.34
Bernal *et al*. (2015)	high job demands	neck	1.34	1.02	1.78
Bernal *et al*. (2015)	high job demands	knee	2.21	1.07	4.74
Bernal *et al*. (2015)	high job demands	any site	1.38	1.09	1.75
Bernal *et al*. (2015)	effort-reward imbalance	any site	6.13	5.32	7.07
Burstrom, Nilsson and Wahlstrom (2014)	whole body vibration	low back	2.17	1.61	2.91
Burstrom, Nilsson and Wahlstrom (2014)	whole body vibration	sciatica	1.92	1.38	2.67
Burstrom, Nilsson and Wahlstrom (2014)	wrist posture	carpal tunnel syndrome	RR 2.01	1.64	2.43
Hauke *et al*. (2011)	depression	upper extremity	1.71	1.31	2.23
Hauke *et al*. (2011)	depression	all locations	1.46	1.19	1.78
Hauke *et al*. (2011)	lack of social support	neck and shoulder	1.15	1.05	1.26
Hauke *et al*. (2011)	lack of social support	upper extremity	1.18	1.06	1.32
Hauke *et al*. (2011)	lack of social support	low back	1.22	1.07	1.38
Hauke *et al*. (2011)	lack of social support	all locations	1.16	1.10	1.23
Hauke *et al*. (2011)	low job satisfaction	upper extremity	1.19	1.03	1.38
Hauke *et al*. (2011)	low job satisfaction	low back	1.59	1.29	1.97
Hauke *et al*. (2011)	low job satisfaction	all locations	1.28	1.13	1.45
Hauke *et al*. (2011)	high job demands	upper extremity	1.18	1.06	1.32
Hauke *et al*. (2011)	high job demands	low back	1.34	1.15	1.58
Hauke *et al*. (2011)	high job demands	All locations	1.19	1.11	1.29
Hauke *et al*. (2011)	low job control	neck and shoulder	1.16	1.05	1.29
Hauke *et al*. (2011)	low job control	upper extremity	1.24	1.00	1.54
Hauke *et al*. (2011)	low job control	low back	1.37	1.01	1.84
Hauke *et al*. (2011)	low job control	all locations	1.21	1.10	1.32
Hauke *et al*. (2011)	effort-reward imbalance	neck and shoulder	1.43	1.25	1.62
Hauke *et al*. (2011)	effort-reward imbalance	low back	1.40	1.10	1.80

DOCUMENT	FACTOR	LOCATION/ MSDs DIAGNOSIS	RATIO (OR if not stated)	LOWER 95% CI	UPPER 95% CI
Hauke *et al*. (2011)	effort-reward imbalance	all locations	1.35	1.22	1.50
Hauke *et al*. (2011)	low skill discretion	upper extremity	1.19	1.03	1.38
Hauke *et al*. (2011)	low skill discretion	low back	1.59	1.29	1.97
Hauke *et al*. (2011)	low skill discretion	all locations	1.24	1.01	1.50

TABLE 1: Significant risk factors for MSDs

The following risk factors were found to be non-significant at the 95% CI:

DOCUMENT	FACTOR	LOCATION/ MSDs DIAGNOSIS	RATIO (OR if not stated)	LOWER 95% CI	UPPER 95% CI
Hauke *et al*. (2011)	job insecurity	low back	0.85	0.43	1.69
Hauke *et al*. (2011)	job insecurity	all locations	1.12	0.87	1.45
Hauke *et al*. (2011)	low skill discretion	neck and shoulder	0.95	0.63	1.44
Hauke *et al*. (2011)	effort-reward imbalance	upper extremity	1.09	0.85	1.39
Hauke *et al*. (2011)	high job demands	neck and shoulder	1.11	0.97	1.27
Hauke *et al*. (2011)	job stress	upper extremity	1.56	0.57	4.23
Hauke *et al*. (2011)	job stress	low back	1.22	0.96	1.55
Hauke *et al*. (2011)	job stress	all locations	1.15	0.94	1.40
Hauke *et al*. (2011)	low job satisfaction	neck and shoulder	1.11	0.95	1.30
Hauke *et al*. (2011)	depression	low back	1.40	0.73	2.66
Hauke *et al*. (2011)	depression	neck and shoulder	1.27	0.85	1.90
Burstrom, Nilsson and Wahlstrom (2014)	foot posture	lower extremity	RR 1.09	0.78	1.52
Bernal *et al*. (2015)	lack of social support	any site	1.20	0.91	1.59
Bernal *et al*. (2015)	wrist posture	carpal tunnel syndrome	4.73	0.41	53.32
Azizpour *et al*. (2017)	repetition	shoulder	1.42	0.91	2.22
Azizpour *et al*. (2017)	job insecurity	shoulder	1.12	0.93	1.36
Azizpour *et al*. (2017)	shoulder load	shoulder	2.00	1.90	2.10
Azizpour *et al*. (2017)	lack of social support	shoulder	1.05	0.83	1.33
Azizpour *et al*. (2017)	duration of computer use	neck	RR 1.07	0.91	1.24
Azizpour *et al*. (2017)	low break time	neck	RR 1.13	0.92	1.39
Azizpour *et al*. (2017)	screen height	neck	RR 1.12	0.88	1.42
Azizpour *et al*. (2017)	duration of computer use	neck	RR 1.07	0.91	1.24
Azizpour *et al*. (2017)	low break time	neck	RR 1.13	0.92	1.39
Azizpour *et al*. (2017)	high BMI	low back	1.21	0.84	1.74

TABLE 2: Non-significant risk factors for MSDs

Biomechanical risk factors

The vast majority of research into the risk factors for WRMSDs has been directed at the biomechanical or physical risk factors (van der Beek *et al*., 2017). Given the well-established nature of this literature, and it having been the focus of existing interventions, the biomechanical literature was only briefly summarised as part of the quantitative risk factors. Instead the focus of the risk factors review is on other risk factors that are recognised in the literature, but may not be given as much attention as physical risk factors. The biomechanical risk factors identified in the quantitative literature are:

- posture-related risks
  - hands above shoulder
  - wrist posture
- physical loading/manual handling
  - repetition
  - hand-arm force exertion
  - force
  - force/repetition interface
- poor equipment design
  - hand arm vibration
  - whole body vibration
- poor workstation design
  - close keyboard position/

In addition screen height and foot posture were found to be non-significantly related to WRMSDs.

The overall lack of attention given to physical risk factors in this document does not mean that these risk factors are unimportant. Instead these are generally the best managed and most easily recognisable risk factors for WRMSDs.

Risk factors for risk factors

In addition to assessing the epidemiological literature for assessments of risk factors directly measured against MSDs, the review also explored meta-analyses that assessed the relative risk or odds ratios of one risk factor for another. The significantly associated relationships between risk factors are given below:

DATE	FACTOR	OUTCOME	OR	LOWER 95% CI	UPPER 95% CI
Theorell *et al*. (2015)	increased job control/decision latitude	depressive symptoms	0.73	0.68	0.77
Theorell *et al*. (2015)	job strain	depressive symptoms	1.74	1.53	1.96
Theorell *et al*. (2015)	bullying	depressive symptoms	2.82	2.21	3.59
Heikkila e t al. (2012)	no drinking	job strain	1.1	1.05	1.14
Heikkila e t al. (2012)	intermediate drinking (15–20 drinks/week (women), 22–27 drinks/week (men)	job strain	0.92	0.86	0.99
Heikkila e t al. (2012)	heavy drinking (≥21 drinks/ week (women), ≥28 drinks/ week (men)	job strain	1.12	1	1.26
Kuoppala *et al*. (2008)	considerate leadership	job satisfaction	RR 2.23	1.39	3.51
Kuoppala *et al*. (2008)	considerate leadership	job well-being	RR 1.40	1.36	1.57

DATE	FACTOR	OUTCOME	OR	LOWER 95% CI	UPPER 95% CI
Virtanen *et al*. (2005)	temporary employment	psychological distress	1.25	1.14	1.38
Uehli *et al*. (2014)	sleep problems	injuries	RR 1.62	1.43	1.84
Virtanen *et al*. (2015)	long work hours (≥49 hours, *cf.* 35–40 hours)	new risky alcohol use (>14 drinks/week (women), 21 drinks/ week (men)	1.12	1.04	1.2
Virtanen *et al*. (2015)	long work hours (≥49 hours, *cf.* 35–40 hours)	alcohol use (>14 drinks/week (women), 21 drinks/week (men)	1.1	1.04	1.18
Madsen *et al*. (2017)	job strain	depressive symptoms	RR 1.77	1.47	2.13
Madsen *et al*. (2017)	job strain	depressive symptoms	HR 1.27	1.04	1.55
Madsen *et al*. (2017)	job strain	depressive symptoms	RR 1.16	1.07	1.25
Madsen *et al*. (2017)	depressive symptoms	job strain	RR 1.46	1.36	1.57
Madsen *et al*. (2017)	effort-reward imbalance	depressive symptoms	RR 1.49	1.23	1.8
Stansfeld and Candy (2006)	decision authority	common mental disorders	1.21	1.09	1.35
Stansfeld and Candy (2006)	decision latitude	common mental disorders	1.23	1.08	1.39
Stansfeld and Candy (2006)	psychological demands	common mental disorders	1.39	1.15	1.69
Stansfeld and Candy (2006)	job strain	common mental disorders	1.82	1.06	3.1
Stansfeld and Candy (2006)	social support	common mental disorders	1.32	1.21	1.44
Stansfeld and Candy (2006)	effort-reward imbalance	common mental disorders	1.84	1.45	2.35
Stansfeld and Candy (2006)	job insecurity	common mental disorders	1.33	1.06	1.67
Van der Molen *et al*. (2020)	effort reward imbalance	stress-related mental disorders	1.91	1.7	2.15
Van der Molen *et al*. (2020)	low procedural justice	stress-related mental disorders	1.74	1.62	1.86
Van der Molen *et al*. (2020)	low relational justice	stress-related mental disorders	1.55	1.44	1.67
Van der Molen *et al*. (2020)	high job demands	stress-related mental disorders	1.6	1.41	1.72
Van der Molen *et al*. (2020)	low coworker support	stress-related mental disorders	1.29	1.17	1.43
Van der Molen *et al*. (2020)	low supervisor support	stress-related mental disorders	1.27	1.16	1.38
Van der Molen *et al*. (2020)	low supervisor and coworker support	stress-related mental disorders	1.41	1.18	1.69
Van der Molen *et al*. (2020)	emotional demands	stress-related mental disorders	1.58	1.35	1.84

DATE	FACTOR	OUTCOME	OR	LOWER 95% CI	UPPER 95% CI
Van der Molen *et al*. (2020)	low decision authority	stress-related mental disorders	1.34	1.2	1.49
Van der Molen *et al*. (2020)	job insecurity, men	stress-related mental disorders	1.63	1.18	2.27
Schuring *et al*. (2013)	fixed term	all morbidity	RR 1.56	1.23	1.97
Dzhambov and Dimitrova (2017)	noise exposure 90-95 dB	injury	RR 2.16	1.61	2.9
Garbarino *et al*. (2016)	obstructive sleep apnoea	injury	2.18	1.53	3.1
Jadhav *et al*. (2015)	full time farming	injury	2.17	1.12	4.21
Jadhav *et al*. (2015)	owner-operator status (*cf.* family or hired workers)	injury	1.64	1.13	2.38
Jadhav *et al*. (2015)	prior injury	injury	1.75	1.58	1.94
Jadhav *et al*. (2015)	regular medication use	injury	1.57	1.23	2
Jadhav *et al*. (2015)	stress/depression	injury	1.86	1.6	2.16
Jadhav *et al*. (2015)	hearing loss	injury	2.01	1.57	2.57
Toovey *et al*. (2017)	ACL	hamstring injury	2.25	1.34	3.76
Sagherian *et al*. (2019)	fatigue	long term sickness absence	1.35	1.23	1.47
Fischer *et al*. (2017)	4th consecutive night shift	injury	RR 1.36	1.14	1.62
Fischer *et al*. (2017)	12th hour at work	injury	RR 2.73	2.02	3.69
Fischer *et al*. (2017)	>12 hour shifts	injury	RR 1.34	1.04	1.51
Fischer *et al*. (2017)	<31 min rest break	injury	RR 0.47	0.34	0.67
Fischer *et al*. (2017)	31–60min rest break	injury	RR 0.35	0.29	0.43
Fischer *et al*. (2017)	30–59 mins on task	injury	RR 1.43	1.17	1.74
Lee *et al*. (2017)	night shift	depressive symptoms	1.43	1.24	1.64

TABLE 3: Significant underlying risk factors for MSDs

The following associations were tested but found to be non-significant at the 95% CI:

DATE	FACTOR	OUTCOME	OR	LOWER 95% CI	UPPER 95% CI
Kuoppala *et al*. (2008)	considerate leadership	job performance	RR 1.13	0.55	1.2
Kuoppala *et al*. (2008)	considerate leadership	likelihood of sick leave	RR 0.73	0.7	0.89
Virtanen *et al*. (2005)	temporary employment	poor physical health	1.08	0.94	12.3
Virtanen *et al*. (2005)	temporary employment	sickness absence	0.77	0.65	0.91
Virtanen *et al*. (2015)	short work hours (<35/week, *cf.* 35–40 hours)	alcohol use (>14 drinks/week (women), 21 drinks/week (men)	0.94	0.88	1.02
Van der Molen *et al*. (2020)	job insecurity, women	stress-related mental disorders	0.94	0.56	1.59

DATE	FACTOR	OUTCOME	OR	LOWER 95% CI	UPPER 95% CI
Van der Molen *et al.* (2020)	decision latitude	stress-related mental disorders	1.07	0.92	1.25
Van der Molen *et al.* (2020)	low skill discretion	stress-related mental disorders	1.11	0.94	1.32
Watanabe *et al.* (2016)	overtime	developing depressive symptoms	RR 1.08	0.83	1.39
Watanabe *et al.* (2016)	working 50+ hours/week	developing depressive symptoms	RR 1.241	0.88	1.75
Schuring *et al.* (2013)	fixed term	injury	RR 4.75	2.54	8.88
Schuring *et al.* (2013)	temporary agency work	injury	RR 1.37	0.94	2.02
Schuring *et al.* (2013)	precarious work	all morbidity	RR 0.96	0.61	1.51
Schuring *et al.* (2013)	temporary agency work	all morbidity	RR 1.37	0.94	2.02
Jadhav *et al.* (2015)	health problems	injury	1.21	0.96	1.53
Toovey *et al.* (2017)	groin injury	hamstring injury	1.14	0.29	4.51
Fischer *et al.* (2017)	night shift	injury	RR 1.33	0.98	1.8
Fischer *et al.* (2017)	afternoon shift	injury	RR 0.97	0.63	1.49
Fischer *et al.* (2017)	3rd consecutive night shift	injury	RR 1.16	0.96	1.4

TABLE 4: Significant underlying risk factors for MSDs

The data summarised above was also inputted into an AcciMap, with each risk factor being assigned to the system level that was judged to be most causative of the risk factor. For instance long work hours was assigned to the 'management' level. However this assignment does not mean that other levels of the safety system do not impact on a particular risk factor, neither is it an objective identification. Instead it is a subjective assessment of the most suitable level of the safety system within which to align a risk factor in order to assist the targeting of interventions.

This review of the epidemiological evidence was conducted later and was larger than Goode *et al.*'s (2016) review, and drew on meta-analyses instead of systematic reviews. However, the findings were similar. This suggests that, despite not being systematic, a degree of saturation of the evidence was reached regarding the epidemiological evidence.

5.3 Qualitative themes

The quantitative, epidemiological literature constitutes the bulk of research on work-related musculoskeletal disorders; however as discussed in chapter 4, it has significant limitations and is restricted in what data it uses and how it uses it. However, from a realist perspective it is prudent to assess the smaller, more heterogeneous qualitative literature alongside the epidemiological literature.

The qualitative literature is best dealt with as recurring 'themes' as opposed to the artificially isolated risk factors discussed in the epidemiological literature. The highlighted themes share many features of risk factors (and are often referred to as such) however, they are less definitive and are largely inter-related and inseparable from each other as well as the context in which they occur. As MacEachen *et al.* (2010) put it, they cannot be isolated from one another but instead mix to create a 'toxic dose' that causes and impedes the treatment of MSDs.

Prioritisation of financial demands over health and safety

There is a general acceptance in the qualitative literature that financial demands trump health and safety for profit-driven businesses (Robertson *et al*., 2020). Financial pressures trumping health and safety results in several behaviours that cause, or exacerbate MSDs including fast work pace, long work hours, repetitive task design (Mayhew & Quinlan, 2006; Nordlöf *et al*., 2015), the use of insecure or temporary contracts (Tappin *et al*., 2006) and managers dissuading employees from taking sick leave or adjusting their work to prevent the worsening of their conditions (Oakman, Rothmore, *et al*., 2016).

While they are most often identified at the company or industry level, financial pressures occur at all levels of the socio-technical system. Businesses have the demand to be profitable, and therefore reduce costs and increase productivity. Managers often have limited budgets and production targets and workers may fear losing their job if they raise health and safety issues, or if they refuse to work unhealthy hours (Tappin *et al*., 2006). Financial pressures also contribute to a competitive and exploitative industry, leading to a lack of learning from mistakes, cutting corners and excessive pressure being put on workers (Johnstone *et al*., 2005).

Presenteeism

Presenteeism refers to the practice of workers turning up to work when they are sick or injured. Worker presenteeism is a significant, if under-researched risk factor for increasing poor health and safety outcomes. It can be understood as the result of 'attendance demands' on workers, which can include both formal policies and informal social norms (Aronsson *et al*., 2000; Bergstrom *et al*., 2009; Holland & Alison, 2016).

In their study of a New Zealand meat works plant, Dew and Taupo (2009) found that job insecurity is an attendance demand that increases presenteeism. Work organisation can also reinforce and accentuate the constraints on workers to remain at work or return to work too soon. For example, teamwork models can contribute to presenteeism, especially when workers have specific duties that will have to be performed by their team if they call in sick (Chambers *et al*., 2010; Dew *et al*., 2005; Dew & Taupo, 2009). The pressure to remain at work was present in fairly hostile workplaces, but also occurred in otherwise supportive workplaces, with workers feeling a sense of obligation toward their workplace 'family'. However, in the latter case colleagues would generally pressure the injured worker to take time off (Dew *et al*., 2005). Grinyer and Singleton (2000) found a combination of cultural attitudes, a view that work could not be delayed and punitive approaches by management toward what they perceived to be 'casual sick [leave]' all resulted in increased presenteeism and greater sickness among staff. The importance of managerial support has been echoed in other studies (Dew & Taupo, 2009; Grinyer & Singleton, 2000; Holland & Alison, 2016). Working mothers and professionals with children were more likely to demonstrate presenteeism, which the authors considered could be due to the taxing nature of home life for these workers preventing it from being a space for relaxation or recuperation, which highlights that attendance demands are not exclusive to the workplace (Dew & Taupo, 2009).

Given the varied nature of attendance demands on workers, Holland and Alison (2016) have suggested that presenteeism includes both voluntary and involuntary presenteeism. Their interviews of sufferers of rheumatoid arthritis found a mix of a desire to work in order to remain productive, active and receive social stimulation (and to distract from pain), combined with harsh sickness absence policies and/or pressure from managers contributing to sufferers continuing to work despite feeling unable to. Several participants reported feeling fear and anxiety about job loss or punishment by management if they took sick leave due to their MSDs. Furthermore, while some reported changes to their role and working environment were made as a result of their condition, they

also noted that over time there was increased pressure to work longer hours and that flexible working arrangements would be withdrawn by managers who were concerned about unequal treatment, suggesting that changes may be short term (Holland & Alison, 2016).

The presenteeism literature, and the work by Holland and Alison (2016) in particular, highlights that there is a two way relationship between WRMSDs and employment. Not only are MSDs caused by risk factors that employees are exposed to at work, but the presence of MSDs (whether caused by work factors or not) are an impediment to continued work participation. As the literature discussed above demonstrates this can be a reciprocal relationship, with presenteeism possibly making existing conditions worse, particularly if the employee is unable to manage their work environment and task design. As other qualitative themes demonstrate, the nature of MSDs can also have wider effects on individuals' self-perception, identity and social lives.

MSDs as 'part of the job' and the need to 'tough it out'

In many industries there is a view that bodily damage and pain is inevitable and unavoidable. Consequently WRMSDs, particularly gradual process/repetitive strain injuries such as carpal tunnel syndrome that do not immediately impede workability are often treated as 'part of the job' (Breslin *et al*., 2007; MacEachen, 2005). Furthermore many sufferers of WRMSDs who are able to keep working perceive the damage as already having been done to their body, and that a stoic attitude is required to keep working despite the pain and impediments of their condition (Boniface *et al*., 2016; Lovelock, 2012; MacEachen, 2005). Wynne-Jones suggests that this attitude may be more prevalent among managers than employees (Wynne-Jones *et al*., 2010). While these attitudes are **held** at the individual level, a recurrent finding of the qualitative literature is the central role social factors and cultural norms, reinforced by management, co-workers and a more general sense of worker identity have in creating and reinforcing the values of stoicism and acceptance of pain.

Workers learn the culturally 'correct' norms toward pain and injury on the job, and this socialisation quickly overrules formal training among new workers (Boniface *et al*., 2016; Gherardi & Miele, 2018; Gherardi & Nicolini, 2002). These cultural norms:

> "often originate prior to and outside the organisation in which they are observed. They originate in the organisational and institutional culture, the corpus of rule and regulation at the national and international level, in the tradition of the community of practice and in the interests of the owners. All of these interact with the individualities of workforce in a particular workplace to define which version of safety is activated and transmitted to novices, who in turn make their own contribution by perpetuating or altering" (Gherardi & Nicolini, 2002, pp. 217–218).

Although they originate outside a particular work environment, cultural norms require reinforcement locally by the attitudes and actions of management and experienced workers, either explicitly such as by treating MSDs are 'part of the job', and the need for workers to 'tough it out' to be successful in the industry (MacEachen, 2005). Norms can also be reinforced through silence and inaction at the managerial level, as this functions to delegitimise complaints and normalise pain (Boniface *et al*., 2016; Gherardi & Nicolini, 2002). Unequal power relations and the feeling of powerlessness among new workers further reinforce cultural norms and the acceptance of WRMSDs. MacEachen, Polzer and Clarke (2008) go further to suggest that managerial practices often aim to encourage stoicism to produce 'resilient and compliant' workers who are able to cope with intense work

conditions (if only for the short term) as a more profitable alternative to enacting long-term organisational changes to work practices to mitigate the risk factors for WRMSDs.

Male and female workers frequently adopt stoic and accepting attitudes toward work-related WRMSDs (Barnes *et al*., 2008; Boniface *et al*., 2016; Breslin *et al*., 2007; MacEachen, 2005). However, stoicism is a cornerstone of many forms of masculinity with a perception among participants in several studies that men 'tough it out' whereas 'women are complainers' (Breslin *et al*., 2007; Lovelock, 2012) or take sick leave to look after children (Barnes *et al*., 2008). The gendering of stoicism de-legitimises complaints from both men and women in different ways, with men expected (particularly by older male workers) to prove they can 'do the job' by not reporting pain and women being discouraged by the perception that they are 'complainers' and their complaints not being taken seriously by managers (Breslin *et al*., 2007; MacEachen, 2005). The gendering of complaints is also generalised to occupations traditionally filled by women, viewed as less demanding and so pose no threat to workers' health (Breslin *et al*., 2007; MacEachen, 2005).

Power inequalities

All of the qualitative themes discussed relate to power relations within the workplace. Power produces ways of acting while excluding other ways of acting. Power relations in the workplace have been identified as restricting workers' ability to control their environment, while also making them responsible for their own health and safety.

Power relations and the constraints they put on workers, particularly insecure, young or other low status workers are a recurrent theme in the qualitative literature. Power relations impact on workers' perceptions and behaviours around risk through the imparting of cultural norms and by placing constraints on acceptable behaviour by increasing the economic, cultural and social costs to the worker of behaviours such as reporting MSDs or taking time off to recover. As Breslin *et al*. summarise this means that "rather than seeing young workers as having distorted or faulty perceptions of risk, we suggest that, by virtue of their subordinate position in the workplace, young workers have little choice but to accept certain injuries as part of the job[…]" (Breslin *et al*., 2007, p. 788). They further suggest that these constraints can be expanded to all workers in insecure employment.

Jaye and Fitzgerald (2010b), in their interviews with New Zealand workers echo the constraints and costs imposed on workers identified by Breslin *et al*.. They add that workers were aware of having to balance unrealistic/harmful demands for productivity and performance targets by management and the safety messages in the workplace (Jaye & Fitzgerald, 2010b). At the same time, however, workers feared a loss of employment and being 'thrown on the scrapheap' by employers after their conditions made them unproductive (Jaye & Fitzgerald, 2010b). Oakman *et al*. (2017) also noted that many workers were conscious of a lack of alternative employment options available to them.

A lack of power, particularly for low-status workers manifested in a lack of control over contracts, work environment or job design (van den Berg *et al*., 2011). It also resulted in conflicts where workers individualised the responsibilities for both developing and managing MSDs conditions, but felt that they lacked the ability to modify their work environment to allow them to manage their conditions (Larsson *et al*., 2009). Higher status and middle class workers such as managers in contrast reported greater control over their job design, being able to choose their work hours and approaches to manage their conditions often by becoming self-employed (Oakman *et al*., 2017). Managers could also change the work environment to suit their condition, such as prioritising certain types of ergonomic equipment or redesigning tasks (Oakman *et al*., 2017).

Inequalities between workers and managers also manifested in the 'us' versus 'them' attitudes within both groups noted by Joel Rasmussen and Kroon (2012), Wynne-Jones *et al*. (2010) and MacEachen (2005). Workers and managers constructed themselves 'us' as being primarily concerned with health and safety, but with the other group 'them' being a hindrance toward improved safety. Notably a Chief Executive Officer interviewed by Rasmussen and Kroon initially claimed that there was a good, cooperative relationship between workers and management at the company before repairing their claim to state that an antagonistic relationship was normal in industrial employment (Rasmussen & Kroon, 2012). The division in perceptions between managers and workers has also been found in the WEPR literature, where management resistance to bottom-up worker engagement has been suggested to be the result of the non-alignment between the two groups' interests resulting in ineffective or top-down WEPR practices (Walters *et al*., 2012). Walters and Frick have argued that structural health and safety practices need to recognise and account for these different perspectives (Walters & Frick, 2000, p. 44).

Inadequate worker engagement, participation and representation

As noted above, there is a tendency for both workers and managers to place responsibility for MSDs on workers. However, it was also noted that many workers lack the ability to change their environment or to influence their job design. For this reason management attitudes and leadership styles are an important risk factor for the development of MSDs.

MacEachen's (2005) interviews of managers of Canadian newspaper companies found that managerial attitudes toward gradual process MSDs varied significantly. As mentioned above, some managers delegitimised MSDs, seeing complaints as either copycat complaints, or part of a complaints culture. Managers at other companies were more open to change, reporting that they had changed ergonomic equipment in response to complaints. However, once these changes were made, they viewed the responsibility for preventing conditions to have shifted to their workers as opposed to a collaborative approach. Similarly ergonomics training was also seen as passing responsibility for preventing and managing conditions to workers (MacEachen, 2005).

Robertson *et al*. (2020) have also found that organisational policies rarely aligned with managerial practices. They suggest that policies are more often designed to align with legislative or regulatory frameworks rather than as attempts to change behaviour and address risks. This finding aligns well with the dominance of tacit knowledge and knowledge as practice over formal education discussed earlier.

However, despite the strong theoretical arguments for the effectiveness of WEPR and some quantitative studies having found a correlation between representation and rates of fatalities. Walters *et al*. have noted that it is difficult to ascribe a causal relationship between worker participation, representation and engagement and any injury and health outcomes but also emphasise that this does not mean that there is no connection (Walters *et al*., 2012).

Experience of MSDs

Understanding the experience of people who suffer WRMSDs, particularly in the early stages of gradual process MSDs can facilitate the improvement of secondary and tertiary programmes to prevent further MSDs. Furthermore, understanding how MSDs are perceived can also help comprehend how messages will be received by the target populations. Given this, experience of MSDs, while not directly responsible for generating WRMSDs are underlying or contributory risk factors.

This section will outline the literature around the experience of MSDs and the association of having a WRMSDs with identity. It will also outline the relevance of these findings for WorkSafe.

IDENTITY AND MSDs

The cultural norms a worker is exposed to are internalised by workers and become part of their identity. For instance, Lovelock (2012) notes that physical ability and the values of stoicism and toughness in the face of pain are part of the identity of New Zealand farmers. These values, combined with farmer's masculinity and the perceived importance of farmers to New Zealand mean that the disabled farmer loses more than economic capital from work, but also their social and cultural capital that forms the basis of their identity. Conversely working through pain and disability are necessary to maintain a farmer's sense of identity (Lovelock, 2012).

The importance of stoicism in workers' identities is not limited to farmers, with de Vries *et al*. (2011) noting that workers who suffered from chronic pain take pride in their perception of having a higher than average pain threshold. Holland and Alison (2016) also found that retaining a sense of normalcy was important for people with recently diagnosed WRMSDs. Working through pain was seen as a way of giving structure and purpose to sufferers' lives and could even be perceived as a distraction from pain (de Vries *et al*., 2011). Larsson *et al*. (2009) also found that sufferers of chronic pain tended to individualise it and disliked relying on others to manage the disorder, with the exception of seeking medical health if the condition was perceived as worsening. Cultural dimensions can also be significant, as McGruer *et al*. (2019) note osteoarthritis among Māori can result in feelings of shame, depression and frustration. It can also result in isolation from communities due to physical limitations and in people hiding their conditions from the community.

Workers who develop MSDs such as occupational overuse syndrome/repetitive strain injury construct an identity of being highly motivated workers with a strong work ethic who were injured due to this motivation and work ethic (Jaye & Fitzgerald, 2010a, 2010b). The inability to continue working due to the symptoms of MSDs posed a threat to this identity, with many sufferers feeling (or worrying) that they were labelled malingerers, liars or lazy (Jaye & Fitzgerald, 2010a). The contested status of many gradual process MSDs discussed below exacerbated this feeling among many New Zealand workers (Jaye & Fitzgerald, 2010a).

Informal labelling of certain diseases can also de-legitimise them if there are certain stigma or assumptions attached. For instance, Dalbeth *et al*. found that in the New Zealand population in general, and the Māori population in specific, labelling an illness 'gout' as opposed to 'urate crystal arthritis' made people more likely to perceive the illness as being caused by the patient's own actions and requiring lifestyle changes (Dalbeth *et al*., 2020).

DE-LEGITIMISATION AND DISCRIMINATION

For many MSDs there has been a long series of battles for their recognition as being legitimate by medical professionals, government agencies (such as ACC), workplaces and (particularly in the USA) insurance companies (Jaye & Fitzgerald, 2010b). A lack of perceived legitimacy for a condition likely contributes to the massive underreporting of MSDs (Oakman, Clune, *et al*., 2019). Bureaucratic impediments to accessing treatments, coupled with a lack of understanding about the nuanced nature and experience of gradual process MSDs also discouraged reporting (Larsson *et al*., 2009). Finally, ongoing contests around legitimacy of RSIs and OOS may also have resulted in a decline of medical research and a decline in interest among regulators (MacEachen, 2005).

At an organisational level workers have often reported that their conditions and circumstances were often ignored or delegitimised by employers (Breslin *et al*., 2007; MacEachen, 2005; Wynne-Jones *et al*., 2010). MacEachen's interviews with managers and employers found that many managers dismissed gradual process injury complaints as being a failing of character rather than an injury resulting from work environments. Managers of workplaces with large numbers of complaints dismissed them as resulting from a 'claims culture', either emerging from copy-cat complaints or the result of union agitation (MacEachen, 2005). This de-legitimisation was associated with a perception of the work being physically undemanding and so posing no danger to workers' health (MacEachen, 2005).

If workers do raise issues they were often discouraged from reporting conditions by management (MacEachen, 2005; Oakman *et al*., 2017). For example, one interviewee of Oakman *et al*. (2017) said there was a threat of their manager 'making their life miserable' if they let their condition impair their work. In many cases, workers fearing discrimination from current or future employers did not disclose their condition, leading to many disclosures occurring once the condition became severe enough to prevent the worker from continuing to work (Oakman *et al*., 2017). Oakman *et al*. also noted that if the condition was disclosed, future employers would expect workers to sign agreements to not submit a claim relating to their condition and to take responsibility if it impaired their ability to work (Oakman *et al*., 2017).

Discouragement of workers' reporting conditions could also result from organisational bureaucratic practices such as incident reporting forms lacking fields for certain hazards and conditions (Robertson *et al*., 2020). Robertson *et al*.'s interviews suggest that in many cases this may be due to a perceived absence of conditions or hazards by management. However, in other cases they found that their absence was due to an explicit desire to avoid having to address issues, with one health and safety manager feeling that it was better to let 'sleeping giants' such as psychosocial hazards sleep (Robertson *et al*., 2020).

5.4 Potential other risk factors from previous literature reviews

There are inevitable gaps in the risk factor map, even if the epidemiological and qualitative literatures are combined. This is particularly likely with underlying risk factors at higher levels of the social system, where it is hard to produce empirical evidence of direct correlations between risk factors and diseases. In order to address this gap, this review incorporates the findings from earlier literature reviews conducted by WorkSafe. The risk factors identified in this way are not specific to WRMSDs, and the findings have been collected for a range of purposes using a range of methodologies. Thus these findings should only be considered **potential** risk factors that have been identified using expert knowledge rather than the stronger empirically supported findings discussed above.

Economic fluctuations

There is a complex relationship between health and safety and economic fluctuations, with the traditional perspective being that recessions or industry quiet periods lead to fewer accidents and the following upturn in activity, with new untrained workers entering the workforce, resulting in a spike in accidents (Boone & Van Ours, 2006). However, based on their analysis of OECD data, Boone and van Ours (2006) observe that while reported injury rates decline during recessions, fatalities do not. This suggests that the apparent decline is only a change in reporting as workers are less likely to report health and safety incidents or accidents when unemployment is high, or when their jobs are at risk.

Technological changes

Changing practices of health and safety management are generally slower than technological change, particularly at higher levels of the health and safety system such as changes in legislation and regulation (Svedung & Rasmussen, 2002). As highlighted in the unsafe equipment section, new technologies can create or expose workers to new hazards and risks, and these need to be managed and regulated for. In discussing risk factors for MSDs Wilkin noted that new technologies such as VDUs and chairs place new stressors on the body and so increased the risk of MSDs among workers who used them (Wilkin, 2009). However, he did not provide an empirical study to provide verifiable support.

Social status

The Whitehall II studies of public servants in the UK (Marmot, 1991) found that social status within the workplace affected health outcomes, with lower status public servants having a higher mortality rate than those of a higher status. This gradient existed despite the overall high status and high pay among public servants, suggesting that status relative to peers has a significant impact on health. Psychosocial work environment and job control explain much of this gradient, as lower status workers tend to have lower job control and report poorer psychosocial health (Marmot *et al*., 1997; Steptoe & Willemson, 2004). High job demands were also associated with higher incidence of hypertension and coronary heart disease among lower status workers (Kuper & Marmot, 2003).

The relationship between social status and psychosocial risk factors suggests that social status is a risk factor for MSDs. However whether this impact is in addition to, or explained by the increased psychosocial stress from low social status needs to be explored in further detail.

Regulatory and legislative failure

For the past 50 years, health and safety regulation and the associated legislation in Anglophone countries has been based off the Robens model. There is a recognition that many of the assumptions that Robens style legislation is based off are now out of date, or too blunt for adequate implementation due to the changing nature of work (MacEachen *et al*., 2016). Robens style legislation is not nuanced enough to address the increasingly complex and varied work contracts, nor can they address emerging grey zones (MacEachen *et al*., 2016). Additionally, much legislation is based on faulty assumptions, such as how workers and employers will behave. MacEachen *et al*. (2016) add that even when legislation and regulation are suitable, they are often unenforced or underenforced due to under resourcing, poor coordination and adverse workplace conditions for inspections and representation.

Research has suggested that the Robens model may be too blunt to address insecure and temporary employment (James *et al*., 2007; Johnstone *et al*., 2005; Mayhew & Quinlan, 2006), particularly enforcing worker employment, participation and representation (Gallagher & Underhill, 2012) and restricting work hours (Hobbs *et al*., 2011; Johnson & Lipscomb, 2006). This suggests that it may be a secondary risk factor for work-related MSDs.

Neoliberalism

Neoliberalism, the collection of deregulatory and privatisation policies enacted in the 1980s and 1990s, is a key contributing factor for poor health and safety outcomes identified by several authors (Gunningham, 2015). Many of the outcomes of neoliberalism such as the encouragement of competition within industries, anti-unionism, and the loosening of labour laws and regulation all negatively impact on health and safety. Furthermore, the use of temporary and

insecure labour, contractors, and frequent restructuring have all been identified as outcomes of neoliberal policies (Quinlan *et al*., 2001). Neoliberal policies have resulted in work intensification and the reduction of labour costs at the expense of health and safety (Mayhew & Quinlan, 2006).

Defence in depth fallacy

Multiple defensive layers have been suggested as ways to improve overall safety by building in redundancy. James Reasons' Swiss cheese model is an example of such thinking, where every defensive layer needs to fail concurrently for an accident to occur (Reason, 2000). However, Rasmussen (1997) suggested that this is often a fallacy for two reasons. Firstly, due to redundancy, failure at one system level may not be immediately apparent. Secondly, due to multiple demands on actors, apparent redundancy may lead to cost-cutting and a loss of effectiveness of each defensive layer. Furthermore, adding complexity to a safety system makes unsafe interactions between components more likely, particularly where an act that appears safe in isolation is unsafe in the wider socio-technical system (Leveson, 2012; Leveson *et al*., 2010).[4]

Inadequate mental model of the socio-technical system

A common observation about government interventions is that they are generally top-down and rarely account for the tacit knowledge held by actors or the complex interactions and understandings of social life. Two prominent system thinking theorists, Rasmussen and Leveson, have noted that the further away from the accident environment someone is the more simplified, inaccurate and slow to change their mental model will be (Leveson, 2012; Leveson *et al*., 2010; Svedung & Rasmussen, 2002). Machinery and plant operators and workers have up-to-date and accurate models of what is going on, whereas their supervisors typically have less information. Furthermore, regulators and government more likely have detached and outdated models of what action is occurring. The divergence of different mental models makes systems failure more likely, however changes should be driven from the bottom-up as much as possible because on-site operators and workers have the most up-to-date and accurate mental models of their working environments.

Learning safety

Although complex and requiring more research, the social nature of learned behaviours is a key feature of the qualitative literature on work related MSDs. Contrary to the conventional understanding of learning involving a simple transfer of information between a knowing and unknowing participant, generally in a formal setting, "knowing is social, material and performative and cannot be separated from practice" (Gherardi & Miele, 2018).

The importance of tacit knowledge is a key finding of the qualitative research, and is something that authors such as Pawson have argued is neglected in the epidemiological literature and in evaluations. Tacit knowledge is the embodiment of the practice of knowledge that is built in an organisation over time. It is not formalised or official policy but due to the primacy of practical or tacit knowledge over formal training in determining behaviour it is the more important consideration when designing interventions (Gherardi & Miele, 2018).

Tacit knowledge is 'sticky' in that, although it can be changed these changes take time to occur as organisational practice is difficult to change and (although not explicit) individuals within an organisation may resist changes (Gherardi & Miele, 2018; Gherardi & Nicolini, 2002).

[4] Reason has offered an alternative argument that defence in depth improves safety but makes a system more opaque and complex which "together, they conspire to ensure that those whose business it is to manage [a] safety system will often have their eyes firmly fixed on the wrong ball" Reason, J. (2008). *The Human Contribution: Unsafe Acts, Accidents and Heroic Recoveries*. Ashgate Publishing.

Poor health and safety culture and climate

Safety culture has been a controversial concept since it was first posited as an outgrowth of 'organisational culture' in the late 1980s. The concept has, since it's formulation, been ill-defined, unmeasurable, and a topic of significant debate (Guldenmund, 2000; Le Coze, 2015b). It has also been difficult to differentiate between safety culture as a potential topic of study and it being a fad in management consulting (Le Coze, 2019).

Despite the significant definitional issues associated with safety culture, the notion that some forms of organisational culture and attitudes toward safety affect the harms experienced within organisations is generally taken to have some validity (Cooper, 2000; Guldenmund, 2000). Safety culture itself is also agreed to be difficult if not impossible to directly assess. Instead researchers are reliant on safety **climate**, the perceived importance put on safety, as a proxy measure of safety culture (Zohar, 2010).

Unfortunately, safety climate is itself heterogeneous and measured in multiple ways. Despite this heterogeneity, meta-analyses have demonstrated a link between safety climate and safety compliance and participation (but less evidence for safety outcomes) (Casey *et al*., 2017; Clarke, 2006; Nahrgang *et al*., 2011). It is generally assumed that the **perceived** importance of safety in the workplace (safety climate), both reflects and reinforces the actual safety practices in the workplace (Wallace *et al*., 2006). However, safety climate is also likely more varied both over time and between workers within the same workplace (Williamson *et al*., 1997).

Restructuring and downsizing

Restructuring and downsizing leads to a redistribution of workloads, which can result in increased intensity, changes in expectations for workers and workers performing tasks they have not been trained to perform safely (Di Nunzio *et al*., 2009; Quinlan, 2007). The fear of job loss can also lead to increased risk taking and also greater reluctance for workers to report health and safety issues (Boone & Van Ours, 2006; Quinlan, 2007; Quinlan & Boyle, 2009). Restructuring can also harm the relationships between management and remaining workers.

Restructuring can lead to long-term negative impacts on occupational health and safety due to declines in training, corner cutting to save costs and a loss of commitment by management (Quinlan & Boyle, 2009; Sheeran *et al*., 1998). Restructuring is also commonly associated with poor management behaviours such as bullying or abuse of workers (Sheeran *et al*., 1998). However, Di Nunzio *et al*. (2009) also suggest that it may lead to increased teamwork strain as work control decreases. Older workers are more likely to suffer stress and distress by restructuring than younger workers, and more committed workers are more negatively affected by restructures (Quinlan & Boyle, 2009).

Small and medium enterprises

Small and medium enterprises (SMEs) have poorer health and safety outcomes than larger organisations (Arewa & Farrell, 2012; Legg *et al*., 2015). Research carried out by MBIE (Searle *et al*., 2015) and WorkSafe (Houghton & Cornforth-Camden, 2017) into the Canterbury rebuild (after the 2011 earthquake) found that small contract businesses often did not have the time, money or knowledge to invest in building good health and safety processes into their business. Financial pressures are particularly significant, as SMEs have fewer resources than larger organisations and the cost of compliance with health and safety regulations is higher per employee for SMEs. Furthermore, there is evidence that the disproportionate costs of compliance for SMEs is increasing (Arewa & Farrell, 2012).

SMEs are less likely to have formal health and safety management systems in place, due to a lack of knowledge and time restrictions making it a low priority for businesses (Arewa & Farrell, 2012; Bradshaw *et al*., 2001; Legg *et al*., 2015). What health and safety management exists in SMEs is generally informal and place responsibility on workers rather than the owner-operator (Bradshaw *et al*., 2001; Legg *et al*., 2015). Regulating and inspecting SMEs is more difficult than with larger enterprises due to their dispersed nature, short life-spans, dispersion and heterogeneity (Legg *et al*., 2015).

New Zealand data suggest that bullies and sexual harassers are most commonly employers or managers of small businesses (Poulston, 2008). Migrant workers often work in industries dependent on smaller business (Searle *et al*., 2015). Smaller businesses are also more resistant to WEPR than larger organisations (Walters *et al*., 2012).

Understaffing

Although it is understudied (Hudson & Shen, 2015; Shen *et al*., 2019; Weiss & Hoegl, 2015), understaffing provides a linking risk factor between many types of precarious or poor employment practices and immediate risk factors such as high work demands, stress or long work hours (Quinlan & Boyle, 2009). Shen *et al*. (2019) suggest that, despite a lack of attention, understaffing is a prevalent work-related stressor. The same authors also suggest that good leadership can help moderate the impact of understaffing on burnout and performance.

Precarious employment practices are often employed as cost-cutting measures and result in the intensification of work or the removal of permanent staff in favour of more flexible or outsourced forms of working. This can result in understaffing as the remaining permanent staff are expected to pick up the workload. Understaffing can also hinder improvement, as the remaining staff focus on maintenance rather than innovating or improving on current work practices (Weiss & Hoegl, 2015).

5.5 Conclusion

Together the epidemiological and qualitative risk factor literatures highlight the complex, interrelated nature of risk factors for WRMSDs. The epidemiological literature, although focused on the lower levels of the social system it suggests that there is interplay between workplace culture, managerial support, poor psychosocial health and specific task demands which, together determine much of the risk for WRMSDs. The reviewed qualitative literature echoes many of the risk factors identified in the epidemiological literature but expands on the cultural aspects, both by contextualising workplace cultures and beliefs within wider social norms such as occupational self-identity, gender norms and the perceived (lack of) legitimacy of certain WRMSDs. The qualitative literature also highlights the difference in perceptions between workers and managers, with both seeing the other as primarily responsible for the management of MSDs risks.

Job control and insecurity are recurring themes in the qualitative literature, and recognised risk factors for WRMSDs in the epidemiological literature. Workers' direct control over their job design and environment is key in both preventing MSDs and allowing the management of gradual process injuries while remaining at work. The qualitative literature highlighted a class divide between middle class professionals and managers who were able to control and change their working environment (including by becoming self-employed) and the working class, who have less control over work pace, workplace design, work hours or the type of work they were performing. The qualitative literature also indicates that workplace culture and in particular a commitment to colleagues or clients (such as patients) were a form of informal restriction on job control, as they prevented workers from taking the time off they needed.

Much like the epidemiological literature, the qualitative literature identified specific task demands and practices that increased the risk of MSDs in parts of the working population. For instance, Boniface *et al*. (2016) reported that community nurses faced excessive risk of MSDs when having to care for patient's legs and feet due to the bending and awkward positioning involved.

Other authors contextualised these risks, for instance MacEachen (2005) noted that practices such as encouraging workers to work from home and re-designating them as contractors was in-part designed to make work-related task risks appear to be non-work related, rather than as a way to address risks. Grosse *et al*. (2016) observing the risks in warehouse order picking suggested that these risks may be exacerbated by the prioritisation on efficiency rather than human-centric design. However this was only a proposal and empirical work is needed in this area.

Managerial support and employment relations are another theme that runs throughout the qualitative themes and epidemiological literature. Given the large number of risk factors it impacts, ranging from the safety culture of the workplace to specific task methods, support for supervisors and managers appears to be a lynchpin risk factor for WRMSDs. Inadequate managerial support prevents complaints from being taken seriously, impedes on changes to the working environment and impedes a range of management and treatment options for emerging injuries. However, as Wynne-Jones *et al*. note of their interviewed managers they:

> "appeared to be walking a fine line between supporting their employees through their illness and ensuring that the rest of the team were not adversely affected and that the company targets were met or that services were delivered" (Wynne-Jones *et al*., 2010, p. 35).

This highlights that managerial behaviour is also responsive to demands further up the health and safety system, and that wider structural change is needed in order to produce sustainable change in the risk factors for WRMSDs.

Existing WorkSafe reviews have also identified a number of likely risk factors for WRMSDs at higher systems levels that have not be captured by either the epidemiological or qualitative literature. The identification of these reviews is based on expert opinion, rather than empirical data. Consequently while they should still be considered in intervention design, designers should note the weaker link between them and WRMSDs, in comparison with risk factors identified by either epidemiological or qualitative evidence.

6.0 Interventions to address work-related musculoskeletal disorders

IN THIS SECTION:

This chapter aims to provide a brief summary of primary, secondary and tertiary interventions commonly used in the prevention and treatment of work-related musculoskeletal disorders.

The discussion in this chapter will remain high level and generalised, rather than dividing up intervention by industry or specific disorder. This is justified by Oakman *et al*. who note that while there is diversity in the causes and diagnoses of musculoskeletal conditions, there are sufficient similarities that "examining the effectiveness of interventions across painful musculoskeletal conditions is, therefore, appropriate" (Oakman, Keegel, *et al*., 2016, p. 206).

This chapter is divided into four sections. The first section summarises the epidemiological studies that have been extensively covered by systematic reviews and meta-analyses. The second section provides an initial sketch of other evaluations and findings that are generally excluded from systematic reviews. The third section summarises the features of successful interventions and the last section summarises the barriers to success that need to be addressed by interventions.

6.1 Epidemiological evaluations

As with the risk factors evidence, analyses of interventions to address MSDs have been dominated by epidemiological studies. There is a tendency for this literature to prioritise randomised control trials and laboratory studies as exemplars of evaluations, which as discussed earlier, has limited the type of interventions that can be evaluated. The tendency for epidemiology to decontexualise evaluations also restricts the depth and insights from such evaluations. The consistency of epidemiological evaluations does make reviewing outcomes easier, however and this review has identified 17 systematic reviews that have addressed the epidemiological evidence.[5]

[5] Andersen *et al*. 2011; Cole *et al*., 2005; Cullen *et al*., 2018; Desmules *et al*., 2012; Hoe, *et al*. 2018; Kennedy *et al*., 2009; Mansi, Milosavljevic, Baxter, Tumily, & Hendrick, 2014; Moreira-Silva *et al*., 2016; Oakman, Keegel, *et al*., 2016; Palsson *et al*., 2020; Plessas, 2018; Rivilis *et al*., 2008; Samsson, *et al*., 2020; Silverstein & Clark, 2004; Stock *et al*., 2018; Tompa, Dolinschi, De Oliveira, *et al*. 2010; van Oostrom *et al*., 2009.

These are summarised in the table below.

INTERVENTION LEVEL	INTERVENTION	OUTCOME MEASURED	EVIDENCE QUALITY AND SUMMARY FINDING	NUMBER OF REVIEWS
Overall	workplace interventions	sick leave, time off work	moderate positive	1
		injury and disorder rates	low positive	2
Multifaceted interventions	multilevel/multifaceted interventions	sick leave, time off work	moderate positive	2
		injury and disorder rates	very low null	1
		pain and symptoms	low mixed	2
		productivity	moderate positive	1
		cost-benefit	moderate positive	2
Organisational change/company level interventions	staffing level increase	injury and disorder rates	positive	1
	participatory ergonomics	sick leave, time off work	low positive	3
		injury and disorder rates	low positive	4
		pain and symptoms	low positive	3
	rest breaks	injury and disorder rates	low positive	3
		pain and symptoms	low positive	1
	organisational policy changes	pain and symptoms	low mixed	1
	work organisation adjustment	sick leave, time off work	moderate positive	2
		cost-benefit	low positive	1
Individual and behavioural interventions	workplace exercise/work hardening	Sick leave, time off work	mixed	1
		pain and symptoms	mixed to positive	3
		productivity	low null	1
		cost-benefit	insufficient	1
	ergonomics training/exercise	injury and disorder rates	mixed	2
		pain and symptoms	mixed	1
		cost-benefit	insufficient	1
	pedometers	pain and symptoms	strong positive	1
		productivity	strong positive	1
	educational campaigns	pain and symptoms	low mixed	2
		cost-benefit	insufficient	1
	cognitive-behavioural therapy	sick leave, time off work	strong positive	2
		pain and symptoms	low null	1
		productivity	moderate positive	1
	stress management training	pain and symptoms	moderate null	1
	individual interventions	sick leave, time off work	moderate positive	1
		pain and symptoms	low null	1
		cost-benefit	low null	1

INTERVENTION LEVEL	INTERVENTION	OUTCOME MEASURED	EVIDENCE QUALITY AND SUMMARY FINDING	NUMBER OF REVIEWS
Equipment interventions	workstation adjustment	injury and disorder rates	moderate null	2
		pain and symptoms	strong null	1
	workstation adjustment and ergonomics training	pain and symptoms	low positive	1
	lumbar supports (possibly back belts but not defined in review)	pain and symptoms	strong null	1
	alternative keyboards	pain and symptoms	low positive	1
	arm supports	pain and symptoms	moderate positive	2
	ergonomic chairs	pain and symptoms	low positive	1
	ergonomic chairs – saddle seats	pain and symptoms	moderate positive	1
	dental magnification loupes	pain and symptoms	low positive	1
	ergonomic mice	injury and disorder rates	moderate null	1
		pain and symptoms	mixed	1
	ergonomic mice and arm support	injury and disorder rates	moderate positive	1
	lifting equipment	injury and disorder rates	positive	1
	wrist braces	pain and symptoms	limited positive	1
Healthcare provision	physician training	sick leave, time off work	limited null	1
	alternative triaging (physiotherapists)	sick leave, time off work	low null	1
		injury and disorder rates	moderate null	1
		cost-benefit	low null	1
	advanced practice physiotherapy	pain and symptoms	positive	2
		cost-benefit	positive	1

TABLE 5: Interventions to address MSDs

The 17 systematic reviews reviewed here are felt to adequately cover the epidemiological literature and, consequently quantitative, epidemiological trials and evaluations are not discussed further in this review. Readers should note that there are likely overlaps in the studies included in the 17 reviews above, but that this was not explored further due to time constraints.

6.2 Features of successful interventions

While epidemiological evaluations have dominated the occupational health and safety literature in general, and the MSDs literature in particular, there are a small number of evaluations that provide more contextualised and deeper insights into the features of successful interventions. The key findings from these interventions are summarised in this section.

Many of these insights have had evidential support since the 1990s, but practice has not kept up with developments in academia and findings from evaluations (MacDonald & Oakman, 2015). In particular, current practices tend to ignore complex organisational and psychosocial risk factors and exclusively focus on physical hazards and engineering controls.

It also needs to be acknowledged that academic studies have contributed to the gap between research and findings (Rae *et al*., 2020). This is in part through the proliferation of what Rothmore *et al*. (2013) term 'pedantic science' rather than practical science. Pedantic science is high in rigor, but low in relevance and, rather than aiming to add to human understanding, aims for publication through easily controlled interventions with predictable or already known results. The tendency for pedantic science is likely the reason for the limited number of intervention evaluations and why some interventions (such as participatory ergonomics) tend to be over-studied, while more complex multi-faceted interventions are under-studied. Rothmore *et al*. (2013) also note that MSDs prevention practice tends to be dominated by physical trainers and physical ergonomists, who focus on physical risks at the expense of cognitive and organisational ergonomics.

National level interventions

Boocock *et al*. (2018) have provided a recent review of the (lack of) national MSDs interventions in New Zealand and also reviewed the literature and found no evaluations of national MSDs programmes internationally (Boocock *et al*., 2018). However ACC's Discomfort, Pain and Injury (DPI) programme has been evaluated, and will be discussed here (Edwin, 2010).

The DPI programme developed in 2006 as an update of ACC's 'Prevention of OOS Advisor's Manual', with a belief that the less medical term of 'discomfort, pain and injury' would be more familiar for lay persons (Edwin, 2010). The programme was somewhat multifaceted, with it identifying seven groups of risk factors for WRMSDs, which were:

- environmental issues
- individual factors
- psychosocial factors
- work organisation factors
- loading and forceful movements
- task invariability
- workstation layout/awkward posture.

As should be immediately apparent, these factor groupings closely align to the risk factors commonly identified by the quantitative literature discussed in the previous chapter (Edwin, 2010).

The DPI intervention approach was multi-faceted with training on stretching and workplace practices, encouraging businesses to change practices and mass communication via the ACC website. The DPI programme adopted a 'myth-fact' approach that was aimed at discouraging sick leave, promoting continued work and discouraging workers from seeking medical attention for musculoskeletal symptoms.

Despite claims of success of the DPI programme, the analysis provided in ACC's evaluation suggests that costs and numbers of DPI claims increased from 2000 to 2009. While the DPI programme may have had some benefits in certain sectors (such as Freezing works) the ongoing high number of claims suggests that far more work is needed to address WRMSDs (Edwin, 2010).

A systems approach and macroergonomics

As noted by the epidemiological literature, there is moderate evidence that multifaceted and multi-level interventions have positive impacts on MSDs-related sick leave and have positive efficacy. There is only low quality evidence, however, within the epidemiological literature for their impact on injury rates and pain symptoms. Despite this, many authors have advocated a systems-based approach for practical, theoretical and efficacy reasons that broaden and deepen the literature drawn upon beyond epidemiology.

Taking a broader approach than the epidemiological reviews, Oakman, Rothmore and Tappin conclude that:

> "strong support exists for a number of interventions and approaches that are effective in reducing MSDs risk. These include: a participative approach, the use of multilevel interventions, provision of adequate financial and human resources, and having senior leadership support. Similarly, there is strong evidence that a number of commonly used interventions do not work, including: technique-based manual handling training, job rotation, back belts, and the provision of advice without organisational support" (Oakman, Rothmore, *et al*., 2016, p. 184).

Earlier reviews recommended a focus on individual interventions, particularly after changes to workplace organisation had taken place (Bongers *et al*., 2006). These have shown effectiveness in many industries. Garg and Kapullusch (2009) provide a few large examples of this in the USA including:

- the USA railroad industry providing tables, dollies and carts to aid the handling of railroad car parts in the 1980s
- the identification and elimination of 'high risk tasks' in the chemical manufacturing industry and the reduction of chemical bag weights from 40kg to 27kg
- the inclusion of pneumatic wall lifts and vertical lift systems in the US home building industry in the 1990s.

Other examples include the provision of patient and resident lifting equipment in hospitals and care homes to remove dangerous lifts (Collins *et al*., 2004), or better gripping protective gloves in the meat industry (Tappin *et al*., 2006). In some fields, such as construction, it appears that interventions continue to be limited to addressing physical risks through exercise, training and engineering controls (see for example Choi *et al*., 2014).

The effectiveness of these traditional approaches is limited by the risk factors that they address. In particular they tend not to address psychosocial and organisational risk factors (Moore *et al*., 2006; Tappin *et al*., 2006). Consequently there is a need for interventions to move toward a systems-level 'macro-ergonomic' approach that expands interventions beyond physical risk factors (Holden *et al*., 2015; Oakman, Keegel, *et al*., 2016; Oakman & MacDonald, 2012).

As Yazdani *et al*. (2015) note in their thematic review, wider WRMSDs risk factors and hazards are rarely incorporated into management systems. They suggest that this in part may be due to the lack of ergonomics tools available to managers, particularly as ergonomists have kept tools and techniques to themselves instead of disseminating them; a finding echoed in a later qualitative study by the same authors (Yazdani *et al*., 2018). This later qualitative study, which involved semi-structured interviews of 23 key stakeholders also noted that the separation of ergonomics tools from management tools in general resulted in the siloing of MSDs prevention and often resulted in it being dropped, as it conflicted with other organisational demands (Yazdani *et al*., 2018). They also suggest that despite the difficulties in incorporating MSDs into traditional health and safety management systems, the barriers to doing so are surmountable.

Oakman *et al*. (2016) provide a series of recommendations from a systems-level macro-ergonomics perspective for interventions to address work-related musculoskeletal disorders. Eight of these recommendations are targeted at the regulator, which are:

1. develop web-based MSDs risk management guidance and resources customised to individual jobs in high-risk sectors
2. change the advice focus from secondary and tertiary prevention to primary prevention and highlight the need for employers to focus on organisational and psychosocial hazards
3. promote educational programs on psychosocial hazards targeting managers and supervisors
4. develop and promulgate best-practice case studies in managing psychosocial hazards
5. promote more holistic risk management tools
6. promote the need for paid worker consultation and participation in risk assessment and control procedures
7. promote the need for senior managers to develop and maintain a detailed understanding and valuing of OHS issues and receiving feedback from staff
8. review existing information and advice to ensure relevance.

Four more of the recommendations are targeted at organisations:

1. ensure site managers and coordinators are educated and trained on their own impact on risk and how to manage the risk
2. reduce management siloing particularly around psychosocial risks
3. ensure worker participation, representation and engagement
4. ensure senior managers have open engagements with staff to facilitate communication and feedback.

Unsurprisingly most of these recommendations refocus effort away from exclusively work-focused training and job design to address the wider environment in which work occurs. This aligns with the findings of the risk factors review conducted earlier, which emphasises the need for more attention toward organisational and systems-level risk factors rather than specific job demands or worker behaviour. The recommendations may also work to improve existing commonly used interventions to address MSDs, such at participatory ergonomic interventions or inspections, rather than requiring new interventions to be designed from scratch.

As well as providing potential improvements for preventative interventions, the need for systems-level interventions has also been identified in the return to work literature where MSDs related disability is "no longer seen simply as the consequence of an illness (or impairment), but rather as the result of interactions between the worker and three main systems: the healthcare, work environment and financial compensation systems" (Briand *et al*., 2007).

Interventions to address psychosocial hazards

It is widely recognised in the literature that organisational practices to manage and reduce harm from MSDs have inadequately addressed psychosocial risk factors (MacDonald & Oakman, 2015; Oakman, MacDonald, *et al*., 2016; Robertson *et al*., 2020).

A large part of the omission of psychosocial risk factors has been on managerial unawareness that psychosocial factors can result in physical harm. The relative difficulty of addressing psychosocial risk factors is also a likely contributor. For instance, Robertson *et al*. (2020) found that managers who were aware of the psychosocial risk factors for MSDs saw it as a 'sleeping giant' that should not be woken. Oakman *et al*. (2019) found that managers who were aware of psychosocial risk factors saw them as beyond their control and that psychosocial harm was a failure of individual workers rather than the work environment.

Some authors note there is a need for government to provide more advice on how organisations should manage psychosocial hazards (MacDonald & Oakman, 2015; Robertson *et al*., 2020). This advice needs to dispel the Cartesian myth of the mind and body being separate that reinforces "the common misconception that psychosocial hazards are relevant only to mental rather than physical health problems" (MacDonald & Oakman, 2015).

While many academics have called for a greater focus on psychosocial risk factors and for tools to address them, there is a lack of guidance on how regulators and businesses should address psychosocial risk factors. The review has found no nation or regulator level evaluations of interventions designed to address the psychosocial risk factors for work-related MSDs.

While not exclusive to WRMSDs, Queensland provides a useful case study of regulator interventions to address psychosocial hazards, having implemented a slowly growing inspectorate response in 2005 to reports of psychosocial hazards, initiated by two psychosocially-trained inspectors in 2004 (Johnstone *et al*., 2011). The response was initially reactive but became a state-wide strategy. Inspectorate actions were dictated by the perceived ability of the organisation to self-regulate with low-risk organisations with well-established HR departments being self-regulated. Low risk organisations without HR departments had inspectorate visits where the inspector would help find an external expert to investigate potential risks and tailor a response. High risk organisations were subject to a full investigation by a specially trained psychosocial inspector that focused on reducing harassment through organisational changes and human resource activities. Eventually the programme was broadened out to include 6 areas:

- harassment
- occupational stress
- fatigue
- cognitive issues in design
- safety culture and safety behaviour
- a 'People at Work' multi-organisational campaign.

The interventions also included an update to regulations and guidance and assessment tools used by inspectors. Despite this the inspectorate was still generally reluctant to address psychosocial issues, and by 2011 there had been no prosecutions related to psychosocial harm in Queensland (Johnstone *et al*., 2011).

While a comprehensive analysis is out of scope, this brief overview has highlighted both the importance of, and difficulty in, addressing psychosocial harm in the workplace and its relationship to MSDs. The recommendations by Oakman and colleagues suggest that updating guidance, updating regulation and providing inspectors with training in dealing with psychosocial issues are an important first-step in addressing psychosocial risk factors for MSDs.

Paricipatory ergonomics

There is a general acceptance in the literature that employee participation is key to the success of MSDs interventions. Employee participation is a cornerstone of human factors/ergonomics. Participatory ergonomics (PE) has also been coined as a commonly used term (Franche *et al*., 2005; MacDonald & Oakman, 2015). However, Tappin *et al*. (2006) have noted that despite serious issues with the participatory ergonomic literature, which means that successes are more likely to be reported than failures, there is a general consensus that some degree of employee participation is beneficial in interventions addressing MSDs (Tappin *et al*., 2006). Typically, "a participatory ergonomics program [...] employs one or more teams assembled for the purpose of improving the design of work, and the common element is to ensure utilisation of the expert knowledge that workers have of their own tasks by involving the workers, and others potentially affected by proposed changes" (Burgess-Limerick, 2018, p. 290).

Worker participation is particularly important for addressing psychosocial harms: "because many are not observable by others and their severity is strongly influenced by workers' perceptions" (MacDonald & Oakman, 2015, p. 298). However, they also noted that participation is often poorly implemented and limited in interventions leading to a lack of evidence (MacDonald & Oakman, 2015; Robertson *et al*., 2020).

These teams are generally trained by an ergonomist or similar. They do not always involve worker engagement, as some teams may be committees constituted of managers and experts, but in general, PE is seen as most effective when worker engagement is part of its foundation (Van Eerd *et al*., 2008). Whilst PE is traditionally focused on ergonomics and harm prevention, it also encourages workers to help identify and remove issues in their workplace that might cause or aggravate discomfort, injury or ill health (Henning *et al*., 2009). These interventions often involve workers receiving training in ergonomics, the time to identify and design their own changes to the work process and receiving support for implementing the changes. In short they allow workers to be recognised as subject-matter experts in the risks and harms in their workplaces. Engaged workers are more likely to identify ways of improving outcomes, develop a shared understanding of problems and be more accepting of changes than when they are instructed to make changes by management (Henning *et al*., 2009).

As included in the summary of the epidemiological literature, Van Eerd, *et al*. (2006) reviewed 33 peer reviewed and 19 grey literature evaluations of PE interventions to look for tendencies, consistencies, barriers and facilitators to the success of PE. Overall, they found that PE interventions were successful (but see Tappin *et al*.'s caveats above). They were also heterogeneous, but most included some form of training for workers, frequently supervisors in the intervention (about half also included upper management) and were voluntary (if this was mentioned). They noted that there were numerous contextual factors that needed to be considered when designing an intervention. These included:

- workplace size and site number
- workplace culture
- unionisation
- economic context and workplace stability
- production changes
- workforce demographics.

Nearly all interventions reviewed by Van Eerd *et al*. (2006) resulted in changes to tools/equipment used by workers, with fewer changing work processes and very few changing work organisation. They suggest this was the result of the limited remit given to teams, coupled with the ease of identifying changes in equipment compared to changes in processes or organisation. They noted that in most cases, worker teams were given a problem-solving remit and rarely had responsibility to either design or monitor the PE intervention. Lastly, they identified large numbers of barriers and facilitators. The most common ones were management support, the resources provided, the training quality, team creation, levels of communication and organisational knowledge.

Rivilis *et al*. (2008) conducted a different systematic review about the effectiveness of PE interventions on health outcomes. Twelve studies were appraised using a best evidence synthesis approach to be of sufficient methodological quality to use, five of which focused on manufacturing or factory workers. Eleven of the 12 studies reported a positive effect on health outcomes associated with PE interventions. However, due to the heterogeneity in methodological approach between the studies, the authors concluded that there was only partial to moderate evidence that PE interventions are effective in improving health outcomes.

The success of PE interventions depends on management commitment levels, with a lack of commitment at all levels from management being the most likely cause of failure of a PE programme (Burgess-Limerick, 2018). Other studies have supported this argument, for instance, Dale *et al*. found that in one PE programme in the construction industry, whilst many workers were receptive, many contractors were unsupportive especially if they believed the programme would interrupt their work and would be costly (Dale *et al*., 2016). Van der Molen *et al*. (2005) found a similar attitude in bricklaying.

Burgess-Limerick (2018) suggests that PE programmes are likely to be most successful in organisations that already have many of the features of worker participation. They note that PE interventions are more likely to be successful in organisations that are less hierarchical, have better labour relations, have a tradition of consultation and have good communications channels. Furthermore, most PE programmes limit worker participation to initial consultation. Workers are generally responsible for identifying problems and solutions under the guidance of an external ergonomist, and the decision-making process remained with management, with little worker input and infrequent union involvement (Burgess-Limerick, 2018). These findings suggest that it is less a case of PE improving participation but instead PE is dependent on existing practices of worker consultation and participation to be successful.

Franche *et al*. (2005) have noted the need for a macro-ergonomics approach to address conflicts between stakeholders, which they refer to as 'dissonant paradigms'. They note that these paradigms inevitably create friction that cannot be entirely removed, but can be mitigated though the recognition of a shared goal "of returning workers to safe, sustainable, and meaningful work" (Franche *et al*., 2005, pp. 531–532) and by clear communication and increasing awareness of other stakeholders' concerns.

Henning (2009) argues that PE programmes exist along a spectrum from top-down to full PE programmes (shown below). This follows a similar schedule of engagement from no engagement through consultation, partial engagement and full worker participation and engagement in workplace redesign with assistance from external experts. From this perspective, elements of the organisation that limit worker control over the workflow processes are barriers to improved health outcomes, and management should be encouraged to empower workers to be more deeply involved.

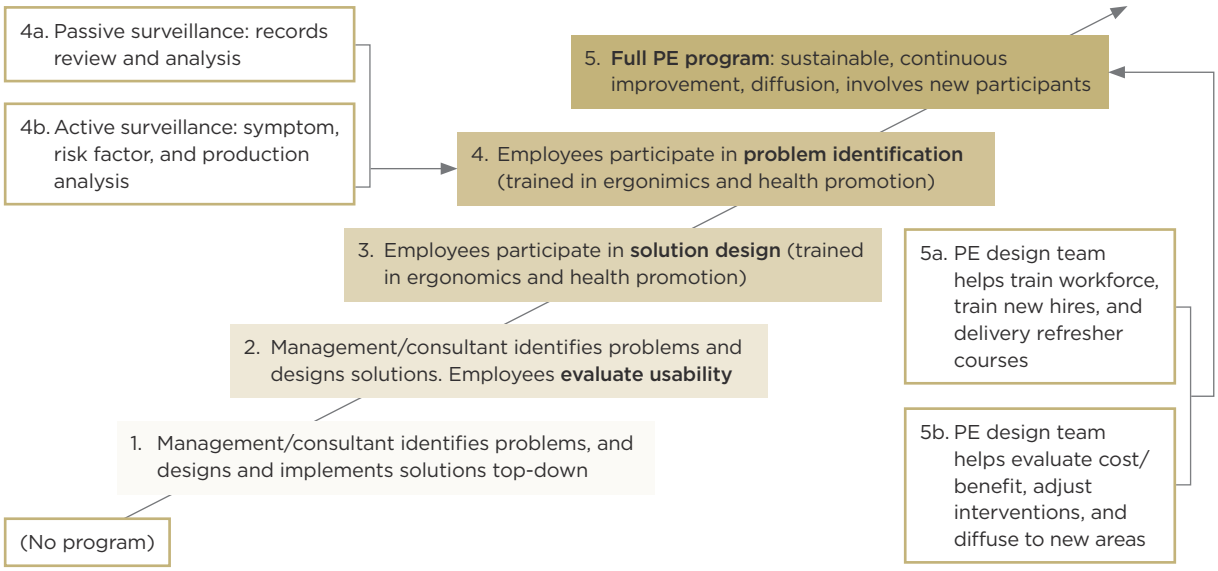

FIGURE 3: PE programme spectrum (Henning, 2009)

Participatory ergonomics interventions can be successful in many but not all workplace environments. The voluntary nature of such programmes means that they are unlikely to be attempted in workplaces that do not already prioritise OHS and are more likely to be implemented in high-performing organisations. Furthermore, it is important to ensure that participatory ergonomics programmes are not behavioural management schemes dressed up as participatory programmes. As the Henning diagram indicates, top-down approaches prevent adequate participation and are unlikely to result in significant improvement in occupational health and safety management.

Assessing and addressing safety culture

Oakman, Rothman *et al*. (2016) argue that the safety culture of an organisation is absolutely key to the success of an intervention, but that it is poorly understood (see Guldenmund (2000) for a detailed discussion of safety culture). More tentatively earlier work by Franche *et al*. (2005) suggest that a good organisational culture improves the chance of return to work strategies being successful. These views echo the findings of the risk factors section that highlighted the importance of safety culture, but also the complexity of the concept and lack of insights provided about it.

Unfortunately, there also seems to be a lack of safety culture focused interventions that have been evaluated in the literature. This is perhaps unsurprising given the tendency for ergonomics and human factors researchers to focus on user, machine and the workspace and omitting systems-level factors such as organisational or cultural factors despite the importance of organisational commitment in determining the success of interventions (Bentley & Tappin, 2010). Bentley and Tappin (2010) note the lack of practical guidance both on how to apply safety culture to ergonomics and also how managers could incorporate ergonomics into their managerial activities. They suggest this is largely due to ergonomists protecting their tools and expertise rather than disseminating them more widely.

To remedy the deficiency of tools Tappin *et al*. (2015) developed and assessed the MSDs Cultural Assessment Tool (CAT). The tool is a modification of the stage of change tool with five categories of safety culture (pathological, reactive, calculative, proactive and generative). Bentley and Tappin (2010) also suggest 12 aspects of safety culture:

- top management commitment/organisational commitment
- OHS communication
- OHS training/job competency training
- OHS management system
- OHS organisation
- employee safety commitment and behaviour
- OHS reporting
- OHS model for investigations
- OHS meetings
- contractor management and OHS standards
- employee involvement/engagement in OHS
- work pressure.

Tappin *et al*. (2015) found that the MSDs CAT was applicable in measuring the safety culture of both an aged care organisation and a timber processing organisation, however their evaluation did not measure outcomes. The question set of the MSDs CAT is included in Appendix 4

Ergonomics evaluations appear to continue to lack assessments of safety culture. However, this review did find one evaluation by Yazdani *et al*. (2018). This evaluation has highlighted the importance of an organisation's culture being 'ready' for MSD prevention interventions. This was also demonstrated in Yazdani *et al*. (2018) who note that since MSDs prevention strategies required organisational change, there needed to be both dedication and alignment from management to make them successful.

While not the primary focus of their intervention, Schroeder (2009) noted that organisational cultural change was key in the success of an industrial MSDs prevention program as it encouraged early reporting of MSDs symptoms which allowed lighter preventative interventions, rather than more invasive interventions when cases became severe.

The relationship between safety culture and MSDs is under-researched in the evaluation literature but is generally assumed to be important and in need of greater attention if a systems approach to intervention design is to be successful. It appears that assessing the readiness of an organisation to address MSDs and the managerial practices is key to tailoring interventions. Furthermore, commitment to change is key in ensuring that interventions are implemented and sustained over time.

6.3 Barriers to interventions

Oakman, MacDonald and Kinsman (2019) have identified a number of barriers to improvements in MSDs management in the workplace. Based on 67 semi-structured interviews with managers and stakeholders at a range of Australian organisations they found that:

- most organisations' guidance and policies on MSDs focused exclusively on manual handling and biomechanical risks
- managers were generally unaware of the importance of psychosocial risk factors for MSDs
- managers who were aware of the importance of psychosocial risk factors saw them as beyond their control
- managers never mentioned staffing levels or high workloads as risk factors for MSDs
- compliance with occupational health and safety policies was seen as workers' responsibility and not the consequence of workplace environments
- occupational health and safety was given a low priority in many workplace resulting in inadequate funding (Oakman, MacDonald, *et al*., 2019).

Furthermore Oakman, Rothmore *et al*. (2016) noted that managerial attitudes "greatly influence the impact of advice provided by the ergonomist" in the workplace (Oakman, Rothmore, *et al*., 2016, p. 179). Many of the barriers identified by Oakman and her colleagues have been identified in other reviews, and also align well with the risk factors mentioned earlier. They also highlight the challenges that are faced by systems-level interventions and the appeal of simpler and worker-focused manual handling policies among managers. Interventions aiming to reduce work-related MSDs will have to address these barriers.

Goode *et al*. (2019) observed similar barriers to reporting in Australian businesses. As with Oakman *et al*. they found that training, equipment purchases and changes in work practices were the most common responses to MSDs reports. They also noted that most policies were either vague in what constituted reportable MSDs and that others included no guidance at all. There was also a feeling among managers that reporting was a tick-box exercise and that follow-up action should be directed at the individual worker. They also noted that most organisations had an ad hoc approach to follow-up analyses. However, one organisation's use of a cluster analysis to identify risk and target intervention was seen as a positive intervention development.

As mentioned above, Franche *et al*. (2005) argued that there are inevitable conflicts between stakeholders and that, while they cannot be entirely removed, they do need to be addressed and mitigated where possible. They suggest that a starting point for understanding stakeholder motivations around MSDs is that:

- employers generally have financial concerns that will trump health and safety concerns, but stronger business cases for disability management may be changing this
- supervisors may have conflicting responsibilities to assisting workers to follow medical prescriptions and the responsibility to produce (increase production)
- coworkers can have the burden of extra work as well as supporting an injured colleague
- healthcare providers such as physiotherapists need to ensure the continued utilisation of services but also to demonstrate success in returning workers to work
- there may be a conflict in the rights of workers in a seniority scale, which can hinder RTW measures
- insurers' motivation is returning workers to work at the lowest cost and possibly in determining the work-relatedness of the injury (Franche *et al*., 2005).

They suggest that there is a need for as many of these motivations to be addressed in a return to work intervention, but that the optimal return to work intervention would involve the employer asking and accommodating what the worker needs to address and adapt to their condition.

Employment patterns can also provide barriers to the success of interventions in addressing musculoskeletal disorders. Most obviously the use of insecure or contract workers both outsources risk management and hinders many features of successful interventions such as worker participation, training and improved psychosocial health. However, otherwise favourable employment can also have an impact, such as the barriers created by seniority and pay scales in meat processing (Tappin *et al*., 2006).

6.4 Conclusion

This chapter has briefly outlined the features of interventions that increase their likelihood of improving MSDs outcomes in the workplace. The epidemiological evidence, summarised by 17 systematic reviews found moderate evidence that workplace interventions improve sick leave and time off work.

There is strong evidence that:

- cognitive-behavioural therapy **targeted and tailored for the specific workplace context** improves sick leave and time off work
- lumbar supports[6] have **no** impact on reported pain and symptoms
- workstation adjustment alone has **no** impact on reported pain and symptoms.
- Pedometers may be used to encourage exercise, which in turn may improve reported pain and symptoms and worker productivity.

There is moderate evidence that:

- multifaceted interventions have a positive effect on sick leave, time off work, productivity and a positive cost-benefit
- work organisation adjustments have a positive effects on sick leave, time off work
- cognitive behaviour therapy **targeted and tailored for the specific workplace context** improve productivity
- individual interventions have a positive impact on sick leave and time off work

[6] The systematic review this result is from does not define what was included in lumbar supports.

- arm supports, ergonomic mice with arm supports and ergonomic chairs have a positive effect on pain and symptoms
- ergonomic mice have **no** impact on injury and disorder rates
- triaging by advanced physiotherapists have the same impact on injury and disorder rates as triaging by physicians
- workstation adjustments alone have **no** impact on injury and disorder rates.

Most other forms of interventions and outcomes have limited, mixed or insufficient evidence to support intervention development according to the evidence rating in epidemiology. This does not mean that these interventions are ineffective, but it does highlight the large gaps in evidence within epidemiology.

Broader evidence, largely reliant on expert opinion and the few qualitative studies that evaluate individual interventions in addition to the findings of epidemiology has suggested a number of features of interventions that impact on their effectiveness. These include:

- a systems-based or macro-ergonomics approach that addresses the wider context within which work occurs
- interventions that address psychosocial risk factors for WRMSDs and the causes of psychosocial harm
- certain forms of participatory ergonomics that promote deep and meaningful worker engagement and organisational changes
- interventions that result in changes in managerial and cultural changes both within an organisation and between organisations
- the proper targeting and tailoring of interventions to the specific organisational and work context that MSDs harms occur within.

Unfortunately, as with many academic findings these features of interventions are high-level and limited in the practical advice they provide. Still they are important consideration for intervention designers. Furthermore Oakman *et al.*'s (2016) guidance provides some practical tools for designing interventions along these lines and is worth repeating here:

1. change the advice focus from secondary and tertiary prevention to primary prevention and highlight the need for employers to focus on organisational and psychosocial hazards
2. promote educational programs on psychosocial hazards targeting managers and supervisors
3. develop and promulgate best-practice case studies in managing psychosocial hazards
4. promote more holistic risk management tools
5. promote the need for paid worker consultation and participation in risk assessment and control procedures
6. promote the need for senior managers to develop and maintain a detailed understanding and valuing of OHS issues and receiving feedback from staff
7. review existing information and advice to ensure relevance.

Four more of the recommendations are targeted at organisations:

1. ensure site managers and coordinators are educated and trained on their own impact on risk and how to manage the risk
2. reduce management siloing particularly around psychosocial risks
3. ensure worker participation, representation and enegagement
4. ensure senior managers have open engagements with staff to facilitate communication and feedback.

Obviously, these points will require tailoring to specific industries and organisations, but they do provide a framework for developing primary preventative interventions to address work-related musculoskeletal disorders in the workplace.

7.0
Limitations and future research

While this review has aimed to provide an overview of the WRMSDs literature that aligns to a realist methodology and a systems-theory perspective it is not comprehensive.

Time and resource limitations mean that the review of the epidemiological literature was limited to meta-analyses and systematic reviews. As mentioned, this was felt to provide a reasonably comprehensive overview. However, this approach does include several limitations, notably:

- the decontexualisation and generalisation of findings, already common in epidemiology is particularly problematic in meta-analyses and systematic reviews which merge multiple studies from different contexts into a single finding
- the use of meta-analyses and systematic reviews reinforces the focus of epidemiology on a few known risk factors and marginalises studies that adopt novel approaches in favour of those that reproduce existing findings
- the non-systematic review undertaken may result in some reviews and meta-analyses being omitted from this review.

While these limitations are acknowledged, drawing on the qualitative literature has mitigated them by bringing in nuance and context into the findings. The more heterogeneous qualitative literature also helped to broaden the focus of the review.

While there are some New Zealand studies on WRMSDs, much of the literature reviewed is international and may not be transferrable to the New Zealand context. This is particularly true of the intervention literature, where the success or failure of an intervention may not be generalisable.

There is the danger that the wider approach of developing an AcciMap from the risk factors and interventions outlined here may produce a static, calcified model of the socio-technical system. This has been noted as a danger by various theorists.

In addition to these limitations there are avenues of further work that are either underway or should be considered.

The general dearth of quality evaluations requires addressing, and it is also important to build understanding of how different interventions work or fail to work in the New Zealand context.

8.0 Conclusion

IN THIS SECTION:

This document has aimed to collect and outline the literature on work-related musculoskeletal disorders (WRMSDs) relevant to WorkSafe and to supplement it with insights into WorkSafe's current intervention approaches and insights from WorkSafe's survey programme.

This document has covered a large quantity of literature from a range of different disciplines that cover many different aspects of WRMSDs. In order to make sense of this literature, it has been structured accordingly:

- literature covering the risk factors of WRMSDs and risk factors for those risk factors (underlying risk factors)
- literature covering evaluations of interventions aiming to address WRMSDs.

The key findings from each of these sections are given below before an overall summary of the evidence around WRMSDs. With the size of the literature around WRMSDs, all of these findings have been covered by other authors, some to extensive detail.

8.1 Risk factors key findings

Research and Evaluation reviewed a wide range of literature on risk factors for WRMSDs, and the findings from various methodologies and disciplines has been presented in different, often non-comparable ways. However, there are some key summaries that can be drawn from this literature, which include that:

- the risk factors for MSDs are complex and interrelated
- there is a need to focus on organisational and wider systemic risk factors for WRMSDs, beyond a narrow focus on worker and task design
- psychosocial risk factors in particular need to be addressed
- workplace culture is a key underlying risk factor for WRMSDs
- physical and biomechanical risk factors are known and remain relevant
- the different demands and drivers for workers and managers is an important consideration and underlying risk factor.

A vast majority of the risk factor literature addressed specific physical hazards and individual risk factors for WRMSDs. This is unsurprising due to the predominance of epidemiological studies in the WRMSDs literature. However, as emphasised in the risk factors discussion, further insights can be gained by incorporating the small amount of available qualitative research into the risk factors of WRMSDs. This literature highlights the organisational and cultural risk factors for WRMSDs. For instance several studies have suggested that job control is more prevalent among managers and white-collar workers and is a key determinant in preventing and managing WRMSDs. It also highlights the struggle for legitimacy that many sufferers of WRMSDs experience and how the de-legitimisation of MSDs by employers and government agencies make the prevention, reporting and management of WRMSDs more difficult. Lastly it also demonstrates how varied organisational risk factors for WRMSDs are, with various features such as teamwork resulting in presenteeism, management attitudes and individual self-perception all being highly variable risk factors.

A supplementary chapter expanded the risk factor literature review to incorporate potential risk factors for WRMSDs that have been identified in other literature reviews undertaken by Research and Evaluation. These risk factors are not ones that have been directly associated with WRMSDs in the empirical literature, but have been judged by the Research and Evaluation team to be potential factors that should be considered in intervention design.

8.2 Interventions key findings

Much of the epidemiological research is of limited applicability to WorkSafe, with most studies finding little to no effect or lacking adequate assessment of context or causality to establish why interventions are or are not effective. However, other academics with significant experience in addressing WRMSDs have provided guidance on key features of interventions. Oakman *et al.*'s (2016) recommendations for regulators are likely useful starting points. These were:

- change the advice focus from secondary and tertiary prevention to primary prevention and highlight the need for employers to focus on organisational and psychosocial hazards
- promote educational programs on psychosocial hazards targeting managers and supervisors
- develop and promulgate best-practice case studies in managing psychosocial hazards
- promote more holistic risk management tools
- promote the need for paid worker consultation and participation in risk assessment and control procedures
- promote the need for senior managers to develop and maintain a detailed understanding and valuing of OHS issues and receiving feedback from staff
- review existing information and advice to ensure relevance.

Expert recommendations suggest that successful interventions will be ones that:

- are systems-based or macro-ergonomics approach that address the wider context that work occurs within
- address psychosocial risk factors for WRMSDs and the causes of psychosocial harm
- use participatory ergonomics that promote deep and meaningful worker engagement and organisational changes
- result in managerial and cultural changes both within an organisation and between organisations
- are properly targeted and tailored to the specific organisational and work context that MSDs harms occur within.

These recommendations highlight the need to avoid prescriptive recommendations for interventions, but instead for the need for regulators to tailor their interventions to particular contexts and to involve workers, managers and organisations in the development of interventions.

Appendices

IN THIS SECTION:

Appendix 1: Definitions

TERM	DEFINITION
Musculoskeletal disorders	MSDs are a group of chronic/gradual process and acute disorders/injuries of muscles, tendons, blood vessels and nerves resulting from excess strain on bodily tissues.
Work-related musculoskeletal disorders	Work-related musculoskeletal disorders are a group of chronic or gradual/injuries process and acute disorders of muscles, tendons, blood vessels and nerves, which are caused or aggravated by work-related excess strain on bodily tissues.
Musculoskeletal symptoms	Musculoskeletal symptoms include discomfort, pain and fatigue, are subjective feelings and self-reports and may be undiagnosed. This is the common way that epidemiological data on MSDs are collected. These are distinct from the signs which are externally observed evidence of a musculoskeletal disease.
Musculoskeletal conditions/diseases	Musculoskeletal conditions/diseases are diagnosed conditions of the musculoskeletal system. These are recognised by the medical profession, and are listed in the International Classification of Diseases.
Body Stressing	Body stressing is a compensation classification referring to injuries or diseases that result from stress placed on muscles, tendons, ligaments and bones.
Sprains and Strains	Sprains and Strains are two common types of musculoskeletal injuries.

Appendix 2: Abbreviations

ACC	Accident Compensation Corporation
ANZSCO	Australian and New Zealand Standard Classification of Occupations
ANZSIC	Australian and New Zealand Standard Industrial Classification
BMI	Body Mass Index
WRMSDs	Work-related Musculoskeletal Disorders
CAT	Cultural Assessment Tool
CI	Confidence Interval
COPSOQ-III	Copenhagen Psychosocial Questionnaire (third edition)
dB	Decibels
DPI	Discomfort, Pain and Injury Programme run by ACC
EU OSHA	European Union Occupational Safety and Health Agency (European Union Agency for Safety and Health at Work)
HAV	Hand-arm vibration
HR	Hazard Ratio
LEED	Linked Employer-Employee Data, a quarterly dataset produced by StatsNZ
MA	Meta-analysis
MBIE	Ministry of Business, Innovation and Employment
MSDs	Musculoskeletal disorders
OECD	The Organisation for Economic Co-operation and Development
OHS	Occupational Health and Safety
OOS	Occupational Overuse Syndrome
OR	Odds Ratio
PCBU	Person Conducting Business or Undertaking
PE	Participatory Ergonomics
RCT	Randomised, Control(led) Trial
RR	Risk Ratio/Relative Risk
RSI	Repetitive Strain Injury
SME	Small and Medium Enterprise (generally of 20 full time equivalent employees or fewer)
SPSS	Statistics Package for the Social Sciences
SR	Systematic review
VDU	Visual Display Units (such as computer monitors)
WBV	Whole Body Vibration
WEPR	Worker Engagement, Participation and Representation
WHO	World Health Organisation

Appendix 3: Definitions of epidemiological risk factors

Work

POOR WORKSTATION DESIGN

A workstation that does not fit the human and the task outcome. In this way the quality of a workstation design is determined by its relations to the task(s) and the worker(s) performing them.

VIBRATION

Hand-arm vibration

Hand–arm vibration (HAV) is defined as the transfer of vibration from a tool to a worker's hand and arm (Heaver *et al*. 2011).

The DIRECTIVE 2002/44/EC of the European parliament and the council defined WBV as "the mechanical vibration that, when transmitted to the human hand-arm system, entails risks to the health and safety of workers, in particular vascular, bone or joint, neurological or muscular disorders" furthermore maximum "daily exposure limit value standardised to an eight-hour reference period shall be $5m/s^2$" (European Union, 2019).

Whole body vibration

Whole body vibration exposure "can be defined in terms of intensity, duration, and number of intervals in exposure time" (Tiemessen *et al*., 2007, p. 246).

The DIRECTIVE 2002/44/EC of the European parliament and the council defined 'whole-body vibration' as: "the mechanical vibration that, when transmitted to the whole body, entails risks to the health and safety of workers, in particular lower-back morbidity and trauma of the spine" furthermore maximum "daily exposure action value standardised to an eight-hour reference period shall be $0.5m/s^2$ or, at the choice of the Member State concerned, a vibration dose value of $9.1m/s^{1.75}$" (European Union, 2019).

Noise

Workplaces must make sure (as far as is reasonably practicable), that workers are not exposed to peak noise over 140dB or an average of 85dB over an eight hour period.

LOW TEMPERATURE

The World Health Organization has found that "there is no demonstrable risk to human health of healthy sedentary people living in air temperature of between 18 and 24°C" (World Health Organisation, 2018). However most epidemiological studies and meta-analyses use self-reports of workers perceived time in temperatures they perceive as cold.

POOR EQUIPMENT DESIGN

Not defined.

WORKING WITH COMPUTERS/VDUs

In epidemiological studies working with computers/Visual display units is based on either observational studies of posture in laboratory settings or self-reported time working with computers/VDUs (Gerr *et al*., 2002; Lee *et al*., 2009). There are a number of risk factors associated with working with computers, among which were repetitive work, and awkward postures of the trunk, neck and upper limbs.

HIGH REPETITION AND TASK INVARIABILITY

In machine paced work "work-cycle-paced activities define the rate of work by the cycle time of each machine operation. With shorter cycle times (seconds, a few minutes) there is less opportunity for a worker to vary the rate of performing specific tasks." Machine pacing can either be continuous (such as conveyor assembly lines) or discrete cycles of operations (Smith, 1985, p. 52).

POSTURE-RELATED RISKS

"Working posture[s are] the posture[s] adopted by an employee while performing working tasks. It can be altered often, or a single posture can be sustained for an extended time. The human body can be represented by segments, such as arm, forearm, thigh or trunk, connected to other segments by joints. Working posture can be described by angles between body segments" (EU OSHA, 2020).

PHYSICAL LOADING/MANUAL HANDLING

Department of Labour and ACC Codes of Practice define manual handling as "any activity requiring a person to lift, lower, push, pull, carry, throw, move, restrain, hold or otherwise hand any animate, or inanimate, object" (Department of Labour & ACC, 2001). As with many risk factors, epidemiological studies generally rely on self-reports of manual loading (van den Berg *et al*., 2011).

JOINTS WORKING AT EXTREMES OF EXTREMES OF POSTURE

Not defined.

Staff

HIGH BMI

High BMI is defined as the individual having a BMI >25, with a further distinction between overweight (BMI 25–29.9) and obese (BMI >30) (World Health Organisation, 2020).

EXPOSURE DURATION

Exposure duration can be defined as the amount of time workers are estimated to be exposed to particular risk factors for work-related MSDs. In epidemiological studies it is measured by proxies of lifetime employment, and time in current role. In MSDs risk evaluation task repetition and duration are combined with load and posture variables (and other factors) to determine a risk score.

EXPERIENCE OF DISCRIMINATION

According to MBIE: "It is discrimination in employment if an employer:

- won't or doesn't give an employee the same terms of employment, work conditions, fringe benefits, opportunities for training, promotion and transfer as other employees:
  - with more or less the same qualifications, experience, or skills, and
  - who are employed in the same or substantially similar circumstances, or
  - dismisses an employee or does something that has a negative effect on their employment, job performance or job satisfaction when they are not treating other employees doing the same type of work in the same way, or
  - retires an employee or makes the employee retire or resign (for example, by creating unfavourable working conditions in order to make the person resign), and
  - the reason is directly or indirectly a prohibited ground of discrimination" (MBIE, 2020).

As with many risk factors however, most epidemiological studies are reliant on self-reported data on discrimination. Furthermore there is rarely distinction between discrimination by employers and co-workers, unlike in the MBIE definition.

LACK OF TRAINING

Not defined.

DEMOGRAPHIC FACTORS

A number of demographic factors have been identified as risk factors for work related musculoskeletal disorders. However, the general lack of causal evidence and because demographic factors are outside of the regulator's ability to influence these factors are best treated as prevalence factors and so have only been listed (and not defined) as risk factors for comprehensiveness in reviewing the epidemiological literature.

Female gender

Not defined.

Older age

Age bands or comparator ages generally tend to be on 10 or 5 year bases, with the most common point where age becomes significant is ~40s. However some MSDs such as lower back pain may be more prevalent in younger populations (Erick & Smith, 2011; Long *et al*., 2012; Osborne *et al*., 2012).

Prior history of MSDs

"Those returning from sickness absence following illness or injury (particularly work-related MSDs), are likely to be less able to cope with the demands of work on their return. As a result, interventions to modify work have been identified as a key factor in facilitating the re-integration of these individuals back into the work environment" (Whysall, 2006, p. 42).

Ethnicity

Ways of classifying ethnicity vary by country and, in some countries such as the USA 'race' continues to be used. Generally ethnicity is self-defined identity based on a prescribed list of options with the space to add an additional ethnicity. Meta analyses and systematic reviews generally do not state if primary ethnicity or all ethnicity is used.

Migrant workers

A migrant worker is "someone who has migrated to another country to take up work and who currently does not have a permanent status in the receiving country" (Sargeant & Tucker, 2009).

Smoking

Not defined.

Alcohol consumption

Not defined.

Management

WORKING UNDER TIME PRESSURES

Work Pace deals with the speed at which tasks have to be performed. Work Pace is a measure of the intensity of work which may be machine driven, but not necessarily (Burr *et al*., 2019). A fast work pace can exacerbate physical risk factors such as heavy physical loading. It is also closely related to a lack of recovery time as there are often inadequate micropauses and breaks.

HARASSMENT/BULLYING/VIOLENCE

Conflicts and offensive behaviour cover on the one hand being subjected to negative acts such as bullying and threats of violence at the workplace and on the other hand conflicts between people at the workplace (Burr *et al*., 2019).

Bullying is in this context if one has experienced this act at the workplace. Bullying is defined as being exposed repeatedly over a longer period to unpleasant or degrading treatment and not being able to defend himself or herself against this treatment (Burr *et al*., 2019).

GENDER-BASED DIVISION OF WORK

Despite legal restrictions gendered division of work exists between occupations, within occupations, levels of seniority and between paid labour and unpaid labour (Huws, 2012).

INADEQUATE JOB DESIGN

Job design can be defined as designing the characteristics of work including the task, job, social and organisational aspects of a job (Morgeson & Humphrey, 2006). Job design is a complex process with many important characteristics that are often neglected in common measures such as the Job Diagnostic Survey or the Job Design Questionnaire.

LACK OF RECOVERY TIME

See *Fatigue*.

INADEQUATE RESOURCE PROVISION

Not defined.

LACK OF JOB CONTROL

Questions on job control concerned workers' influence on the planning of tasks, ability to interrupt work if necessary, and whether or not they had a say on completion of deadlines (van den Berg *et al*., 2011).

MONOTONOUS AND REPETITIVE TASK DESIGN/TASK INVARIABILITY

Cox defined monotonous work as "work in which discrete sets of work activities are repeated in the same order [...] The cycle time for the set of activities may be measured and used as an index of the repetitiveness of the work" (Cox, 1985). However, it is generally self-reported and is also conflated with job 'underload' as the causes of boredom or stress. However there is overlap between tasks that require attention but provide little stimulation, or 'uneventful monotony' (Melamed *et al*., 1995).

PSYCHOSOCIAL RISK FACTORS

Psychosocial risk factors are those factors that impact on psychosocial health. They are a group of related risk factors, and are generally captured by the measurement of workers' psychosocial health using questionnaires such as the General Health Questionnaire (GHQ-12) (Hausser *et al*., 2010) or the COPSOQ-III (Burr *et al*., 2019).

As noted by Martikainen *et al*. (2002), psychosocial health is generally employed as an umbrella term with no consideration of its meaning or potential and they suggest that it should be conceptualised as a meso-level concept between social structure and individual psychological factors.

Lack of job satisfaction

Job satisfaction deals with the employees' experience of satisfaction with various aspects of work (Burr *et al*., 2019).

Depression

Depressive symptoms cover aspects which together indicate depression (Burr *et al*., 2019).

Burnout

Burnout concerns the degree of physical and mental fatigue/exhaustion of the employee (Burr *et al*., 2019).

Anxiety

Self-report of feelings of tenseness, calm, relaxation, worry, unease, contentment (Jones *et al*., 2011).

Poor sleep

Sleeping troubles deal with sleep length, determined by, for example, sleeping in, waking up and interruptions of sleep, and quality of sleep (Burr *et al*., 2019).

Effort-reward imbalance

The effort-reward imbalance model is based upon the premise that work-related benefits depend upon a reciprocal relationship between efforts and rewards at work. Efforts represent job demands and/or obligations that are imposed on the employee. Occupational rewards distributed by the employer (and by society at large) consist of money, esteem, and job security/career opportunities. More specifically, the effort-rewards imbalance model claims that work characterized by both high efforts and low rewards represents a reciprocity deficit between ‘‘costs’’ and ‘‘gains’’. This imbalance may cause sustained strain reactions (van Vegchel *et al*., 2005).

Job-related stress

Stress here is defined as a reaction of the individual. Stress is here defined as a combination of tension and displeasure. As elevated stress levels over a longer period are detrimental to health, it is necessary to determine long-term states of stress (Burr *et al*., 2019).

“Stress is best described as an umbrella term for a wide variety of circumstances and reactions” it is both the environmental cases and the individual’s reaction to those environmental cases (Fisher, 1985).

Fatigue

There is no shared definition of fatigue in the literature, and fatigue is often used interchangeably with sleepiness, or is used to describe a particular type of ‘wearing out’ such as compassion fatigue. Lerman *et al*. defined fatigue as “the body’s response to sleep loss or to prolonged physical or mental exertion” (Lerman *et al*., 2012, p. 231). Bridger suggests that “the best early index of fatigue is not performance of the task itself but a measure of the effort needed to maintain the level of performance” (Bridger, 2009). Courtney defines fatigue as “a general tiredness and lack of energy irrespective of whether an individual has had enough sleep or has been working hard, which persists even on rest days and holidays” (Courtney, 2013).

There are also various subtypes of fatigue, such as mental fatigue (Van Cutsem *et al*., 2017), physical fatigue or compassion fatigue (Aycock & Boyle, 2009). Miller (2008) would classify as 'chronic fatigue', as distinct from acute fatigue (tiredness lasting only one day) or cumulative fatigue (an intermediate state that requires a rest day or holidays to recover from). These types of fatigue fall under the definitions given above, in that they are manifested through difficulty in performance due to prolonged periods of activity but are specific to types of activities.

Lack of social support

Social support from colleagues deals with the employees' impression of the possibility to obtain support from colleagues if one should need it and sense of community at work concerns whether there is a feeling of being part of the group of employees at the workplace, for example, if employees relations are good and if they work well together (Burr *et al*., 2019).

Company

INADEQUATE LEADERSHIP

There are various forms of leadership that are seen as better for health and safety than others, with hierarchical, corrective, absent and 'transactional' leadership all identified as risk factors for poorer safety outcomes and health and safety practices and behaviour (Clarke, 2013). Furthermore failure by leaders to demonstrate idealised behaviours and practices lead to poorer health and safety behaviours (Clarke, 2013).

PRECARIOUS EMPLOYMENT

Job Insecurity deals with aspects of security of the employment of the employee, for example, regarding the risk of being fired or the certainty of being reemployed if fired (Burr *et al*., 2019).

POOR SAFETY CLIMATE (AND UNDERLYING CULTURE)

Safety climate refers to the perceptions employees have over their organisation's commitment and actions toward safety. It is often used as a proxy for safety culture which is a phenomena of shared attitudes, beliefs and norms toward safety in an organisation but which cannot be directly measured (Guldenmund, 2000). However safety climate is also a narrower concept (Yule, 2003).

Regulatory bodies and associations

No risk factors identified.

Government

No risk factors identified.

Appendix 4: The musculoskeletal disorder cultural assessment tool

– Tappin *et al*. (2015)

Tappin *et al*. (2015) created a list of questions and follow-up questions to be used in the MSDs CAT tool these were:

QUESTIONS	FOLLOW UP QUESTIONS/PROMPTS
Employee questions	
Do you routinely check for MSDs hazards in your work area?	– Who encourages you to check for hazards, report hazards? – Who do you report them to?
Are you encouraged to report all strain or sprain incidents, or physical discomfort?	– Who encourages you to report incidents? – How often are you reminded to report hazards and incidents?
Are there any reasons you would not report a strain or sprain or physical discomfort?	– Are you comfortable reporting these? – Is there anything stopping you?
Is the procedure for reporting strains or sprains or other injury types accessible and user-friendly?	– Do you know where to find the information and forms? – Are they easy to complete?
Do you receive information about MSDs hazards in your workplace?	– Do you understand the language used? – Who gives you this information? – How often? In what form?
Is information on hazards shared at team briefings/ toolbox meetings/breaks?	– Is this regularly?
Manager questions	
Do you regularly disseminate information on MSDs hazards and incidents in your workplace?	– How often? – How is the information disseminated? – How do you know it is received?
Is there a formal reporting system for MSDs reporting?	– Do people find this system easy to locate and use?
Are there any barriers to reporting MSDs in this workplace?	– Is the reporting system simple and factual? – Is there a fear of escalation?
How is collated MSDs information used in this organisation?	– Are there potentially negative outcomes for staff for reporting? – Are reports welcomed and encouraged? – Are regular analyses undertaken on MSDs data to identify patterns and trends? – How does this information inform MSDs prevention? – Is this information shared with employees?

Implementation site 1

Evidence provided by the MSD CAT tool to assess level of advancement of MSD culture

MSD CULTURE ASPECT	ADVANCEMENT LEVEL	SUMMARY EVIDENCE FOR ASSESSMENT OF ADVANCEMENT LEVEL
Top management commitment and MSD prevention prioritisation	Calculative	– Company systems show a commitment to improving OHS performance but the vision for specifically addressing MSD is less clear – OHS given equal priority with productivity in meetings and procedures – Main focus perceived by staff as being production and managing risks to it – Emphasis for MSD is on secondary prevention measures – MSD prevention is well resourced, although seen as a lower priority than immediate serious injury risks (for example, crush, amputation)
MSD communication	Proactive	– Good communication systems for OHS (including MSD) in place and operating effectively – Communication channels include both top-down and bottom-up – Reporting system ensures feedback occurs on every issue raised – Feedback on MSD-related reports is usually prompt
MSD reporting	Calculative	– People usually report MSD, although barriers such as literacy and concerns about job security may affect reporting rates – Information on MSD occurrences or hazards are disseminated company-wide – State of understanding about MSD reduces efficacy of possible interventions in response to reported cases or hazards
MSD training	Reactive	– Staff training needs for MSD are provided for in response to MSD risks – Task training, including techniques to prevent MSD, is buddy-based training on the process line – Training is often aimed at the person – handling and fitness techniques
Employee involvement in MSD management	Proactive	– High levels of formal and informal involvement in MSD management throughout the organisation are indicated through interview responses and OHS procedures – Communication on MSD is two-way (interviews and documents) – Differences indicated in practices between day and night shifts
MSD-related procedures	Proactive	– Procedures are in place but not necessarily for MSD – Safety procedures are seen as occasionally inconvenient – Encouraged to adhere to SOPs but also to challenge procedures with management if there are concerns over OHS issues
Work control and pressure	Proactive	– Most work is machine-paced, although risks associated with this are recognised and opportunities made available for rest and recovery – Remuneration structures are not a barrier to taking breaks – Differences are reported in levels of flexibility and work pressure between shifts – Mill management are under pressure, have less control over their work, and while able to have breaks are unwilling to do so
MSD-related perceptions	Proactive	– The boundaries between acceptable and unacceptable behaviour are generally understood and followed – Where the actions of managers and staff put them or others at risk, they are told so quickly and firmly
Investigation andanalysis of incidents	Proactive	– Investigation can adopt a complex approach, using root cause analysis – Blame is not an issue, although the investigation may result in disciplinary action as one of the outcomes – MSD may not always be thoroughly investigated, and measures aimed at mitigation rather than prevention – Trends in reported MSD are not always investigated

Implementation site 2

Evidence provided by the MSD CAT tool to assess level of advancement of MSD culture

MSD CULTURE ASPECT	ADVANCEMENT LEVEL	SUMMARY EVIDENCE FOR ASSESSMENT OF ADVANCEMENT LEVEL
Top management commitment and MSD prevention prioritisation	Proactive – Generative	– Senior management are strongly committed to MSD prevention and practice this in a number of company level OHS initiatives – MSD prevention treated as a strategic matter for the organisation – Resources are made available for addressing known MSD risk factors – The link between staff health and well-being and strong company performance is recognized and supported – The OHS manager is part of the senior leadership team – Handling requirements of residents are continuously reviewed and updated where required (indicated through interviews and documents)
MSD communication	Proactive	– Senior management try to create an organisational culture that encourages reporting and giving prompt feedback – Staff are encouraged to raise MSD issues and can use a number of channels to do this – Information on all OHS matters is made available to staff – Perceptions on levels of MSD communication varies between homes
MSD reporting	Proactive	– Reporting systems are in place and a 'no blame' culture encouraged for reporting incidents where procedures were not followed – There are small variations in the reporting culture between homes – Barriers to reporting exist such as lack of time, not wanting to draw attention to themselves, or reporting unfamiliar to their own culture
MSD training	Proactive	– Senior management involved in setting training standards and competencies for all staff roles – OHS data for each home helps to inform content of training – Physiotherapists on site ensure training is updated and relevant – Staff also have input into training – Much of the training is aimed at the person and immediate equipment
Employee involvement in MSD management	Calculative	– Staff are involved in initiatives at individual home level but have little input at a company level – Bottom-up communication for home staff is through quality or health and safety committee meetings – Consultation occurs with staff and family but primary focus is risk management for the resident
MSD-related procedures	Proactive	– Staff are able to question compliance to reduce MSD risks, but the primary focus is on reducing risk to the resident – Cultural difference sometimes act as barriers to understanding handling procedures – MSD procedures spread best practice, but mainly within homes rather than across the organisation
Work control and pressure	Calculative	– Patient needs come first, leaving little flexibility for staff in how tasks are undertaken, the time taken, and balancing effort and rest – There is recognition by management of the MSD risks associated with work tasks and these are considered in work rosters
MSD-related perceptions	Proactive	– Homes have a caring culture where staff look out for each other and work well in teams to help reduce MSD risks for each other – Staff speak up if they observe people stating or doing things that create MSD risk, although there are some variations between homes
Investigation and analysis of incidents	Proactive	– Investigation process for serious incidents looks at whole work system, involving all parties including senior managers – Incidents with lesser outcomes are investigated locally and are more problem focused and less comprehensive – There is limited collective analysis of incidents across the organisation – Known MSD risk factors are monitored by care home management and reflected in work scheduling and training

Appendix 5: Risk factors from cohort studies and surveys

Results from Nambiema *et al*. (2020) the COSALI study (n = 1246)

cohort study	**precarious employment**	**all locations**	**PR 1.49**	**1.35**	**1.65**
cohort study	**high physical exertion**	**upper extremity**	**RR 1.52**	**1.06**	**2.17**
cohort study	**male high physical exertion**	**upper extremity**	**RR 2.38**	**1.41**	**4.04**
cohort study	women high physical exertion	upper extremity	RR 0.74	0.41	1.33
cohort study	high task repetitiveness (>4 hours/day)	upper extremity	RR 1.15	0.81	1.64
cohort study	**sustained raised shoulders**	**upper extremity**	**RR 1.57**	**1.04**	**2.39**
cohort study	sustained shoulder abduction	upper extremity	RR 1.26	0.88	1.81
cohort study	repeated elbow flexion	upper extremity	RR 1.00	0.69	1.46
cohort study	wrist twisting	upper extremity	RR 0.99	0.67	1.46
cohort study	**low social support**	**upper extremity**	**RR 1.41**	**1.03**	**1.92**
cohort study	**age 35-44 (*cf.* <35)**	**upper extremity**	**RR 1.54**	**1.03**	**2.29**
cohort study	**age >=45 (*cf.* <35)**	**upper extremity**	**RR 2.13**	**1.44**	**3.16**

Results from Gale et al. (2019) Harvard Flight Attendant Health Study (n = 4459)

cohort study	**working in cold 75% of time**	**pain in 1–2 sites**	**1.15**	**0.92**	**1.44**
cohort study	**working in cold 75% of time**	**pain in 3+ sites**	**2.02**	**1.64**	**2.48**
cohort study	**threats or verbal abuse**	**MS strain, sprain, joint aches, and pain**	**1.62**	**1.38**	**1.91**
cohort study	**threats or verbal abuse**	**MS fracture or contusion**	**1.72**	**1.28**	**2.33**
cohort study	**threats or verbal abuse**	**MS strain, sprain, joint aches, and pain**	**1.56**	**1.14**	**1.77**
cohort study	threats or verbal abuse	MS fracture or contusion	0.93	0.49	1.77
cohort study	**sexual harassment**	**MS strain, sprain, joint aches, and pain**	**1.83**	**1.52**	**2.21**
cohort study	**sexual harassment**	**MS fracture or contusion**	**1.51**	**1.13**	**2.02**
cohort study	**sexual harassment**	**MS strain, sprain, joint aches, and pain**	**1.76**	**1.18**	**2.61**
cohort study	sexual harassment	MS fracture or contusion	1.09	0.49	2.45
cohort study	**sexual assault**	**MS strain, sprain, joint aches, and pain**	**1.96**	**1.08**	**3.67**
cohort study	sexual assault	MS fracture or contusion	1.64	0.77	3.49
cohort study	sexual assault	MS strain, sprain, joint aches, and pain	2.58	0.70	9.48
cohort study	sexual assault	MS fracture or contusion	2.74	0.54	13.94

Results from Halonen et al. (2019) Young Finns Study (n = 1056)

cohort study	physically heavy work in young adulthood	all locations	RR 1.55	1.05	2.28
cohort study	**physically heavy work in later adulthood**	**all locations**	**RR 1.46**	**1.01**	**2.12**
cohort study	**physically heavy work in young and late adulthood**	**all locations**	**RR 1.99**	**1.44**	**2.77**

Results from Viester et al. (2013) The Netherlands Working Conditions Survey (n = 44,793)

cohort study	**BMI 25–29.9**	**neck and shoulder**	**1.07**	**0.90**	**1.28**
cohort study	**BMI 25–29.9**	**upper extremity**	**1.23**	**1.01**	**1.47**
cohort study	BMI 25–29.9	low back	1.13	0.95	1.35
cohort study	**BMI 25–29.9**	**lower extremity**	**1.34**	**1.13**	**1.60**
cohort study	BMI ≥30	neck and shoulder	1	0.76	1.33
cohort study	**BMI ≥30**	**upper extremity**	**1.51**	**1.14**	**1.98**
cohort study	BMI ≥30	low back	0.94	0.69	1.28
cohort study	**BMI ≥30**	**lower extremity**	**2.11**	**1.64**	**2.72**

Results from Coenen et al. (2016) SMASH cohort study (n = 1989)

cohort study	**kneeling**	**low back**	**1.44**	**1.04**	**2.00**
cohort study	**trunk flexion**	**low back**	**1.40**	**1.00**	**1.95**
cohort study	arm elevation	neck-shoulder	0.64	0.41	1.00
cohort study	**arm elevation**	**shoulder**	**0.50**	**0.29**	**0.87**
cohort study	arm elevation	neck	0.77	0.49	1.23
cohort study	kneeling	Low back	0.92	0.64	1.33
cohort study	trunk flexion	low back	1.11	0.77	1.61
cohort study	arm elevation	neck-shoulder	0.83	0.51	1.34
cohort study	arm elevation	shoulder	0.95	0.57	1.59
cohort study	arm elevation	neck	0.75	0.48	1.18

Results from Karkkainen et al. (2012) Swedish Twins Study (n = 27165)

cohort study	**1–10 years night work**	**all locations**	**HR 1.33**	**1.17**	**1.53**
cohort study	**>10 years night work**	**all locations**	**HR 1.39**	**1.18**	**1.64**

Results from Nyman et al. (2009) Swedish Twins Study (n = 16107)

cohort study	**high physical workload**	**either low back or non-specific**	**1.47**	**1.37**	**1.57**

Results from Widanarko et al. (2014) survey of New Zealand workers (n = 3003)

survey	**awkward or tiring position (3/4 to full time)**	**neck and shoulder**	**1.45**	**1.12**	**1.86**
survey	**awkward or tiring position (3/4 to full time)**	**Low back**	**1.28**	**1.07**	**1.52**
survey	**awkward grip or hand postures (3/4 to full time)**	**neck and shoulder**	**1.50**	**1.01**	**2.24**
survey	**awkward grip or hand postures (3/4 to full time)**	**upper extremity**	**1.64**	**1.30**	**2.08**
survey	**awkward grip or hand postures (3/4 to full time)**	**wrist**	**2.70**	**1.75**	**4.16**
survey	**vibration**	**upper extremity**	**1.98**	**1.13**	**2.48**
survey	lifting (3/4 to full)	neck and shoulder	0.90	0.68	1.18
survey	lifting (3/4 to full)	upper extremity	1.30	0.96	1.76
survey	lifting (3/4 to full)	wrist	0.83	0.61	1.11
survey	repetitive tasks (3/4 to full)	neck and shoulder	1.09	0.87	1.37
survey	repetitive tasks (3/4 to full)	upper extremity	1.12	0.85	1.46
survey	repetitive tasks (3/4 to full)	wrist	1.15	0.89	1.50
survey	working at high speeds (3/4 to full)	neck and shoulder	0.97	0.78	1.20
survey	working at high speeds (3/4 to full)	upper extremity	1.11	0.87	1.42
survey	working at high speeds (3/4 to full)	wrist	1.11	0.88	1.40
survey	standing (3/4 to full)	neck and shoulder	0.96	0.76	1.21
survey	standing (3/4 to full)	upper extremity	1.14	0.89	1.46
survey	standing (3/4 to full)	wrist	1.23	0.97	1.56
survey	sitting (3/4 to full)	neck and shoulder	1.14	0.91	1.44
survey	sitting (3/4 to full)	upper extremity	0.89	0.69	1.14
survey	sitting (3/4 to full)	wrist	0.75	0.59	0.96
survey	working in cold 75% of time	neck and shoulder	1.26	0.94	1.70
survey	working in cold 75% of time	upper extremity	1.01	0.74	1.39
survey	working in cold 75% of time	wrist	1.31	0.98	1.77
survey	working in heat 75% of time	neck and shoulder	1.13	0.86	1.49
survey	**working in heat 75% of time**	**upper extremity**	**1.40**	**1.04**	**1.88**
survey	working in heat 75% of time	wrist	0.88	0.66	1.18

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Notes

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