

Evidence on the impact of the coronavirus (COVID-19) pandemic on work-related musculoskeletal disorders: evidence summary to 29 April 2021

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Scientific evidence about COVID-19 was vital to inform decision making by HSE, across Government, and other professionals involved in the national response to the pandemic. This report summarises published scientific evidence about the impact of the COVID-19 pandemic on work-related musculoskeletal disorders (WRMSDs). The researchers considered three groups of workers: key workers including in healthcare, construction, education, transport, and public services; workers who changed to homeworking; and furloughed workers. Ten scientific studies and ten other publications available before 29 April 2021 were considered to be from authoritative sources. Based on this research, for WRMSDs there was consistent evidence for increases in psychosocial risk factors for key workers and those homeworking, and limited evidence for increases in physical risk factors. For furloughed workers, there was limited evidence for increases in psychosocial risk factors, and for physical risk factors potential that there may be increased risk of WRMSDs on return to their normal work due to ‘physical deconditioning’ from a lack of activity during furlough. There was minimal evidence that WRMSD symptoms increased among key workers and those homeworking, and no literature was found on symptoms in furloughed workers. These findings reinforce existing information in HSE’s guidance about homeworking <https://www.hse.gov.uk/home-working/index.htm>. The national and global scientific evidence continued to develop after this review was completed.

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Evidence on the impact of the coronavirus (COVID-19) pandemic on work-related musculoskeletal disorders: evidence summary to 29 April 2021

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We conducted focus groups and workshops with stakeholders who were attending in a professional capacity in accordance with the Data Protection Act 2018 and GDPR (General Data Protection and Regulation) and professional standards for ethics.

Abbreviations

DSE	Display Screen Equipment
H&S	Health and Safety
MSD	Musculoskeletal disorder
NHS	National Health Service
OH	Occupational health
PHE	Public Health England
USDAW	Union of Shop, Distributive and Allied Workers
WRMSD	Work-related musculoskeletal disorder
WRMSDs	Work-related musculoskeletal disorders

Key messages

Work-related musculoskeletal disorders (WRMSDs) are injuries and conditions that are caused or made worse by work, and can affect the back, joints and limbs. Risk factors associated with WRMSDs include physical risk factors such as heavy lifting and psychosocial risk factors such as stress.

This report describes a study to consider the evidence on the impact of the coronavirus (COVID-19) pandemic on work-related musculoskeletal disorders. The report summarises the evidence in published scientific and other literature to the 29 April 2021. The report also describes and summarises a small supporting consultation exercise with fifteen stakeholders to further understand the impact of the pandemic on WRMSDs and their associated risk factors.

The evidence summary considered three groups of workers: key workers including in healthcare, construction, education, transport, and public services; workers who changed to homeworking; and furloughed workers.

The research identified twenty publications addressing the impact of COVID-19 on WRMSDs: ten published scientific studies and a further ten publications from the grey literature which includes government and policy reports, news articles and blog posts. Based on this evidence our findings for WRMSDs are that there is:

- Limited evidence for increases in physical risk factors for key workers and those homeworking and potential that there may be increased risk of WRMSDs for furloughed workers on return to their normal work due to 'physical deconditioning' from a lack of activity during furlough.
- Consistent evidence for increases in psychosocial risk factors for key workers and those homeworking. Limited evidence of increased psychosocial risk factors for furloughed workers.
- Minimal evidence that WRMSD symptoms increased for key workers and homeworkers during the pandemic. No literature was found on symptoms in furloughed workers.

Executive summary

Introduction

The coronavirus (COVID-19) pandemic necessitated rapid changes to working practices and environments at the individual, organisational and national levels. These changes may have altered the risk of work-related musculoskeletal disorders (WRMSDs) by changing exposure to known risk factors. Firstly, increased demands, such as longer work hours, were placed on key workers – including healthcare, construction, education, transport and public services – increasing their work-related physical and psychosocial burdens. Secondly, workers from many occupations were furloughed, such as those from the travel, tourism and hospitality industries. While this may have initially reduced their daily exposure to physical and psychosocial WRMSD risk factors, the potential for muscular deconditioning, such as lack of physical activity leading to deterioration of muscles, during a sustained period away from work may have increased their risk of WRMSDs on their return. Finally, people who began working from home due to the pandemic, for instance managers, directors, office workers, and administrative staff, faced unexpected changes in their working environments. As a result, some employees may have worked with inadequate computer and workstation set-ups.

Aims

This work aimed to:

- conduct an evidence summary into the impact of COVID-19 on WRMSDs and their associated risk factors
- offer suggestions for how to control and manage the risk of WRMSDs in the future

Methods

The project was divided into three main work packages:

1. A literature review with two searches: search A focused on WRMSD risk factors prior to COVID-19 and search B focused on COVID-19's subsequent

impact on risk factors and WRMSD outcomes. Both searches comprised two academic database searches in PubMed and Scopus, and search B also included a series of targeted searches in Google Scholar for grey literature (e.g., government documents, reports, white papers, newspaper articles, blog posts). This resulted in a total of 44 sources from all searches combined: search A found 24 published scientific studies; search B found 20 sources (10 published scientific studies, 10 grey literature sources).

2. A small supporting consultation exercise with 15 participants acting in their professional capacity. The consultation exercise involved an asynchronous online focus group (digital bulletin board) (11 participants) and two 2-hour workshops conducted via video conference (13 participants).
3. A report of the findings (results – section 3 of this report), a discussion of the implications (section 4) and a summary of conclusions (section 5).

Results from the literature review and stakeholder consultations

Based on evidence from the literature and stakeholder consultations, we identified three main groups of workers to broadly represent experiences during the pandemic: key workers, furloughed workers, and people who continued their roles by working from home.

The literature we identified on WRMSD risk factors pre-COVID-19 (24 sources published between 2002 and 2021) showed that the most commonly reported WRMSDs affected the upper limbs (shoulder, neck, arms, wrists, hand, and fingers), lower back, or were related to hip/knee osteoarthritis. Common physical risk factors associated with these WRMSDs included prolonged work, repetitive movements, heavy lifting, computer use, awkward postures, prolonged standing, vibrations, inappropriate furniture, intense physical exertion and walking on uneven ground. Common psychosocial risk factors associated with these WRMSDs were stress, high job demands, time pressures, low job satisfaction, 'boring' work, insufficient social support, lack of control around decision-making at work and poor work-life balance.

The literature we identified on the impact of COVID-19 on risk factors (20 sources published between January 2020 and April 2021) highlighted the detrimental effect

that COVID-19 had on psychosocial risk factors associated with WRMSDs across key worker and work-from-home populations. There was only limited evidence of an impact on psychosocial risk factors for furloughed worker populations from the evidence summary. In addition, limited evidence suggested increases in physical risk factors were reported among work-from-home and key worker populations, and the potential for physical deconditioning was mentioned for furloughed workers. The published scientific literature reported minimal evidence (4 studies) of increased WRMSD symptoms such as musculoskeletal discomfort, neck, shoulder and back pain during the COVID-19 pandemic in key worker and work-from-home populations. However, it was too early for conclusive evidence of the pandemic's impact on WRMSD outcomes at the time of data collection.

Evidence from the supporting stakeholder consultation suggested that working hours and intensity may have increased for key worker and work-from-home populations during the pandemic, thereby increasing psychosocial risk factors for WRMSDs. However, stakeholders also reported that health and wellbeing were more widely spoken about due to the pandemic, with some workplace changes offering potential methods for reducing WRMSD risk among work-from-home and furloughed workers; for instance, flexible working hours and more time for habits supporting musculoskeletal health.

Discussion and conclusion

The literature and supporting stakeholder consultation provided various suggestions for addressing the physical and psychosocial risk factors of WRMSDs. For physical risk factors, they suggested that the following control measures could be considered by duty holders, where it was appropriate, by: providing aids for lifting; ensuring ergonomically sound workstation set-ups; encouraging regular postural changes; and providing easy-to-apply guidance on display screen equipment across varied workplace settings, including for home settings. For psychosocial risk factors, it was suggested that the following control measures could be considered by duty holders, where it was appropriate, by: the provision of mental health support; encouraging peer support; helping workers manage their workload; and fostering teamwork.

Table of Contents

Acknowledgements	4
Abbreviations	5
Key messages.....	6
Executive summary	7
Table of Contents	10
Index of tables.....	11
Index of figures.....	12
1. Introduction	13
1.1 Background	13
1.2 Aims	15
2. Methods	17
2.1 Research questions and conceptual framework.....	17
2.2 Overview of the approach	19
2.3 Literature review.....	20
2.4 Stakeholder consultation	30
3. Results	38
3.1 WRMSDs and WRMSD risk factors (pre-COVID-19).....	38
3.2 The impact of COVID-19 on WRMSD risk factors and WRMSDs	42
3.3 Considerations for supporting WRMSD health based on the research evidence	49
4. Discussion.....	53
5. Conclusion	57
References.....	59
Appendices	66
A1. Literature search strategies	66
A2. Data-extraction templates	70
A3. Characteristics of included articles from search A	74
A4. Characteristics of included articles from search B	86

Index of tables

Table 1. Types and examples of WRMSD risk factors	14
Table 2. Inclusion and prioritisation criteria for sources related to Search A (reviews of the impact of work environments and practices on WRMSDs pre-COVID-19)...	23
Table 3. Inclusion and prioritisation criteria for sources related to Search B (the impact of COVID-19 on work environments and practices).....	24
Table 4. Information extracted from included sources.....	27
Table 5. Indicative mapping table used to synthesise findings.....	30
Table 6. Overview of participating stakeholders.....	32
Table 7. Questions used on the online asynchronous focus group platform	33
Table 8. Outline of the interactive whiteboard	36
Table 9. Key pre-COVID -19 WRMSDs and WRMSD risk factors found in the included literature	39
Table 10. Characteristics of included articles from search A (N=24).....	74
Table 11. Characteristics of included articles from literature search B and grey literature (N=20)	86

Index of figures

Figure 1. The pathways between work-related psychosocial risk factors and WRMSDs	16
Figure 2. The conceptual study framework	18
Figure 3. Overview of the study approach.....	19
Figure 4. Literature review tasks	20
Figure 5. Selection of articles for inclusion	26
Figure 6. Post-it notes on which to write risk factors to be used with the table above	36

1. Introduction

1.1 Background

Work-related musculoskeletal disorders (WRMSDs) are injuries and conditions that are caused or made worse by work, and can affect the back, joints and limbs (1). Approximately 480,000 workers were affected by WRMSDs in Great Britain in 2019/2020, accounting for 30% of all work-related ill health and resulting in 8.9 million lost working days (2). Prior to the COVID-19 pandemic, the rate of self-reported WRMSDs showed a generally downward trend (2). However, the COVID-19 pandemic required rapid changes to working practices and environments at the individual, organisational and national levels to protect people from infection (3,4). These changes may have affected exposure to known WRMSD risk factors and may also have been impacted by the perception that COVID-19-adaptive behaviours were temporary and transitory. There was also the potential for more permanent changes following many months of working/staying at home activities during the COVID-19 pandemic (5–7).

Psychosocial and physical risk factors for WRMSDs

A RAND Europe report for Public Health England (PHE) that explored practices for health and wellbeing at work highlighted that WRMSDs might result from one or more risk factors (8). These can be broadly categorised into individual, physical and psychosocial risk factors; some examples are presented in Table 1 (1,9,10).

Table 1. Types and examples of WRMSD risk factors

Individual risk factors	Physical risk factors	Psychosocial risk factors
<ul style="list-style-type: none"> • Age • Sex • Recent or existing injuries or health conditions 	<ul style="list-style-type: none"> • Prolonged repetitive work • Awkward postures • Vibration (driving or using power tools) • Extreme temperatures • Working with display screen equipment (computers, laptops, tablets, smartphones) • Manual handling (bending, crouching, lifting, pushing, pulling, dragging heavy or bulky loads, stretching, twisting, reaching, applying sustained or excessive force) 	<ul style="list-style-type: none"> • Stress • High workload • Tight deadlines/time pressures • Lack of/low job control • Lack of/low social support • Poor/low job satisfaction • Financial instability/ low job security/

Physical risk factors are variables that may affect a worker’s physiological response to their work and workplace conditions, often relating to their environment and behaviour (11). Psychosocial risk factors are variables that may affect a worker’s psychological response to their work and workplace conditions and relate to the interrelation of psychological and contextual social (e.g. workplace) factors (10). Psychological processes (i.e. mental or emotional) can also contribute to physiological processes such as physical stress/strain, which increases WRMSD risk (Figure 1). Psychological stress can impact WRMSDs through biological and chemical processes, contributing to a short-term stress response (e.g. increased muscular tension or joint swelling) and potentially followed by a long-term stress response (e.g. chronic muscle tension) and ultimately WRMSDs. Stress can also

have cognitive responses (e.g. increased sensitivity to pain), leading to physiological responses (e.g. muscle spasms) and potentially WRMSDs. Also, psychological ill-health (e.g. anxiety and/or depression) can lead to cognitive responses (e.g. reduced pain tolerance), resulting in physiological responses (e.g. reduced movement) and increased risk of WRMSDs.

1.2 Aims

This work aimed to conduct an evidence summary to understand the changing world of work in the UK during the COVID-19 pandemic, the effect that this is having on WRMSDs, and post-pandemic considerations. The evidence summary identified three groups of workers to broadly represent experiences during the pandemic: key workers, furloughed workers, and those who continued in their roles by working from home. We present evidence supporting a better understanding and management of WRMSD risks during COVID-19 and in the future.

Figure 1. The pathways between work-related psychosocial risk factors and WRMSDs

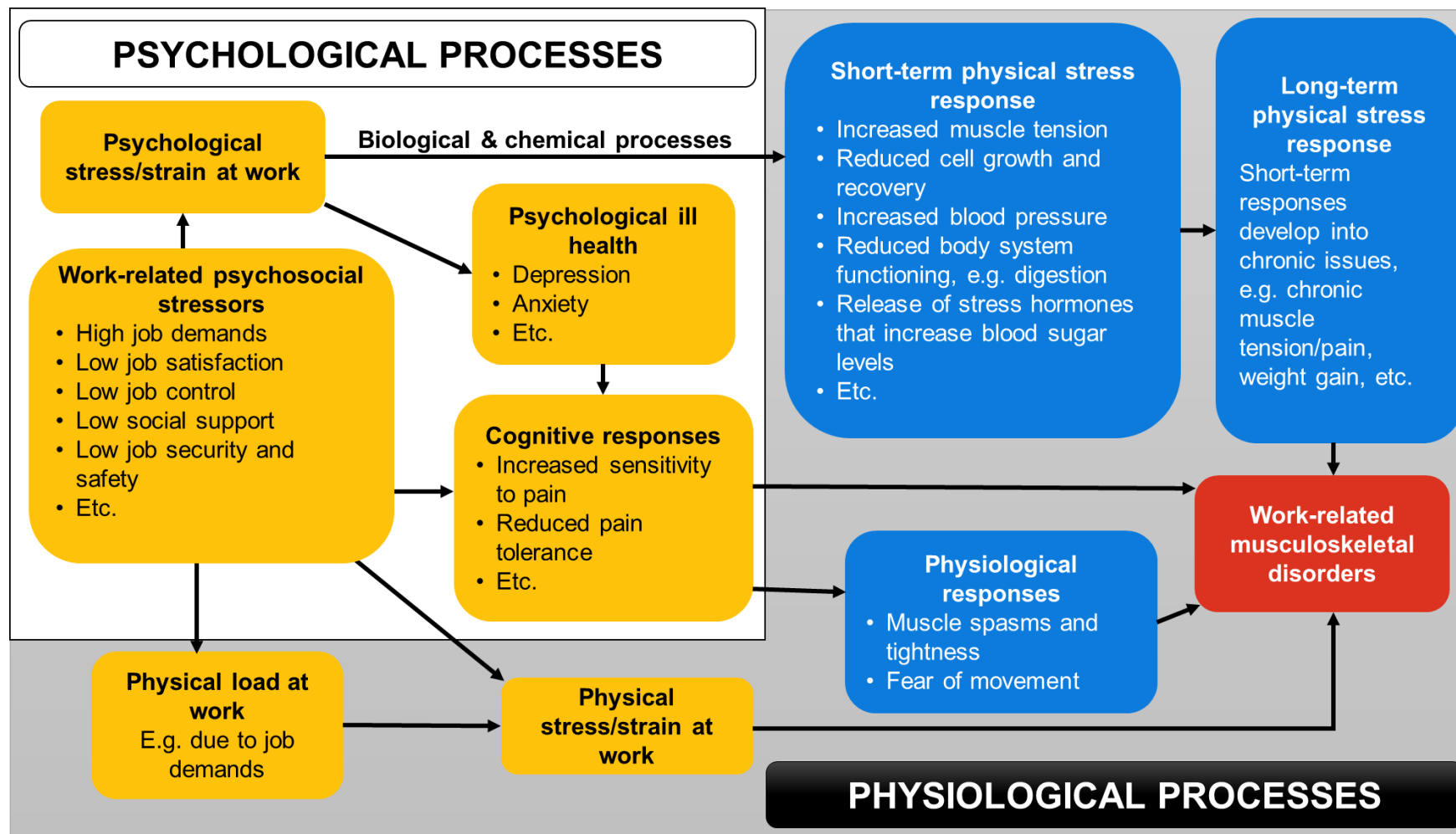


Figure informed by Hauke et al., 2011 (12) and Eatough et al., 2012 (13)

2. Methods

2.1 Research questions and conceptual framework

To meet this study's aims, we sought to understand (i) the risk factors for WRMSDs across different occupations and environments pre-COVID-19, (ii) how COVID-19 changed occupations and work environments, and (iii) how these changes might affect WRMSDs and exposure to WRMSD risk factors. These formed the study's research questions:

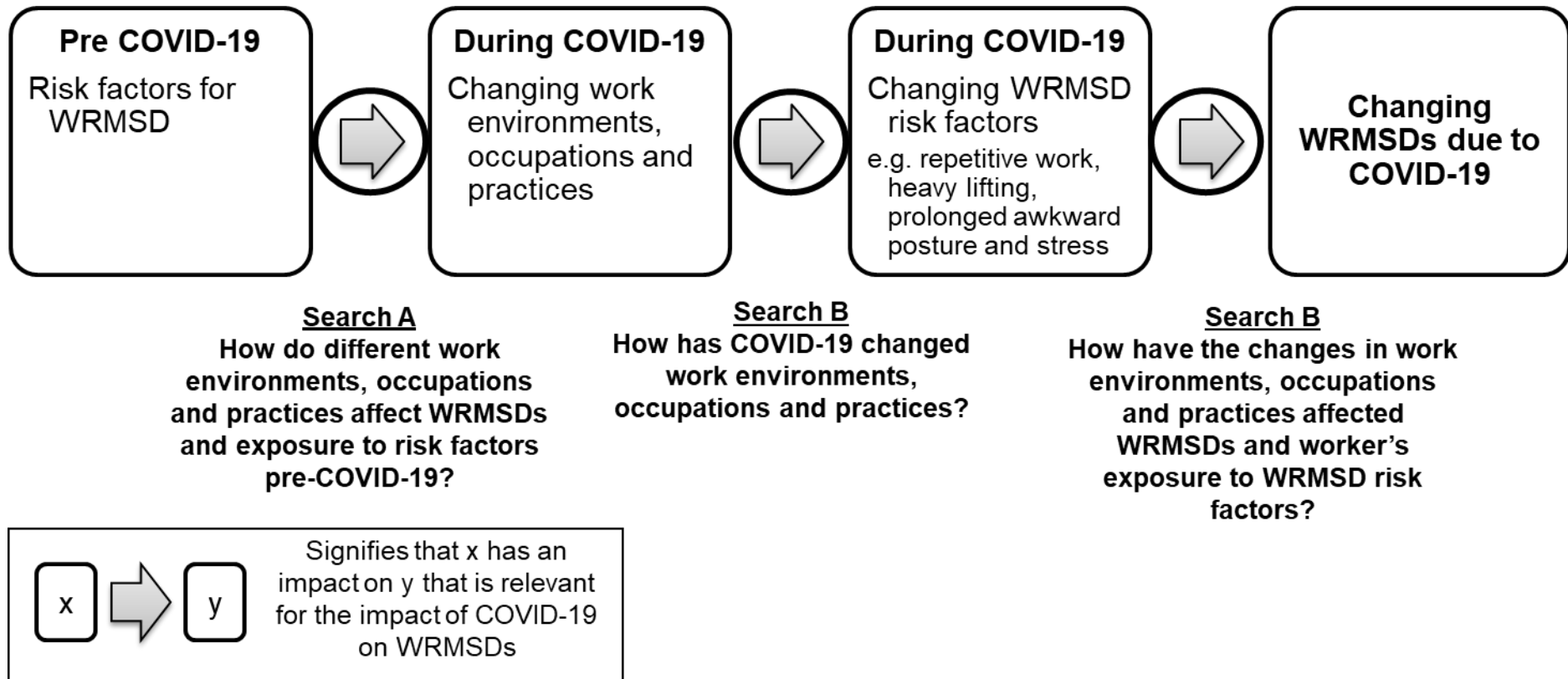
RQ1: How did different work environments, occupations and practices affect WRMSDs and exposure to WRMSD risk factors pre-COVID-19?

RQ2: How has COVID-19 changed work environments, occupations, and practices?

RQ3: How have these changes in work environments, occupations and practices affected WRMSDs and workers' exposure to WRMSD risk factors?

Based on scoping research and in collaboration with our academic advisors, we developed a conceptual framework to structure our thinking about how the COVID-19 pandemic might have affected the current and future world and impacted the risk of WRMSDs. As outlined in Figure 2, our framework examines how COVID-19 may have changed work environments, occupations, and practices and, as a potential consequence, changed workers' exposure to WRMSD risk factors and WRMSDs.

Figure 2. The conceptual study framework



The remainder of this chapter details how we used the chosen research methods to gather the evidence required.

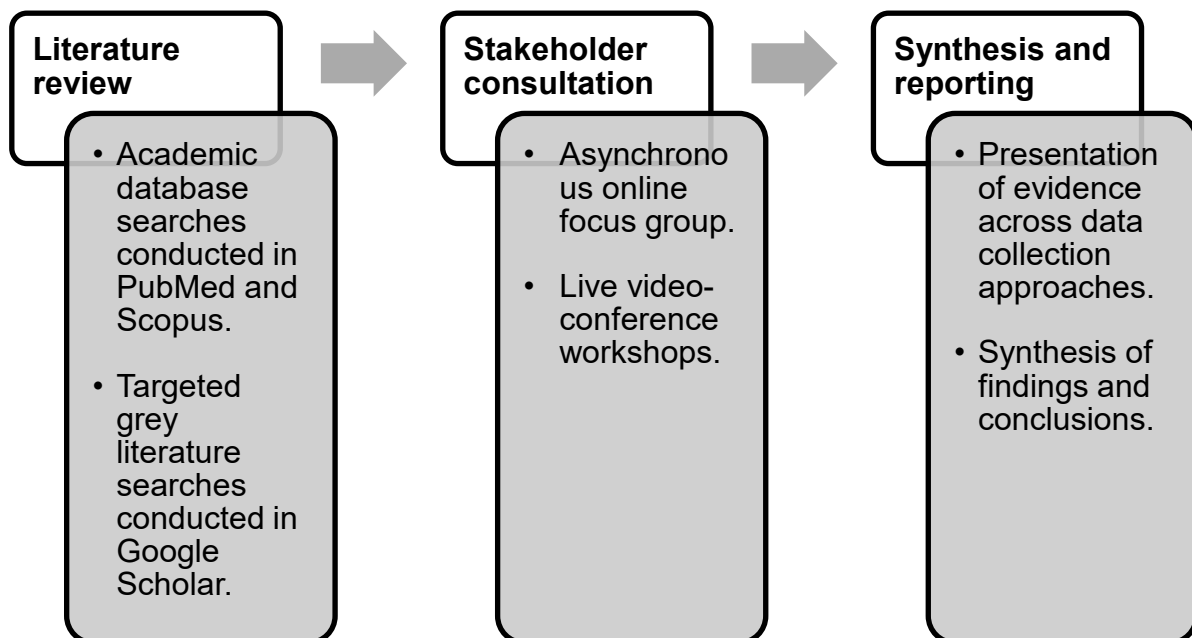
2.2 Overview of the approach

The project was divided into three main work packages:

1. A literature review, comprising two academic database searches and targeted grey literature (e.g., government documents, reports, white papers, newspaper articles, blog posts) searches.
2. A small supporting stakeholder consultation involving a five-day asynchronous online focus group (digital bulletin board) and two 2-hour workshops conducted via video conference.
3. A presentation of findings across the first two work packages (results – section 3), a discussion of the implications (section 4) and a summary of conclusions (section 5).

Figure 3 provides an overview of the study approach.

Figure 3. Overview of the study approach



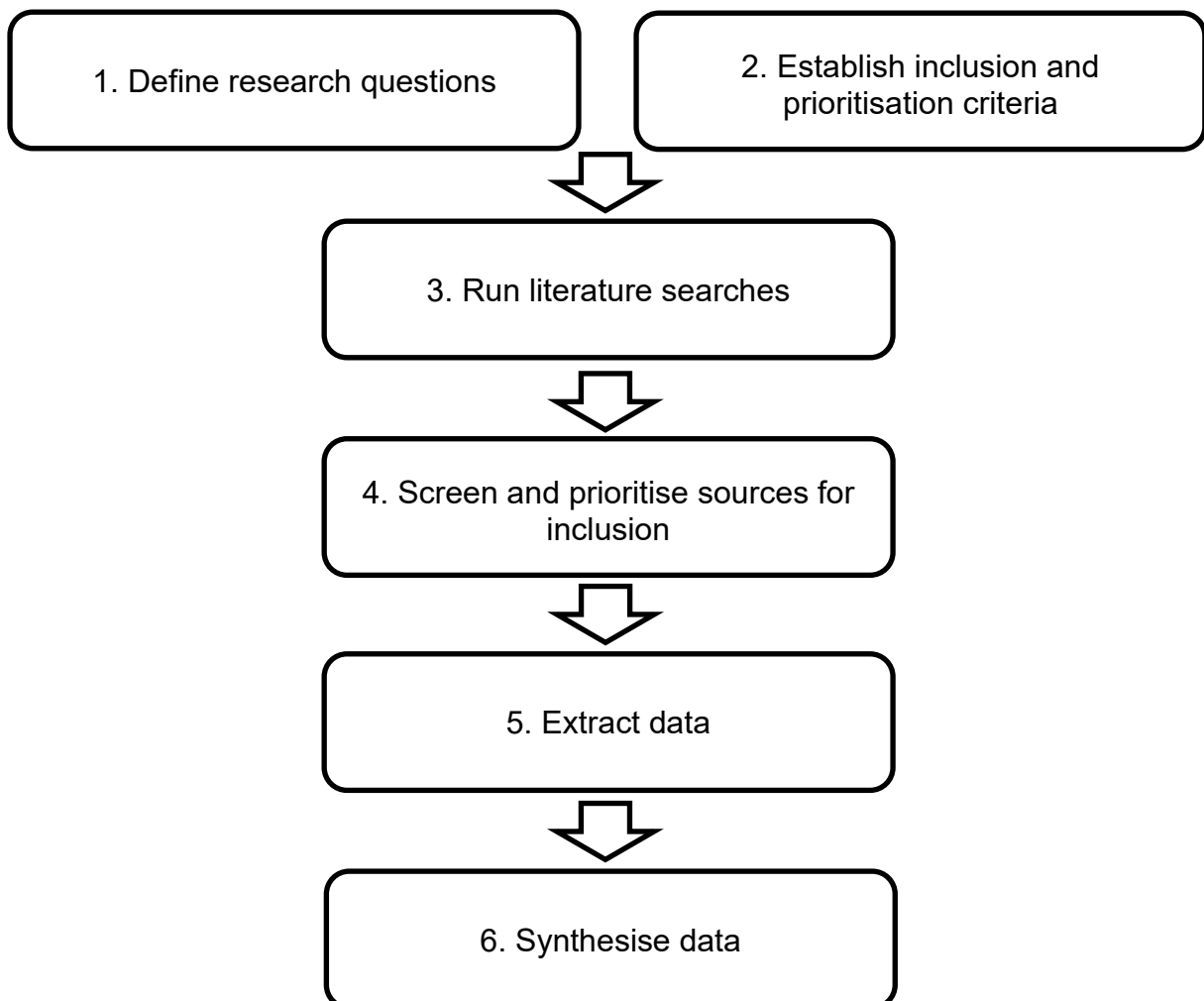
2.3 Literature review

This section describes the methods we employed to search the relevant published scientific studies and grey literature.

Overview of the literature

The literature review comprised six tasks: (1) Defining the question and search strategy, (2) establishing the inclusion criteria for selecting and prioritising sources, (3) running the literature searches, (4) selecting studies via title-and-abstract screening and prioritising relevant sources (5) extracting data, and (6) synthesising data to identify preliminary findings and inform the development of materials for the stakeholder consultation. Figure 4 provides a visual overview of the literature-review process.

Figure 4. Literature review tasks



Defining the research questions and literature review searches

Informed by the conceptual framework presented in Figure 2, we identified two relevant bodies of literature to explore as detailed in Search A and Search B. These combined academic-database searches and targeted grey-literature searches to help answer our research questions:

- Search A: the impact of work environments and practices on WRMSDs pre-COVID-19, both directly and indirectly (via physical and/or psychosocial risk factors). We ran an academic-database search in PubMed and Scopus, limiting it to literature reviews published between 2011 and 2021 due to the volume of material. We focused on answering the following research question:
 - RQ1: How did different work environments, occupations and practices affect WRMSD and exposure to WRMSD risk factors pre-COVID-19?
- Search B: The impact of COVID-19 on changes to work environments and practices, both during the pandemic and looking to the future, based on an academic-database search in PubMed and Scopus, and targeted searches of the grey literature in Google Scholar, limiting it to literature published between 2020 and 2021. We focused on answering the following research questions:
 - (RQ2) How has COVID-19 changed work environments, occupations, and practices?
 - (RQ3) How have the changes in work environments, occupations and practices affected WRMSDs and workers' exposure to WRMSD risk factors?

Inclusion and prioritisation criteria were also determined at this point in the literature review process (described in the below section on 'Source selection').

We provide the search strategies for each search in Appendix A1. Search A (pre-COVID-19) was conducted on 31 March 2021, the academic literature from search B (during COVID-19) was conducted on 12 April 2021, and the grey literature searches from search B were conducted from 27 to 29 April 2021.

Source selection

Sources for inclusion were selected in two phases: (a) an initial screening phase, reviewing the titles and abstracts of all identified sources against the pre-defined inclusion criteria, and (b) a prioritisation phase, selecting sources for inclusion based on pre-defined prioritisation criteria. Given the vast wealth of WRMSD-related literature, prioritisation was necessary to focus available resources on sources of greatest relevance and value to answering the research questions. We also conducted the process to ensure that the final body of included literature covered a wide range of WRMSDs, industries and occupations. Specific inclusion and prioritisation criteria are detailed in Table 2 and 3.

Table 2. Inclusion and prioritisation criteria for sources related to Search A (reviews of the impact of work environments and practices on WRMSDs pre-COVID-19)

	Inclusion Criteria	Prioritisation Criteria
Health topic	Any WRMSD or symptom of WRMSDs (e.g. pain)	No particular WRMSD was prioritised over another, but the final selection of sources aimed to ensure that a variety of WRMSDs were represented in the data
Workplace	Any workplace or occupation	Workplaces and occupations were prioritised according to the combined extent of COVID-19's impact on the industry while maintaining a broad selection of workplaces and occupations in the final dataset
Source type	Any review type published as an academic journal article	Systematic reviews and meta-analyses were prioritised over scoping and narrative reviews
Publication date	2011 to 2021	Articles published more recently were prioritised over older articles (all other things being equal)
Geographical context	Global	Sources focusing on the UK or high-income countries.
Language	English	N/A (only English-language sources were eligible for inclusion)

Table 3. Inclusion and prioritisation criteria for sources related to Search B (the impact of COVID-19 on work environments and practices)

	Inclusion Criteria	Prioritisation Criteria
Health topic	Any WRMSD, symptom of WRMSD (e.g. pain) or risk factor for WRMSD (e.g. physical inactivity, job demands, stress)	Sources explicitly discussing the impact of COVID-19 on WRMSDs were prioritised over those discussing risk factors only. No particular WRMSD risk factor was prioritised over another, but the final selection of sources aimed to ensure that a variety of WRMSD risk factors were represented in the data
Workplace	Any workplace or occupation	Workplaces and occupations were prioritised according to the combined extent of COVID-19's impact on the industry while maintaining a broad selection of workplaces and occupations within the final dataset
Article/ study type	Any academic or grey literature source	Empirical studies were prioritised over opinion pieces; grey literature reports and blog posts from expert/authoritative sources were prioritised over newspaper/magazine articles
Publication date	2020 to 2021	Articles published more recently were prioritised over older articles (all other things being equal)
Geographical context	Global	Sources focusing on the UK or high-income countries
Language	English	N/A (only English-language sources eligible for inclusion)

We conducted two searches of academic databases. Search A (pre-COVID-19 literature) returned 2506 unique articles, and search B (during COVID-19) returned 1756 unique articles, totalling 4262 articles for screening (Figure 5). Two researchers worked together to complete both stages of study selection. For both academic database searches, each researcher independently screened the same 100 titles and abstracts for inclusion or exclusion. They then compared their

decisions and discussed any discrepancies, with more than 95% agreement after the initial screening and 100% agreement after a brief discussion to establish a united approach. Screening of the grey literature (e.g. government documents, reports, white papers, newspaper articles, blog posts) was initially completed by one researcher and then checked by the second for time efficiency. Sixty-eight unique grey literature sources were screened.

Prioritisation followed a similar approach. Both researchers independently reviewed all titles and abstracts identified as potentially relevant against the prioritisation criteria, selecting a feasible set of sources to extract within the study timeline. After comparing their results, the two researchers discussed and ranked their respective sources against the prioritisation criteria to agree on a shortlist of sources. This shortlist was then shared with the study's academic expert advisors, whose comments were used to finalise which sources to include. A total of 44 articles were included in the literature review: 24 from Search A, 20 from Search B (10 published scientific studies, 10 grey literature) – see Figure 5.

Data extraction

We extracted data from each included source into one of two data-extraction templates, tailored either to Search A or Search B. Table 4 (below) summarises the information extracted from each source, with full data-extraction template headings available in Appendix A2.

Figure 5. Selection of articles for inclusion

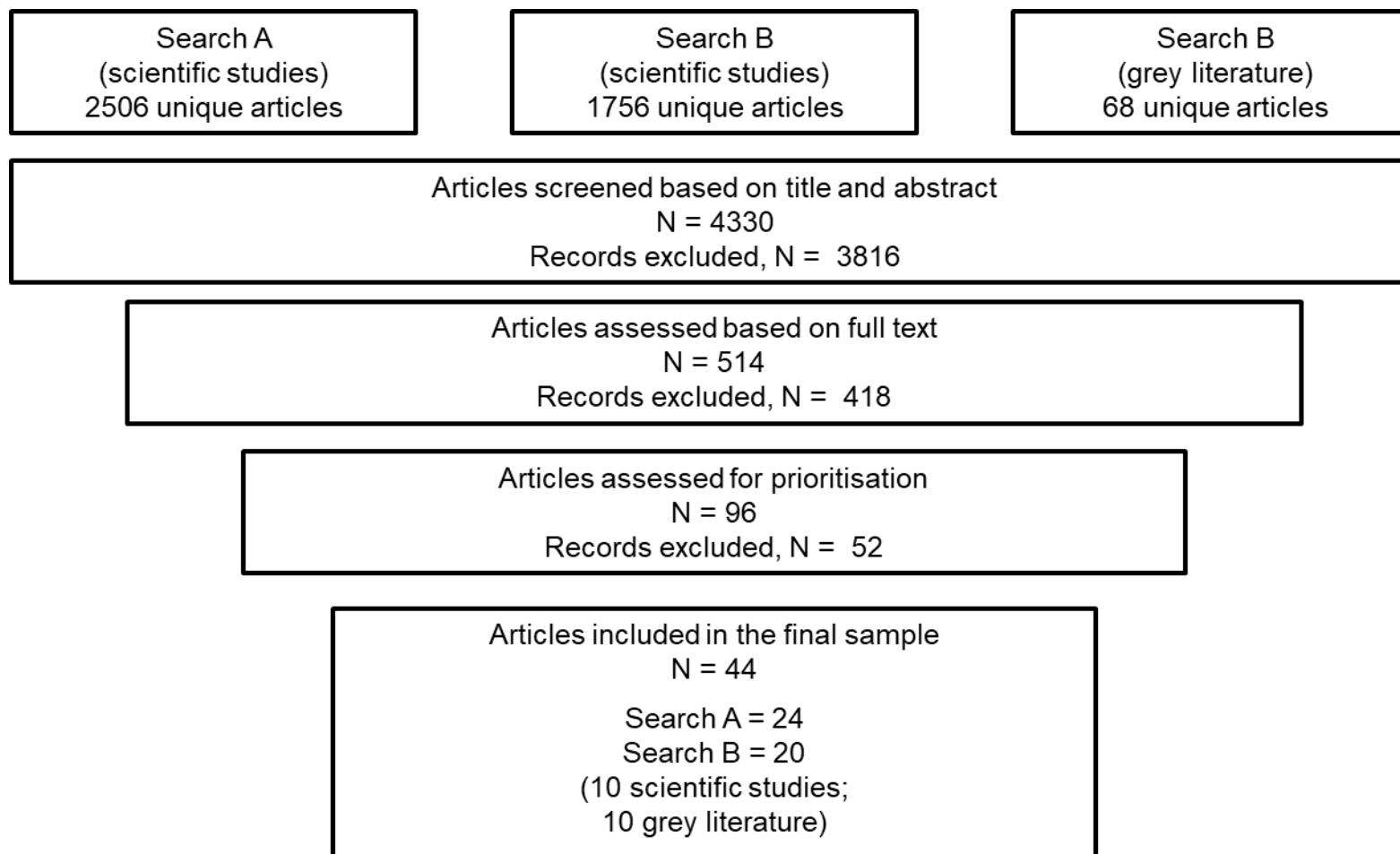


Table 4. Information extracted from included sources

Search	A: What impact do work environments and practices have on WRMSDs?	B: What impact has COVID-19 had on work environments and practices?
Extracted Information	<ul style="list-style-type: none"> • Article information (e.g. publication year, source type, study type, source/study aims, relevant outcomes, number and type of studies/participants, analysis employed) • Geographical setting • Population (i.e. industries, job types and specific occupations) • Overview of WRMSDs discussed and their prevalence in the population of interest • WRMSD risk factors related to the physical work environment • WRMSD risk factors related to the psychosocial work environment • WRMSD risk factors related to other aspects of work • Source quality, strengths and limitations (both as reported by source authors and as assessed by the reviewer) • Recommendations (both for supporting/protecting workers and for future research) • Any other relevant information or reviewer comments 	<ul style="list-style-type: none"> • Article information (e.g. publication year, source type, study type, source/study aims, relevant outcomes, number and type of studies/participants, analysis employed) • Geographical setting • Population (i.e. industries, job types and specific occupations) • Overview of WRMSDs discussed and how COVID-19 has affected them • How COVID-19 has affected physical WRMSD risk factors • How COVID-19 has affected psychosocial WRMSD risk factors • How COVID-19 has affected other WRMSD risk factors • Source quality, strengths and limitations (both as reported by source authors and as assessed by the reviewer) • Recommendations (both for supporting/protecting workers and for future research) • Any other relevant information or reviewer comments

We conducted a pilot extraction exercise to ensure that the two researchers doing the data extraction were consistent in their interpretation and use of the extraction template. For the pilot extraction exercise, both researchers independently extracted data from the same four sources (two from each search). They then compared their completed templates to verify they were extracting the same data and that neither was missing relevant information. One researcher then reviewed each source and extracted relevant data following discussion and agreement on what to include.

Data presentation

We combined data from the literature review using a framework synthesis approach which uses pre-defined thematic categories to organise data into a matrix for analysis. We organised our findings (section 3) around three main groups affected differently by COVID-19:

- *The key worker population:* employed in essential industries such as health, social care, education, transport, essential public services, public safety, and food production and distribution. With some exceptions, these workers continued their roles as usual (though often with added pressures caused by the pandemic) (14).
- *The work-from-home population:* able to conduct most, if not all, of their job requirements from home. This group primarily comprises desk workers (15).
- *The furloughed population:* unable to work, with their employment activities paused or significantly reduced during the pandemic. Many remained on 80% of their salary during this time (16). We focused on furloughed workers from key industries where many workers were furloughed, including hairdressers, cabin crew, and hospitality staff.

Worker types were allocated to each group in consultation with our academic advisors and based on role distinctions evident in the literature.

Key findings from the literature review were organised into a mapping table, as shown in Table 5 which presents a blank mapping table. This process helped

identify evidence gaps, informing priority areas to cover in the subsequent supporting stakeholder consultation activities.

Table 5. Indicative mapping table used to synthesise findings

	Overview of WRMSD in population	Physical risk factor: Posture	Physical risk factor: lifting or carrying	Physical risk factor: Etc.	Psychosocial risk factor: Job stress	Psychosocial risk factor: Lack of support	Psychosocial risk factor: Etc.
Key worker							
Example: Farming							
Example: Nursing							
Etc.							
Work-from-home							
Example: Desk workers							
Furloughed							
Example: Cabin crew							
Example: Catering							
Etc.							

2.4 Stakeholder consultation

We conducted two small supporting stakeholder consultations to (a) better understand the impact of COVID-19 on WRMSDs and their risk factors in key industries not yet reported on in the literature, and (b) explore gaps in the research evidence along with any emerging insights from the evidence summary. We conducted the first stakeholder consultation via an asynchronous online focus group and the second via live workshops. An asynchronous online focus group is a digital bulletin board that is open for a set number of days whereby a moderator/

researcher posts a question and participants can respond multiple times, day or night, until the focus group closes (17). This section describes the methods used to recruit and engage relevant stakeholders in the consultations.

Recruitment

Our stakeholder recruitment aimed to capture a diversity of sectors while engaging individuals with a direct understanding of COVID-19 related occupational health (OH) issues, e.g. company OH therapists or health-and-safety (H&S) leads (Table 6). We aimed to recruit stakeholders from sectors significantly affected by COVID-19 and those for which there was little evidence from the literature review. We recruited stakeholders through the extended networks of our team and academic experts, all of whom are senior experts in health-and-wellbeing research and policy in the UK. They were thus able to recommend and connect individuals well-suited to the focus group and workshops' needs. We invited all stakeholders to participate in the asynchronous focus group and the live workshop.

Of the 17 stakeholders invited, 15 participated in the asynchronous focus group and/or one of the live workshops. Table 6 provides an overview of participants' industries and job roles by engagement activity. Overall, participants represented organisations of various sizes from the following sectors: manufacturing, construction, transport, logistics, healthcare, banking, local government, pharmaceuticals and academia. Public-sector stakeholders included the National Health Service (NHS), local government, and public transport.

Table 6. Overview of participating stakeholders

Industry	Role	Participated in asynchronous focus group	Participated in live workshop
Academia	Academic lead and project specialist in health, work, and wellbeing	Y	Y
Banking	Programme Director	Y	Y
Construction	Executive Director focusing on wellbeing and safety	Y	Y
Construction	Head of Health, Safety and Environment	Y	
Health provider	Specialist occupational health physiotherapist	Y	Y
Health provider	Specialist occupational health physiotherapist	Y	
Health provider	Specialist occupational health physiotherapist	Y	Y
Local Government	Occupational Health & Well-Being Manager	Y	Y
Logistics, shipping, and courier services	Health & Safety Director		Y
Logistics, shipping, and courier services	Head of Safety		Y
Manufacturing	Head of HR	Y	Y
Pharmaceuticals	Health, Safety & Environment Head	Y	Y
Trade Unions	National Health & Safety Officer		Y
Transport	Head of Health & Wellbeing		Y
Transport	COVID-19 response manager	Y	Y
	Total participants	11	13

Asynchronous online focus group

Stakeholders were invited to participate in an online asynchronous focus group that was live for 5 working days (seventeen stakeholders were invited, of which 11 participated). The asynchronous focus group allowed the research team to gather some initial information from stakeholders to draw upon during the live workshops and enabled two stakeholders who could not attend live workshops to participate in the study. The asynchronous focus group was a semi-structured group discussion within a virtual message board, supported by the VisionsLive online platform (18). The research team posted pre-formulated questions onto the board before the live period started, enabling participants to reply at any point while the platform was live. This set-up meant that participants could join and leave the platform at times that were convenient for them. Participants could either answer in a questionnaire-style format (independently of other participants) or engage in a more interactive discussion/dialogue by replying to other respondents' answers. A research team member monitored board engagement, provided practical support, posted follow-up questions to prompt further thinking and sent out summary messages and reminders to the participants. The final questions are presented in Table 7 below.

Table 7. Questions used on the online asynchronous focus group platform

	Question	Response format
Question 1.1	How well do you feel you are aware of the WRMSD risks for your employees who are/were working as usual?	Multiple-choice response: <ul style="list-style-type: none">• not at all• not well• some of them• well• very well• not applicable Participants were also given the option to provide a supporting text answer to their multiple-choice response if they wished.

<p>Question 1.2</p>	<p>How well do you feel you are aware of the WRMSD risks for your employees who are/were working remotely?</p>	<p>Multiple-choice response:</p> <ul style="list-style-type: none"> • not at all • not well • some of them • well • very well • not applicable <p>Participants were also given the option to provide a supporting text answer to their multiple-choice response if they wished.</p>
<p>Question 1.3</p>	<p>How well do you feel you are aware of the WRMSD risks for your employees who are/were furloughed?</p>	<p>Multiple-choice response:</p> <ul style="list-style-type: none"> • not at all • not well • some of them • well • very well • not applicable <p>Participants were also given the option to provide a supporting text answer to their multiple-choice response if they wished.</p>
<p>Question 2.1</p>	<p>Have you observed any change in WRMSDs, any new WRMSD risk factors, or any change in employee behaviours that might impact WRMSD risk regarding workers who continued as normal during COVID-19?</p>	<p>Open-text response</p>
<p>Question 2.2</p>	<p>Have you observed any change in WRMSDs, any new WRMSD risk factors, or any change in employee behaviours that might impact WRMSD risk regarding workers who switched to remote working during COVID-19?</p>	<p>Open-text response</p>

Question 2.3	Have you observed any change in WRMSDs, any new WRMSD risk factors, or any change in employee behaviours that might impact WRMSD risk regarding workers who were furloughed during COVID-19?	Open-text response
Question 3	If your organisation had a return-to-work period after a COVID-19 lock-down, what did you see regarding WRMSDs or risk factors for WRMSDs?	Open-text response
Question 4	Has your organisation changed any WRMSD risk mitigation measures as a result of COVID-19?	Open-text response
Question 5	In the future, how easy will it be to identify and address WRMSDs or WRMSD risk factors?	<p>Multiple-choice response:</p> <ul style="list-style-type: none"> • easier • the same • harder • not sure <p>Participants were required to provide a supporting text answer to their multiple-choice response.</p>

Live workshops

A total of 13 participants took part in a live online workshop to better understand the impact of COVID-19 on WRMSDs and their risk factors in key industries not yet reported on in the literature and to explore research gaps and insights. We undertook the same online workshop twice to capture as many stakeholders' views as possible (with 9 participants in the first and 4 in the second).

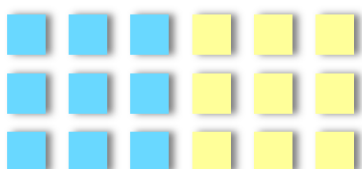
We organised the workshop in two parts. In the first part, the research team introduced the topic, outlined the workshop's practicalities and presented the main findings from the literature review and the asynchronous focus group. In the second

part, we invited participants to comment on the findings and add new thoughts as part of a facilitated discussion supported by an interactive whiteboard. Table 8 (below) outlines the interactive whiteboard's format.

Table 8. Outline of the interactive whiteboard

	Risk factor reduced	No evidence of risk factor change	Risk factor increased
Key-worker population			
Work-from-home population		Boxes in which to place risk factor post-it notes according to row and column headings	
Furloughed population			

Figure 6. Post-it notes on which to write risk factors to be used with the table above



Where appropriate, we used breakout groups and an anonymous voting exercise (where participants indicated in the software which five risk factors were of top priority in their opinion) to encourage all attendees' active participation.

3. Results

This section presents the findings from the literature review (published scientific studies and grey-literature searches) and supporting stakeholder consultation exercise (the asynchronous online focus group and live workshops) without any author discussion or commentary. We included a total of 44 articles in the literature review (24 from Search A, 20 from Search B). Section 3.1 reports the results of our literature review identifying the salient WRMSD risk factors (Search A) pre-COVID-19. Section 3.2 describes how COVID-19 impacts those risk factors and WRMSDs (Search B and stakeholder consultation). Section 3.3 reports future considerations for how COVID-19 might continue to impact on WRMSDs.

Within each sub-section, the results are organised by job type regarding the impact of COVID-19 on work environments and practices, i.e. key workers, the work-from-home population, and furloughed workers. We intentionally selected the occupational groups presented here to represent different industries and the three worker populations as fully as possible based on the literature available. As health workers were over-represented in the literature, we only selected some examples to represent this sector. Since office workers were the dominant group represented in the literature as working from home during the pandemic, we present them as the work-from-home population.

3.1 WRMSDs and WRMSD risk factors (pre-COVID-19)

Overview

The first phase of the literature review (Search A) investigated WRMSDs and WRMSD risk factors pre-COVID-19 for each worker population of interest (i.e. key workers, those working from home, and furloughed workers), answering research question 1. Findings from Search A supported later research phases into how these might have been impacted by changing work practices related to the COVID-19 pandemic.

Search A initially included 23 academic review articles published between 2011 and 2021. Since none of the included reviews represented the agricultural industry, we

followed expert academic advice and included a 2002 review contributing WRMSD knowledge on this industry, making 24 published scientific studies in total. Appendix A3 details the characteristics of the articles included from Search A. Table 9 provides an overview of the literature findings relating to commonly reported WRMSDs and risk factors pre-COVID-19.

Table 9. Key pre-COVID-19 WRMSDs and WRMSD risk factors found in the included literature

Key WRMSDs reported	Physical risk factors	Psychosocial risk factors
Upper limbs (shoulder, neck, arms, wrists, hand, fingers)	<ul style="list-style-type: none"> • prolonged work with arms overhead • repetitive movements • heavy lifting • computer use • awkward postures 	<ul style="list-style-type: none"> • general work stress • high job demands • time pressure • low job satisfaction • ‘boring’ work • insufficient social support • lack of control over decision-making
Low back pain	<ul style="list-style-type: none"> • lifting • working long hours • prolonged standing • walking on uneven ground • regular heavy lifting • vibrations • awkward postures • repetitive movements • inappropriate furniture • intense physical exertion • computer use 	<ul style="list-style-type: none"> • high/increasing job demands • work-life imbalance • lack of social support
Hip/knee osteoarthritis	<ul style="list-style-type: none"> • prolonged standing • walking on uneven ground • regular heavy lifting • vibrations • awkward postures 	<ul style="list-style-type: none"> • none reported

Some identified articles were not specific to a job type and were applicable across multiple industries (19–29). Physical risk factors mentioned included physical strain and high-frequency tool use (20), manual handling (e.g. lifting, awkward postures, vibration, repetitive movements, arm elevation, force, shoulder load, kneeling, squatting, standing, walking, climbing, carrying/lifting)(21–28), awkward postures (25,26,30) and computer use (22). Psychosocial risk factors mentioned included psychological job strain (12,19,20), social support, decision latitude, job control and job security (12,26).

WRMSDs and WRMSD risk factors by worker type

The key worker population

Key worker occupations represented in the pre-COVID-19 literature included healthcare, food production and distribution, manufacturing, construction, waste collection, agriculture, and education. Articles on other key worker industries, such as transport, were not identified in the literature search.

Farmworkers appear to have a higher risk of experiencing hip osteoarthritis, knee osteoarthritis and lower back pain (31), with risk factors including prolonged standing and walking on uneven ground, regular heavy lifting, and vibration from tools and tractor driving (31). Additional risks for tractor drivers include the awkward postures required to climb in and out of the cabin and twist in the driver's seat (31). The upper limb musculoskeletal health of orchard farmers, glasshouse workers and foresters are impacted by prolonged overhead work. Similarly, the high prevalence of arm pain in dairy workers is likely influenced by repetitive milking movements and lifting heavy milk cans (31).

Manufacturing workers may be put at particular risk by lean production approaches geared heavily towards minimising waste and maximising productivity (32). High intensity, fast-paced work with little built-in recovery time creates a physical environment conducive to upper-limb extremity WRMSDs. High stress levels and pressure from colleagues to continue working when in pain fosters a psychosocial environment that does the same (32). The high prevalence of lower back disorders

among waste-collection workers and construction workers is similarly associated with the role's physical demands, including prolonged and repetitive manual handling, awkward postures, lifting and vibration (30,33).

Teachers were another key worker group with a high prevalence of WRMSD, particularly neck and/or shoulder pain (34). Contributory risk factors include long working hours, extended periods of standing, inappropriate furniture, and, particularly in the case of teachers working with younger children, time in unnatural postures such as kneeling, stooping, squatting and bending (34).

WRMSDs were also associated with physical and psychosocial risk factors among healthcare key workers, including in systematic reviews focusing specifically on nurses (35) and workers in the elderly care industry (36). Nurses' upper limbs WRMSDs (shoulders, neck, arms, wrists, hands and fingers) increased with general work-related stress, high job demands, time pressure, low job satisfaction, 'boring' work, and, to a lesser but still measurable extent, insufficient support and lack of decision latitude (35). The most significant associations were between:

- job stress and neck/shoulder WRMSDs
- time pressure and wrist/hand WRMSDs
- 'boring' work and wrist WRMSDs
- insufficient support and shoulder WRMSDs (35)

Similar psychosocial factors contributed to WRMSD among people working in elderly care homes – specifically low back pain (36). Factors included high or increasing job demands, disconnect between effort and reward, poor work-life balance, lack of social support, and/or poor working relationships, and conflict with colleagues or elderly patients/residents (36). Job strain, defined as a combination of high demands and low control in the work environment (37), was strongly associated with back and shoulder injuries (36). In addition, care workers reported that assisting residents (e.g. dressing residents and transferring them from bed to wheelchair) and working long shifts increased the risk of low back pain, attributing them to a lack of lifting equipment and frequent lone working (36).

The work-from-home population

Evidence on work-from-home occupations was extremely limited in the pre-COVID-19 literature. As most workers required to work from home during the pandemic were likely to use computers, we used office workers to represent this population's pre-COVID-19 WRMSD risk factors and WRMSDs. Commonly reported pre-COVID-19 WRMSDs among office workers included discomfort or pain in the back, neck, shoulders, elbows, forearms, wrists and hands (38,39). These were likely due to poor posture and prolonged computer, keyboard and mouse use without breaks (38).

Workers from industries furloughed due to the COVID-19 pandemic

People from industries primarily furloughed during the pandemic (e.g. hairdressers, cabin crews and hospitality staff) commonly reported WRMSDs related to the lower back, neck and upper back and shoulders, hands and wrists. This was especially evident in those who worked in allied health professions, such as sports and massage therapists (40), and non-essential services such as hairdressing (41). For those in catering or hospitality, the lower back, neck, shoulder, elbow, upper leg and ankle/foot were the most frequently affected body parts (42). Many of these physical occupations' WRMSD risk factors relate to manual handling, joint loading, lifting/carrying heavy loads, awkward postures, forward flexion and backward extension of the torso, twisting motions, working in the same position for long periods, and repetitive movements (40–42). Stress was also reported as a causal factor for WRMSDs (40), alongside burnout and low social support (41).

3.2 The impact of COVID-19 on WRMSD risk factors and WRMSDs

Overview of findings

Results presented in this section are from Search B of the literature review and supporting stakeholder consultation, which investigated the impact of the COVID-19 pandemic on WRMSD risk factors and WRMSDs. We included 10 academic articles published in 2020 or 2021 (up to April) and 10 highly relevant sources (e.g. reports and blogs) from the targeted grey literature searches (all published in 2020),

totalling 20 included sources. Characteristics of the included literature from Search B are provided in Appendix A4.

Findings from the literature review and supporting stakeholder consultation refined by risk-factor and worker type

Physical risk factors

The key-worker population

There was some limited evidence suggesting that WRMSD risk factors increased during the pandemic for key workers (43–45). For example, suboptimal posture when conducting scans is a WRMSD risk factor for sonographers. During the COVID-19 pandemic, sonographers had to transport their equipment and perform examinations in rooms not designed for this purpose and reported taking less time to optimise their ergonomic set-up during the pandemic (45), increasing their risk of WRMSDs. The pandemic also increased WRMSD physical risks experienced by haulage drivers, most significantly through a relaxation of restrictions that have allowed them to work longer hours with inadequate periods of rest (43,44).

Stakeholders also suggested several other physical risk factors increased, for example warehouse workers manual handling levels and the time healthcare workers spend on their feet.

The work-from-home population

There was some limited evidence suggesting that physical WRMSD risk factors increased for those working from home (46–48). Many workers across different industries were required to work from home during the pandemic, typically involving computer work similar to that of office workers pre-COVID-19. We could not break down results by industry or job as this information was unavailable in the literature. However, the most commonly mentioned physical risk factors were related to ergonomics and posture. Examples included non-adjustable chairs and working surfaces (48) (46) and unsuitable physical environments (e.g. temperature, lighting) (46,47).

Many stakeholders suggested that poor set-ups were partly due to a 'short-term mindset', with people initially believing that working from home would only be short-term and thus proper ergonomic equipment was unnecessary. Therefore, workers may have persevered with less-than-adequate equipment, e.g. unsuitable chair and/or monitor heights and sub-optimal home working conditions. Some stakeholders suggested that some employers may not have considered sub-optimal homeworking conditions and thus may have neglected to provide adequate support. However, other stakeholders noted that some employees may have benefited from increased methods to support homeworkers (e.g. desk assessments undertaken remotely) and the expanded availability of online resources related to home office set-ups.

Participants in the asynchronous focus group suggested that some workers might take fewer breaks and have more back-to-back virtual meetings, meaning they may be sedentary for long periods throughout the day without changing postures. Although some stakeholders reported that their organisations encouraged staff to stretch and even exercise during some meetings, others felt this would not be culturally acceptable within their organisation. Some stakeholders changed hour-long meetings to 45 or 50 minutes to ensure 'back-to-back' meeting cultures did not interfere with staff breaks and movement.

The furloughed population

There was limited evidence from the literature of increased risk of physical risk factors for WRMSDs for furloughed workers (46,47). According to the literature, many furloughed employees reported declines in their physical health, primarily due to reductions in physical activity and changes to their usual routine (49,50). Workers who engaged in repetitive movements, prolonged and/or awkward postures, or work with raised hands and arms may have experienced physical deconditioning due to being furloughed and the potential for increased risk of WRMSDs on return to normal work (49,51).

There was mixed evidence from the small supporting stakeholder engagement about the impact of COVID-19 on physical risk factors for furloughed workers. Some stakeholders suggested that furloughed workers may have experienced

physical deconditioning due to reduced physical activity and a more sedentary lifestyle. For example, some workers had an entirely or partially active commute before the pandemic (e.g. walking or cycling), which disappeared during the pandemic. Conversely, other stakeholders highlighted furloughed workers who returned to work healthier, with a reduced risk of WRMSD, as they prioritised their health during furlough.

Psychosocial risk factors

The key worker population

There was consistent evidence to suggest that psychosocial risk factors for WRMSDs increased among key workers during the pandemic (43,44,52–58). A systematic review of 59 studies involving 54,707 healthcare workers tentatively concluded that sleep problems in this population have increased (54). Occupational stress levels among healthcare workers were also affected by increased workloads and work-related pressures, often accompanied by rotation schedules that did not allow adequate rest and restoration between shifts (54,55). Healthcare workers were also rotated to the frontline and assigned new responsibilities contributing to the pandemic response. The resulting job unfamiliarity created additional stress, increasing WRMSD risk factors (54) (see Figure 1 in Section 1.1 for an overview of how work-related stress may contribute to WRMSDs). Taking on extra work and roles was also seen in education, with educators providing emotional support and extra help to students, often impeding their own free-time and/or family time (55).

A survey of 152 nursing-home staff identified similar psychosocial stressors to those reported by healthcare workers (58). This group, which typically endures lasting staff shortages and high rates of burnout, reported pandemic-related physical and mental fatigue due to increased workload, new responsibilities and the emotional burden of caring for isolated residents (58). These changes occurred in a social climate where many respondents reported feeling undervalued (58). Staff also reported stress due to the fear of infection, exacerbated by shortages of personal protective equipment (PPE) (58).

Psychosocial risk factors for WRMSDs also increased in many other key worker professions. Police officers (56), retail workers (57), haulage drivers (43,44) and warehouse workers (52) all faced the stress of working with potential exposure to the virus. Police officers experienced additional stress responding to changing regulations and enforcing unpopular lockdown restrictions (56), leading to increased abuse from the public in some cases, as was also experienced by shopworkers. The Union of Shop, Distribution and Allied Workers (USDAW) reported more than double the rate of assault, threatening behaviour or abuse towards shop workers during the first month of the pandemic than in 2019 (57). Out of nearly 5,000 shopworkers responding to USDAW's survey, 196 reported being physically assaulted (57). However, despite the well-documented relationship between workplace assault and WRMSDs, the underlying mechanisms are less clear (59). While some assaults may result in direct physical damage, psychological responses such as stress and anxiety are most likely responsible for resulting WRMSDs in many cases (59).

For some key workers (e.g. haulage drivers, police officers, and retail workers), the pandemic exacerbated existing risk factors in their usual work environments. For example, the transition from classrooms to online education caused a fundamental change in teachers' work settings and practices. One study of 40 teachers found that time spent using technological devices increased significantly during the pandemic, and depression symptoms and work-life balance significantly worsened (53).

Stakeholders repeatedly mentioned psychosocial risk factors for WRMSDs in the asynchronous focus group and live workshops, highlighting a perceived deterioration in key workers' general mental health and increased stress, anxiety and depression. Most stakeholders reported that key workers' workload intensities had typically increased during the pandemic. The asynchronous focus group data pointed to a general increase in demand for the services provided by key workers such as healthcare workers and delivery drivers, often coupled with workers taking on extra shifts to cover for ill or isolating colleagues.

Several stakeholders suggested that health and safety considerations for key workers became more focused on limiting COVID-19 transmission, temporarily de-

prioritising more traditional health and safety measures. For example, one transport representative reported more slipping and tripping in the last year than during the previous three years and more workplace injuries in transport-related construction, suggesting this had been more common when construction was paused and then resumed.

The work-from-home population

The literature also provides consistent evidence that psychosocial risk factors for WRMSDs increased for those working from home, including perceptions of excess work pressure and insufficient time to get work done (48,60–62). Some stakeholders felt that the ‘emergency mindset’ many homeworkers experienced early in the pandemic exacerbated increased working hours, with people initially working longer hours because it felt like a temporary situation. However, workers may not have transitioned out of this ‘emergency’ thinking, thereby losing perspective on their excessive workload. In addition to the links between work-related stress and WRMSDs outlined in Figure 1 of Section 1.1, stakeholders suggested the stress might also contribute to stooped postures and muscular tightness.

Some stakeholders suggested that people working from home might have been sleeping more poorly than before and feeling increased exhaustion due to worry and/or long and irregular working hours. They highlighted that the boundaries between home-life and work-life may have blurred, leaving workers more prone to stress and anxiety. One example given was the absence of a commute for homeworkers, which may have made switching on/off from work more difficult.

Conversely, some stakeholders mentioned that homeworking gave employees more autonomy over their work-life balance, reducing stress and improving overall mental health. They reported that some workers used the extra time in their day to engage in WRMSD risk-reducing behaviours such as exercise. Others mentioned that the pandemic spotlighted WRMSD risks, creating a more open culture for discussing WRMSD issues with colleagues and managers.

The furloughed population

Limited evidence suggested that psychosocial risk factors increased for furloughed workers (50,63). Many furloughed workers reported that their mental health declined during the pandemic, which they attributed to financial concerns, fear of job loss, stress, missing their normal routine and spending more time alone (50,63). Some stakeholders mentioned that staff may have experienced poor mental health while furloughed. However, a minority reported that their staff coped well. Across most industries represented, stakeholders reported furloughed staffs' concerns about their job security. They commented that many furloughed workers may have been anxious about returning to work, particularly regarding COVID-19 risks and new practices and requirements in the workplace.

WRMSD symptoms

Our review found minimal evidence about WRMSD symptoms in workers (45,49,53,60). The available evidence is summarised below.

The key worker population

In a survey of conference attendees, 89% reported that their key workers experienced the same or significantly increased muscular discomfort during the pandemic (49). A survey of 68 cardiac sonographers found that 22% experienced more or worse WRMSD symptoms during the pandemic than before (45).

Teachers, who were largely required to teach online from home, reported increased musculoskeletal discomfort and lower back pain disability (53).

The work-from-home population

One study reported an increase in WRMSD symptoms in people working from home since the pandemic began, particularly in neck, shoulder and back symptoms (60). Stakeholders also reported an increase in WRMSD symptoms associated with poor work-from-home set-ups.

The furloughed population

No studies reported explicitly on WRMSD symptoms in furloughed workers. One reported that 95% of survey respondents expected WRMSDs to either stay the same or increase once all employees returned to work (49). Some stakeholders reported that older workers appeared to experience less musculoskeletal pain while furloughed, possibly because they had more time for exercise. However, one clinician reported a higher level of recreational-related MSDs linked to people taking up new hobbies (e.g. running) during lockdown and/or furlough.

3.3 Considerations for supporting WRMSD health based on the research evidence

Mitigating physical risk factors during the COVID-19 pandemic and beyond

Suggestions for mitigating physical risk factors come primarily from the pre-COVID-19 literature but are still applicable to work practices during COVID-19 and beyond. Working environments may temporarily or permanently change, potentially altering the risk factors associated with particular jobs.

Suggestions from the pre-COVID-19 literature focus on adjusting work activities and equipment to minimise manual handling and exposure to lifting, bending, squatting and kneeling (27,31,36,40,45). Additional considerations from the literature include designing jobs, workplaces, tools and equipment to avoid repetitive movements where possible and training staff appropriately to minimise exposure (42). Workers were more likely to buy into efforts to redesign work practices, schedules and equipment if they were actively involved in the redesign (55). This participatory approach supports the adoption of ergonomic improvements and the achievement of their benefits (55). For those jobs involving manual handling, lifting or carrying, mechanical aids should be used to minimise strain on individuals (40). For tasks involving repetitive movements, the literature recommended increasing individuals' task variety, e.g. through job rotation or enrichment (35). This is particularly important for physically demanding activities, where steps should be taken to minimise individual time spent on them (28). The literature also suggested

encouraging muscle-strengthening activities as an injury prevention measure (28,51) and regular rest breaks (29,43,44). For key workers who spent significant time in a vehicle, such as haulage drivers, ensuring the vehicle design allows for seat-and-steering-wheel adjustment to the driver's dimensions was noted as critical (29). Training on using new or existing equipment was also important for those returning to work and taking on new roles (29,36,45).

For those working from home, the literature highlighted the importance of suitable home-working set-ups to promote good posture, including providing equipment and guidance for employees, conducting risk assessments and minimising risk where possible (47,48,60,62). Taking regular active breaks (i.e. performing specific movements or exercises) and regularly changing working postures were also noted as methods of reducing WRMSDs and their associated discomfort (39,60).

Stakeholders' suggestions regarding physical risk factors were similar to those found in the literature. They also suggested the potential benefits of updated Display Screen Equipment (DSE) assessment protocols because newer technologies use laptops, tablets and multiple screens.

Regarding their organisation's plans, stakeholders commented that many workers may continue working either partly or entirely from home post-pandemic. This shift partly reflects growing recognition of the potential benefits of homeworking for employers and employees. Stakeholders also emphasised the importance of joint employer/worker involvement in homeworking decisions. They suggested that employers provide suitable equipment for home and hybrid working, pointing out that guidelines relating to employers' responsibilities regarding homeworking would help support this.

Stakeholders suggested that workers who have experienced new or exacerbated WRMSD risk factors due to the pandemic may require workplace accommodations, adjustments and/or additional consideration in risk assessments to address their potentially higher risk of WRMSD. At the same time, stakeholders felt that employers may require support and guidance in identifying those at risk and supporting and enabling suitable homeworking situations.

Some stakeholders highlighted that older members may have worked through the pandemic with underlying health conditions for which treatment may have been postponed. One stakeholder noted that the UK's ageing healthcare worker population meant many employees in their sixties worked long hours on their feet throughout the pandemic, possibly while waiting for musculoskeletal treatments such as hip or knee replacements. Stakeholders suggested that COVID-19's impact on WRMSDs was seen more frequently in OH provider settings and was presenting workforce issues with people needing time off or a change in duties to recover from WRMSDs. This led to dynamic individual and organisational responses, such as physiotherapy initiatives, guidance, and additional funding for ergonomic equipment.

Mitigating psychosocial risk factors during the COVID-19 pandemic and beyond

Literature published before and during the COVID-19 pandemic provided suggestions for reducing psychosocial risk factors for WRMSD, for example supportive leadership to cultivate justice and fairness in the workplace (35,56,58). Such factors were particularly important during the COVID-19 period, with clear communication and social integration among co-workers crucial for minimising the pandemic's mental health impacts and thus the psychosocial risk factors for WRMSD (35,54,56,62). Some authors also proposed that stress management training should accompany individual ergonomic training (35,56), including yoga, meditation and talking therapies (56).

Peer-support networks among colleagues can be built and strengthened by providing training to encourage prosocial behaviour (e.g. helping, donating, volunteering, sharing and co-operating), benefitting whole teams rather than just individuals (56). Such support could also be fostered by encouraging social connections and informal, unstructured conversations (e.g. virtual lunch breaks) to promote social connectedness while people work remotely (62,64). The literature also recommended that employers consider providing support to minimise psychosocial risk factors for WRMSD, rethinking performance targets and monitoring (e.g. work quality rather than quantity), and involving employees in

decision-making regarding their workload (47,60). Employers could also help minimise stress and depression among their employees when they return to work by supporting their wellbeing and ensuring they feel appreciated (50,63,64).

Stakeholders also provided suggestions on harnessing some of the changes brought about by home working to promote positive musculoskeletal health. These included providing advice on conducting home workstation DSE assessments and taking advantage of the time saved by not commuting to get employees active, strengthening their muscles and/or stretching. Some stakeholders suggested that people may self-manage their musculoskeletal health better at home if empowered, for example by encouraging lying down or stretching during group meetings. Some stakeholders also suggested several other potential benefits of flexible working. These included the possibility for people to intersperse desk time with physical activity – by taking a longer lunch break to exercise during daylight hours, for example – or balance work with other activities, promoting improved work-life balance, reduced stress and more relaxed muscles.

Improved WRMSD awareness in desk working environments

Most stakeholders felt that the pandemic improved individual employee and organisational awareness about desk workers' musculoskeletal health. They suggested that the 'shared experience' of working from home encouraged workers to talk about their work-related upper-limb issues and associated risk factors. Stakeholders suggested that these conversations could help improve future ergonomic home and office set-ups and promote more self-management of WRMSD risk among desk workers.

Management role in reintegration of workforce

Stakeholders also highlighted the role of management in facilitating reintegration of the workforce, reducing tension and minimising the potential impact of muscle tightness on WRMSDs.

4. Discussion

This section includes commentary from the authors (RAND Europe) based on previously synthesised results from the available published scientific studies, other published literature and supporting stakeholder consultation activities.

This research aimed to conduct an evidence summary to understand the UK's changing working world during the COVID-19 pandemic, the effect on WRMSDs and post-pandemic considerations. Our report has highlighted the main factors workers and organisations were dealing with at the time of data collection and made suggestions for mitigating those risks, providing examples of how organisations are already responding to them. We synthesised the key literature-review findings (from academic-database and targeted grey-literature searches) and the stakeholder consultations (asynchronous focus group and live workshops) and discuss their potential implications below.

After identifying known pre-COVID-19 WRMSD risk factors (Search A, RQ1), this study found that the COVID-19 pandemic has changed work environments and practices (RQ2). Evidence from the literature (Search B) and the small supporting stakeholder consultation indicates that the pandemic affected key workers, those working from home, and furloughed workers – and their work environments – differently, leading to differences in WRMSD risk factors and potentially in WRMSDs (RQ3). Many changes to WRMSD risk factors and work environments are likely to negatively affect WRMSDs. However, this study also identified some examples of the pandemic's potentially positive impacts on WRMSD risk factors.

The impact of COVID-19 on WRMSD risk factors and WRMSDs

Findings from the literature (Search B) and stakeholder consultation activities indicate that COVID-19 had a generally detrimental effect on psychosocial risk factors for WRMSD across all worker population groups. This effect was often attributed to increased workloads, increased hours, fewer breaks, fear of infection (and the impact of managing or avoiding it in working practices), and increased stress, anxiety and depression. Supporting workers with their mental health and

making reasonable adjustments to help them maintain a healthy work-life balance may reduce the potential for WRMSDs.

Although the pandemic may have also changed workers' exposure to physical risk factors for WRMSDs, the evidence for this is limited. The available evidence suggests that the pandemic may have increased physical risk factors for WRMSDs among key workers and those working from home, and for furloughed workers on their return to normal work. Increased risk factors were frequently attributed to extended duties or rotation into different, unfamiliar jobs or tasks, poor posture over extended periods, or poor workstation design, especially regarding ergonomics. Stakeholder consultations suggested that employers have opportunities to support workers by providing ergonomically appropriate working environments. Stakeholders also highlighted the role of regulatory agencies in providing appropriate guidance on how best to support workers under new working arrangements, for example by providing updated DSE guidance for those working from home.

Amongst some key workers and people working from home, there is some minimal evidence from the literature that WRMSD symptoms have worsened since the pandemic began. However, this evidence comes from cross-sectional surveys and thus cannot show causality (45,48,60). Stakeholders suggested that the impact of COVID-19 on WRMSDs was being seen more frequently in OH provider settings and is presenting issues for some workforces with people needing time off to recover from WRMSDs or a change in duties.

While the pandemic has primarily negatively affected WRMSD risk factors, this study also identified potentially positive influences. Stakeholders suggested that more flexible working hours for those working from home enabled some to engage in physical activity during the day. The time and stress saved by not commuting to work could also have reduced the risk of WRMSDs in this group. Employers and employees may wish to consider how to retain these potential benefits of homeworking, such as flexible working, and their positive impact on WRMSDs.

Wider considerations

The stakeholder consultation indicated that many companies plan to retain some degree of homeworking post-pandemic. Therefore, employers should consider the needs of those who may work from home, as workers' homes may not always be compatible with a permanent workstation. For some, this may be due to a lack of space, creating practical difficulties (i.e. insufficient space for ergonomic equipment or physically separating home and work-life). For others, their home life may increase stressors when working from home. Employers should not assume that people working from home have the space and resources to develop a suitable workplace and take appropriate steps to manage this.

Individuals may have changed their work practices in response to the COVID-19 pandemic on the assumption that this phase would be transitory, believing that suboptimal practices would not matter long-term because work practices would quickly return to pre-COVID-19 routines. Organisations need to ensure that suboptimal temporary working practices do not become entrenched, reviewing and updating them where necessary.

Finally, the synthesised evidence suggests the importance of treating workers as individuals rather than a homogenous group, recognising that people have different physical, mental and family needs. Circumstances will vary between companies and job roles and may have changed since COVID-19. A personalised approach to staff support including helping staff to manage health and wellbeing at an individual level is important. This has been shown in the stakeholder research where health and wellbeing conversations, as well as training and inclusion into annual appraisals and return to the workplace assessments, have been incorporated into standard practice.

Stakeholders highlighted COVID-19's broader societal impacts and possible knock-on effects for WRMSDs. For example, workers' concern about exposure to COVID-19 may have led them to delay visiting their GP for advice about new or recurring issues, such as those related to WRMSDs. Similarly, people already receiving treatment for their WRMSDs may have had appointments or procedures cancelled due to lockdowns and/or health professionals' rotation away from non-critical work

to support the COVID-19 response. Therefore, the workforce may have unmet needs for WRMSD-related healthcare. As well as its direct link to musculoskeletal health and WRMSD risk factors for workers in all industries, this backlog may place further physical and psychosocial stress on the healthcare workforce responsible for reducing lengthy treatment waiting lists.

Strengths and limitations

The predominant strength of this review is that it is one of the first to consider the impact of the COVID-19 pandemic on WRMSD across multiple industries affected differently by the pandemic. The evidence summary followed a systematic process throughout recording all decision rationales. Incorporating stakeholder consultation also strengthened our review by providing insights not yet captured in the published literature. All stakeholders were selected based on their knowledge of WRMSD risk factors and WRMSDs to represent a variety of UK industries able to provide specialist knowledge specific to the research.

However, there were some limitations. Searches were restricted to two academic databases, introducing a possibility that some relevant articles may have been missed. Additional targeted grey literature searches were conducted to minimise this risk. It is recognised that the stakeholder consultation also has its limitations, with only a small sample size of 15 different people being involved across the asynchronous and live consultation sessions. Furthermore, our review only included English-language articles, potentially missing relevant articles written in other languages. In addition, our prioritisation exercise was subjective. Despite our efforts to include a broad range of industries, some may have been missed or not fully represented by the selected articles. We also allocated industries to the three worker types based on broad assumptions about the workforce that may not represent every worker within the industry. For example, some health or retail workers might have been furloughed during the pandemic, while some in primarily furloughed industries may have continued working.

5. Conclusion

This section includes commentary from the authors (RAND Europe) based on previously synthesised results from the available literature and small supporting stakeholder consultation activities.

This study's literature review and stakeholder consultation activities indicate that the COVID-19 pandemic has impacted on physical and psychosocial WRMSD risk factors. This applies to various work-related environments, including traditional workplaces and home-working environments.

We found consistent evidence that key workers and those working from home experienced increased psychosocial risk factors during the pandemic – for example increased stress in the workplace, lack of peer and management support, intensified workloads – and limited evidence that furloughed workers also experienced increases in psychosocial risk factors. We suggest that employers could consider developing a workplace culture supportive of employees' psychosocial needs as one part of their overall WRMSD risk reduction strategy. This could include strategies such as creating an environment where employees feel safe to discuss their mental health needs, something that stakeholders suggested was already happening more frequently in relation to COVID-19 related mental health needs.

The increasing likelihood that workplaces adopt permanent or partial home working means that ergonomic risk factors will remain important going forwards. Stakeholders suggested updating guidance to include home and hybrid working, and laptop, tablet and mobile-device use, and highlighted the need to consider workers without suitable home-working arrangements.

Some stakeholders suggested that health and safety became 'COVID-19 safety' for key workers as attention turned to limiting COVID-19 transmission, temporarily deprioritising traditional health and safety measures. This study confirmed the continuing importance of known physical and psychosocial risk factors for WRMSDs (e.g. repetitive movements, awkward postures, general work stress),

highlighting the need for employers to continue to address traditional health and safety measures alongside COVID-19 related health and safety measures.

There is evidence of COVID-19's differential impact on WRMSDs across worker groups (e.g. key workers seeing an increase in physical risk factors related to long work hours and the work-from-home population being impacted by unsuitable physical environments). A one-size fits all approach to workforce risk management may not be appropriate in all situations or circumstances and employers should consider assessments and training to meet particular circumstances and individual employee's needs, where appropriate.

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Appendices

A1. Literature search strategies

Database search strategy for academic sources relevant to Search A: How do work environments and practices impact WRMSDs directly and indirectly (via physical and/or psychosocial risk factors)?

Searches run on 31st March 2021	PubMed	Scopus
A1 Work	work[TI] OR workplace[TIAB] OR "work-related"[TIAB] OR working[TI] OR worked[TI] OR job[TIAB] OR employment[TIAB] OR employed[TI] OR employer[TIAB] OR employee[TIAB] OR "occupation"[TIAB] OR industry[TIAB] OR industrial[TIAB] OR organisational[TIAB] OR organizational[TIAB] OR (work n2 (home OR remote))	TITLE-ABS-KEY (workplace OR "work-related" OR job OR employment OR employer OR employee OR "occupation" OR industry OR industrial OR organisational OR organizational OR (work W/2 (home OR remote))) OR TITLE (work OR working OR worked OR employed)
A2 Musculoskeletal disorders	(((joint OR bone OR spine OR spinal OR back OR hip OR knee OR shoulder OR neck) n3 (disorder OR condition OR pain OR injury OR fracture OR break OR sprain OR strain)) OR musculoskeletal OR MSK OR MSD OR arthritis OR osteo* OR hernia OR "carpal tunnel syndrome")	TITLE-ABS-KEY ((((joint OR bone OR spine OR spinal OR back OR hip OR knee OR shoulder OR neck) W/3 (disorder OR condition OR pain OR injury OR fracture OR break OR sprain OR strain)) OR musculoskeletal OR msk OR msd OR arthritis OR osteo* OR hernia OR "carpal tunnel syndrome")))
A Reviews of the impact of work on MSD (2011-2021)	A1 AND A2 Filters: Review, Systematic Review, 2011-2021 = 1,067 hits	A1 AND A2 Filters: 2011-2021 = 1,897 hits

Database search strategy for academic sources relevant to Search B: What impact has COVID-19 had on work environments and practices, both during the pandemic and looking to the future?

Searches run on 12th April 2021	PubMed	Scopus
B1 Work environments	work[TI] OR workplace[TIAB] OR "work-related"[TIAB] OR job[TIAB] OR employ[TI] OR employment[TIAB] OR employer[TIAB] OR employee[TIAB] OR "occupation"[TIAB] OR industry[TIAB] OR industrial[TIAB] OR organisational[TIAB] OR organizational[TIAB] OR (work[TIAB] n2 (home[TIAB] OR remote[TIAB]))	(TITLE-ABS-KEY (workplace OR "work-related" OR job OR employment OR employer OR employee OR "occupation" OR industry OR industrial OR organisational OR organizational OR (work W/2 (home OR remote))) OR TITLE (work OR working OR worked OR employed))
B2 MSD risk factors	ergonomic OR "physical activity" OR "physical inactivity" OR sedentary OR sitting OR obesity OR "mental health" OR "mental wellbeing" OR burnout OR psychosocial_hazard OR psychosocial_risk OR physical_risk OR work_quality OR work_redesign OR work_characteristic* OR work_feature* OR work_environment OR job_quality OR job_redesign OR job_characteristic* OR job_feature* OR job_environment OR job_rotat* OR employment_quality OR employment_redesign OR employment_characteristic OR employment_feature OR employment_environment OR meaningful_work*	(TITLE-ABS-KEY (ergonomic OR "physical activity" OR "physical inactivity" OR sedentary OR sitting OR obesity OR "mental health" OR "mental wellbeing" OR burnout OR "psychosocial hazard" OR "psychosocial risk" OR "physical risk"))

<p>B3 Musculoskeletal disorders</p>	<p>((joint OR bone OR spine OR spinal OR back OR hip OR knee OR shoulder OR neck) n3 (disorder OR condition OR pain OR injury OR fracture OR break OR sprain OR strain)) OR musculoskeletal OR MSK OR MSD OR arthritis OR osteo* OR hernia OR "carpal tunnel syndrome")</p>	<p>(TITLE-ABS-KEY ((((joint OR bone OR spine OR spinal OR back OR hip OR knee OR shoulder OR neck) W/3 (disorder OR condition OR pain OR injury OR fracture OR break OR sprain OR strain)) OR musculoskeletal OR msk OR msd OR arthritis OR osteo* OR hernia OR "carpal tunnel syndrome")))</p>
<p>B4 COVID-19</p>	<p>COVID[TIAB] OR 2019-nCov[TIAB] OR SARS-CoV-2[TIAB] OR "severe acute respiratory syndrome coronavirus 2"[TIAB] OR SARS-COV2[TIAB] OR nCOV-19[TIAB] OR pandemic[TIAB]</p>	<p>(TITLE-ABS-KEY (covid OR 2019-ncov OR sars-cov-2 OR "severe acute respiratory syndrome coronavirus 2" OR sars-cov2 OR ncov-19 OR pandemic))</p>
<p>B All article types about the impact of COVID-19 on work environments and practices</p>	<p>(B1) AND (B2 OR B3) AND (B4) = 867 hits</p>	<p>(B1) AND (B2 OR B3) AND (B4) = 1,480 hits</p>

**Targeted Google searches for grey literature sources relevant to Search B:
How has COVID-19 impacted work environments and practices during the
pandemic and for the future?**

Search Terms (date searched)
"Effects of COVID-19 on work-related musculoskeletal disorders" (27.04.21)
"Musculoskeletal problems during COVID-19 pandemic" (27.04.21)
"Effect of covid-19 pandemic on retail workers" (27.04.21)
"Experience of working in supermarkets during covid-19 pandemic" (27.04.21)
"Experience of waste collectors during covid-19 pandemic" (27.04.21)
"Experience of hairdressers during covid-19 pandemic" (27.04.21)
"Experience of furloughed workers during covid-19 pandemic" (27.04.21)
"Experience of construction workers during covid-19 pandemic" (28.04.21)
"Impact of COVID-19 on construction musculoskeletal disorders" (28.04.21)
"Impact of COVID-19 on retail musculoskeletal disorders" (28.04.21)
"Impact of COVID-19 on manual labour musculoskeletal disorders" (28.04.21)
"Impact of COVID-19 on manual labour musculoskeletal disorders" (28.04.21)
"Experience of manufacturing workers during covid-19 pandemic" (28.04.21)
"Impact of covid-19 on manufacturing industries" (28.04.21)
"Experience of delivery driver workers during covid-19 pandemic" (28.04.21)
"Impact of covid-19 on delivery drivers" (28.04.21)
"Experience of cleaners during covid-19 pandemic" (28.04.21)
"Impact of covid-19 on cleaners" (28.04.21)
"Experience of farmers during covid-19 pandemic" (29.04.21)
"Impact of covid-19 on farmers UK" (29.04.21)
"Experience of agricultural workers during covid-19 pandemic UK" (29.04.21)
"Impact of covid-19 on agricultural workers UK" (29.04.21)

A2. Data-extraction templates

Data-extraction template for sources relevant to Search A: How do work environments and practices impact WRMSDs directly and indirectly (via physical and/or psychosocial risk factors)?

Article Information

Citation	Publication Year	Article Type	Pre-Registered on PROSPERO?	PROSPERO Number	Review aims	Outcomes of interest	Number of databases searched	Included Study Types	Number of Studies included	Number of participants
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Population

Countries	Region/ Continent	Inclusion population description	Job type as affected by COVID-19	Job sector or occupation
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Key findings

Commonly experienced MSDs	MSD risk factors related to the physical work environment	Reported links between physical risk factors and specific MSDs	MSD risk factors related to the psychosocial work environment	Reported links between psychosocial risk factors and specific MSDs	MSD risk factors related to other areas	Reported links between other risk factors and specific MSDs
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Quality

Quality of Studies included as reported	Study strengths as reported	Study limitations as reported	Reviewer comments on quality
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Recommendations

Recommendations for supporting/protecting workers	Recommendations for future research
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Other

Other comments or relevant information from the article

Data extraction template for sources relevant to Search B: How has COVID-19 impacted work environments and practices during the pandemic and for the future?

Article information

Citation	Publication Year	Article Type	Article and/or study aims	Outcomes of interest	Number and type of studies/ participants (where relevant)
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Population

Countries	Region/ Continent	Inclusion population description	Job type as affected by COVID-19	Job sector or occupation
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Key findings

Work-related MSDs described as relevant to the occupation during COVID-19	Reported impact of COVID-19 on these MSDs	Physical risk factors discussed as relevant to the occupation during COVID-19	Reported impact of COVID-19 on these physical risk factors	Psychosocial risk factors discussed as relevant to the occupation during COVID-19	Reported impact of COVID-19 on these psychosocial risk factors	Other risk factors discussed as relevant to the occupation during COVID-19	Reported impact of COVID-19 on these other risk factors
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Quality

Study strengths as reported	Study limitations as reported	Reviewer comments on quality
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Recommendations

Recommendations for supporting/protecting workers	Recommendations for future research
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Other

Other comments or relevant information from the article

A3. Characteristics of included articles from search A

Table 10. Characteristics of included articles from search A (N=24)

Ref #	Author	Year	Analysis method (e.g. systematic review, narrative review, cross-sectional survey)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(19)	Amiri and Behnezhad	2020	Systematic review and meta-analysis	Musculoskeletal pain	N=21 Longitudinal cohort studies	The Netherlands, Iran, Canada, Sweden, USA, Thailand, Belgium, Finland	Mixed	Mixed and not clearly described
(30)	Anwer, Antwi-Afari, and Wong	2021	Systematic review	WRMSD-related outcomes, including musculoskeletal pain, repetitive motion injuries, repetitive strain injuries, regional musculoskeletal disorders, and soft tissue disorders	N=20 (cross-sectional =13, observational= 6, longitudinal survey=1) 194,863 participants	Denmark, India, Japan, Lithuania, the Netherlands, Nigeria, Sweden, Taiwan, Thailand, Trinidad, and the USA	Briefly furloughed	Construction

Ref #	Author	Year	Analysis method (e.g. systematic review, narrative review, cross-sectional survey)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(33)	Asante et al.	2019	Systematic review	Low back disorders	N=13 (Cross-sectional = 12, prospective cohort=1) 3,188 participants	Egypt, USA, Germany, Brazil, Denmark, India, Holland, Iran, Japan, Ghana, China	No Change	Waste collection
(27)	Canetti et al.	2020	Systematic review and meta-analysis	Risk factors for lower limb osteoarthritis	Systematic review (28 studies: cohort=2, case-control=10, cross-sectional=16) Meta analysis (25 studies)	NR	Some furloughed, some returned to work if COVID safe	Physically demanding jobs

Ref #	Author	Year	Analysis method (e.g. systematic review, narrative review, cross-sectional survey)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(36)	Caponecchia et al.	2020	Systematic review	Risk factors for MSD	N=63	NR	No Change	Health
(38)	Coenen et al.	2019	Systematic review and meta-analysis	Neck and upper extremity symptoms	N=12 (longitudinal cohort studies – 19 articles but 12 studies) 18,538 participants	NR	Remote working	Office workers/ computer users
(29)	Crawford et al.	2011	Systematic review	Health, psychosocial, and ergonomic effects of home working, and organisational/ management factors	N=11 (review=1, cross-sectional and longitudinal =1, cross-sectional=7, descriptive paper=2)	NR	No Change	Remote working

Ref #	Author	Year	Analysis method (e.g. systematic review, narrative review, cross-sectional survey)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(34)	Erick and Smith	2011	Systematic review	Prevalence and risk factors of MSD	N=33 (cross-sectional=32, case-control=1)	Japan, Turkey, China, Brazil, Sweden, Estonia, US, Greece, France, Philippines, Malaysia	Mostly remote working with some in-person teaching	Education (teachers)
(20)	Ferguson et al.	2019	Systematic review	Wrist pain	N=32 (cross-sectional or longitudinal)	NR	Mixed	Any worker
(12)	Hauke et al.	2011	Systematic review and meta-analysis	MSDs in various body regions (neck/shoulder; upper extremities (including arms, forearms, elbows, hands and wrists); low back)	Systematic review: 54 longitudinal studies Meta-analysis: 52 longitudinal studies	Netherlands, Denmark, Sweden, the USA, the UK, Finland, Canada, France, Norway, Belgium, Hong Kong, Switzerland, Germany, Greece	Mixed	Blue-collar workers, white-collar workers and some healthcare professionals.

Ref #	Author	Year	Analysis method (e.g. systematic review, narrative review, cross-sectional survey)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(21)	Hulshof et al.	2021	Systematic review and meta-analysis	2 Outcomes Outcome A: Any selected other MSD (defined as one or more of: shoulder disorders: rotator cuff syndrome, bicipital tendinitis, calcific tendinitis, shoulder impingement, bursitis shoulder; elbow disorders: epicondylitis medialis, epicondylitis lateralis, bursitis elbow; hip disorders: trochanter and other hip bursitis; and knee disorders: chondromalacia patella, meniscus disorders and bursitis knee.) Outcome B: Osteoarthritis of the hip or knee	2 Outcomes Outcome A: N=5 (cohort studies=4, case control study=1) 2,377,375 participants Outcome B (case-control studies=3) 1,354 participants	2 Outcomes Outcome A: Finland, Germany, France, Denmark Outcome B: Japan, Germany, Iran	2 Outcomes Outcome A: Mixed Outcome B: Mixed	2 Outcomes Outcome A: Working-age population Outcome B: Working-age population

Ref #	Author	Year	Analysis method (e.g. systematic review, narrative review, cross-sectional survey)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(32)	Koukoulaki	2014	Narrative review	Occupational health and related risk factors	N=36 (cross-sectional=14, pre-post=2, cohort=2, historic perspective=4, time-series=2), case study=6, comparative study=2, longitudinal=3, qualitative=1)	NR	Mixed	Manufacturing (lean industry)

Ref #	Author	Year	Analysis method (e.g. systematic review, narrative review, cross-sectional survey)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(22)	Kozak et al.	2015	Umbrella Review	Risk factors	N=10	USA, France, Australia, Denmark, Netherlands, Great Britain	Mixed	Employed adults
(41)	Kozak et al.	2019	Scoping Review	WRMSD	N=44 (cross-sectional=23, pre-post evaluation =7, case-control=4, measurement =3, surveillance =3, cohort=4, registry data analysis=1)	USA, France, Finland, Nigeria, Italy, England, Taiwan, Portugal, Belgium, Turkey, Sweden, Netherlands, Brazil, Denmark, Norway, Egypt, India, Germany, Iran, Australia, South Africa, Greece	Furloughed	Hairdressing
(23)	Mayer, Kraus, and Ochsmann	2012	Systematic review	Work-related physical exposures influencing neck and/or shoulder disorders	N=21 (longitudinal)	NR	Mixed	Working-age population

Ref #	Author	Year	Analysis method (e.g. systematic review, narrative review, cross-sectional survey)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(40)	Milhem et al.	2016	Narrative review	Risk factors and preventative methods for low back pain	NR	NR	Furloughed unless completing medical treatments	Health (physical therapists)
(28)	Schram et al.	2020	Umbrella Review	Risk factors and prevention	N=16 (systematic review=14, narrative review=2)	NR	Mixed	Physically demanding occupations

Ref #	Author	Year	Analysis method (e.g. systematic review, narrative review, cross-sectional survey)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(24)	Seidel et al.	2019	Systematic review	Prevention	N=10 (cross-sectional=5, cohort=3, triple case-referent study=1, quality case-referent study=1)	NR	Mixed	Working-age population
(25)	Swain et al.	2020	Systematic review	Low back pain and physical exposures	N=41 (systematic review=30, systematic review with meta-analysis component=11)	NR	Mixed	Working adults

Ref #	Author	Year	Analysis method (e.g. systematic review, narrative review, cross-sectional survey)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(26)	van der Molen et al.	2017	Systematic review and meta-analysis	Clinically assessed soft tissue shoulder disorder	Systematic review=27 Meta-analysis=7 (cross-sectional, case-control and cohort studies – specific numbers not reported)	NR	Mixed	Mixed: assembly workers, fish processing workers, slaughterhouse workers, sewing machine operators, manual workers, fishermen, construction and interior workers, metal workers, nurses, and workers in the army, air force and marines
(31)	Walker-Bone and Palmer	2002	Systematic review	MSD prevalence	Cross-sectional, case-control, cohort, and longitudinal	NR	Key workers	Agriculture (Farmers)

Ref #	Author	Year	Analysis method (e.g. systematic review, narrative review, cross-sectional survey)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(39)	Waongenngarm et al.	2018	Systematic review	Low back pain	N=11 (randomised-control trials=8, non-randomised-control trial=3) 515 participants	NR	Remote working	Office workers/ computer users
(42)	Xu, Cheng, and Li-Tsang	2013	Systematic review	WRMSD	N=12 (cross-sectional=9, case-control=2, prospective cohort=1) 55,430 participants	Taiwan, Japan, US, Ireland, Finland, Hong Kong	Furloughed	Catering

Ref #	Author	Year	Analysis method (e.g. systematic review, narrative review, cross-sectional survey)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(35)	Zare et al.	2021	Systematic review and meta-analysis	Upper limb MSD and psychosocial risk	N=66 (prospective =6, longitudinal =1, retrospective epidemiological analysis=2, cohort=1, cross-sectional=56)	Brunei, Malaysia, Iran, Japan, Sweden, Italy, Netherlands, Brazil, Taiwan, USA, Canada, Iceland, New Zealand, Germany, Australia, Norway, Vietnam, France, South Korea, India, England, China, Saudi Arabia, Turkey, Sri Lanka, Hong Kong, Denmark	No Change	Health (Nurses)

Note: NR=not reported

A4. Characteristics of included articles from search B

Table 11. Characteristics of included articles from literature search B and grey literature (N=20)

Ref #	Author	Year	Article type (e.g. review article, original research, commentary, policy report)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, homemaker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(49)	Barker and Sinkwitts	2020	Grey - blog	Physical deconditioning due to inactivity during COVID	N/A	N/A	Mixture	Mixture
(60)	Bevan, Mason, and Bajorek	2020	Grey - interim report of survey results	MSD, mental health	500 participants	UK	Homeworking	NR
(52)	Bratskeir	2020	Grey – article	Psychosocial, workplace environment	2 people	USA	Key worker	Distribution
(46)	Davis et al.	2020	Academic - cross-sectional survey	Home work station set up	41 workstations (of 29 female and 12 male participants)	USA	Remote working	Office and Education

Ref #	Author	Year	Article type (e.g. review article, original research, commentary, policy report)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, homeworker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(63)	Görlich and Stadelmann	2020	Academic - cross-sectional web-based online survey	Depression, anxiety and stress	Sample 1 (May 2019): 105 employees of 12 airlines Sample 2 (April 2020): 1,119 employees of 22 airlines (still flying=146, stay-at-home=972.	Unclear but "study was conducted online in German and posted on German-speaking websites"	Furloughed	Travel and tourism - Flight cabin crew
(47)	International Labour Organisation	2020	Grey - report	Psychosocial risk factors	N/A	N/A	Mixture	Mixture
(51)	IPRS health	No Date	Grey - information sheet	Returning to work and MSD	N/A	N/A	Mixture	Mixture
(44)	Johnson and Holdsworth	2020	Grey – academic blog	MSD risk factors, mental health	N/A	UK	Key worker	Transport and logistics

Ref #	Author	Year	Article type (e.g. review article, original research, commentary, policy report)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, homeworker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(43)	Johnson	2020	Grey – academic commentary	MSD risk factors, mental health	N/A	UK	Key worker	Transport and logistics
(53)	Kayabınar et al.	2021	Academic - cross-sectional survey	MSD, anxiety, depression	40 participants	NR	Key worker	Education
(61)	Lucy	2020	Grey - blog	Wellbeing	N/A	N/A	Mixture	Mixture
(45)	Mazal et al.	2021	Academic - letter to the editor	WRMSD	68 sonographers	USA	Key worker	Health
(48)	Moretti et al.	2020	Academic - cross-sectional analysis	Perceived productivity and job satisfaction, and onset or changes of previous MSK disorders, particularly lower back pain and neck pain	51 home-workers	Italy	Homeworking	Home office workers

Ref #	Author	Year	Article type (e.g. review article, original research, commentary, policy report)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, homemaker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(54)	Muller et al.	2020	Academic - rapid systematic review	Anxiety, depression, sleep problems, and distress	59 studies 54,707 participants	China, France, Germany, India, Iran, Italy, Singapore, USA, Australia, Bahrain, Bulgaria, Canada, Denmark, Egypt, Finland, France, Hungary, Ireland, Israel, Kuwait, Malaysia, Mexico, New Zealand, Pakistan, Poland, Republic of the Congo, Romania, Saudi Arabia, South Africa, Switzerland, Taiwan, Turkey, United Arab Emirates, United Kingdom	Key worker	Health
(62)	Oakman et al.	2020	Academic - rapid review	Pain, self-reported health, safety, well-being, stress, depression, fatigue, quality of life, strain and happiness	21 studies	USA, UK, Australia, New Zealand, Japan, Belgium, South Africa, Brazil, Germany, The Netherlands	No change	Working from home

Ref #	Author	Year	Article type (e.g. review article, original research, commentary, policy report)	Outcomes of interest	Number and type of studies/ participants	Countries	Job type (key worker, remote worker, homeworker, furloughed worker, mixed)	Job sector (e.g. education, health, transportation)
(55)	Sigahi et al.	2021	Academic - systematic review	Ergonomics, mental health,	258 studies	NR	Key worker Key worker Mixture	Health Education Other
(56)	Stogner, Miller and McLean	2020	Academic - long commentary	Stress, mental health and resiliency	N/A	N/A	Key worker	Public Services
(57)	Union of Shop, Distribution and Allied Workers (USDAW)	2020	Grey - report	Psychosocial	N/A	UK	Key worker	Retail
(50)	Westfield Health	2020	Grey - blog	Psychosocial	N/A	NR	Furloughed	Mixture
(58)	White et al.	2021	Academic - cross-sectional survey	Mental health	152	NR	Key worker	Health

Note: NR=not reported; N/A=not applicable

Scientific evidence about COVID-19 was vital to inform decision making by HSE, across Government, and other professionals involved in the national response to the pandemic. This report summarises published scientific evidence about the impact of the COVID-19 pandemic on work-related musculoskeletal disorders (WRMSDs). The researchers considered three groups of workers: key workers including in healthcare, construction, education, transport, and public services; workers who changed to homeworking; and furloughed workers. Ten scientific studies and ten other publications available before 29 April 2021 were considered to be from authoritative sources. Based on this research, for WRMSDs there was consistent evidence for increases in psychosocial risk factors for key workers and those homeworking, and limited evidence for increases in physical risk factors. For furloughed workers, there was limited evidence for increases in psychosocial risk factors, and for physical risk factors potential that there may be increased risk of WRMSDs on return to their normal work due to ‘physical deconditioning’ from a lack of activity during furlough. There was minimal evidence that WRMSD symptoms increased among key workers and those homeworking, and no literature was found on symptoms in furloughed workers. These findings reinforce existing information in HSE’s guidance about homeworking <https://www.hse.gov.uk/home-working/index.htm>. The national and global scientific evidence continued to develop after this review was completed.