NSW GOVERNMENT

The link between workplace stressors and physical injury: A systematic review and qualitative study

Centre for WHS

LA TROBE UNIVERSITY

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Table of Contents

Executive summary

Background

Musculoskeletal disorders (MSDs) are a significant workplace problem with substantial impacts on individuals and society more generally. MSDs are complex, multifactorial problems which require identification and then control of all relevant hazards—physical and psychosocial—to maximise the effectiveness of prevention programs. Whilst a wide range of hazardous task identification tools exist to support work health and safety (WHS) practitioners in developing effective MSD risk management strategies, little is known about the availability of comprehensive tools which cover both physical and psychosocial hazards.

Purpose

The overarching aim of this project was to understand the barriers and facilitators to implementation of comprehensive approaches to risk management of MSDs. To address knowledge gaps in relation to barriers to the uptake of more comprehensive MSD prevention strategies, the current project aimed to:

1) Identify tools, approaches and guidance materials to support comprehensive MSD prevention
2) Explore barriers and enablers to the implementation of comprehensive MSD prevention tools in a range of industry settings
3) Using a systems approach explore the current MSD tools and strategies being used in industries
4) Develop a matrix of MSD prevention tools to assist industry stakeholders in their selection of appropriate tools.

The current project occurred in three phases: two systematic reviews followed by multiple stakeholder interviews. Systematic review 1 (SR1) aimed to identify tools, approaches, and guidance materials used to support comprehensive MSD prevention. Systematic review 2 (SR2) sought to review the barriers and enablers to the implementation of comprehensive MSD prevention tools in a range of industry settings. These reviews were used as the basis for interviews with industry stakeholders which aimed to identify which tools are currently being used in industry. A matrix of tools was then developed for dissemination to industries for use when developing MSD prevention programs.

Methods

SR1: A list of search terms was devised, based on three search concepts: MSDs/mental health outcomes, prevention tools, and work. Four electronic databases, that covered a wide range of health science and ergonomic journals, were searched: Web of Science, Medline, ProQuest Central, and PsychInfo. Studies were imported into Covidence software and all studies were screened by two authors independently for inclusion. Validated MSD risk management tools were extracted from the studies and a descriptive statistical analysis was conducted. A grey literature search was also undertaken.

SR2: A list of search terms was devised, based on four search concepts: MSD outcomes, tools, work, barriers/facilitators. Retrieved studies were loaded into Covidence software for independent screening by four authors. Data was extracted from relevant studies, and the risk of bias was assessed. Studies were grouped according to the type of intervention involved, and barriers and facilitators were analysed using a workplace systems framework.

Stakeholder interviews: Industry stakeholders (WHS professionals) were recruited through LinkedIn, direct email, snowballing sampling and contacts of Centre for WHS, SafeWork NSW, and the research team. Recruited stakeholders (n = 29) were provided with participant information and consent forms prior to their interview. All interviews were conducted via Zoom and lasted approximately one hour. Interviews were transcribed and data was extracted using thematic analysis with assistance from NVivo software.

Findings

SR1: Following the full text screening, 548 studies were assessed as relevant for inclusion; 137 reported on tools covering physical hazards, 254 on psychosocial and 228 covered comprehensive tools (both physical and psychosocial hazards). Some studies reported on more than one type of tool. These reported on 30 physical hazard tools, 35 psychosocial hazard tools, and 16 comprehensive tools. Six additional physical hazard tools were found through the grey literature search. There were 23 studies based in Australia, which represented 15 tools. An interim tool matrix for use in the stakeholder interviews was developed from this literature review.

SR2: Twenty-nine relevant studies were located through the database search. The majority of studies were qualitative in nature and had a low to moderate overall risk of bias rating. For the purposes of this report, only the 15 studies containing comprehensive tools were analysed. Studies involved tools that were implemented in at least nine industry sectors – some studies did not specify the industry sector. The most frequently reported sectors were Healthcare & Social Assistance (12 studies), Manufacturing (7 studies), and Construction (6). The articles covered a wide range of MSD risk management tools: ten studies looked at comprehensive tools (targeting both physical & psychosocial factors), 14 examined non-comprehensive tools

(targeting only physical factors), and five included both types of tools (comprehensive and physical). There were no tools that only targeted psychosocial factors. Each of the reported barriers and facilitators were grouped into the relevant work-systems category: external factors, workplace environment, work organisation & job design, task & equipment, and workers' personal characteristics. Analysis of the data revealed the work organisation & job design level as having the highest number of reported barriers. The main barriers in this level were related to lack of management commitment, counterproductive management attitudes, and high costs.

Stakeholder interviews: Twenty-nine interviews were conducted with WHS professionals from six industry sectors: manufacturing, health & social assistance, public administration, construction, agriculture, and transport/logistics/ warehousing. The majority of participants (n=27) had a formal WHS qualification. Participants reported a range of barriers to effectively managing MSD risk. The majority of barriers were located in the organisational level of the workplace system model. Most of the MSD risk management strategies currently utilised by participants were focussed at the individual and equipment/task levels of the workplace system. All participants were aware of at least one validated tool from the tool matrix (from SR1), however only nine participants were currently using a validated tool in their workplace. Reported reasons for poor uptake of validated tools were related to 1) perceived deficits of the tools, or 2) barriers to implementation (mostly organisational level barriers).

Tool matrix development*:* Following the stakeholder interviews, the interim tool matrix was refined (which included the addition of a psychosocial tool identified through the interviews) to include only validated tools that were accessible (online tools or downloadable & includes instructions or guidance for use) and able to be used by workplace practitioners.

Conclusion

Two literature reviews were undertaken to identify MSD risk management tools, and barriers and facilitators to the implementation of comprehensive tools. The first literature review resulted in a large number of tools being identified, however only a relatively small number were comprehensive in their focus. Of those tools identified as comprehensive, most of them did not meet the tool matrix inclusion criteria (they were either unable to be accessed or were research tools). The second literature review revealed the organisational workplace level as being the source of most barriers to successful implementation of comprehensive MSD risk management strategies. Correspondingly, the organisational workplace level was also responsible for most of the facilitators.

Tools, barriers, and facilitators were also explored from the perspective of key stakeholders, WHS professionals. The majority of stakeholders interviewed had formal WHS qualifications, were working at a managerial level, and were aware of some of the validated tools; however,

most were not currently using a validated tool in workplace management of MSD risk. Reasons for poor uptake of validated tools were related to 1) perceived deficits of the tools, 2) barriers to implementation (mostly organisational level barriers), and 3) awareness and availability of tools. A matrix of tools available in Australia was compiled through the literature search and stakeholder consultation; however, many of the included tools have limitations including: a singular focus on either physical or psychosocial hazards, lack of worker participation, and overly complex. Opportunities exist for tool refinement and provision of tool implementation guidance material. In addition, awareness of tool availability and implementation needs to be improved through education and promotion activities/resources.

List of Tables and Figures

Introduction

A substantial body of literature supports the complex aetiology of work-related musculoskeletal disorders (MSDs) which arise from exposure to physical and psychosocial hazards (Coenen et al., 2014; Eatough, Way, & Chang, 2012; Gerr, Fethke, Anton, et al., 2014; Gerr, Fethke, Merlino, et al., 2014; Hauke, Flintrop, Brun, & Rugulies, 2011; Lang, Ochsmann, Kraus, & Lang, 2012; Macfarlane et al., 2009; National Research Council (US) and Institute of Medicine (US) Panel on Musculoskeletal Disorders and the Workplace, 2001). However, current workplace prevention strategies primarily focus on the identification and control of physical hazards, with limited attention to the psychosocial aspects of work (Dunn, Campbell, & Jordan, 2013; Leka, Jain, Iavicoli, & Di Tecco, 2015; Linaker, Harris, Cooper, Coggon, & Palmer, 2011; Van Rijn, Robroek, Brouwer, & Burdorf, 2014). The significant societal and personal burden associated with MSDs (International Labour Organisation, 2015; Oakman, Clune, & Stuckey, 2019), should result in prioritisation of prevention programs but this is not always the case. Improved understanding of the barriers to implementation of more comprehensive approaches is required.

Comprehensive approaches to MSD prevention require the identification of physical and psychosocial hazards, and the subsequent development of risk controls, to be maximally effective (W. Macdonald & Oakman, 2015). However, most risk management strategies in workplaces use linear transactional approaches focused primarily on the physical aspects of work. Many risk assessments focus on individual tasks and not the job, an approach which does not capture workplace exposure to the broad range of physical and psychosocial hazards. This is exacerbated by the narrow focus of most risk assessment tools and guidance materials available to occupational safety professionals and ergonomists, which are focussed on identifying and controlling single hazards of a physical nature related to manual tasks (Oakman, Clune, et al., 2019). In addition, many of the currently available tools are based on observations of workers undertaking their work, with limited worker input, despite the extensive evidence base which supports the important role of worker participation (Burgess-Limerick, 2018; Cole et al., 2009; Rivilis et al., 2008). To effectively manage psychosocial hazards, workers must be engaged in the process and this necessarily involves them reporting on their work environment (Kop, Althaus, Formet-Robert, & Grosjean, 2016).

Barriers or challenges to changing the current approaches to MSD prevention has been previously explored (Oakman, Macdonald, & Kinsman, 2019; A. Yazdani & Wells, 2018). Oakman and colleagues (2019) used a systems approach to identify barriers to more effective prevention and found a key issue was that few people knew of the need to manage MSD risk arising from work-related psychosocial hazards. In addition, the work health and safety (WHS)-related skills of key managers were often reported as inadequate, particularly concerning management of risk from psychosocial hazards. A further barrier has been the reticence to ask workers about their work environment, for fear of identifying a range of issues (Robertson, Jayne, & Oakman,

2020). A scoping review by Yazdani and Wells (2015), identified the following barriers to implementation of change to MSD prevention: lack of time and resources, poor communication, lack of knowledge and training, resistance to change, changes in work practices, and difficulty in implementing controls.

A core component of MSD prevention is the use of tools and resources to support hazard identification (Oakman, Clune, et al., 2019). Currently available tools typically focus on tasks within jobs rather than the whole job undertaken by workers. A key issue with this narrow approach is that interactions of different hazards are not accounted for (Roman-Liu, 2014). A comprehensive assessment requires the use of a combination of methods to ensure hazards are assessed (Roman-Liu, 2014) but guidance on such approaches is limited and the inclusion of psychosocial hazards is rarely considered core to occupational health and safety. As such, the tools for MSD prevention do not include coverage of these hazards (Oakman, Clune, et al., 2019). The traditional use of observational methods for MSD prevention has been examined, with questions about the adequacy of these approaches (Diego-Mas, Alcaide-Marzal, & Poveda-Bautista, 2017). Diego-Mas (2017) and colleagues reported a third of the 442 risk assessments undertaken by health professionals in their study contained errors when using a range of common tools such as RULA (Rapid Upper Limb Assessment Tool), REBA (Rapid Entire Body Assessment Tool), OCRA (Occupational Repetitive Actions Method) and NIOSH (U.S. National Institute of Occupational Safety & Health). The study had some limitations; it was undertaken in 20 countries, all Spanish speaking, with the additional limitation with observational tools of the potential for workers to change their usual practice when they know they are being observed.

For comprehensive approaches to the prevention of MSDs, consideration of the large and diverse range of factors known to be of relevance to the aetiology is required, as shown in Figure 1. This model shows two groups of factors that are largely beyond the control of workplace managers. Firstly, *Workers' Personal Characteristics*, which are the unique physical and psychological strengths and weaknesses that people bring with them to work, including vulnerabilities arising from fatigue or stress due to inadequate sleep, non-work personal responsibilities and problems, pre-existing injuries or health problems and so on. Secondly, *External Factors* that include: WHS regulatory enforcement practices; interaction with external business partners; injury compensation legislation and practices; state of the job market, pay levels and other economic factors; general societal norms concerning absenteeism and a 'fair day's work'; and of course, WHS legislation and associated codes, regulatory standards and related guidance information (W Macdonald, Munk, & Evans, 2003).

The following sets of workplace factors are largely within the remit and control of the organisation and managers' responsibilities:

- *Task & Equipment Factors*: characteristics of specific work tasks and the tools or equipment used in performing these tasks. These include the physical hazards associated with 'manual handling' tasks, which are widely recognised as affecting MSD risk.
- *Work Organisation and Job Design Factors*: how jobs are designed, including management and organisational structures that underpin job design. These factors include working hours, work pace, rest breaks, shift work, job control (e.g. moving assembly line, deadlines), level of interest, level of support from supervisors or colleagues, level of rewards (not only financial) in relation to personal effort invested, level of management commitment, style of management, commercial imperatives (including productivity demands), business structures etc.
- *Workplace Environment Factors*: physical environment factors include air quality, extreme heat or cold, loud noise. This also includes physical infrastructure such as building dimensions, internal fittings and fixtures, etc.

Figure 1 System of workplace factors affecting workers' health, safety and performance. (W Macdonald et al., 2003)

To address knowledge gaps in relation to barriers to the uptake of more comprehensive MSD prevention strategies, the current project aimed to:

1) Identify tools, approaches and guidance materials to support comprehensive MSD prevention.
2) Explore barriers and enablers to the implementation of comprehensive MSD prevention tools in a range of industry settings
3) Explore the intervention strategies currently being used in industries, using a systems approach.
4) Develop a matrix of MSD prevention tools to assist industry stakeholders in the selection of appropriate tools.

Method

The overall purpose of this project was to develop a matrix of tools for use in Australian workplaces to support the prevention of MSDs. In particular, the aim was to identify a set of tools, which include coverage of physical and psychosocial hazards, and determine barriers and enablers to the implementation of these tools in industry.

The first phase of this process was to compile a list of relevant tools (for the purposes of this report, the word 'tools' will also refer to approaches and guidance materials). To inform the development of this list, researchers conducted a systematic review and grey literature search to identify relevant tools for the prevention of MSDs. To ensure comprehensive capture of tools which identify workplace psychosocial hazards, the term *stress related mental health disorders* was included as an outcome in the search. While it is acknowledged that this was not in the original project brief, without this outcome only a few physically-hazard focussed tools would have been identified; many tools used to identify mental health disorders (MHDs) also identify factors which contribute to the development of MSDs.

The second phase of this process was to conduct a rapid review of literature to identify barriers and enablers to the use of comprehensive MSD risk management tools (tools that address psychosocial and physical hazards). Phase three further explored this issue; in depth interviews were conducted with WHS professionals in high-risk industry sectors (construction, manufacturing, agriculture, healthcare & social assistance, transport/ postal/ warehousing) to determine their perspectives on implementation of tools.

Systematic Literature Review 1 (SR1)

Researchers conducted a systematic literature review to address the following research question: What are the available and empirically tested tools, approaches and guidance for prevention of work-related MSDs and MHDs outcomes and exposure to psychosocial hazards, and in what circumstances/business settings should they be used. In addition to the systematic search in electronic academic databases, researchers conducted a search of the grey literature to identify any empirically tested tools.

Search Strategy

A list of search terms was devised, based on three search concepts: MSDs and mental health outcomes, prevention tools, and work (Appendix 1). Four electronic databases, that covered a wide range of health science and ergonomic journals were searched: Web of Science, Medline, ProQuest Central, and PsychInfo. Further refinement included English language, adult, and

human. The initial trial search yielded an unmanageable number of articles, so some additional exclusion terms were included in the final search (Appendix 1).

Study selection

Studies were loaded into the Covidence software program (Veritas Health Innovation Ltd., 2020). To be included, studies had to meet the following criteria: include an MSD or MHD risk management tool that is used in the workplace, be about work-related psychosocial or physical hazards, and include an established validated tool. Studies involving military personnel were not included as it was considered that the military context was too specialised and tools used in this arena may not be readily applied to other workplaces (refer

Figure 2). All researchers independently assessed studies for initial inclusion, based on title and abstract. Studies were then screened independently, using full text, by two researchers; where there were discrepancies between the researchers' decisions, two further researchers assessed the disputed studies and reached consensus.

Data extraction

The included studies were exported into an excel spreadsheet. Data extracted into the spreadsheet included the title, author, year of publication, name of the tool included in the study, country where the study was conducted and industry sector of study participants. The included studies were also coded according to whether the tool addressed physical hazards, psychosocial hazards, or both physical and psychosocial hazards (i.e. comprehensive tools). The data extraction was verified independently by three of the researchers.

Data analysis

A list of identified tools was compiled from the data extraction spreadsheet and supplemented with tools from the grey literature search. A frequency analysis was conducted on the types of tools used by year, country and sector.

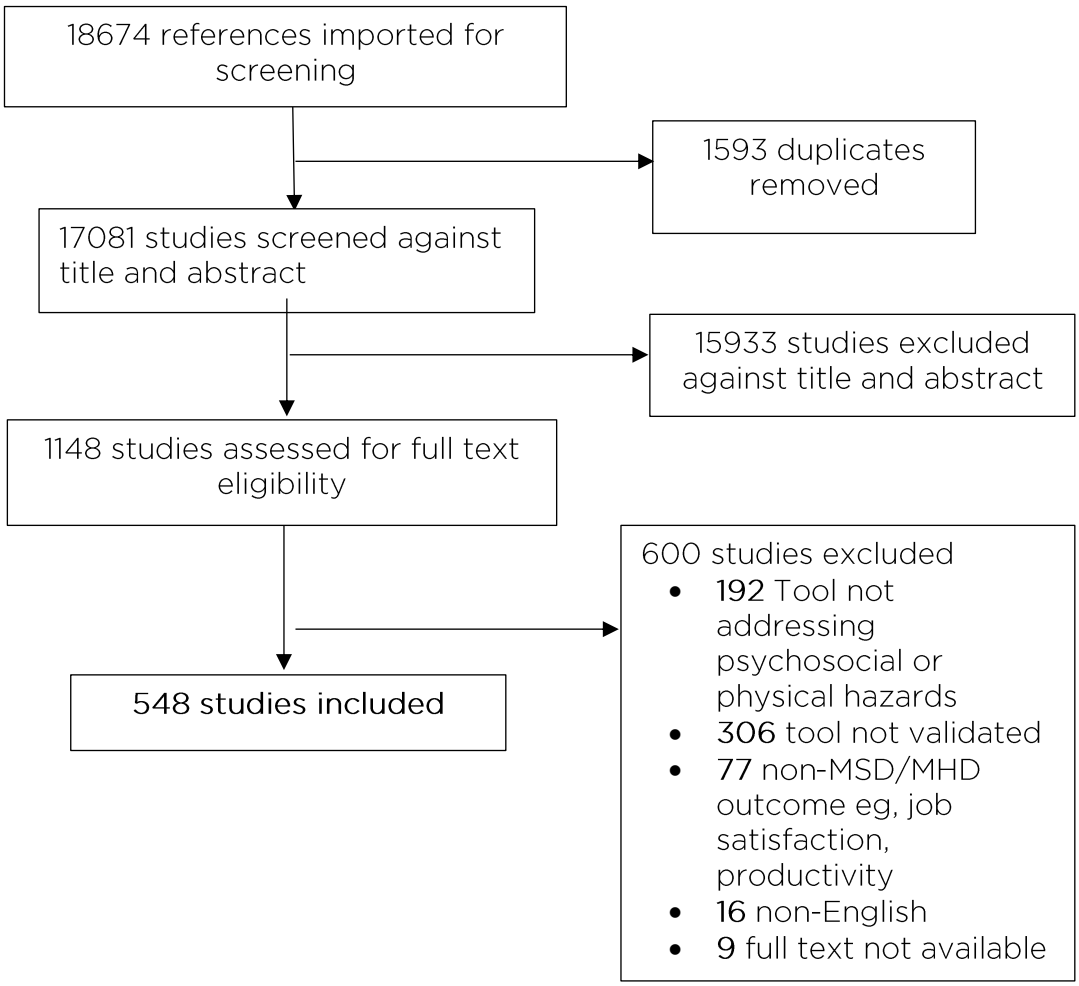

Figure 2 PRIMSA diagram study selection SR1

Grey literature review

The grey literature search included searches of WHS regulator websites: Health & Safety Executive UK, Australian state regulators, WorkSafe British Columbia. Research organisation websites were also searched: NIOSH CDC, Institute for Work and Health Canada, Safe Work Australia. In addition to websites, discipline journals (Applied Ergonomics, and Ergonomics) and PREMUS (Prevention of Musculoskeletal Disorders) conference proceedings were searched. Tools identified through this search were added to the interim matrix presented to interview participants.

Rapid Systematic Literature Review 2 (SR2)

Search strategy

A rapid literature review was conducted to identify barriers and facilitators to the use of comprehensive (those that address both psychosocial and physical hazards) work-related musculoskeletal disorder (WMSD) risk management tools. Search terms were categorised into the following concepts: MSD outcomes, tools, work, barriers/facilitators. For a full list of search terms refer Appendix 2. The following electronic databases were searched: Embase, PsychInfo,

Medline, CINAHL, Proquest Central. The search was limited to English language, peer reviewed journal articles, and human adults. In addition to the database search, relevant studies were sought by searching the references lists of included studies.

Study selection

All studies were assessed independently by two researchers. Any discrepancies were resolved by two alternative authors reaching consensus. Studies were included if they met the following criteria: based in a workplace, examined barriers and/or facilitators to implementation of risk management strategy/tools, and involved a risk management strategy/tools to address MSDs (refer Figure 3). Screening for relevant studies was conducted using Covidence software (Veritas Health Innovation Ltd., 2020).

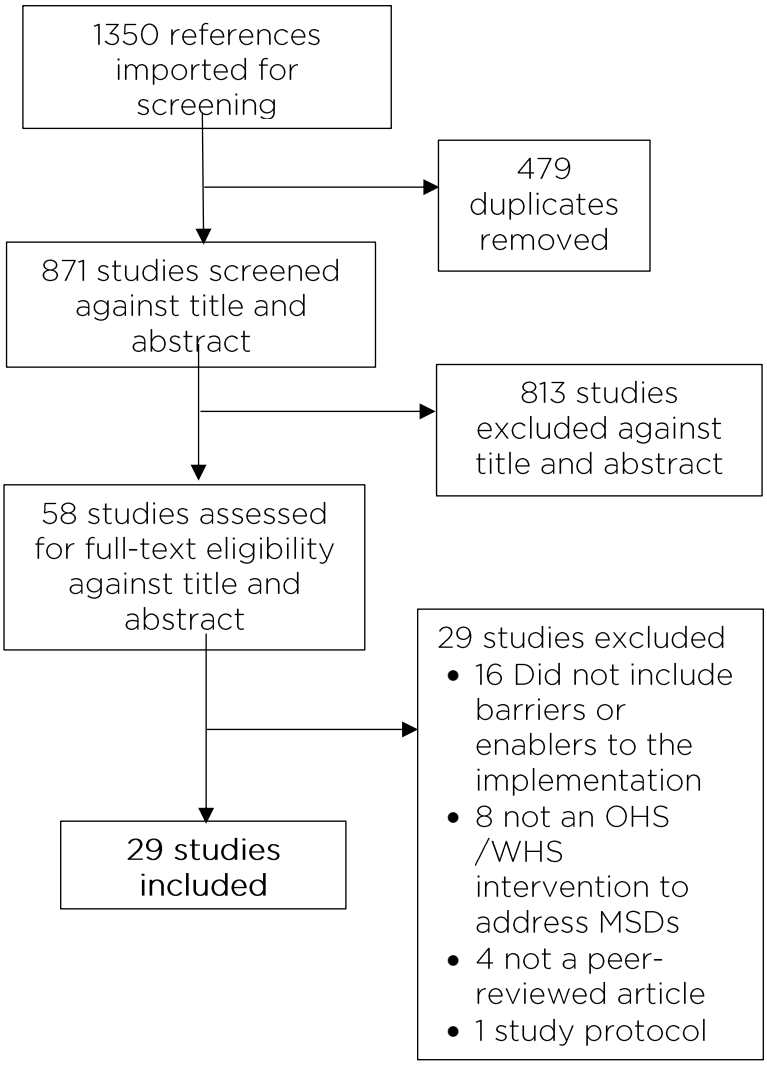

Figure 3. PRISMA diagram study selection SR2

Data extraction and quality assessment

A data extraction form was used to collect the following study characteristics: author, date of publication, country study conducted in, study design, type and number of participants, industry sector (based on Australian Bureau of Statistics categories), intervention description (including whether it was a comprehensive tool/strategy – psychosocial and physical hazards addressed), barriers, and facilitators. Given the rapid nature of the review, data extraction for each study

was conducted by at least one researcher and a sample of studies were checked by a second researcher.

All included studies underwent a quality assessment using risk of bias as a proxy. Researchers used a risk of bias assessment form that consisted of criteria derived from previously validated assessment tools: RTI research bank, Cochrane Collaboration tool quality assessment, Joanna Briggs appraisal tools for qualitative research and systematic reviews (Higgins et al., 2011; Viswanathan & Berkman, 2012; Waters, Le Bao Le, Morgan, Turley, & Steele, 2014). Each quality assessment criteria were assessed as high, low, or unclear. An overall quality assessment of each study was determined using a previously published rating system (Waters et al., 2014). Studies that were rated 'low' for the confounding factors criteria and also had a higher number of 'low' risks than 'high' or 'unclear' risks, were deemed to have a 'low' overall risk of bias. Studies with a 'high' risk for the confounding factors criteria and more 'low' risks than 'high' or 'unclear' risks, were assessed as 'moderate' overall risk of bias. Studies with a 'high' risk of bias for confounding factors criteria, and more 'high' or 'unclear' risks than 'low' risks were assessed as 'high' overall risk of bias. Randomised control studies were able to achieve a 'very low' overall risk of bias rating if they were rated low risk of bias for the allocation concealment and randomisation (provided they also met the criteria for 'low' overall risk of bias rating). All studies were assessed independently by two authors. Authors then met and resolved any discrepancies by consensus.

Data analysis

Studies were grouped according to whether they included comprehensive (addressed both physical and psychosocial factors) tools or non-comprehensive (addressed only physical factors or only psychosocial factors) tools. Reported barriers and facilitators, from studies that included comprehensive tools, were examined using a workplace factors system framework (refer Figure 1).

Industry stakeholder interviews

Participants

A recruitment strategy was developed in collaboration with Centre for WHS. An email was drafted and distributed which contained a registration of interest link. Potential participants were asked to register their interest (via an online survey platform) by providing basic information about the location, industry sector, and size of their business, as well as their contact details. Researchers then contacted potential participants who met the following inclusion criteria: WHS managers, over 18 years, within a high-risk industry business located in NSW. However, due to low recruitment levels this was expanded to include WHS managers

from any Australian state, and other WHS professionals. Participation was limited to one person from each organisation.

The email was distributed by SafeWork NSW, to WHS managers of businesses in high-risk sectors. The email was also distributed through the research team's professional networks, along with an advertisement on LinkedIn. The study was also promoted by the researchers at various industry/ government events and meetings.

Researchers contacted registered potential participants and scheduled an interview time. A copy of the participant information statement was provided to participants when the interview was scheduled. Verbal consent was obtained prior to the commencement of the interview.

Ethics approval was provided by the La Trobe University Human Ethics Committee (HEC20337).

Data collection

Semi-structured interviews were conducted to collect qualitative data on participants' experiences of managing MSD risk in their workplace, and their use of risk management tools. The interview schedule was developed by the authors, in conjunction with staff from the Centre for WHS, and included the following topic areas: background information about the business and job role, currently used risk management procedures and resources, and perceptions of MSD prevention tools. Preliminary findings from the rapid reviews also informed the interview schedule. Participants were presented with a matrix of tools identified through SR1 and the grey literature review. The matrix of tools was developed by selecting the most widely reported tools in the review, and those that were reported as being used in Australia. Participants were asked if they were familiar with the tools, and if so, whether they had used them (including reasons why/why not). Interviews were conducted via Zoom and were approximately 60 minutes duration. The first seven interviews were conducted jointly by two members of the research team and the interview questions schedule slightly amended to improve the interview flow. All subsequent interviews were conducted by a single member of the research team. All interviews were recorded and transcribed verbatim.

Quantitative data was also collected during the registration and interview phase: age, gender, qualifications (including any OHS/WHS training), industry sector, workplace geographic location, workplace size.

Data analysis

Prior to data analysis, participants were provided with an opportunity to review their interview transcript and make any amendments. NVivo software was used to assist with thematic analysis of the data. Three researchers (JO, VW, NK) independently coded the first two interviews to

identify categories using a 'bottom up' inductive approach. Any discrepancies in coding were resolved via consensus. The three researchers jointly devised the themes and sub-themes for the coding framework. Two researchers (VW & NK) independently coded the remaining interviews. A sample of themes were screened for coding consistency – any discrepancies were resolved via consensus between researchers NK and VW. This process followed the 'six phases of thematic analysis' identified by Braun & Clarke (Braun & Clarke, 2006): familiarisation of the data, generation of initial codes, searching for themes, reviewing themes, defining and naming of themes, production of publication.

Tool Matrix development

The literature search was used to identify suitable tools for inclusion in a matrix. A pragmatic approach was used to develop an interim tools matrix for use in stakeholder interviews; the most frequently reported tools, and any tools used in studies undertaken in Australia, were included in the matrix to be shared with participants.

Feedback from interviewees was used to refine the interim matrix into a final matrix. For inclusion in the final matrix, tools needed to be accessible (online tools or downloadable & includes instructions or guidance for use), and able to be used by workplace practitioners.

Tools were classified as being focussed at an organisation, job, task or individual level. Classification was based on the primary focus of the assessment, some tools collect data on individual tasks but do not have a formal methods to collate these at job level, in this instance they would be classified as task level.

A draft of the matrix was developed by one member of the research team and then checked by a second member of the team.

Results

Systematic literature review 1 (SR1)

Following the full text screening, 548 studies were assessed as relevant for inclusion; 137 reported on tools covering physical hazards, 254 on psychosocial and 228 covered comprehensive tools (both physical and psychosocial hazards). There were 30 physical hazard tools, 35 psychosocial hazard tools and 16 comprehensive tools. Some studies included more than one tool. Tables 1-3 show the breakdown of tools by industry sector in which they were used. Data for physical tools or psychosocial tools is only presented when at least two studies used the tool. For the comprehensive tools all data is presented as fewer tools were reported.

Physical tools

The manufacturing sector (n = 41) had the highest number of studies reporting on the use of physical hazard identification tools, followed by agriculture (n = 26) and health care (n = 26). For the physical tools, Rapid Upper Limb Assessment (RULA) (n = 24), objective data capture tools (video recordings, Electromyography (EMG) (n = 19) and Rapid Entire Body Assessment (REBA) (n = 19) were the most highly reported.

Psychosocial tools

Health care (n = 86) was the sector most widely reported in relation to the use of psychosocial tools, followed by retail (n = 20) and then education (n= 18). The Copenhagen Psychosocial Questionnaire (COSPSOQ) (n = 60) was the tool most frequently reported in the articles, followed by the Effort Reward Imbalance Questionnaire (ERI) (n = 55), and Health & Safety Executive Stress Indicator Tool (n = 20).

Comprehensive (Physical and Psychosocial) tools

Health care (n = 74) was the sector most commonly reported, followed by manufacturing (n = 26) and transport (n = 19). The Job Content Questionnaire (JCQ) (n = 194) was the most highly used tool for identification of both, physical and psychosocial hazards. The second most reported tool was the European Working Conditions Survey (n = 14) and then the Korean Working Conditions Survey (n = 13).

Tools in the Australian context

The use of tools was analysed by the country in which the study was undertaken. For the purpose of this report, studies in Australia are described here. For physical tools, only three studies were identified as located in Australia. Tools used were: Occupational Sitting and

Physical Activity Questionnaire, Job Requirements & Physical Demands Survey and Participatory Ergonomics for Manual Tasks (PERFORM).

For the psychosocial tools, 13 studies were undertaken in Australia which included; Nursing Stress Scale (n = 3), COPSOQ (n = 2), Psychosocial Safety Climate (PSC)-12 (n = 2), Standardised Nordic Questionnaire (n = 1), Work Environment Survey (n = 1), Job Demand Control Questionnaire (n = 1), HSE Stress Indicator Tool (n = 1), ERI, (n = 1) and Occupational Stress Scale (n = 1).

For the tools covering physical and psychosocial hazards, 10 studies were undertaken in Australia. The following tools were used; Work Organisation Assessment Questionnaire (WOAQ) (n = 5), JCQ (n = 4), A Participative Hazard Identification and Risk Management Toolkit (APHIRM) (n = 1).

Table 1 Physical hazard identification tools as reported by industry sector

		Administrative & support services	Agriculture, Forestry, Fishing	Construction	Education & Training	Electricity, Gas, Water and Waste Services	Financial & Insurance Services	Healthcare & Social Assistance	Information, Media & Telecommunications	Manufacturing	Mining	Public administration & safety	Retail Trade	Transport, Postal & Warehousing	Other Services	Not specified
Tool/number of times reported		5	26	8	7	1	1	20	3	41	2	2	5	7	1	43
RULA (Rapid Upper Limb Assessment tool)	24	1	7	0	2	0	0	0	2	5	1	1	0	0	1	4
REBA (Rapid Entire Body Assessment Tool)	19	0	5	0	2	0	0	2	0	8	0	0	0	0	0	2
Objective physical measures	19	2	1	0	0	1	0	0	0	2	0	0	2	3	0	8
Dutch Musculoskeletal Questionnaire	18	0	0	0	1	0	1	5	1	3	0	0	0	0	0	7
Rated Perceived Exertion (RPE) - (Borg's)	17	0	0	2	0	0	0	5	0	4	0	0	0	0	0	6
NIOSH Lifting equation	12	0	1	1	0	0	0	0	0	4	0	0	1	1	0	4
OCRA/ Upper Limb Risk Assessment	10	1	3	1	0	0	0	0	0	4	0	0	0	0	0	1
OWAS	10	1	3	0	0	0	0	0	0	4	0	0	0	1	0	1
Rapid Office Strain Assessment	5	0	0	0	2	0	0	0	0	0	0	0	0	0	0	3
Strain Index	5	0	1	0	0	0	0	1	0	1	0	0	0	0	0	2
3DSSPP Michigan University	4	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1
ACGIH TLV	3	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0
Physical Workload Index	3	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Rodgers Muscle Fatigue Assessment	3	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1
ActiGraph sensors	2	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
European Assembly Worksheet	2	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
RAMP I & RAMP II	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
CtdMAP™	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Hazard Zone checklist	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Industrial ergonomics screening tool	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
ISSO 11226 standards	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Job Requirements & Physical Demands Survey	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MAC - Manual Handling Assessment Chart	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Manchester Occupational Physical Demands Questionnaire	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MSD Risk Assessment. Industrial Accident Prevention Association	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Occupational Sitting and Physical Activity Questionnaire	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
PEForM (Participative ergonomics for manual tasks)	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Posture Activity tools handling (PATH)	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Risk Filter and Risk Assessment Worksheets (from HSE document HSG60)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
VIDAR (a participative video-based method for ergonomic assessments_	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Table 2 Psychosocial hazards tools by industry sector

		Accommodation & food services	Administrative and support services (incl cleaning & [illegible])	Agriculture, Forestry, Fishing	Arts, Recreation Services	Construction	Education and Training	Electricity, Gas, Water & Waste Services	Financial & Insurance Services	Healthcare & Social Assistance	Information, Media & Telecommunications	Manufacturing	Mining	Professional, scientific & technical services	Public administration & safety	Retail Trade	Transport, Postal & Warehousing	Other Services (hairdressing, beauty, tattooing, mechanic etc)	Not specified
Tool/number of times reported		3	6	3	2	2	18	4	9	87	4	18	6	1	5	20	3	13	67
Copenhagen Psychosocial Questionnaire (COPSOQ)	60	0	2	0	1	1	3	2	2	16	1	4	0	1	0	1	1	6	19
ERI questionnaire	55	1	0	1	1	0	3	1	2	16	0	5	3	0	3	2	1	3	13
HSE Stress Indicator Tool	20	0	2	0	0	0	2	0	1	5	0	0	1	0	0	3	0	0	6
Job Demand Control Questionnaire	18	0	0	0	0	0	1	1	1	7	1	0	0	0	0	0	0	0	7
Korean Occupational Stress Scale	17	0	2	1	0	0	0	0	0	3	0	5	0	0	0	1	0	1	4
General Nordic Questionnaire (QPS Nordic)	12	0	0	1	0	0	0	0	1	2	0	0	1	0	1	1	0	0	5
Brief Job Stress Questionnaire	9	0	0	0	0	0	0	0	1	2	1	0	0	0	0	1	0	0	4
NWI-EO	7	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0
Occupational Stress Index (OSI)	7	1	0	0	0	0	0	0	0	1	0	1	0	0	0	2	0	1	1
VBBA	7	1	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0	2	0
Occupational Stress Inventory	6	0	0	0	0	0	2	0	0	3	0	0	1	0	0	0	0	0	0
Nursing Stress Scale	5	0	0	0	0	0	0	0	0	4	0	0	0	0	1	0	0	0	0
Police Stress Survey	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Occupational Stress Indicator	4	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1
ASSET - A shortened stress evaluation tool	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1
Conditions of Work Effectiveness Questionnaire	3	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Pressure Management Indicator	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2
Psychosocial Safety Climate (PSC)-12	3	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1
Work Environment Scale	3	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Work related quality of life survey	3	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1
Job Diagnostic Survey	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**
job stress questionnaire (NIOSH)	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**
Job stress survey	**2**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Standardised Nordic Questionnaire	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**

Working Conditions and Control Questionnaire (WOCCQ)	**2**	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Areas of Worklife Scale - AWS	**1**	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Danish Psychosocial Work Environment Questionnaire	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
EBD Teacher stressors questionnaire	**1**	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Job Descriptive index	**1**	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
NIOSH generic job stress questionnaire	**1**	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Nordic questionnaire on working conditions and health	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Nurses Occupational Stressor Scale (NOSS)	**1**	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
South African Employee Health and Wellness Survey (SAEHWS)	**1**	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
U.S. National Home Health Aide Survey (NHHAS)	**1**	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Work Environment Survey	**1**	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Table 3 Comprehensive (Physical and Psychosocial) tools by industry sector

		Accommodation & food services	Administrative & support services (incl cleaning & gardening)	Agriculture, Forestry, Fishing	Construction	Education & Training	Electricity, Gas, Water & Waste Services	Financial & Insurance Services	Healthcare & Social Assistance	Information, Media & Telecommunications	Manufacturing	Mining	Professional, scientific & technical services	Public administration & safety	Retail Trade	Transport, Postal & Warehousing	Other Services (hairdressing, beauty, tattooing, mechanic etc)	Not specified
Tool/Number of times reported		2	2	8	2	12	3	5	74	3	26	2	6	10	4	19	3	79
Job Content Questionnaire (JCQ)	**194**	2	2	5	0	10	3	4	65	1	17	1	5	8	3	16	3	49
European Working Conditions Survey	**14**	0	0	0	2	0	0	0	0	0	1	1	0	0	0	0	0	10
Korean Working Conditions Survey	**13**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
Quick Exposure Checklist (QEC)	**9**	0	0	2	0	0	0	0	2	0	1	0	0	0	1	1	0	2
Dutch (Maastrict) Musculoskeletal Upper Extremity Questionnaire	**7**	0	0	0	0	1	0	0	1	2	1	0	0	1	0	0	0	1
Work Organisation Assessment Questionnaire (WOAQ)	**6**	0	0	0	0	0	0	0	4	0	1	0	0	1	0	0	0	0
NASA Task Load Index	**4**	0	0	0	0	1	0	0	2	0	0	0	0	0	0	1	0	0
Basic Occupational health questionnaire	**3**	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0
Ergonomics Workplace Analysis method	**2**	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Occupational Risk Factor Questionnaire	**2**	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
A Participative Hazard Identification and Risk Management (APHIRM) Toolkit	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Spanish Survey of Working Conditions	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Swedish Longitudinal Occupational Health survey	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Netherlands Periodic Occupational Health Survey	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Veterinary Job Demands & Resources Questionnaire (Vet-DRQ).	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Quebec Survey on Working & Employment Conditions & OHS (EQCOTESST)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Grey Literature

The following six additional physical hazard tools were identified from the grey literature: MaNTRA, Assessment of Repetitive Tasks, Key Indicator Methods, Hand and Upper Limb, Composite Strain Index, and Cumulative Strain Index.

Rapid literature review 2 (SR2)

Following screening, 29 articles were assessed as meeting the inclusion criteria. Articles included four literature reviews, seven quantitative studies (including two RCTs), thirteen qualitative studies and five mixed methods studies. Studies were conducted in a total of nine countries: France, USA, The Netherlands, Denmark, Australia, New Zealand, Canada, UK, and South Africa. The four systematic review studies included additional countries.

Tools were implemented in at least nine identified industry sectors – some studies did not specify the industry sector (refer Appendix 3: Data extraction). The most frequently reported sectors were Healthcare & Social Assistance (12 studies), Manufacturing (7 studies), and Construction (6 studies). The articles covered a wide range of MSD risk management tools: 10 studies looked at comprehensive tools (targeting both physical and psychosocial factors), 14 examined non-comprehensive tools (targeting only physical factors), 4 systematic reviews included both types of tools, and 5 included both non-comprehensive and comprehensive tools. There were no tools that only targeted psychosocial factors.

Risk of bias assessment

Retrieved studies were assessed using previously validated risk of bias criteria. Only one study, an RCT, achieved a very low risk of bias rating. Nine studies were rated as having an overall low risk of bias, nine were moderate risk and five were high risk. Systematic review articles were not given an overall risk rating (Tables 4-6). However, as illustrated in Table 6, the criteria for three of the four systematic review studies had mostly low risk ratings and it can therefore be concluded that these studies are of a high quality.

Table 4 Quality assessment of quantitative studies

	Inclusion criteria	Recruitment	Allocation sequence	Allocation concealment	Ethics	Protocol	Blinded assessors	Measures	Follow up	Outcome data	Selective reporting	Confounders	Other risks	Overall risk
Anderson & Zebis (2014)	-	-	-	-	-	?	-	-	-	?	-	?	-	v. low
Byrns et al (2004)	-	N/A	N/A	N/A	-	N/A	N/A	-	N/A	-	-	-	-	Low
Hess et al (2010)	-	N/A	N/A	N/A	-	N/A	N/A	?	N/A	+	-	-	+	Mod
(Noble & Sweeney, 2018)	+	N/A	N/A	N/A	+	-	N/A	?	N/A	?	?	+	?	High
Rasmussen et al (2017)	-	-	-	+	-	-	+	-	-	?	-	-	-	Low
Schall et al (2018)	-	N/A	N/A	N/A	-	N/A	N/A	?	N/A	?	-	+	+	High
Scholl & Salisbury (2017)	-	N/A	N/A	N/A	+	N/A	N/A	+	N/A	?	-	+	-	High

Note: Low risk (-) high risk (+) not applicable (N/A) unclear (?)

Table 5 Quality assessment of qualitative & mixed method studies

	Inclusion criteria	Method & aim congruity	Method & data collection congruity	Participant voices	Ethics	Measures	Outcome data	Outcome reporting	Confounders	Other risks	Overall risk
Ajidahun et al. (2019)	-	-	-	-	-	-	-	-	-	+	Low
Bosch et al. (2018)	-	-	-	-	+	-	-	-	+	+	Mod
Bredahl et al. (2015)	-	-	-	-	-	N/A	-	-	N	-	Mod
Cha et al. (2020)	-	-	-	-	-	?	-	-	+	+	Mod
Cole et al. (2009)	+	-	-	-	-	-	?	?	-	?	Low
Cuny-Guerrier et al. (2019)	+	-	-	?	+	N/A	?	?	N	?	Mod
Dale et al. (2017)	+	-	-	-	-	?	-	-	+	-	Mod
Driessen et al (2010)	-	-	-	-	-	-	-	-	+	+	Mod
Entzel et al. (2007)	-	-	-	-	+	-	?	-	-	+	Low
Jensen et al. (2002)	+	-	-	-	+	-	?	-	-	+	Low
Koma et al. (2019)	-	-	-	-	-	-	-	-	+	+	Mod
Koppelaar et al. (2011)	+	-	-	-	?	-	?	-	-	?	Low
Kramer et al. (2010)	+	-	-	-	-	?	?	+	-	-	Low
Oakman et al. (2019)	-	-	-	-	-	-	N/A	-	-	-	Low
Richardson et al.(2019)	-	-	-	-	-	-	-	-	+	+	Mod
Van Eerd et al. (2016)	+	-	-	-	-	N/A	-	-	+	+	Mod
Whysall et al. (2004)	?	-	-	-	+	N/A	N/A	?	?	+	High
Yazdani et al. (2018)	-	-	-	-	-	-	N/A	-	?	-	Mod

Note: Low risk (-) high risk (+) not applicable (N/A) unclear (?)

Table 6 Quality assessment of systematic review studies

	Review question	Inclusion criteria*	Search strategy	Sources*	Appraisal criteria*	Appraisal assessment*	Data extraction	Combining studies*	Publication bias*	Recommendations	Directives	Overall risk
Koppelaar et al. (2009)	-	-	-	+	+	+	-	-	+	-	-	High
Sultan-Taïeb et al. (2017)	-	-	-	-	-	-	-	-	+	-	-	Mod
van Eerd et al. (2010)	-	-	-	-	-	-	-	-	+	-	-	Mod
Yazdani & Wells (2018)	-	-	?	-	?	-	-	-	+	-	-	High

Low risk (-) high risk (+) not applicable (N/A) unclear (?)

Findings

Barriers and facilitators reported in the 10 studies involving comprehensive tools, and five studies that included both types of tools, were analysed using the workplace factors system framework (see Figure 1). Each of the barriers and facilitators were grouped into one of the following relevant categories: external factors, workplace environment, work organisation & job design, task & equipment, and workers' personal characteristics. Analysis of the data revealed the work organisation & job design level as having the highest number of reported barriers (refer Table 7). The number of barriers and facilitators identified are shown in brackets and correspond to the number of articles that mentioned that factor.

External factors (9 Barriers and 5 Facilitators)

Barriers related to external factors centred around the external business environment which included broad economic issues such as the economic climate, inadequate funding from external sources (e.g. government organisations), and industrial relations (perception that worker protection legislation impedes innovations). The lack of MSD hazard awareness of external business partners relates to employees who work offsite, e.g. construction contractors who travel to various sites and are subjected to MSD risks that are not controlled by their direct employer. The invisible nature of MSDs, and the delayed impact of prevention activities on MSDs, is an overriding barrier that, to some degree, filters down to most levels of the workplace system. This barrier was reported in three studies and can potentially make it difficult for tools/strategies to be supported, particularly if personnel have limited WHS knowledge.

Workplace environment (1 Barrier and 0 Facilitators)

Reported barriers that occur within the workplace environment were mentioned in four studies; these related to the limitations imposed by the physical infrastructure of the workplace, including patients in hospitals whose weights exceeded lifting machine capacity (Sultan-Taieb et al., 2017). For example, one study reported that hospital ceiling lifts were not compatible with older buildings (Koppelaar et al., 2009), and another study reported that a modified construction tool for drilling did not reach high ceilings (Dale et al., 2017).

Work organisation & job design (47 Barriers and 28 Facilitators)

Barriers at the work organisation and job design level were the most commonly reported and included management commitment, business structure, productivity, cost, management attitudes, knowledge, nature of work, and changes to work process. Several studies mentioned the lack of management support and engagement in WHS interventions as a contributing barrier to the effective implementation of comprehensive tools. This is closely associated with

some of the business structure barriers such as the disconnect between MSD prevention strategies and management systems framework. These could result in management, particularly with limited time and resources, to focus on other business priorities which are perceived as having a greater return on investment. Cost as a barrier was also linked with the structure of the business, with several studies reporting financial costs and lack of resources as barriers to implementing comprehensive tools.

Task and equipment factors (10 Barriers and 4 Facilitators)

Task and equipment barriers were all focused on the availability, cost, and efficiency of equipment to reduce mechanical loads for employees. No barriers were identified at the task level. For facilitators, which were fewer in number, the equipment needed to be available and easy to use.

Workers' personal characteristics (10 Barriers and 10 Facilitators)

Broad categories for barriers include culture and demographics. Cultural barriers refer to cultural norms that inhibit the effective implementation of a tool – the cultural norms may relate to pre-existing work practices, or ingrained attitudes of workers. For example, workers may frown upon the use of physical aids such as 'sitting down on the job', or they may not use the aids because there is a culture of bad habits and apathy. This is associated with another reported barrier, bravado of workers, which leads to reluctance of workers to engage with an intervention. Workers' perception of their situation was another barrier and included fear of job loss, loss of authority, and lack of trust. Reported demographic barriers were ageing workforce, low literacy, and staff fitness.

Table 7 Barriers & facilitators (number of articles that mentioned that factor)

	Barriers (B)	Facilitators (F)
External factors 9 B 5 F	• Invisible nature of MSDs and non-immediate impact of prevention activities (3) • External business partners/consultants lack WMSD hazard awareness (2) *External business environment* • Economic crisis climate (1) • Inadequate funding model (1) • Expectations of others (1) • Industrial relations (1) • Unfair competition (1) • Changing work environment (1) • No viable technology available (1)	*Resources* • Availability of potential interventions/devices available for the employer in the sector (3) *External agencies* • Pressure from insurance companies to adopt ergonomics solutions (1) • Enforcement of health & safety regulations (1) • External clients favour new MSD prevention technology so more likely to get contracts (1) • Bid requirements associated with best value contracting (1)
Workplace environment 1 B	• Modified equipment not compatible with existing infrastructure (e.g., bathrooms, construction sites) (4)	
Work organisation (include management & job design factors 47 B 28 F	*Management commitment level* • Lack of employer/manager commitment and support to interventions/WHS low priority (8) • Poor management & inadequate enforcement of regulation (2) • Poor management communications (4) • Hierarchical culture (1) • Less attention paid to temporary workers (1) • Organisational culture – stigma of MSDs (1) • Senior management not involved in WHS consultant engagement/advice/intervention (2) • Employer reluctant to use mechanical aids (1) • No-one taking leadership for intervention (1) *Business structures* • Small size of employer firm (1) • WHS admin system issues (3) • Gaps between policy & practice (1) • MSD prevention strategies disconnected from management systems (1) • High staff turnover/job insecurity (3) • Organisational structures other priorities (1) • Competing pressures care, time, profitability) (2) • Complex stakeholder relationships (2)	*Management commitment* • Communication & participation (2) • Effective implementation process/systematic approach (2) • Employer aware/engaged in intervention implementation (2) • Open attitude of employer to implement interventions (1) • Employer shows understanding to workers (1) • Regular steering committee meetings for senior managers to focus on MSD occurrence & management (1) • Concern for workers health & safety (1) • Management support for intervention (2) • Management willing to change (1) • Resources available (2) • Adequate staffing (1) • Climate of workplace (1) • Leadership role for implementation (1) *Integrated approach* • Training, knowledge & ergonomists support (1) • Integration of MSD prevention strategies into management systems (1) • High employer–worker involvement (1) • Senior managers share knowledge (2)

	• No clear return on investment (3) • Lack of collaboration within teams/supervisors (2) *Productivity Demands* • Negative productivity impacts (4) • Difficult to apply new procedures (4) • Time pressures (1) • Reduces the job quality (1) • Lack of time (2) • Interferes with work task e.g., gloves (2) • High production standard/pressure (2) • High workload (1) • Inadequate staff numbers (2) *Cost* • Lack of employer/manager time (2) • Financial costs (4) • Lack of resources (4) *Management Attitudes* • Employer not receptive to worker input (1) • Negative history of previous interventions (1) • Employer resistant to change (1) • Resistance to change (fear of sharing intervention ideas with competitors) (2) • Incorrect assumptions of employer re job changes (1) • Ergonomists' perception that psychosocial factors outside their remit (1) • Denial that complaints are work related (1) • Employer's adoption of prevention strategies dependent on having sick leave issues (1) *Knowledge* • Lack of employer WHS competencies (6) *Nature of work* • Remote workers (1) • Short term nature of working locations (e.g., trades) (1) • Risk inherent in nature of work (1) • Emergency situations e.g., nurses not following MSD prevention strategies when patient at risk (1) *Changes to work processes* • Changes nature of job so needs different workers (1) • Changes the sequence of the job (1) • Intervention introduced new hazards (1)	• Mandatory use of equipment (1) • Multimodal knowledge transfer to workers (1) *Perceiving benefits* • Perceived cost benefit (decreased absenteeism) (1) • Reduced workers' compensation costs (1) • Positive culture/ history of previous interventions (2) • Savings on labour costs (2) • Urgent need for employer to engage (e.g., otherwise worker have to leave) (1) • Advantages easy to see (e.g., hand protection from gloves) (1) *Improved Productivity* • Not a big change required – easy for workers/low training requirements (4) • Increased productivity (2) • Worker has time to get used to implementation of intervention/technical aids (1)

Task & equipment factors 10 B 4 F	*Equipment (availability, cost, efficiency)* • Modified equipment not readily available e.g., machine shared between wards (2) • Slow speed of modified equipment (1) • Difficult to transport equipment (2) • Expensive to maintain/clean equipment (2) • Inadequate pre-existing equipment (1) • High costs for workplace adjustments (1) • No time for workers to learn & get used to aids (4) • Lack of training/inexperience with intervention/aid (2) • Introduces other risks such as damaging materials (1) • Lack of patient embracement to be in lifting machines (1)	*Productivity* • Equipment easily accessible (1) • Equipment saves time (1) • Coupling identification of stressful postures with 'advice on the job' (1) • Relatives able to use hoist without nurses (1)
Workers personal characteristics 10 B 10 F	*Culture* • Cultural norms/workers not willing to change/apathy – culture of bad habits, short cuts (5) • Cultural difference (1) • Bravado attitude causing reluctance to use intervention (3) • Personality conflicts amongst co-workers (1) • Workers' limited acceptance of intervention/negative reaction (e.g., exercises) (2) • Workers who work alone not taking a break (1) • Workers perceptions (fear of job loss, lack of trust, loss of authority) (3) *Demographics* • Ageing workforce (1) • Low literacy (1) • Staff fitness/attitudes (2)	*Worker engagement* • Worker aware of work ability & risk factors (1) • Maintenance of professional competence of workers (1) • Worker involved in intervention process (1) • Worker awareness of symptoms (1) • Worker aware of financial consequence of work disability (1) • Higher educational level (1) • Worker employability threatened is opportunity to introduce preventive intervention (1) • Worker urgency to implement (e.g., otherwise worker has to leave company) (1) • Worker willing to change (1) • Staff acceptance of equipment (1)

Industry Stakeholder Interviews

Participant Characteristics

Thirty-three potential participants expressed interest in joining the study. Of these, one did not meet the inclusion criteria (due to their overseas location), one was employed in the same organisation as another potential participant, and one was a student of the researchers and was therefore excluded on the grounds of conflict of interest. The remaining thirty participants were invited to participate, and an online interview was scheduled. One of the participants did not arrange an interview or respond to follow up contact by researchers. A total of 29 participants from 6 high risk industries (agriculture, construction, health & social assistance, manufacturing, public administration, and transport/postal/warehousing) were interviewed. Background characteristics of participants is presented in Table 8. Summary of organisations is provided in Table 9.

Table 8 Participant characteristics

	All (N = 29)
Age (years)	(%)
25-34	4 (14)
35-44	4 (14)
45-54	9 (31)
55-65	12 (42)
Gender	
Female	12 (42)
Male	17 (59)
Job Role	
WHS/HSE Manager	17 (59)
Executive	2 (7)
RTW Coordinator	1 (3.5)
Safety/Project officer	2 (7)
Manual Handling Coordinator/ Health Specialist	3 (10.5)
WHS Advisor	2 (7)
WHS Consultant	2 (7)
Length of time in role (years)	
< 1	5 (17)
1-2	9 (31)
3-5	6 (21)
>10	5 (17)
Not provided	4 (14)
Formal WHS training?	
Yes	27 (93)
No	2 (7)
Type of WHS training	
Certificate IV	4 (14)
Diploma	2 (7)
Bachelor's degree	5 (17)
Graduate Certificate	1 (3.5)
Graduate Diploma	8 (28)
Masters	7 (34)

Table 9 Sectors included in interviews

Industry sector	Organisation Size (number organisations)			
	Small	Med	Large	TOTAL (%) N=29
Agriculture	1		1	2 (7)
Construction		2	2	4 (14)
Health & social assistance			9	9 (31)
Manufacturing		1	4	5 (17)
Public administration			1	1 (4)
Transport, postal, warehousing		1	7	8 (28)

Note: small (?), medium (?), and large (?)

Interview responses

Interview duration ranged from 50 minutes to 70 minutes. Analysis of interview transcripts was divided into responses related to current MSD risk management strategies being utilised, barriers and enablers to general MSD risk management, and barriers and enablers to tool implementation. The coding themes for current strategies, and barriers and enablers, were analysed using a workplace systems approach (Fig 1). Themes were organised into the following workplace system levels: External, Physical Workplace Environment, Organisational, Task & Equipment, and Individual Characteristics.

Participants were also asked about their views on specific tools. Responses to these questions were coded into negative aspects (4 themes) and positive aspects (5 themes) (refer Table 13). After providing their feedback about specific tools, participants were asked for their opinions about what constituted an optimal tool, and how they would like future tool information to be disseminated.

Current MSD risk management strategies utilised

All participants reported that they were currently implementing strategies to address MSDs. These strategies were coded into themes and examined within the workplace systems framework. Themes were spread across the following levels of the workplace system: organisational, equipment/task, and individual.

Organisational strategies

The most commonly reported strategy at the organisational level was *engaging and consulting workers.* Examples of engagement included regular management and worker discussion forums, adoption of a participative ergonomics approach, timely communication, and regular visits to the 'coal face' by organisation leaders.

> And one of the things that I kind of - from my own personal point of view, I'm a reasonably good communicator, I don't necessarily forget to get back to people. And if you can do those types of things and maintain that open line of communication, there's a level of appreciation that people have straightaway. (WHS Manager)

Similarly, some participants also had strategies for *engaging the executive team* to support the effective risk management of MSDs. Strategies were focussed on making the executive team aware of the cost benefits of addressing MSDs to reduce compensation claims, and also on educating leaders about the seriousness of WHS deficits within the organisation.

> Education. I'm slowly, slowly, slowly building a relationship with the senior leadership team and more and more they're realising that there is a massive gap in health and hygiene in general. I think they were pretty gobsmacked when they saw the amount of money that was associated with workers compensation claims for musculoskeletal injuries. (WHS Manager)

Six participants employed strategies, to scaffold MSD risk management approaches, which focussed on *upskilling and supporting managers*. Examples of these strategies included leadership education programs, WHS training for managers, and provision of WHS guidebooks to managers.

> So we are using the DuPont Safety Leadership Approach Program at the moment for our leaders, and we are looking at how we restructure our site work, health, safety team to give them better professional support and development and coaching. (Project Officer)

Several participants (n = 6) reported using regular *audits* as a strategy to address MSD risk. The audits targeted risk control, training, and risk profile.

> So regular onsite audits that happen out at the sites, including manual tasks audits, and things to do with training, training records, have people been trained, if not, why not. (Project Officer)

The *existing WHS system* was reported by six participants as their strategy to address MSD risk. WHS systems included four commercially available systems (DoneSafe, ErgoAnalyst, Perform, and Rapid Instance) and generic risk assessment tools.

> It's ultimately using the Donesafe system as such and through risk assessments and the like to determine what the risk is, reviewing our controls, and then ultimately determining what our future controls treatments are. (WHS Manager)

One participant also reported utilising the organisation's *safety committee* as a strategy to address MSD risk.

> We have a Safety Champions Network group that is kind of like an EHS (Environment, Health and Safety) Committee on steroids if you will. But it's to look at what the problems areas are of our business from a safety perspective, that we can explore and offer the National Australasian Business some benefit from. (WHS Manager)

Using *policies* to address MSD risk was quoted by one participant. *Staff supervision* was mentioned by four participants as a strategy to address MSD risk. This included supervision of staff to ensure they were complying with WHS requirements in terms of task execution and incident reporting.

> All our supervisors were tool boxed on visually checking people, if they look like they're sore or slowing down, go and check with them, get an interpreter and check with them. (Safety Officer)

Equipment & task strategies

The majority of participants (n= 20) reported strategies related to *equipment, attire or major infrastructure* changes. Equipment provision included mechanical aids such as lifting machines, attire included provision of personal protective equipment (PPE) such as gloves, and examples of major infrastructure changes included automation of production lines or redesign of storage facilities.

> We're quite lucky we've got a lot of equipment here that can be used for patient transfers and things like that. I've had different types of equipment that were brought in and that we've trialled and they're quite on board to do that. (WHS Manager)

> Some have implemented pallet lifters, and automatic pallet lifters. With others, we often have a little range of very simple platforms at different heights, so the pallet you're working on can go up on a little platform. (Consultant)

Changing processes, either WHS processes or work processes, was the next most commonly reported strategy to address MSD risk (n = 14). Examples of WHS processes included refining the incident reporting system, redesigning risk assessment systems, and upgrading the claims data reporting system. Work processes included changes to production line processes, task methods, and product design.

> I went through and gave him the data and explained it all and said, "This is what the problem is. The business is too busy filling out forms and not worrying about issues related to safety or culture. And what we're going to

> do is, we're going to throw the forms - get rid of the forms. We're going to get rid of the paperwork, we're going to get rid of the bureaucracy. And we're going to replace it with simple tools that people can use. (WHS Manager)

> Change the tie-down straps and the method they use to do that, and we've been using our - we've got a - really fortunate, one of my team is an ergonomist, so she's helping out, doing a fabulous job working with the guys. And we're finding that we are reinventing different ways of loading and unloading. (WHS Manager)

Job safety analysis was reported by nine participants, as a strategy to reduce MSD risk. This predominantly included manual handling checklists.

> I've written the manual handling procedure, I've written the care of the patient with bariatric needs procedure, and their adoptions. (WHS Advisor)

Three participants reported *job rotation*, in the context of manual handling in a production line and aged care services, as a strategy to address MSD risk.

> So we've got a lot – well, a lot of our facilities have got task rotation where they'll go from a – we'll call it a heavier or more frequent task – lifting certain size parcels – and they'll move over to another area where they do induct, where they actually don't lift the parcels. (WHS Manager)

Individual focused strategies

Training and education of workers was reported by 17 participants as a strategy for reducing MSD risk. Training included manual handling training such as correct lifting techniques and correct use of PPE, whilst education was focussed on ergonomic workstation set up and correct workplace practices. Participants reported varying success of their programs and some acknowledged the limitations of training in addressing MSD risk.

> we organised a hand workshop. Where we got experts to come out, and said, "Right. Let's recognise all the issues we could possibly have injuring your hands in the workplace." We rolled that out, to every single labourer and welder in the place, they all said, "Gee that was fantastic, I'm really conscious about my hands." For the next month, hand injuries went up three times. (Executive)

> we've actually adapted ongoing mandatory training modules. So, the guys will get prompted mandatory training pop up about once a month on a certain subject, and ergonomics and work at home checklists are part of that as well. (WHS Manager)

Complementing the training and education strategies, was the *provision of information* to staff which was reported by seven participants. The information related to correct use of PPE, updates to WHS procedures, and health tips, and was provided in screen format, posters or pamphlets/guidebooks.

> lot of video communication, which is shared on screens throughout the organisation. So, back at the depot, the guys can sit there and watch the same thing happening on the screen, with the CEO talking, or the Mayor talking, showing what's going on. (WHS Manager)

> we've got posters all over the place as to what we promote – which gloves you need to wear in which locations, and who's got to do what. (WHS Manager)

Some organisations (n = 3) conducted *functional testing prior to employment* to ensure an applicant was fit for the work.

> I have to think about are you fit for this role or not? Because we'll put you in harm's way. We're reviewing this at the moment, looking at our fitness for duties, fitness for work, as part of onboarding. What can you and what can't you do with people? You can't discriminate, it's just not allowed, but we also can't put people in harm's way. (WHS Advisor)

Three participants also reported referring existing employees to *medical assessments or consultations* (such as physiotherapy sessions) as a strategy to reduce MSD risk.

> undertake more regular functional tests, I think that even the more regular functional tests could continue to test people as well and identify – and it's not to rule people out, it's to understand the capacities that they have and how we can be aware of that and respond to their capacities and their needs differently. Like if I know that you can't or I can't carry 20 kilos or 15 kilos or even 10 kilos, because of the way you're made up, I need to know that to maintain due diligence for your safety. (WHS Manager)

Promoting *workers' exercises* at the workplace was a strategy mentioned by three participants.

> it's essentially just a program to get people moving and in tune with their body… It's essentially all of the base functional movements of the joints that we have. And what we encourage team members to do there is if they recognise any tightness imbalances, et cetera, to go to our early intervention program so that they're supported through prevention early (WHS Manager)

One participant also reported implementing a *healthy lifestyle program* to address workers' eating habits.

General MSD risk management barriers

All participants reported barriers to effective implementation of MSD risk management strategies. Barriers within the organisational level of the workplace system were more widely reported (25 participants) than barriers within the other levels of the workplace system. Barriers are reported here in the context of the workplace system level Error! Reference source not found.).

Table 10 Barriers to MSD risk management

	Barriers identified by number of participants
External factors 3 barriers	*External factors (7)* • Regulator/government/legislation/industrial relations issues (3) • Staff working off site or external clients (5) • Geographically remote (2)
Physical environment 1 barrier	*Physical environment (2)* • Physical environment (2)

Work organisation or psychosocial factors
 	
17 barriers
	Organisational or psychosocial (26)
	• Bureaucracy (4)
	  o Disjuncture between OHS & HR (1)
	  o Process issues (4)
	• Casual workers (1)
	• Communication issues (3)
	  o Between corporate level and on the floor (2)
	  o Between internal departments (2)
	• Competing commercial imperatives with OHS imperatives (7)
	• Culture of workplace (16)
	• Ineffective performance management (4)
	• Lack of OHS skills in management (10)
	• Lack of resources (15)
	  o Insufficient time and/or staff (13)
	  o Insufficient finances (1)
	• Leadership style (2)
	• Level of commitment to OHS (6)
	  o Lack of executive commitment (1)
	  o Lack of management commitment (5)
	• OHS system issues (12)
	• Staff turnover (2)
	• Under-recognising the role of psychosocial (2)

Equipment or task factors 2 barriers	*Equipment or task (14)* • Faulty or inadequate equipment (7) • Inherent difficulties of the job (10)

Individual factors 5 barriers	*Individual (15)* • Worker culture or attitudes (9) • Demographics of staff (9) o Ageing workforce (3) o Ethnicity & language (3) o Fitness level (1) o Level of education & literacy (4)

External

Several participants (n = 7) raised the importance of factors external to the organisation as barriers to MSD management. Examples of this are where work is conducted at sites that are the responsibility of another entity, such as construction sites, shopping centres, or in home environments, or where an organisation has no control over aspects of the work, such as the sizes of packages workers have to handle.

The following participants quotes illustrate difficulties for MSD risk management when work is conducted at premises owned or managed by others.

> We put the equipment in and then we've got to work around everything else that we're confronted with, including public in shopping centres and stuff like that. (WHS Manager)

> We had a situation where because of dignity of choice they could choose to put the bed anywhere in the room, so they could put it up against a wall. That means we can only operate one side of the bed, we can't lift it properly, we can't make the bed properly. (WHS Manager)

Additional to limited control over the physical environment, two participants also discussed the impact of other stakeholders on the way work is conducted. For example, family members of a care recipient, or the care recipient themselves, may have opinions on acceptable risk and safe manual handling technique. Similarly, another participant spoke of service recipients having unrealistic expectations in terms of what can be achieved in a specific timeframe, based on limited, and inaccurate, knowledge.

> And shows like 'The Block' don't help at all, don't help whatsoever. Because you see guys on there, sorry, women and guys, working 24/7. And it's like, "[T]Hey can do it, how come they can get a whole room done overnight." And that's the attitude now. (Consultant)

Two participants commented on work in locations *remote* from the main work site. One reported that in such situations, initial risk assessments may not be completed, leading to the risk being poorly understood and consequently the worker being ill prepared for the job.

Another mentioned the difficulty of ensuring appropriate control strategies are implemented when work is completed off site.

> So depending on where the customer is, it might be more remote, based on capacity, et cetera, to have a service coordinator, et cetera, to go out there to complete that initial assessment. It can be challenging time-wise, location-wise. There can be challenges around finding and getting the equipment that is required to be able to perform then the tasks needed. (WHS Manager)

> It's not the risk assessment, it's the control strategies that go with the risk assessment and how do you get them in when you're not the one providing them. (WHS Manager)

One participant mentioned remote geographical location can make it difficult to keep up with training and therefore ensure contemporary practices are used.

Three participants commented on the role of the *regulator and claims organisations*. One participant noted the associated rise in insurance premium following a claim can lead to a reduced likelihood to claim. This was perceived as a barrier, as these practices can result in the claims data being an unreliable data source.

Two participants commented that perceived lack of support from the regulator is a barrier to managing MSDs. This occurs either due to the inspection process being perceived as a 'tick box' exercise, with no ongoing support or checks provided, or due to the small size of the local regulatory unit and perceived lack of sector-specific experience. A third participant reported the lack of prosecutions does not encourage organisations to change practices related to MSD risk management.

Physical Workplace Environment

The *physical design* of the workplace was cited by two participants as problematic. Older facilities, that may be smaller, are often not designed to accommodate appropriate equipment, and manoeuvring equipment within such spaces can be difficult and lead to workers choosing not to utilise particular items of equipment.

> We have issues with managing equipment, so old facilities, lack of storage space, two far to go to get the equipment. (Project Officer)

Organisational

Workplace culture was seen as important. One participant commented that it can be difficult for people across the organisation to share ideas.

> I think culturally I wouldn't necessarily change much, apart from making it easier for people to share information and share their story and share the good ideas, and what didn't work well, that sort of team culture and team communication. (WHS Advisor)

Difficulties sharing information can also exist due to individual personality issues; one participant commented that some managers are reluctant to take advice on WHS matters due to perceptions their ability to manage is being questioned.

> [Management style is] a very hard topic to broach with managers because obviously at first they feel like you're attacking their ability to manage a site. (WHS Advisor)

Another participant acknowledged there can be diversity in a work team in terms of differences in knowledge, equipment, and opinions. For example, some workers are safety conscious and willing to accept best practice, whereas others believe it is acceptable to continue with outdated work practices.

Another participant discussed problems arising from having a precarious workforce comprising vulnerable workers, labour hire workers, or casual workers, who may not understand what hazards and incidents are.

> Vulnerable workers. Lots of labour hire, lots of casuals [make it difficult to better manage MSDs]. Lots of jargon. People don't understand what a hazard or an incident is. That's jargon to them. (Consultant)

Workplace culture is also important in terms of workers reporting problems and incidents. Two participants spoke of fear amongst employees that punitive action will be taken if they reported hazards, one of these suggesting a 'blokey' culture leads to hazards going unreported.

Another two participants reported that *processes* in place do not support desired outcomes. For example, both the security team and a clinical team may be called to a developing situation with an aggressive client, leading to an escalation of the situation. Another example is where there are too many operational procedures that are not looked at or used on a day-to-day basis.

Two participants commented that investment tends to be in lower order controls, rather than higher order controls, each participant giving a different reason for this. One perceived this was due to the organisation not planning for safety capital, while the other suggested this was due to the automatic discounting of higher order controls before management could consider them.

> The other thing is trying to get an investment in engineering rather than training. So the industry doesn't have an understanding around the engineering – benefits of engineering investment. They don't have safety capital planning. (Health Specialist)

> Because my experience has shown me that often frontline people when they're looking at an incident or a hazard and they're choosing what controls to implement, they automatically discount higher order controls that they believe or even know are unlikely to get approval to go ahead. If they know that it just won't fit into the budget this year or they don't think that there's management will to do something, they don't even bother mentioning it. (WHS Manager)

Another participant considered internal processes to be slow.

> I would probably try and fast track the program, doing the risk assessment for the smaller truck with the winch on it and as soon as we've assessed that it's suitable, fast track the procurement process that is slow and bureaucratic. (WHS Manager)

Organisational maturity was discussed by three participants. One participant considered the WHS in the organisation, and also the sector, as immature, with limited awareness of WHS matters. Another perceived the right people; that is, site leaders rather than the WHS team, were not accountable for site performance, and a third stated the sector as a whole had limited understanding of safety and risk.

> I've come from a heavy, high risk, well-resourced sector to an incredibly under resourced sector that has no safety, zero understanding or culture around safety systems, investment, risk assessment, nothing. (WHS Manager)

One participant reported that staff are not always involved in consultation for design decisions, while another spoke of workers' skills going unrecognised.

> So the other thing that the sector hasn't quite got yet is consultation in the design process. So if they were to actually talk to the staff that have to use that facility, they might be able to design out some of the risk in the new builds and, you know, our company is building new facilities all the time, regularly, at growth phase. So that's really important that we get that right in the design. (WHS Manager)

> So they're often coming in off unemployment benefits for years, or they're new to the country and have all this other set of skills but can't be employed for it. So, it would be that understanding their capability and looking for opportunity for them to express that, more rapidly than they perhaps can through a traditional promotion cycle. (WHS Advisor)

Twelve participants discussed deficiencies in the *WHS system* resulting in the system not being able to provide useful information or not supporting a reduction in injuries.

> [The risk management system is] inadequate to what we say we should do; we're not doing that across the board. There's [*sic*] pockets where that's achieved, so it's not desperate. I think the key thing is usability, so it's not about creating more documentation, because that doesn't get anyone anywhere, really, it's more that understanding what people need, creating the right tools for them to be able to use when they need it. (WHS Advisor)

> We've only just started conducting assessments. So we still don't know what we don't know at this stage. (WHS Manager)

> I think a system is only as good as the information going into it and it's clear from where I look that people really don't understand how to use it properly and how to report incidents properly or how to investigate, to be honest. (WHS Manager)

Two of these participants noted the WHS system does not take account of the role of psychosocial hazards in MSD development.

> [Mental health has not] been linked to the correlation of injury and mental health, they've only looked at fatality and mental health. They need to do that next step and say, "look, guys are getting injured on site because of their mental health, because they are fatigued and tired. Because they're stressed and they're not sleeping, they are fatigued and tired on site. (Consultant)

> All they have to do is a Cert IV in Safety, basically. That's the problem is that they don't understand that there is more beyond musculoskeletal injuries. All they think about of the musculoskeletal injury, is a back injury, and that's it. They just think of it as a back injury, and that's all. (Consultant)

Five participants commented on deficiencies in the implementation process, two noting that communication and feedback to workers can be lacking and good solutions are often not communicated to other parts of the business.

> What we don't have here is a very good implementation process (WHS Advisor)

> The challenge has been people feeling, again this is just my perspective, workers feeling like they haven't been heard. When we have asked them, they go, 'we told you that that's what we wanted to do'. We need to be better at providing feedback and closing the loop with them around where it's up to and why or why not. Because if you don't do that our experience has been that it can have quite a strong negative impact on workers feeling like 'I'm not heard now' and that can increase their frustration and increase their . . . feeling of 'I'm

> not valued'. I think in a big cumbersome system, providing feedback is a challenge for us. (WHS Manager)

An unacceptable performance management culture was raised by four participants, one of who considered such conversations to be hampered by the genial nature of the workplace.

> We don't have a very good incident management culture from a worker perspective. (WHS Advisor)

> . . . there is no performance-based culture around safety at the moment. (WHS Manager)

> Everyone gets on really well, it's a great place to work, the people are fabulous. But that's also its Achilles' heel because people are very reluctant to say, 'hey, you're doing the wrong thing', and call the person out, or at least have that quiet, behind the doors discussion with them. That doesn't take place, therefore you don't get the change, the person continues, likely unaware of the impact of their actions. (WHS Manager)

Limitations in resourcing were mentioned by several participants. Limitations related to staffing numbers and skills, available time, and financial constraints.

Adequate staffing numbers, and an appropriate staff mix, were also recognised as important in creating a team that could tackle problems quickly and effectively, and some difficulties were acknowledged (n = 5). For example, one participant suggested staff needed to be able to complete risk assessments, rather than only focussing on claims. Another noted that assigning duties to other staff (e.g., administrative staff) was not particularly helpful if those staff were already busy. Another participant indicated that working with external personnel, skilled in their area of expertise, may be required.

> I think it's the size of the organisation, I really do. I think that's it's me and four and a half thousand people, or however many people there are. It's very hard to reach every person in it. (Manual Handling Coordinator)

> Because a lot of their managers have excelled purely on a commercial basis of selling something, it doesn't mean that they're skilled in managing people well and identifying risks within a workplace. (RTW Coordinator)

> I think there's an opportunity to bring in or work with some, some external people who are skilled in that area. (WHS Manager)

Two participants mentioned staffing shortages can be exacerbated by turnover.

> The barriers [to managing MSDs] would probably be the very small size of corporate team. I'm a project manager with no project team, so I have to do all

> the strategic and all of the tactical works, so that's just not possible to get everything done. I think the general manager of work, health and safety is very good, and she's very supported, but she's stretched too thin. So we need to, basically, get full recruitment. We've had a lot of turnover in our team, a lot of change, so we need to get the full corporate team on board, I need a couple of project officers who can actually start doing some of the tactical work. (Project Officer)

Staff having limited time to take on safety roles, and duties beyond safety (e.g., quality, infection control) was mentioned by some participants (n = 4). One of these participants noted the COVID-19 pandemic had already imposed an additional load on workers. Another two participants stated that staff can be too busy with their normal duties to work safely.

> . . . at night time we have one RN to 90 residents. They are run off their feet. Of those 90 residents 20 of them are probably wanderers, moving around, incidents occur. It is impossible for one RN to look after 90 residents. (WHS Manager)

In addition to staffing numbers, *lack of staff WHS skills* (in both management [n = 10] and workers [n = 2]) was seen as a barrier to MSD risk management and four participants stated there was a lack of management commitment to safety.

> Managers still look at hazardous manual tasks as an employee's issue as opposed to a holistic issue. They see it differently to other risks, really." (WHS Advisor)

> Management have to be seen. They have to be seen to be doing the right thing and if I was going to try and be influenced further, I would get every manager I have here wearing their bloody hearing protection and their eye protection as they're supposed to. (WHS Manager)

Four participants discussed difficulties with training, including the need to ensure suitable training, one commenting about the lack of resources and information available to the sector.

> With a casual workforce, need to fit a lot of training, about all aspects of work, into a short amount of time. This means some coverage is superficial. (WHS Manager)

> Governments need to take it to the next level and the industry bodies need to take it to the next level and say, 'Okay, for years we've just done all these certificates, Cert IV in Safety, but that doesn't cut it anymore.' (Consultant)

This next participant quote demonstrates how lack of available time for training limits the information conveyed to workers.

> For the first week, or the first week and a half of that, we spend about five hours teaching chemistry 101, because there's unfortunately not a lot of people in it at the moment understand chemicals. We do chemical training, we do the normal evacuations, we teach them compliant spaces. We do a very, very small amount of manual handling – only an hour or so, just to make sure people can lift things, but we don't have the time to do it fully blown area in that induction. We basically have a period of two weeks to train people to get them working flat out, or get them working. We try to push as much as we can in, in a very short time. (WHS Manager)

Time constraints were acknowledged as a problem by a further seven participants. The following participant quote illustrates how time constraints impact managers' and WHS staff's ability to follow up with an injured worker.

> . . . when someone just says they hurt themselves moving a patient or pushing a trolley, and they did it with a straight back or something, then that's all the manager seems to have the capacity to deal with. And so, it's almost - it's tricky. So, I'll try and - for my part, ask the manager to ask these particular questions or whatever - I do what I can - or I'll go and see the injured worker if I possibly can, but it's a big job and I can't always do that. And I can't always - they're on different shifts and it's very tricky. (Manual Handling Coordinator)

Financial considerations, real or perceived, were reported by six participants. This was thought to have an impact on people's behaviour, particularly where perceived competition between *financial and productivity imperatives* existed. For example, workers may decide it takes too long to fetch equipment and even after there has been an MSD injury, the value of purchasing additional equipment may not be recognised.

> So when a resident fell in the corridor, our staff in their wisdom decided to lift that resident off the floor because it was too far to walk to get the lifting machine and then too far to take it back again afterwards, and there may not have been the right size sling there in the first place. So they manually lifted her off the floor, resulted in a musculoskeletal injury to one of the staff and about two weeks' lost time. I requested a second lifting machine so we can have one at either end of the building and have one closer, and I got knocked back on that. They said 'you don't need the second one, it costs too much.' The injury cost a lot more than the 4,500 [dollars] it would have cost for the lifting machine, and I'm putting that argument through very strongly. (WHS Manager)

Similarly, perceived timeframes were also thought to also affect workers' behaviour, with workers taking short cuts and try to work more quickly. Lack of funds influencing this behaviour was mentioned by two participants.

> As a safety profession you always think, don't take shortcuts. But the human factor is, that will happen, particularly if there are other stressors on meeting schedules. (WHS Manager)

Task and Equipment

Some participants (n = 10) discussed the *inherent nature of the work* requires workers to adopt movements or postures that are known MSD risk factors, such as forceful movements or repetitive postures. One participant acknowledged measures to keep working through the COVID-19 pandemic exacerbated this; for example, workers who would normally rotate between different tasks were required to do a particular task for a greater amount of time without rotation, due to the implementation of work zones designed to restrict the spread of COVID-19. Another participant also commented on the impact of changes as a result of COVID-19, such as the need to clean areas more frequently, necessitating and increase in the time for which workers needed to adopt awkward postures and forceful movements.

> We're using microfibre mops, but they're still the big shoulder movements for mopping and cleaning walls and all that sort of thing. (WHS Manager)

Equipment was mentioned by several participants as a barrier to improved MSD risk management. Seven participants stated appropriate equipment is not always available when required, or where required. Workers do not always take to time to procure appropriate equipment, sometimes due to perceived time pressures and other times because the equipment is stored at a location different to their current work site; for example, at the end of corridor, in a different unit, or the equipment may not be available because the worker is working off site.

Two participants commented on the role of asset management and the lack of standardised equipment in the workplace as a barrier to MSD risk management. A lack of standardised equipment results in difficulty establishing standardised procedures and may mean equipment is not maintained appropriately. One participant reported equipment can take a long time to be repaired after faults were reported. Instances of the equipment 'owner' being reluctant to 'lend' it to another work unit were reported. This means workers in a particular work unit may not have access to appropriate equipment.

Procurement of equipment was also raised by other participants. Three participants reported budget constraints can restrict ability to obtain equipment, another raised the importance of being able to trial equipment, to check its appropriateness, while another commented that obtaining new equipment, especially from overseas sources, may involve a long lead time.

> So we changed the steel press recently, so that took four months longer than they expected on their project, because of transport delays from China and manufacturing issues. Once we got it onsite, in terms of safety guardings, Australian standard compliance, it's taken another three months, and weeks of our time…(WHS Advisor)

One participant mentioned another hazard (a fire) was created by a particular piece of equipment, meaning the equipment was not replaced.

Individual Characteristics

Several participants mentioned individual worker characteristics may impact on the ability to effectively manage MSD risk.

Three participants discussed the impact of an *ageing* or an aged workforce, specifically how age impacts workers' abilities when engaging in manual handling. One participant spoke of the need to establish a fitness for duties process and implement ongoing functional checks, similar to checks for suitability to drive a heavy vehicle, but acknowledged this was a contentious issue in the particular workplace. One participant commented that some younger workers might be able to lift heavy loads, but they do not consider the long term impact on their bodies.

Literacy skills were raised by six participants, who either spoke of language barriers (n = 3) or low literacy skills in the workforce (n = 4), that limited workers' abilities to interact with technology, tools, or communications involving the written word.

One participant connected staff shortages to the recruitment of *inadequately prepared workers*, whose expectations may be misaligned with the reality of the work.

> Centrelink in their wisdom decided that they'd train up people to be PCAs (Personal care attendants). It's not a long course and so it's cheap for them to train them, so they've trained them up to be a PCA. They get put into an aged care facility knowing very little about really what a PCA does, and all of a sudden realise you've got to change a few dirty bottoms every now and then, you've got to shower people, you're going to have aggressive clients, you're going to have aggressive visitors. And they'll last a couple of weeks, and they walk out, because they don't know what they're getting themselves into. And it is physically a hard job, it's a very tiring physical job. (WHS Manager)

Cultural issues were raised by several participants (n = 9). One participant commented that health professionals tend to put the client first and themselves last, accepting the risk of sustaining an injury at work. Three other participants spoke of workers' reluctance to speak up if they identified that they were at risk, either due to fear of losing their job if a migrant worker (n

= 1) or because they think they look silly (n = 1). One participant did not provide a reason for why workers might not speak up; however, this participant also mentioned that reports of unsafe situations, although reported to the supervisor, were not recorded.

> . . . they felt that they couldn't say anything about it, which is a little bit sad to hear, or they had reported it, but it might've been midway through a shift and the shift supervisor has gone, "yeah I'll write it down later" and unfortunately then it's got lost. (WHS Advisor)

Two participants commented that workers sometimes perceive they need to lift heavy weights, either to demonstrate their capability to fulfil duties or as a display of *machismo* for their colleagues, without regard for the health implications.

> . . . there is this machoism of 'I can lift that', and sometimes showing their work colleagues, 'well I can lift that.' And the thing might be 75 kilos or something, and yes, they might be able to lift it and not get an injury. But there's not this, 'hang on, let's have a think about this first.' There's very much of, 'I can lift that' or 'it's just part of my job.' (Consultant)

> They think they're Superman, and they have to do everything. And they'll [say], 'I have to lift this on my own, I can't ask for assistance, I've got to be independent.' (Executive)

One participant reported that workers may not report injuries, instead opting to self-treat injuries they sustain.

> But you've certainly got your old school welders and what not, that just say - they'll have their own first aid kits up at their workstations, and don't tell you, and they'll treat themselves. (Executive)

Other cultural issues related to cynicism and scepticism of altered ways of working, particularly if the worker has been performing the job for a long time (n = 2), or may be unwilling to try new ways of working (n = 3). One other participant suggested some workers do not realise work may be causing problems.

> . . . the biggest thing that is stopping me is people actually realising that they do have a problem with it, or it is from what they're doing at work. (WHS Manager)

Tool implementation

Participants were asked if they currently used any tools for managing MSDs. Twenty-four participants reported using some sort of tool and five participants did not currently used any tools. However, of the 24 participants that reported currently using a tool, only nine participants currently used a validated tool with the remainder using generic risk assessment checklists or commercially available risk management systems.

Tool matrix

During the interview, participants were shown a list of 33 tools with evidence of validation derived from the literature search. All participants had heard of at least one tool, however very few had heard of more than ten tools. During the interviews some participants were vague about whether they had heard of a tool. In this situation researchers recorded their response as a positive, so it is likely that there is an over estimation of tool awareness for some participants (Table 11).

Table 11 Awareness & use of matrix tools

Number validated tools aware of	Number of participants
0	2
1	3
2-4	7
5-8	6
9-11	5
12-13	6
14-33	0
Number validated tools currently using	
1	3
2	4
4	1
5	1

Of the 33 interim matrix tools, two tools (Key Indicator Methods and Effort Reward Imbalance) were not known to any participants. In addition, several participants reported using the Manual Handling Assessment Chart. However, on further discussion it became apparent that they were referring to generic assessment charts, not the validated tool (available at https://www.hse.gov.uk/msd/mac/). Video recording was included as a tool in the matrix however, as this has a very broad application and is best used in conjunction with another tool, it was excluded from the data analysis. Despite all participants being aware of at least one validated tool, and 23 reportedly having used a matrix tool in the past, only nine participants currently used a validated tool in their workplace. The validated tools being used by participants (n) were: Perform (6), Borgs RPE (2), NIOSH (2), REBA (2), RULA (2), APHIRM (1), MaNTRA (1), OCRA (1), COPSOQ (1), WOAQ (1), wearables (1) (Table 12).

Table 12 Participants' tool use

TOOL	Have heard of tool	Have used the tool	Tool currently being used
Physical hazard assessment tools			
MAnTRA	14	7	1
PERFORM	20	10	6
RULA	13	9	2
REBA	12	6	2
Borg's RPE	9	6	2
NIOSH	18	13	2
OCRA	3	2	1
ULRA	4	1	
OWAS	4	2	
ROSA	3	1	
Strain Index	4	0	
3DSSPP Michigan	8	4	
ART	2	1	
KIM	0	0	
RAMP	6	1	
COSI	2	0	
CUSI	3	0	
Video recordings	16	16	
HAL	4	1	
Dutch musc questionnaire	2	1	
Manual handling assessment chart	13	12	
Wearable technology	19	7	1
Psychosocial hazard assessment tool			
COPSOQ	7	1	1
HSE stress indicator	5	0	
JDCSQ	4	2	
PSC	4	1	
Nursing Stress Scale	5	0	
ERI	0	0	
Physical and Psychosocial (comprehensive) hazard environment tools			
JCQ	2	0	
QEC	5	3	
WOAQ	2	2	1
NASA TLX	4	0	
APHIRM	15	3	1

Strengths and negatives of tools

Four themes were identified in the participants' responses to questions about negative aspects of matrix tools. Thirteen participants referred to the *complexity* of the tool as being a deterrent to using a tool, including the formality of language.

> It's around just the number and the complexity of some of them. Look at OCRA. I'm a smart guy and I just got confused. (WHS Manager)
> So it can be quite a long process. Yeah, it's probably the main reason, or it can be too, I guess, theory-based, so it doesn't feel applicable or relevant to the work that's being performed. (WHS Manager)

Another reason that some participants (n = 7) did not use a tool was related to *practical limitations* of the tool such as limited hazard focus, not providing a framework to address the hazards, or not being specific to the workplace tasks - either the tool had limited application (physical or conceptual), or the workplace did not engage in tasks that were relevant to the tool.

> Sometimes I've wanted something for one hand to push/pull a door - well, there's nothing like that available. So, they're limited - I use them where I can, but they're limited. (Manual Handling Coordinator)

> Need to know what to do next, not just identify hazards, and use framework approach that also considers psychosocial. (WHS Advisor)

> There were some occasions with the exoskeleton that weren't [positive]. And that was principally because you can imagine when you're wearing something, not that its super bulky, but it would extend from their body trying to get into cramped spaces wouldn't be great. (WHS Manager)

Four participants were sceptical about the benefits of certain tools and reported *no perceived gain* in using a particular tool – that is, the tool did not provide any additional information to their existing MSD risk management data.

> I'm hesitant around, does it kind of tell you what you already thought, what you already knew? Like it, is it sexy technology, or is it useful? (WHS Manager)

The excessive *cost* of some tools was also raised by three participants as a deterrent.

> I think things like the cost of using the tool. Again, my point earlier, we don't want the million-dollar solution to the $5 problem. It needs to be relative. (WHS Manager)

Responses relating to tool strengths were divided into five themes: clear & measurable outcomes, evidence based/looks scientific, simple format/easy to use, targeted, and

participative. The most common strength reported was the *clear and measurable outcomes* (n = 7) provided by the tool.

> Look, if you just change this one thing, it will bring this number down lower, and the lower this number is to zero, the less likely you're going to injure someone", and they go, "Okay, I understand that". (WHS Manager)

Underpinning the clear and measurable outcomes is the *evidence base and scientific look* of the tool, which was reported by as a strength by five participants.

> It was because there was some rigour around them and there had been some papers written that backed up the validity of the tool. (WHS Manager)

Although participants viewed the scientific look of the tool as being a strength, several participants (n=6) also reported the value of having a *simple, easy to use format*.

> I would say they're quite simple. They're not complex and they're easy to show others. When I say others, other levels in the business. (WHS Manager)

The *targeted* nature of the tool, in terms of its application and risk focus, was reported as a strength by four participants.

> …think it's quite practical and to the point, around that particular task you're looking at, rather than – our standard risk templates are quite generic list the risks, and people could go all over the place and not really identify anything from a MSD perspective. (WHS Manager)

> Three participants valued the *participative* nature of tools whereby the tool involved consultation and involvement of workers, "It was really good in the fact that it was a team system" (WHS Manager).

Table 13 Participants' opinions of tools

Negative tool aspects	Positive tool aspects
Complexity Practical limitations No perceived gain Excessive cost	Clear & measurable outcomes Evidence base & scientific look Simple, easy to use format Targeted nature Participative

Barriers to general tool implementation

Thematic analysis of interview data revealed eight key themes. Each theme was then considered within each of the workplace system levels. No themes were related to the physical workplace environment or task and equipment levels.

External factors

The first level of the workplace system, the external factors, included one theme (tool selection) with two sub-themes (deciding which tools & lack of tool availability awareness). Three participants felt overwhelmed by the choice of tools and information available and were not sure how to select a suitable tool.

> Workplaces need something - that's why we go to the government sites to say, well, what is approved, what's been validated, who's done all the hard work for us so we don't have to do all this research on our own … So we need recommendations, really. (Project Officer)

In contrast, some participants (n = 4) reported a lack of awareness of tool availability.

> …in previous safety training (in construction industry) none of these tools were ever brought up as assessments…And that is the biggest problem, none of those are taught as such, or highlighted in the construction industry. (Consultant)

Organisational factors

There were five themes located in the organisational level of the workplace system: bureaucratic structure, lack of management commitment, lack of management WHS skills, lack of resources, and organisational stage of change. Overwhelming, the lack of management WHS skills was reported as the main barrier to implementing MSD risk management tools. This refers to the limited WHS skill capacity of the organisation marked by either limited skills of existing WHS staff, the absence of suitably qualified WHS staff, and/or the inability of executive staff to understand key WHS concepts required for tool implementation.

> And that's the biggest problem, a lot of that is just all gobbledygook to managers and even to people that are classed as safety people in industries. (Consultant)

Compounding the lack of management WHS skills was a perceived *lack of management commitment* to introducing MSD risk management tools. Several participants reported the reluctance of managers to support the introduction of a tool.

> they won't find or give you time for it... and the authority power barriers, from a cultural point of view, won't make it work either. (WHS Advisor)

A lack of resources was the second most common barrier to implementing a risk management tool. Participants anticipated the additional costs associated with tool implementation, would be a barrier. For some participants, this was linked to extra staffing demands required for implementation, whilst others noted the integration of IT requirements to support tools as being a demand on resources.

> That's very time consuming. I look after literally hundreds of incidents every week, I haven't got time to sit down and look at a particular incident and think oh, I could use RULA on that, or I could use a NIOSH assessment on that one. (WHS Manager)

The lack of communication between different departments within some organisations, resulted from *bureaucratic structure* issues that meant some participants were unaware of the process for instigating changes to risk management strategies, "I'm not aware of what corporate team want to do... I'm removed from that..." (WHS Manager). In addition, some participants noted they were inadvertently excluded from the decision-making process, particularly in relation to psychosocial hazards, because the responsibility lay with the Human Resources department, not with the WHS team.

> I think probably just around immaturity of where we're at, in terms of getting our heads around psychosocial risks in the organisation. But perhaps – perhaps maybe our HR team have used some of these, but I haven't. (WHS Manager)

Being in the inappropriate *stage of organisational change* can be a barrier to implementing a new risk management tool. Several participants reported current challenges within their organisation that were not conducive to introducing new systems. For example, one participant noted the highly stressed work environment as being a barrier to introducing a new risk management tool, whereas another noted the organisation's early stage of WHS system development as being a barrier.

> ...we are in the infancy of making genuine change...the important part was going to come in 2021 where we will start using tools of this nature...(WHS Manager)

Individual characteristic factors

There was a perception by two participants, that a *lack of staff commitment* was responsible for the derailing of MSD tool implementation.

> …but if the staff aren't willing to actually do it because of laziness, can't be bothered, whatever - and that can be from a manager's perspective - it becomes extremely frustrating. (WHS Manager)

The level of *staff literacy or understanding of WHS concepts*, including language barriers, was a challenge reported by three participants.

> Because again, if you're just giving out these questionnaires to a heap of workers, sometimes they just don't understand the question and they're just going to tick down the middle and not go to either end. (Consultant)

Optimal tools and dissemination

When asked about tools they would like to see in the future, participants expressed a desire for tools that had the following attributes: simple and easy to use, continuous improvement component, predictive fitness component, customisability, digital format.

Participants wanted a tool that was *simple and easy to use* and presented in language that was easy to understand.

> It needs to be intuitive. If we're going to use a tool and if it's going to be deployed broadly on handsets for workers, then it needs to be easy for them to understand and to interface with. It needs to be a tool that allows us ease of access to get good reports out of it, sensible reports that are structured around what you're trying to achieve. (WHS Manager)

In addition to keeping the tool simple, participants also wanted the tool to contain a *continuous improvement component that provided solutions and examples* of risk controls.

> I think it's great that the tools are there to assess. I think what would really help is how you go about solving some of those challenges, at different levels. Just great ideas to go "Right, I know this is a problem – I don't necessarily need to pull a risk assessment out to tell me it's terrible. How on earth do I go about fixing it – either the gold standard through elimination through to the other options I have underneath that, kind of as I work along the hierarchy". Solutions, and ideas. (WHS Manager)

One participant also indicated they would like to have a *predictive fitness component* in a tool. Several participants noted the advantage of being able to *customise tools* to their specific needs, and the need to have industry specific tools.

The format that participants preferred for tools was a *digital format* that had the ability to automate reporting.

> I think we need to move into more digital and more interactive apps and things where I don't have to carry a huge guidebook around with me, (Project Officer)

Participants suggested the best place to disseminate and promote tools would be government websites such as the State regulator sites. They also wanted links to additional resources.

> But Safe Work as the New South Wales authority – it does have a lot of information on their website, and I think that's probably where it should be. (WHS Manager)

Tool matrix development

Thirty-three tools, identified through the literature review, were included in the interim matrix. Of these, 26 met the inclusion criteria for inclusion in the final matrix. One additional tool, People At Work, was identified through the stakeholder interviews, and added to the final matrix (refer appendix 4).

Discussion

This comprehensive project comprised two extensive literature reviews, and 29 stakeholder interviews, to address key aims of the project which were to identify 1) tools to support a comprehensive approach to MSD prevention, and 2) the barriers and enablers to the implementation of these tools in a range of industry settings. The initial review process identified a significant number of tools for the assessment of physical and psychosocial hazards in the workplace. In addition, tools were identified that assessed both physical and psychosocial hazards (comprehensive tools). Only papers including validated tools were included in this part of the review. The second review explored relevant barriers and enablers to the implementation of MSD prevention approaches and used a systems model to consider at which level these were occurring. The third component of the project interviewed stakeholders to explore barriers and enablers to MSD prevention, in general terms and then more specifically around specific tools that were presented during the interview. In this section, some reflections on the findings of

these three linked parts will be undertaken which can be used to inform further directions to improve current risk management approaches to MSD prevention.

Despite the large number of tools identified in the literature review, a deeper exploration of these tools to ensure that they were accessible to WHS practitioners, resulted in a much smaller final set. For WHS practitioners to be able to utilise tools in their everyday practice they need to be accessible and supported by guidance material to facilitate their use. Many of the tools were not easily located and were not in a format for easy implementation in workplaces. Tools provided in the final matrix were required to meet both of these criteria.

Most of the validated tools included in the final matrix are focussed on physical hazard, observational, and assessment of tasks rather than jobs or organisation level hazards. Observational tools, although popular, have problems with inter and intra rater reliability (Diego-Mas et al., 2017; Takala et al., 2010). Increasingly, evidence supports the need for participative approaches in MSD risk management to improve effectiveness and uptake of interventions to mitigate risk (Burgess-Limerick, 2018; Rivilis et al., 2008). Furthermore, physical and psychosocial hazards must be identified, and then appropriately targeted risk controls developed. A systems approach, which addresses the complexity of the hazards and the workplaces, is required to ensure that risk controls are not focused on fixing the individual workers (Oakman, Macdonald, et al., 2019).

Following the detailed search of the literature, grey literature, and consultation with stakeholders, it appears that very few tools are available that incorporate these key characteristics – and although a combination of tools, including those focused on physical hazards and psychosocial hazards, could be implemented together in a workplace to address MSD risk, guidance material to promote such an approach is not widely available and can be problematic for interpretation of results. Of all the tools identified in this study, only one includes outcome measures for MSDs (APHIRM) and very few are participative in nature. So, although the final matrix provides a list of readily available tools for WHS practitioners, limitations exist with opportunities for tool refinement based on feedback from stakeholders.

The majority of stakeholders interviewed had formal WHS qualifications, were working at a managerial level, and were aware of some of the validated tools; however, most were not currently using a validated tool in workplace management of MSD risk. Many of the MSD risk management strategies currently utilised by participants were focussed at the individual and equipment/task levels of the workplace system and very few were using a comprehensive approach to MSD risk management. This was reflected in the tool selection by the few using validated tools; only two participants were using a comprehensive tool, the remainder were using a combination of one or more physical tools. Reasons for poor uptake of validated tools were related to 1) perceived deficits of the tools, 2) barriers to implementation (mostly organisational level barriers), or 3) awareness and availability of tools.

The stakeholder interview data supported the earlier findings, from SR2, which identified that the main barriers to risk management tool implementation were organisational in nature. Correspondingly, articles included in the literature search outlined strategies to assist the implementation of MSD risk management tools, that largely focused on the organisational level of the workplace system.

Recommendations

Organisations need to be aware of tools and how to access them before they can benefit from improvements to existing tools, as one participant said, You don't know what you don't know…'. To ensure the effective implementation of comprehensive MSD risk management tools, it is essential that the organisational barriers are addressed. In addition, the uptake of validated comprehensive tools and strategies could be improved with greater promotion by the Regulator and Industry Associations. Recommendations for regulators and workplaces to support improvements to comprehensive MSD prevention, and tool implementation, are outlined below. Recommendations are based on data collected in the stakeholder interviews and both literature reviews (SR1 and SR2)

Regulator/Industry associations

- Support development of tools that are: low cost/free, participative, digital, and are able to be customised and incorporated into existing WHS systems
- Provision of resources to support the implementation of comprehensive tools for the prevention of MSDs
- Development of cost benefit/effectiveness analysis formula to support uptake of MSD risk management that address physical and psychosocial hazards
- Provide examples of solutions to both physical & psychosocial hazards from the currently available comprehensive tools.

Workplace

- Risk management education and skills development for managers which outlines the complex aetiology of MSD prevention and the need for inclusion of physical and psychosocial hazards in prevention programs.
- Education to include coverage of managers roles in prevention programs and how to develop effective and targeted risk controls
- Consider risk management tools that can be integrated into currently used programs, so that MSD prevention is integrated rather than a separate process
- Need to implement evidence-based tools which are appropriate for the workplaces, which include identification of both physical and psychosocial hazards to support comprehensive MSD prevention
- Need to use participative approaches in workplaces, and engage workers in both hazard identification and development of risk controls
- Implementation of strategies/risk controls targeted at all levels of the workplace system beyond the individual and task level.

Researchers

- A need for comprehensive tools for MSD prevention that support workplaces in identifying and then controlling MSD risk. Tools need to include coverage of physical and psychosocial hazards.
- Principles of implementation science need to be considered in tool development to facilitate more effective translation of evidence into practice for MSD prevention
- A need for research focused on the implementation of comprehensive approaches to MSD prevention and evaluation of the effectiveness of such approaches.
- Evaluation of comprehensive prevention programs which are embedded in workplaces, involving WHS practitioners, ergonomists and other relevant personnel, are critical to reduce the current evidence to practice gaps.

Limitations

As with all studies, some limitations exist. Two reviews were undertaken as part of this project. Although the search strategies were developed by a highly experienced team and in consultation with a senior librarian, a different search may have produced different results. However, the additional searches (grey literature) that we undertook reduces the likelihood that tools and articles may have been missed. The inclusion of only studies published in English is a limitation as additional tools and studies relating to barriers may be available in other languages. For SR1 the decision not to undertake risk of bias was intentional; this was unnecessary to support the aims of the study which was to identify tools to the quality of the study in which they were used.

There were limitations associated with collecting data related to validated tool recognition and use by stakeholders. It is possible that some participants were uncomfortable in reporting their knowledge levels in relation to tools. However, we informed participants at the start of the relevant interview section that we were not testing them and reassured them that we did not expect them to recognise most of the tools.

Conclusion

Findings from this extensive review provide a comprehensive overview of the currently available tools to support MSD prevention strategies. This is the first review to collate information on the physical and psychosocial hazard identification tools, using stakeholders to confirm their current approaches. The identification of only one comprehensive tool that included an outcome measure specifically for MSD prevention, suggests a range of opportunities exist for improvement.

Many gaps exist in the translation of contemporary research evidence on MSDs, into everyday risk management practices, providing opportunities to develop more comprehensive approaches. A key issue is to ensure that tools and guidance are based on principles of implementation science, so that they are developed in collaboration with the end users (in this case WHS practitioners), to improve uptake and ultimately to reduce the significant burden of MSD.

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Appendices

APPENDIX 1: Search strategy for Systematic review 1

Search ID#	Search Terms
1	(back pain or back pain disorder or neck pain or neck pain disorder or shoulder pain or shoulder pain disorder or elbow pain or elbow pain disorder or upper limb disorder or lower limb disorder or chronic pain or chronic pain disorder or musculoskeletal disorder or musculoskeletal injury or stress or psychological or mental or cumulative trauma disorders or psychosocial or musculoskeletal pain or wellbeing).tw. [tw = title and abstract]

2	(work-related or workplace or "work place" or workers or employees or employment or occupation).tw. [tw = title and abstract]
3	("risk management" or "risk assessment" or "safety management" or "Hazard control" or "questionnaire" or "survey").tw.
4	1 and 2 and 3
5	(cancer or covid or coronavirus or patients or pregnan* or coronary or myocardial or HIV or Surgery or child* or military or soldier or diabetes or clinical trials or clinical drug trial or drug trial or clinical).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms
6	4 not 5
7	limit 6 to (english language and humans and "all adult (19 plus years)" and english)

APPENDIX 2: Search strategy for Systematic review 2

Search ID#	Search Terms
1	("back pain" or "chronic pain" or "neck pain" or "shoulder pain" or "musculoskeletal pain" or "cumulative trauma disorder*" or "elbow pain" or "upper limb disorder*" or "lower limb disorder*" or "musculoskeletal disorder*" or "musculoskeletal injur*" or "repetitive strain injur*" or RSI or "musculoskeletal disease*").ab,ti.
2	limit 1 to (english language and humans)
3	(work-related or "work place" or workplace or worker* or employee* or employment or occupation or occupational or industry or labour* or labor*).ab,ti.
4	limit 3 to (english language and humans)
5	(barriers or facilitators or obstacles or "problems and solutions" or "organizational difficulties" or enabler* or challenge* or blocks).ab,ti.
6	limit 5 to (english language and humans)
7	(intervention or "prevention and control" or "participatory program" or OHSMS or "risk management" or "hazard control" or "risk assessment" or "safety management" or "work health and safety" or tools or participation or "occupational health and safety" or OHS or WHS or ergonomic* or program or "human factors" or prevention or preventive or "risk control").ab,ti.
8	limit 7 to (human and english language
9	2 and 4 and 6 and 8

APPENDIX 3: Data extraction table - Barriers & facilitators to MSD risk management interventions

Author (year) Country	Participant no. & type	Study design	Industry sector	Intervention (non-comprehensive/ comprehensive) Brief description	Barriers	Facilitators
Comprehensive tools/strategies						
Cuny-Guerrier et al. (2019) France	3 sub-contracting companies to meat processing organisations	Cross sectional (qual)	Manufacturing	Comprehensive Activity centred participatory ergonomics involving a post-study approach based on the reflexive practice; data from practitioners was collection on their reflections on their own activity. The reflexive practice was applied to analyse the process that led to senior managers commitment during the decision-making intervention on MSD prevention.	• Subcontracting context a barrier to mobilizing senior managers because of the complex nature of stakeholder relationships • Managers did not associate results of the intervention with the global performance for them and their contracting company.	• Regular steering committee • Meetings enable senior managers to take advantage of a forum for sharing knowledge on the progress in commitment and reporting of MSD occurrence. • Position of managers on a similar level of the organisation chart could also enable senior managers to benefit from reciprocal knowledge
Dale et al. (2017) USA	86 construction workers in floor laying, carpentry & sheet metal	Cross sectional (qual)	Construction	Comprehensive Participatory Ergonomics program involving training, consultation to identify hazards & solutions: - New equipment - Change in positions - Modification to equipment - PPE	• More to carry onto worksite • More equipment to clean • Equipment not readily available • Slow speed of equipment • Difficult to transport • Not able to use in all situations (limitations of equipment, constraints of building dimensions) • Slows down the work • Financial costs • Interferes with work tasks if not good fit (gloves) • Perceived as 'sitting down on the job' - workforce cultural norms • Lack of management (contractors) support	• Increased productivity • Savings on labour costs • Easy to see the advantages (hand protection from gloves) • New technology perceived as a positive by clients (more likely to get jobs) • Not a big change (easy for workers) • Needs limited training
Driessen et al (2010) The Netherlands	65 workers (questionnaire)	Cross sectional (qual)- within a Clustered RCT	Transport/postal/warehousing, Manufacturing	Comprehensive Participatory ergonomics to address low back pain and neck pain	Organisational level: • nN support from management • Lack of resources	Organisational level: • Support from management

	15 workers (semi-structured interviews)		Education & training		• Collaboration (bureaucracy within the firm/ department) Co-worker level: • Culture (workers' negative reaction and opinions about the intervention) Working group level: • Not having someone taking leadership Ergonomic measure level: • Negative perception of relative advantage (effect on prevention), • Difficulty (to implement) • Compatibility (with present norms and practices) • Complexity (workers' ability to understand and use the intervention)	• Sufficient financial resources • Active collaboration Co-worker level: • Positive culture Working group level: • Composition (someone takes a leading role during the implementation process)
Entzel et al. (2007) USA	43 stakeholders, all in commercial construction: 15 masonry contractors 12 masonry tradespeople 5 occupational health and safety Researchers 4 health and safety specialists 3 contractors association representatives 2 ergonomics consultants 2 representatives of state workers' compensation programs	Cross sectional (qual)	Construction	Comprehensive NIOSH organised masonry stakeholder meeting to explore contractors' and tradespeople's experiences in implementing ergonomic interventions. A range of interventions were discussed including some psychosocial controls (e.g., rest breaks, overtime, worker rotation)	• Financial concerns • Interventions requiring large capital investments were beyond the reach of many contractors • Interventions that may decrease worker productivity, reduce job quality, require frequent and/or costly maintenance, introduce new health or safety hazards, or change the nature of a job so dramatically that it is assumed by another trade or requires added supervision • Design issues, supply problems, job site conditions and management practices (i.e., site planning and coordination) • Space limitations, poor ground conditions, poor weather conditions, and disorderly job sequencing • Architects, engineers and project owners lack awareness and understanding of both WMSD hazards and available solutions • Lack of training, inexperience • Resistance to change, fear of sharing intervention ideas with competitors • Apathy among masonry contractors and tradespeople • Poor labour-management communication on ergonomics issues	• Financial savings, in the form of increased productivity, decreased labour costs, or reduced workers' compensation costs • Concern for workers' health and safety (motivating factor) • Health and safety regulations and the threat of citations • Bid requirements associated with best value contracting • Pressure from insurance companies to adopt new ergonomic solutions

					• Personality conflicts among coworkers • Inadequate enforcement of regulation • Unfair competition • Lack of return-on-investment analysis for individual interventions.	
Jensen et al. (2002) Denmark	102 floor layers 180 apprentice floor layers	Cross section (mixed)	Construction	Comprehensive • Upgraded equipment & materials • Mechanical aids • PPE • Changes in work methods • Planning and organisation • Education of apprentices in use of tools & aids, planning & health • Leadership, communication & process management education courses for contractors and foremen	• Mechanical aids impede work task • Difficult to learn new methods of working • Not enough time to learn new methods and use of aids • Risk of damaging materials if do not use aids correctly • Conservative attitudes/ macho culture • Decrease productivity initially and hence income (most on piecework system) • Small size of the employer firms • Short term nature of working locations	
Oakman et al. (2019) Australia	67 senior managers and other workplace stakeholders (management roles and WHS roles) 26 from aged care organisations 41 from logistics/ transport organisations	Cross Sectional (qual)	Health care & social assistance, and Transport & postal, warehousing	Comprehensive Interviews on barriers to the APHIRM (a Participative Hazard Identification & Risk Management) toolkit.	Job design, work organisation & management: • Inadequate staff numbers/time • Inadequate manager's time • Inadequate WHS stress-related competencies • Inadequate competencies re stress-related issues • Inadequate general WHS competencies • Lack of management communications • Gaps between policy and practice • WHS admin system issues Task/equipment: • Risk is inherent in the nature of the work • Inadequate equipment	

					• Inability to contact staff Workers: • Perceived poor worker attitudes (e.g., taking shortcuts) • Macho attitude • Cultural differences • Low literacy • Ageing workforce External factors: • Inadequate funding model • Organisational structure – other priorities • Lack of control over other workplaces • Commercial imperatives • Competing pressures (time vs care or profitability) • WHS a low management priority • Industrial relations • Expectations of others	
Richardson et al. (2019) New Zealand	5 physiotherapy academics 5 nursing academics	Cross section (qual)	Healthcare & social assistance	Comprehensive Manual handling lifting training Equipment Health & safety policy to ensure employer accountable for staff safety	• Equipment not readily accessible (sharing machines across wards) • Staff personal factors (fitness, attitudes) • Inadequate staffing levels • Time pressures • Culture of bad habits • Workload • Emergency situations • Equipment slows down work	• Equipment easily accessible and saves time
Van Eerd et al. (2016) Canada	529 in total, people who downloaded the guide and consented to participate in survey	Cross sectional (mixed)	Healthcare & social assistance Manufacturing Public administration & safety	Comprehensive Downloadable participative ergonomics guide	• Lack of time* • No opportunity to use the guide* * these were collapsed to "lack of time" based on free text comments • Guide not useful • Lost the guide • No interest	
Whysall et al. (2004) UK	14 Ergonomics consultants	Cross sectional (qual)	Not specified	Comprehensive ergonomics consultancy interventions aimed at reducing risks of MSDs	• Some ergonomists' perception of psychological and psychosocial factors as outside their remit • Lack of techniques in the repertoire of ergonomics methodology	

					available to consultants for assessing psychological and systemic factors • Clients unreceptive to broad investigation • Lack of involvement of senior management in requesting and receiving consultancy advice • Senior management stakeholders having little (if any) involvement in the consultancy process • Clients' understanding of ergonomics and the rationale behind recommendations • Clients' perceptions of cost-benefit of taking action, particularly with regard to preventative action and large scale changes • Clients' unwillingness to fund evaluation, restricting opportunity for consultants to evaluate • Clients' perception that a need for evaluation indicates ineffectiveness	
Yazdani et al. (2018) Canada	7 H&S consultants 5 H&S managers 5 researchers 3 policy makers 3 labour reps	Cross section (qual)	Manufacturing	Comprehensive General MSD prevention programs	• Disconnect of MSD prevention strategies from management systems framework • Invisibility of MSD cause & effect • Difficult to convince management due to impact of MSD prevention activities not being immediate • Organisational culture - illegitimacy or stigma associated with MSD	• Integration of MSD prevention strategies into management systems - avoid silos
Non- comprehensive tools/strategies						
Ajidahun et al. (2019) South Africa	11 musicians	Cross sectional (qual)	Arts & recreation services	Non-comprehensive Exercise-based injury prevention program for string players	• Time constraints, Inadequate knowledge/ information, and organisational structures	• Willing to adopt the exercise program
Andersen & Zebis (2014) Denmark	116 office workers with neck-shoulder pain, 88% were female	RCT	Not stated	Non-comprehensive Training with elastic resistance bands, 5 days per week. Either 2 mins or 12 mins duration, during paid work hours. Follow up after 10 weeks. Barriers and facilitators identified	• Length of exercise time • Progression in exercise too rapid/slow • Only one type of exercise • Some felt 5 sessions per week were too many • Lack of time • Difficulty in starting exercise after illness/holiday	• Type of training was generally appropriate • Support: o Training diary o Manual o Single instructional session o Telephone/email

				via multiple choice question.		
Bredahl et al. (2015) Denmark	476 office workers in the program 18 participants for in-depth interviews	Cross sectional (qual) nested within an RCT	Public administration & safety	Non-comprehensive High-intensity strength training in reducing musculoskeletal pain in the shoulder and neck region in participants who were regularly compliant.	Organisational perspectives: • Flexibility in the job • Guilty conscience about prioritising exercise over work • Feeling like they needed to keep working to support colleagues Implementation perspectives: • Misunderstood exercise schedule and inflexible intervention • Content • No inspiration, monotony, and attention • Competence and behaviour of the instructor	Organisational perspectives • Support from leading authorities • Flexibility in the job planning • Colleagues influencing compliance Implementation perspectives • Reducing physical deterioration and being part of a research project • Using exercises as inspiration • Introduction of correct techniques of exercises and enthusiasm of the instructor
Byrns et al. (2004) USA	270 registered nurses	Cross sectional (quant)	Healthcare & social assistance	Non-comprehensive Mechanical equipment	• Lift not available • Not been trained to use lift • Insufficient time • Patient exceeded weight capacity of lift	
Cha et al. (2020) USA	14 surgical team members	Cross section (qual)	Healthcare & social assistance	Non-comprehensive Exoskeletons, external devices that are worn to support physical demands and task performance for health care workers in operating rooms	• Lack of formal ergonomics training amongst staff (on risk of MSD problems) • Desire for immediate results • Concerns of safety, sterility, storage, of the exoskeleton • Concerns of investment (monetary cost), maintenance, usability (ease of use, mobility, weight, fit) of the exoskeleton	• Individual awareness of musculoskeletal ergonomics problems/need for change, curiosity, champion (interest in ergonomics & willingness to coach for better ergonomics); • Perceived (long-term) benefits (decrease of MSD problems)

Cole et al. (2009) Canada	90 workers, including members of the Ergonomic Change Teams responsible for implementing changes	Case study (mixed)	Manufacturing	Non-comprehensive 4 x participatory ergonomics interventions at different sites. Participatory ergonomics interventions varied between sites (e.g., changes to workstations, design of tools)	• Production pressures • Security involvement of plant personnel to carry out changes • Too many changes at once • Wavering management support • Delays, frustrations, and doubts • Involvement of HQ can seem disconnected and delay responsiveness	• Management support for outsourcing aspects of the change making process • Management support, (including from HQ and a local steering committee)
Hess et al. (2010) USA	183 masonry contractors	Cross sectional (quant)	Construction	Non-comprehensive Nine identified physical work practices	• Cost of equipment • Quality concerns • Maintenance of equipment	• Time savings • Increases in productivity • Increasing safety
Koma et al. (2019) South Africa	4 office workers 4 operational managers 9 health & safety reps	Cross sectional (qual)	Professional, scientific & technical	Non-comprehensive Office ergonomic assessment & implementation of recommendations	• Availability of funds • Lack of in-house specialist • Organisational culture • Lack of general organisational awareness of office ergonomics • Lack of individual knowledge to back up requests for ergonomic adjustments • Attitudes towards implementation; e.g., clients come first	• Management support • Colleague support • Specialist availability
Koppelaar et al. (2011) The Netherlands	247 nurses interviewed 38 managers returned questionnaire Ergocoaches (trained nurses) completed questionnaire (not clear how many also included in 247 nurses)	Cross-sectional (mixed)	Healthcare & social assistance	Non-comprehensive Use of different patient handling devices observed and then nurses were interviewed. Managers completed a questionnaire about organisational policies	• Prevalence of barriers was higher in hospitals compared to nursing homes • Unfavourable ratio of lifting devices. slide sheets, adjustable shower chairs per patient • Devices not close to bed • Management spending little money to maintain ergonomic devices • Management not reserving any money for activities or supplies to reduce • Physical load not a regular topic in team meetings • Nurses not trained in use of ergonomic devices each year • No regular checking of number of ergonomic devices in proportion to mobility of patients	For lifting devices only: • Being motivated to use lifting device • Back complaint in past 12 months • Availability of patient specific protocols with strict guidelines for ergonomic device use

					• No policy on maintenance of ergonomic devices	
Kramer et al. (2010) Canada	54 construction workers 13 construction company employers 38 consultants	Cross section (mixed)	Construction	Non-comprehensive Innovations in tools and equipment to reduce manual handling load	• Cultural barriers - peer pressure if no-one else in sector using the innovation • Macho culture • Tradition • Lack of awareness and knowledge of the innovation	• Productivity increase • Observability (immediately observe the advantage of the innovation) • Easy to use • Reasonable cost • Had multiple advantages (e.g., increased productivity and reduced material costs or improved quality of work)
Noble & Sweeney (2018) USA	107 nurses	Cross sectional (quant)	Healthcare & social assistance	Non-comprehensive Use of mechanical lifting aids	• Staffing levels & workload • Availability of mechanical equipment • Uncooperative/confused patient • Knowledge/equipment difficulties	
Rasmussen et al. (2017) Denmark	594 eldercare workers	RCT	Health care & social assistance	Non-comprehensive Participatory ergonomics, physical training and cognitive behavioural training	Internal factors • Lack of focus on solving the problem in the group or it is not taken seriously by all or there is lack of awareness of the problem and how to solve it • Lack of support from the supervisor and/or management • lack of initiative • focus on solutions at team meetings, lack of guidance from therapists and others with respect to training in transfer techniques and use of assistive devices External factors • Time delays, lack of time and holidays • Limited budgets and budgets that require approval • The resident's attitude, health status and temper • Relatives' attitude and collaboration • A company/a supplier's lack of delivery or materials that are missing or broken	Internal factors • Team dynamics and communication • Supervisor or management take the initiative to implement the solution • Therapist takes the initiative to implement the solution • Information, knowledge and education promote the possibility of successful implementation. • Increased focus and testing of new methods External factors • More time allocated • Money allocated and/or approved budgets and low-budget solutions • Involved residents (e.g., more active/involved in care situations) • Good collaboration with the residents' relatives • Good collaboration with a company or a supplier,

						quick delivery of newly ordered materials/equipment, materials/equipment is functioning
Schall et al. (2018) USA	952 WHS professionals	Cross section (quant)	Manufacturing Construction Education & training Healthcare & social assistance Public Administration & safety Transport/postal/ warehousing Financial services	Non-comprehensive Adoption of wearable sensors	• Employee privacy/confidentiality of collected data • Employee compliance • Sensor durability • Cost/benefit ratio	
Scholl & Salisbury (2017) USA	1234 sonographers	Cross section (quant)	Healthcare & social assistance	Non-comprehensive Adoption of ergonomic scanning practice	• Too busy • Patient obesity • Portable exams • Patients unable to cooperate • Lack of ergonomic equipment • Lack of ergonomic technique awareness	
Study included both comprehensive and non-comprehensive tools/strategies						
Bosch et al. (2018) The Netherlands	9 health & safety consultants	Cross sectional (qual)	Agriculture, forestry & fisheries	Not specified Focus group to identify facilitators and barriers for implementing preventive interventions for employers/workers.	Employers: • Skills - Inadequate competencies and skills of employers • Attitude - Incorrect assumptions of the employer regarding job changes ; Employer reluctant to use technical aids; Less attention paid by employers to temporary workers; Lack of time of the employer; Denial that complaints are work-related • Culture: High production standard; Hierarchical culture among workers • Costs - High costs for employers by workplace adjustments; High costs for employers by job changes Workers- • Knowledge - Little knowledge of risk factors in private life by worker;	Employers: • Knowledge - Higher worker educational level; Worker aware of work ability; Worker is aware of risk factors • Skills - Ensure/maintain high professional competence of workers • Attitude: Employer has open attitude to implementing preventive interventions; continued attention of employer for preventive interventions; High employer—worker involvement; Urgent need for employer to

					Little knowledge of physical capacity in private life by worker • Attitude - Worker has no time to get used to new technical aids; Employer fails to listen to workers' ideas of preventive interventions; Little willingness of the employer if there is no work disability; Worker is not open to change; Little willingness of the worker if there is currently no work disability. • Culture – No time to get used to new methods for worker due to high production demands; Worker's reluctance to use technical aids from a sense of bravado (peer pressure); Workers who work alone not allowing themselves a break; Absence of employer at workplace	implement preventive interventions (i.e., otherwise worker would have to leave the • organisation) • Culture: Employer shows understanding towards workers • Costs - Perception of achieving lower costs by reducing absenteeism • Facilitation - More preventive interventions available for the employer in the sector; Diversity in choice of preventive devices for upper extremities for the employer; Worker has time to get used to new technical aids. Workers' employability being threatened Workers: • Knowledge: Knowledge transfer to workers on paper; Multimodal knowledge transfer to worker; Awareness of symptoms by worker • Skills - Identifying stressful postures experienced by the worker; Coupling identification of stressful postures experienced by the worker with 'advice on the job' • Attitude - Worker feels urgency to implement preventive actions (i.e., otherwise worker has to leave the company) • Income - Worker knows the financial

						consequence of work disability • Facilitation - Diversity in choice of preventive resources available to the employer for UEMSD
Koppelaar et al. (2009) The Netherlands	19 studies	Systematic review	Health care & social assistance	Comprehensive & non-comprehensive A mix of patient handling training, mechanical aids & comprehensive interventions	Mechanical aids: • Time required to implement • Lack of knowledge • Inexperience • Decrease productivity • Difficult to use/incompatibility with pre-existing structures • Patients do not like Training & education: • Staff attitudes - established way of doing things • Lack of time to participate • Lack of availability of devices Comprehensive: • Lack of patient embracement • Lack of resources • High staff turnover • No viable technology available	Mechanical aids: • Policies to support mandatory use • Adequate staffing • Patient preference • Increased perception of safety among staff Training & education: • Management support • Financial support • Staff support • Common work technique across all departments Comprehensive: • Mandatory use of equipment • Relatives able to use equipment without nurses • Staff accept equipment
Sultan-Taïeb et al. (2017) Article from Canada (studies from Netherlands, USA, Canada)	9 studies	Systematic review 3 articles were RCTs and 6 used a quasi-experimental uncontrolled design	Health care & social assistance Transport & postal warehousing Education & training Manufacturing Administrative & support services	Comprehensive & non-comprehensive Mix of patient handling training & lifting training, participatory ergonomics, and workstyle/ empowerment interventions.	Non comprehensive • Equipment doesn't meet workers' needs for repositioning tasks • Some difficulties in applying procedures (resisting, heavy patients, procedural errors) Participatory ergonomics • Limited dose delivered and dose received of fully implemented ergonomic measures • Lack of financial and personal resources • Low adequacy to perceived workers' needs • Low satisfaction among workers • Low direct participation of workers • Limited acceptance by employees in some units Comprehensive • Lower participation of workers to workstyle and physical activity	Non comprehensive • Strong support from nurses, supervisors, co-workers, and patients • Nurses' participation to intervention process • High adequacy to worker's needs for lifting and transferring tasks Participatory ergonomics • High satisfaction among steering groups members • High attendance to meeting of steering groups members • Strong management support for the program • High dose delivered and received

					intervention (attendance to meetings) • Low adequacy with workers' needs for the physical activity component of the intervention • Group meeting may not be suitable for increasing physical activity Comprehensive • Low dose received • Low fidelity to protocol • Low workers' satisfaction toward an intervention tool (rest-break tool) • Difficulties in applying procedures • Economic crisis climate, job insecurity • Low support and commitment of supervisors	Comprehensive • High participation of workers to workstyle intervention (attendance to meetings) • High dose delivered (except for physical activity training).
van Eerd et al. (2010) Canada	52 studies	Systematic review	Mixed	Comprehensive & non-comprehensive: Participatory ergonomics (PE) programs	• Each category can be either a facilitator or a barrier (having resources available is a facilitator, a lack of resources is a barrier) • Support of PE intervention among management, supervisors and workers • Ergonomic training/ knowledge/abilities • Resource availability (time, material, personnel) • Communication • Organisational training/ knowledge/ abilities • Develop and follow systematic plan or approach • PE specialist/leadership/ facilitator • Working relations • Easy changes to implement • Climate of workplace • Production requirements • Personnel turnover among management, supervisors and workers • Awareness of PE intervention among management, supervisors and workers • Change (resistance or ability to change among: management, supervisors and workers)	

					• History of intervention attempts	
Yazdani & Wells (2018) Article from Canada Variety of countries, not always reported for studies.	88 studies	Scoping review	Mixed	Not specified	• Lack of time • Lack of resources • Lack of communication • Lack of management support, commitment, and participation • Lack of knowledge and training • Resistance to change • Changing work environment • Scope of activities • Lack of trust, fear of job loss, or loss of authority • Process deficiencies • Difficulty of implementing controls	• Training, knowledge and ergonomists' support • Communication, participation and support • An effective implementation process

APPENDIX 4. Tools for assessment of workplace physical and psychosocial hazards

Tool	Brief description tool	Method	Target body area/work area	Workplace hazards assessed	Focus of assessment (organisation, job, task, individual level)*
Physical hazard assessment tools: Whole body					
Borg RPE (Rated Perceived Exertion Scale)	Assesses exertion used in manual handling and physically active work.	Survey	Whole body	Effort	Task
DMQ (Dutch Musculoskeletal Questionnaire)	For the analysis of musculoskeletal workload, associated hazardous working conditions and symptom	Survey	Whole body	Force, Repetition, Environmental Factor	Job
KIM (Key Indicator Methods)	Assess risks involved in manual handling of loads	Observational	Whole body	Force, Posture, Duration, Working Conditions	Task
MAC tool (Manual handling assessment charts)	Assessment tool for lifting and lowering, carrying and team handling	Observational	Whole body	Posture, Repetition, Speed, Vibration, Environmental Factor	Task
MAnTRA (Manual Tasks Risk Assessment Tool)	Assesses exposure to musculoskeletal risk factors associated with manual tasks in the workplace	Observational/ Participative	Whole body	Posture, Force, Repetition, Speed, Duration, Vibration	Task
NIOSH LE (National Institute of Occupational Safety & Health Lifting Equation)	Assesses manual handling risks associated with lifting and lowering	Observational	Whole body	Posture, Duration, Repetition, Force, Vibration	Task
OWAS (Ovako Working Posture Analysing System)	Evaluation of postural load during work	Observational	Whole body	Posture, Duration, Repetition	Task
PERFORM (Participative Ergonomics for Manual Tasks)	Simplified manual task risk management program	Observational/ Participative	Whole body	Posture, Force, Repetition, Duration, Vibration	Task
RAMP (Risk Assessment & Management Tool)	Assessment and management of physical risks in physical jobs (not including people)	Observational	Whole body	Force, Frequency, Posture, Repetition, Duration	Task
REBA (Rapid Entire Body Assessment Tool)	Assesses postures to estimate work-related whole-body risk	Observational	Whole body	Posture, Force, Repetition	Task

ROSA (Rapid Office Strain Assessment)	Posture checklist to quantify office work environment risks	Observational	Whole body	Posture, Duration	Task
3DSSPP (3D Static Strength Prediction Program (Michigan University)	Software program to evaluate the physical demands of the job	Observational	Whole body	Posture, Force	Task
Wearable technology	Wearable technology to measure workers movement/activity in the work environment	Objective	Whole body	Posture	Individual
Physical hazard assessment tools: Upper Limb					
ART (Assessment of repetitive tasks)	Assessment of repetitive tasks involving the upper limb	Observational	Upper limb	Force, Posture, Repetition, Duration, Speed	Task
COSI (Composite Strain Index)	Method to quantify biomechanical stressors for complex tasks (task level)	Observational	Upper limb	Force, Posture, Repetition, Duration	Task
CUSI (Cumulative Strain Index)	Method which integrates biomechanical stressors from different tasks to quantify exposure for a whole workday (job level)	Observational	Upper limb	Force, Posture, Repetition, Duration	Job
JSI (Job Strain Index)	Estimates injury risk to wrist and hands	Observational	Upper limb	Force, Posture, Repetition, Duration, Speed	Task
OCRA (Occupational Repetitive Actions Method)	Estimates risk to the upper extremities for repetitive work,	Observational	Upper limb	Force, Posture, Repetition, Duration	Job
RULA (Rapid Upper Limb Assessment Tool)	Assessment of postures to estimate work-related upper limb disorder risk	Observational	Upper limb	Force, Posture, Repetition	Task
ULRA (Upper Limb Risk Assessment)	Assessment of the upper limb load and the risk of developing MSDs	Observational	Upper limb	Force, Posture, Repetition, Duration	Task
Psychosocial hazard assessment tools					
COPSOQ (Copenhagen Psychosocial Questionnaire)	Survey tool to assess a variety of comprehensive set of psychosocial factors for risk assessment at work, involving participation of workers	Survey	Stress	Demands Work Pace Stress Influence Support Recognition Sense of community Work engagement Job Satisfaction Work life interface Trust Bullying and Harassment Burnout	Organisational Job
ERI (Effort Reward Imbalance questionnaire)	Survey tool to measure effort, reward and over commitment at work	Survey	Stress	Rewards Effort	Organisational Job

				Overcommitment	
HSE Stress Indicator Tool	Assesses primary stressors associated with work related stress	Survey	Stress	Demands Control Support Relationships Role Organisational change	Organisational Job
People at work	Measures to identify risks to psychological health and safety	Survey	Stress	Emotional demand Role ambiguity Role conflict Role overload Conflict Job control Support Recognition Bullying/Violence Reward/Recognition Change consultation	Organisational Job
Physical and Psychosocial (comprehensive) hazard assessment tools					
APHIRM A Participative Hazard Identification Risk Management Toolkit	A comprehensive tool which assesses physical and psychosocial hazards at work	Survey Participative	Workplace environment and whole body	Physical Demands Psychosocial Demands (drawn from COPSOQ and WOAQ	Organisational Job
NASA TLX (NASA Task Load Index)	Workload assessment tool across a number of domains	Survey	Workplace environment	Mental Demands Physical Demands Effort Temporal demands Performance Frustration	Job
QEC (Quick Exposure Checklist)	Assesses a range of workplace physical and psychosocial hazards	Observational Participative	Whole body	Force, Duration, Posture, Repetition, Vibration, Work Pace, Speed	Job

D= Duration; Dem = Demands E = Effort; EF = Environmental Factors; F = Force; Fr= Frequency; P= Posture; R= Repetition; S = Speed; St= Stress; V= Vibration; WP= Work pace; WC= Working conditions; PD= physical demands; PsychD= Psychosocial demands; MD= Mental demands. Focus of assessment is the level at which the tool is primarily focused on for data collection and risk assessment.