Work-related musculoskeletal disorders within the construction sector – a systematic review

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Work-related musculoskeletal disorders (WRMSDs) are a major cause of pain, lost working time and economic cost in Great Britain. Construction workers are particularly affected. HSE commissioned this research to better understand which construction jobs and tasks carry the greatest risk.

The research systematically reviewed epidemiological studies of MSD outcomes associated with trades and tasks. It also analysed long-term data from the UK Labour Force Survey and US Survey of Occupational Injuries and Illnesses. Evidence from multiple countries and datasets shows:

- **Construction workers experience higher WRMSD risk than the wider workforce, but this greatly varies across trades.**
- **Finishing trades like floor layers, plasterboard installers, plasterers and joiners, plumbers, and labourers are identified as high-risk groups.**
- **Back disorders and upper-limb injuries dominate the claims burden.**
- **High risk activities involve cumulative physical load or physical stresses for the whole body, heavy materials handling, awkward postures, kneeling and repetitive wrist-intensive tasks.**
- **International data strongly aligns with UK patterns and can support GB-specific interventions where domestic data are limited.**

This evidence provides a robust basis for prioritising preventative actions to reduce risks and feeds into HSE's regulatory approaches.

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Work-related musculoskeletal disorders within the construction sector – a systematic review

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Abbreviations

Abbreviation	Meaning
A/C	Air-conditioning
ADR	Avis de demande de remboursement (CSST refund claim form used in Quebec)
ANSI	American National Standards Institute
aRR	Adjusted rate ratio
BLS	US Bureau of Labor Statistics
CBI	Compensable Back Injuries
CI	Confidence Interval
CIR	Claims Incidence Rate
CPWR	CPWR – The Center for Construction Research and Training; Previously the Center for Protecting Workers' Rights
Crude RR	Crude Rate Ratio, ie a rate ratio before adjustment for confounding variables
CSST	Commission de la santé et de la sécurité du travail du Québec (Quebec Workers' Compensation Board)
CV	Coefficient of Variation
DAFW/DAW	Days away/absent from work
DF	Degrees of freedom
DLR	Days Lost Rate
DMT	Days with modified tasks
Est.	Estimated
FTE	Full-Time Equivalent
GB	Great Britain
HL	Heavy lifting
HPW	Heavy physical work
HR	Hazard ratio
HVAC	Heating, ventilation and air-conditioning
ICD–9	International Classification of Diseases, Ninth Revision
ICD–10	International Classification of Diseases, Tenth Revision
IR	Incidence rate
ISIC	International Standard Industrial Classification of all economic activities

Abbreviation	Meaning
ISCO	International Standard Classification of Occupations
ISCO 88	International Standard Classification of Occupations 1988
Kn/sq	Kneeling or squatting
LFS	Labour Force Survey
LE-MSD	Lower extremity musculoskeletal disorder
M	Male, man or men
MSD	Musculoskeletal disorder
MSDI	MSD and injury
N or No.	Number
NA	Not applicable
NAICS	North American Industry Classification System
2017 NAICS	2017 revision of North American Industry Classification System
n.e.	Not estimable
n.e.c.	Not elsewhere classified
NOC	Not otherwise classified
NS	Not statistically significant
NTST-MSD	Non-traumatic soft tissue musculoskeletal disorders
OA	Osteoarthritis
ONS	Office for National Statistics
OSHA	Occupational Safety and Health Administration
P	Probability that the statistical test result is due to chance
PI	Prevention Index
PR	Prevalence Ratio
PRE	Proportion explained
r	Pearson’s correlation coefficient
RR	Rate ratio
SD	Standard deviation
Sig.	Statistical significance
Sit	Sitting
SOC	Standard Occupational Classification
SOII	Survey of Occupational Injuries and Illnesses
SRR	Standardised incidence rate ratio
Sta/mv	Standing or moving
SWI	Self-reported Work-related Illness

Abbreviation	Meaning
THOR	The Health and Occupation Reporting network
TL	Time lost in days
TWD	Total workdays affected
UE	Upper extremity
UE MSDI	Upper extremity MSD and injury
UK	United Kingdom
UK SIC 2007	UK Standard Industrial Classification 2007 revision
SOC 2000	UK Standard Occupational Classification 2000
UBC	United Brotherhood of Carpenters and Joiners of North America
UK SOC 2010	UK Standard Occupational Classification 2010 revision
UL MSD	Upper limb musculoskeletal disorders
U.S. & USA	United States of America
US 2010 SOC	US Standard Occupational Classification, 2010 edition
W	Woman or women
WA SF	Washington State Fund
WC	Workers' Compensation
WIC	Washington Industrial risk Classification
WMSD or WRMSD	Work-related musculoskeletal disorders

Key Messages

Work-related musculoskeletal disorders (WRMSDs) can develop due to the physical tasks individuals carry out during their normal work. They are a significant issue for workers, employers and the wider economy in Great Britain (GB). HSE is focussed on reducing their impact as part of its overall priority to reduce work-related ill health.

Construction has a particular problem with WRMSDs when compared to the average for all industries. Certain construction trades and tasks carry greater risk. This report reviews scientific evidence on the most significant causes. The specific aim was to link particular construction tasks and trades with an increased risk of WRMSD.

The initial focus was on systematically reviewing epidemiological studies. Evidence was sought that showed which outcomes, such as absence from work due to low back pain, were associated with which trades and tasks. Relevant multiple year data from the UK Labour Force Survey and the annual US Survey of Occupational Injuries and Illnesses were also analysed.

The evidence across multiple countries and datasets shows:

- Construction workers experience higher WRMSD risk than the wider workforce.
- Risk varies widely across trades, with finishing trades, such as floor layers, drywall (plasterboard) installers, plasterers and joiners, plumbers, and labourers being identified as high-risk groups.
- Back disorders, followed by upper-limb injuries, dominate the claims burden.
- Cumulative physical load, heavy materials handling, awkward postures, kneeling, repetitive wrist-intensive tasks, and tasks that create physical stress for the whole body are high risk.
- International data strongly align with UK patterns. This can support GB-specific interventions where domestic data are limited.

This report will be of interest to those who wish to understand the evidence on WRMSDs in construction. The findings strengthen the industry basis for prioritising preventative actions targeting improvements for workers in higher-risk finishing trades or performing physically demanding manual tasks. They also feed into HSE’s regulatory approaches.

Executive Summary

Background

Work-related musculoskeletal disorders (WRMSDs) can develop due to the physical tasks individuals carry out during their normal work. They are a significant issue for workers, employers and the wider economy in Great Britain (GB). HSE is focussed on reducing their impact as part of its overall priority to reduce work-related ill health.

HSE tracks work-related ill-health through the annual Labour Force Survey (LFS). It shows construction has a particular problem with WRMSDs when compared to the average for all industries. Certain construction trades and tasks carry greater risk. This report reviews scientific evidence on the most significant causes.

Aim and approach

The specific aim was to link particular construction tasks and trades with an increased risk of WRMSD. The initial focus was on systematically reviewing epidemiological studies, ie studies that measure the incidence or prevalence of ill-health outcomes. Evidence was sought that showed which outcomes, such as absence from work due to low back pain, were associated with which trade and tasks.

The search strategy identified in excess of 2000 scientific publications concerning WRMSDs and the construction industry. Sorting and evaluating these documents narrowed the focus to studies which examined data collected through injury and compensation claims and medical surveillance databases. Studies that reported data for construction as a whole industry without any breakdown were excluded.

Nineteen studies with suitable data were identified for inclusion. Some of these reported data from the annual UK Labour Force Survey and the annual US Survey of Occupational Injuries and Illnesses. Relevant multiple year data from these surveys were available and were also included for analysis. The periods selected mostly pre-date the Coronavirus pandemic that started in early 2020.

The reviewed studies often grouped data using standardised industrial classifications or occupational groupings. A third approach was by risk of injury.

Findings

Most studies used were from the USA (particularly Washington State), with additional evidence from the UK, Finland, Sweden, Denmark, and Canada. The evidence confirmed that construction as a whole is significantly more hazardous for WRMSDs than other economic sectors. WRMSD patterns from the data indicate:

- WRMSD risks do not relate to the size of an occupational group. Both small and large groups may have high or low risks. It is the tasks performed that substantially influence WRMSD risk. Any intervention needs to consider task-specific exposures rather than relying on job titles.
- Manual occupations show higher prevalence than non-manual/managerial groups.
- Cumulative and repetitive-strain injuries represent the majority of MSD cases and are typically more disabling than sudden injuries.
- Back disorders, followed by upper-limb injuries, dominate the claims burden.
- Strong correlations exist between GB and US incidence rates where comparable occupations can be identified. This suggests that international findings can help identify GB priorities where domestic sample sizes are insufficient.

Despite differences in reporting systems and data collection, the evidence base is sufficiently consistent to identify high-risk trades and tasks.

UK evidence

The highest risk construction industry group is ‘Building completion and finishing’. Within this, joinery installation, floor and wall covering, plastering, painting and glazing, and related finishing trades show particularly high rates. By occupation, manual workers have higher prevalence than non-manual groups. The highest rates occur in Plumbers and heating/ventilation engineers, Carpenters and joiners and the group of construction and building trades that aren’t classified elsewhere.

USA evidence

The highest-risk construction industry groups include finish carpentry, flooring, framing and siding contractor. High-risk occupations include floor sanders/finishers, floor layers, paperhangers, carpet installers, telecommunications installers and HVAC installers. Compensations claim data from Washington State also highlight wallboard installation, masonry, roofing, wood-frame building, and reinforcing steel installation as major high-risk activities. Manual rebar tying poses a specific risk for carpal tunnel syndrome. Data from unionised carpenters show drywall (plasterboard) work as the highest-risk sub-trade, with residential and light commercial carpentry also elevated.

Evidence from other countries:

- **Sweden:** White-collar staff and foremen have lower hospitalisation rates for lumbar disc disease than other construction workers, showing the impact of heavy physical workloads.
- **Denmark:** Kneeling is a key risk factor for lower-limb osteoarthritis; floor layers, bricklayers, and pavers show the highest rates.
- **Finland:** All construction workers are at increased risk of disability retirement due to hip/knee osteoarthritis, with skilled workers at higher risk than unskilled groups.
- **Quebec:** Labourers have the highest incidence, but interior finishing workers have the longest average days lost—suggesting differing injury severity and exposure patterns.

The majority of information analysed pre-dates the Coronavirus pandemic. This removes potential confounding factors from the conclusions. However, there will still be cross-country differences in techniques, design, climate, and job content.

Conclusions

The evidence across multiple countries and datasets shows:

- Construction workers experience higher WRMSD risk than the wider workforce.
- Risk varies widely across trades, with finishing trades, such as floor layers, drywall (plasterboard) installers, plasterers and joiners, plumbers, and labourers being identified as high-risk groups.
- Back disorders, followed by upper-limb injuries, dominate the claims burden.
- Cumulative physical load, heavy materials handling, awkward postures, kneeling, repetitive wrist-intensive tasks, and tasks that create physical stress for the whole body are high risk.
- International data strongly align with UK patterns. This can support GB-specific interventions where domestic data are limited.

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1 Introduction

1.1 Background

Work-related musculoskeletal disorders (WRMSDs) have long been a concern for HSE as they cause a significant burden to the workforce and the economy in Great Britain (GB). HSE used the Labour Force Survey (LFS) to estimate that 477 000 workers suffered from and 7.3 million working days were lost due to new or long-standing WRMSDs in 2021/22[1]. WRMSDs such as low back pain are often associated with manual handling (such as lifting, carrying, pushing or pulling) of loads and repetitive tasks.

The LFS shows that the construction industry has a much higher rate of WRMSDs (approximately 1.75 times for the period from 2019/20 to 2021/22) than the average across all industries. Some tasks within construction create higher risks of MSD than others. HSE is focussed on reducing their impact as part of its overall priority to reduce work-related ill health and asked Science Division to examine relevant scientific evidence.

1.2 The purpose and scope of the study

The purpose of the study was to seek information that would identify the parts of the construction sector that create the highest risk of musculoskeletal disorders.

The specific aim was to search for, collate and analyse existing information in order to rank construction tasks and activities by risk of WRMSDs. This was to be done using a systematic review approach focussing on published scientific studies and statistics linking particular construction tasks and trades with increased risk of WRMSDs. It included use of relevant classification systems and databases on ill health outlined below.

1.3 Business and occupational classification systems

Many studies of WRMSDs report relevant epidemiological data classified using standardised business and occupational classification systems. While the systems in different countries have similar purposes, they differ in detail and therefore comparisons between them are not straightforward.

Businesses in the UK are classified according to economic activity using the UK Standard Industrial Classification (UK SIC)[2], which is a hierarchical system. Occupational groups are classified in terms of their skill level and skill content using the UK Standard Occupational Classification (UK SOC)[3]. USA businesses are classified using the North American

[1] HSE's annually updated statistics on WRMSDs in Great Britain are available at Labour Force Survey - Self-reported work-related ill health and workplace injuries

[2] UK Standard Industrial Classification of Economic Activities - Office for National Statistics (ons.gov.uk)

[3] Standard Occupational Classification (SOC) - Office for National Statistics (ons.gov.uk)

Industrial Classification System (NAICS)[4] which groups them by the production processes they use. In the USA occupations are classified using the Standard Occupational Classification (SOC)[5] which groups occupations with similar job duties, and in some cases skills, education, and/or training. Similar systems exist internationally (ISIC[6] and ISCO[7]).

It should be noted that each worker is classified independently by the pair of systems in use in the country of employment. A construction worker is likely to remain within a trade (for example, an electrician) and so have the same SOC code over a period of years but may move between employers which operate in different parts of the construction sector, which would result in the SIC code of the worker changing.

The national and international classification schemes have been revised at intervals and therefore it is necessary to check that the schemes in use match, even within the same country, when comparing across time and across different studies.

1.3.1 UK SIC

The UK SIC was revised most recently in 2007 (Prosser, 2009)[8]. The 21 Sections have Division numbers distributed unevenly between 01 and 99 – with some gaps. The construction sector forms Section F of the classification and includes three divisions – F41, F42 and F43. The three divisions are further subdivided into a total of nine groups and 22 classes. The decimal point after the two-digit division number is followed by one or two digits to identify the group or class, respectively. Table 1 lists all 35 codes within Section F. It should be noted that where a group contains only a single class, the final digit of the class is 0 and the description of the class is identical to the description of the Group at the level above. This only affects two of the 35 groups, meaning there are 33 unique classifications.

Table 1. UK SIC 2007 codes for the construction sector

UK SIC 2007 code	Level	Industry description
F	Section	Construction
F41	Division	Construction of buildings
F41.1	Group	Development of building projects
F41.10	Class	Development of building projects
F41.2	Group	Construction of residential and non-residential buildings
F41.20	Class	Construction of residential and non-residential buildings
F42	Division	Civil engineering

4 North American Industry Classification System (NAICS) U.S. Census Bureau
5 SOC home: U.S. Bureau of Labor Statistics (bls.gov)
6 International Standard Industrial Classification of All Economic Activities (ISIC) - ILOSTAT
7 International Standard Classification of Occupations (ISCO) - ILOSTAT
8 UK Standard Industrial Classification of Economic Activities - Office for National Statistics (ons.gov.uk)

UK SIC 2007 code	Level	Industry description
F42.1	Group	Construction of roads and railways
F42.11	Class	Construction of roads and motorways
F42.12	Class	Construction of railways and underground railways
F42.13	Class	Construction of bridges and tunnels
F42.2	Group	Construction of utility projects
F42.21	Class	Construction of utility projects for fluids
F42.22	Class	Construction of utility projects for electricity and telecommunications
F42.9	Group	Construction of other civil engineering projects
F42.91	Class	Construction of water projects
F42.99	Class	Construction of other civil engineering projects n.e.c.
F43	Division	Specialised construction activities
F43.1	Group	Demolition and site preparation
F43.11	Class	Demolition
F43.12	Class	Site preparation
F43.13	Class	Test drilling and boring
F43.2	Group	Electrical, plumbing and other construction installation activities
F43.21	Class	Electrical installation
F43.22	Class	Plumbing, heat and air-conditioning installation
F43.29	Class	Other construction installation
F43.3	Group	Building completion and finishing
F43.31	Class	Plastering
F43.32	Class	Joinery installation
F43.33	Class	Floor and wall covering
F43.34	Class	Painting and glazing
F43.39	Class	Other building completion and finishing
F43.9	Group	Other specialised construction activities
F43.91	Class	Roofing activities
F43.99	Class	Other specialised construction activities n.e.c.

Data derived from the lfsinjind.xlsx file available at https://www.hse.gov.uk/statistics/lfs/tables.htm.

1.3.2 UK SOC

The UK SOC was revised in 2010 and most recently in 2020 (Office for National Statistics, 2010). Only data from the 2010 revision are included in this report because it better aligns with the period considered and pre-dates the effect of the Coronavirus pandemic on the economy. The SOC system is also hierarchical. UK SOC 2010 codes consist of up to four digits. The first digit identifies the ‘Major Group’ the occupation is within. The second and third digits identify the ‘Sub-Major’ and ‘Minor’ groups, respectively. The fourth digit identifies the ‘Unit Group’. The nature of the hierarchy means that unit groups for the construction industry are spread across several major groups. For example, the construction-specific unit group of ‘Production managers and directors in construction’ (code 1122) falls within ‘Managers, directors and senior officials’ (code 1), ‘Bricklayers and masons’ (code 5312) fall within ‘Construction and building trades’ (code 531), ‘Skilled construction and building trades’ (code 53), and ultimately ‘Skilled trades occupations’ (code 5), which also contains non-construction occupations. Identifying construction occupations therefore required a review of all the group titles within the hierarchy.

Table 2 lists the 62 identified groups across the four levels and notes whether the code is specific to the construction industry or contains construction-specific occupations. Across the four levels:

- all six major groups contain construction occupations, but none of their titles are specific to the construction industry
- of the nine sub-major groups, one is construction-specific and the other eight contain construction occupations
- of the14 minor groups, seven are construction-specific and seven contain construction occupations
- of the 33 unit groups, 30 are construction-specific and three contain construction occupations

Workers within major groups 1 ‘Managers, directors and senior officials’, 2 ‘Professional occupations’ and 3 ‘Associate professional and technical occupations’ are unlikely to be in roles which require significant manual activities. They are therefore likely to be at lower risk of WRMSDs. Skilled construction workers within sub-major group 52 ‘Skilled metal, electrical and electronic trades’, and the whole of sub-major group 53 ‘Skilled construction and building trades’ are likely to be carrying out manual tasks. At the minor group level, unskilled construction workers are likely to be found in groups 814 ‘Construction operatives’ and 912 ‘Elementary construction occupations’.

Table 2. UK SOC 2010 codes for construction occupations

UK SOC 2010 code	Level	UK SOC 2010 group title	Construction-specific?
1	Major group	Managers, directors and senior officials	Contains
11	Sub-major group	Corporate managers and directors	Contains
112	Minor group	Production managers and directors	Contains
1122	Unit group	Production managers and directors in construction	Yes
2	Major group	Professional occupations	Contains

UK SOC 2010 code	Level	UK SOC 2010 group title	Construction -specific?
21	Sub-major group	Science, research, engineering and technology professionals	Contains
212	Minor group	Engineering professionals	Contains
2121	Unit group	Civil engineers	Yes
24	Sub-major group	Business, media and public service professionals	Contains
243	Minor group	Architects, town planners and surveyors	Yes
2431	Unit group	Architects	Yes
2432	Unit group	Town planning officers	Yes
2433	Unit group	Quantity surveyors	Yes
2434	Unit group	Chartered surveyors	Yes
2435	Unit group	Chartered architectural technologists	Yes
2436	Unit group	Construction project managers and related professionals	Yes
3	Major group	Associate professional and technical occupations	Contains
31	Sub-major group	Science, engineering and technology associate professionals	Contains
311	Minor group	Science, engineering and production technicians	Contains
3114	Unit group	Building and civil engineering technicians	Yes
312	Minor group	Draughtspersons and related architectural technicians	Yes
3121	Unit group	Architectural and town planning technicians	Yes
3122	Unit group	Draughtspersons	Yes
5	Major group	Skilled trades occupations	Contains
52	Sub-major group	Skilled metal, electrical and electronic trades	Contains
521	Minor group	Metal forming, welding and related trades	Contains
5215	Unit group	Welding trades	Contains
5216	Unit group	Pipe fitters	Contains
522	Minor group	Metal machining, fitting and instrument making trades	Contains
5223	Unit group	Metal working production and maintenance fitters	Contains
5225	Unit group	Air-conditioning and refrigeration engineers	Yes

UK SOC 2010 code	Level	UK SOC 2010 group title	Construction -specific?
524	Minor group	Electrical and electronic trades	Contains
5241	Unit group	Electricians and electrical fitters	Yes
53	Sub-major group	Skilled construction and building trades	Yes
531	Minor group	Construction and building trades	Yes
5311	Unit group	Steel erectors	Yes
5312	Unit group	Bricklayers and masons	Yes
5313	Unit group	Roofers, roof tilers and slaters	Yes
5314	Unit group	Plumbers and heating and ventilating engineers	Yes
5315	Unit group	Carpenters and joiners	Yes
5316	Unit group	Glaziers, window fabricators and fitters	Yes
5319	Unit group	Construction and building trades n.e.c.	Yes
532	Minor group	Building finishing trades	Yes
5321	Unit group	Plasterers	Yes
5322	Unit group	Floorers and wall tilers	Yes
5323	Unit group	Painters and decorators	Yes
533	Minor group	Construction and building trades supervisors	Yes
5330	Unit group	Construction and building trades supervisors	Yes
8	Major group	Process, plant and machine operatives	Contains
81	Sub-major group	Process, plant and machine operatives	Contains
814	Minor group	Construction operatives	Yes
8141	Unit group	Scaffolders, stagers and riggers	Yes
8142	Unit group	Road construction operatives	Yes
8143	Unit group	Rail construction and maintenance operatives	Yes
8149	Unit group	Construction operatives n.e.c.	Yes
82	Sub-major group	Transport and mobile machine drivers and operatives	Contains
822	Minor group	Mobile machine drivers and operatives	Contains
8221	Unit group	Crane drivers	Yes
9	Major group	Elementary occupations	Contains
91	Sub-major group	Elementary trades and related occupations	Contains
912	Minor group	Elementary construction occupations	Yes

UK SOC 2010 code	Level	UK SOC 2010 group title	Construction -specific?
9120	Unit group	Elementary construction occupations	Yes

Construction occupations identified from Office for National Statistics (2010).

1.3.3 North American Industrial Classification System (NAICS)

NAICS is a hierarchically structured classification system of all economic activity that groups establishments into industries by their production processes (Office of Management and Budget, 2017). It is used across North America, ie Canada, the USA and Mexico. Classifications are largely comparable across the participating countries, with most differences at the lowest level of classification. The most recent version is from 2022[9]. This report uses the 2017 NAICS as this also aligns with the period considered and pre-dates the Coronavirus pandemic.

NAICS uses up to six digits to classify an industry. Each classification has a short name as well as the full name, though in many cases these are identical. It divides the economy into 20 sectors; construction is Sector 23. Sector 23 is divided into three subsectors *236: Construction of buildings*; *237: Heavy and civil engineering construction*; and *238: Specialty trade contractors*. These are further divided into 10 industry groups identified by 4-digit codes. These 10 industry groups are further divided into 28 industries with 5-digit codes. All but four of the 31 6-digit construction sector classifications are identical to 5-digit classifications.

There are 32 unique codes that are not subdivided at a lower level of classification. Twenty-eight codes at the 5-digit level are listed in Table 3, of which four are identical to the 4-digit codes at the level above. The four 6-digit codes that are the very detailed subdivisions of codes 2361/23611 'Residential building construction' have been omitted from the table.

Table 3. Lowest level of 2017 NAICS codes for construction industries (to 5-digits)

Code	Full NAICS industry name	Short NAICS industry name
23611	Residential Building Construction	Residential building construction
23621	Industrial Building Construction	Industrial building construction
23622	Commercial and Institutional Building Construction	Commercial building construction
23711	Water and Sewer Line and Related Structures Construction	Water and sewer system construction
23712	Oil and Gas Pipeline and Related Structures Construction	Oil and gas pipeline construction

[9] North American Industry Classification System (NAICS) U.S. Census Bureau

Code	Full NAICS industry name	Short NAICS industry name
23713	Power and Communication Line and Related Structures Construction	Power and communication system construction
2372	Land Subdivision	Land subdivision
2373	Highway, Street, and Bridge Construction	Highway, street, and bridge construction
2379	Other Heavy and Civil Engineering Construction	Other heavy construction
23811	Poured Concrete Foundation and Structure Contractors	Poured concrete structure contractors
23812	Structural Steel and Precast Concrete Contractors	Steel and precast concrete contractors
23813	Framing Contractors	Framing contractors
23814	Masonry Contractors	Masonry contractors
23815	Glass and Glazing Contractors	Glass and glazing contractors
23816	Roofing Contractors	Roofing contractors
23817	Siding Contractors	Siding contractors
23819	Other Foundation, Structure, and Building Exterior Contractors	Other building exterior contractors
23821	Electrical Contractors and Other Wiring Installation Contractors	Electrical and wiring contractors
23822	Plumbing, Heating, and Air-Conditioning Contractors	Plumbing and HVAC contractors
23829	Other Building Equipment Contractors	Other building equipment contractors
23831	Drywall and Insulation Contractors	Drywall and insulation contractors
23832	Painting and Wall Covering Contractors	Painting and wall covering contractors
23833	Flooring Contractors	Flooring contractors
23834	Tile and Terrazzo Contractors	Tile and terrazzo contractors
23835	Finish Carpentry Contractors	Finish carpentry contractors
23839	Other Building Finishing Contractors	Other building finishing contractors
23891	Site Preparation Contractors	Site preparation contractors
23899	All Other Specialty Trade Contractors	All other specialty trade contractors

Construction industries identified from Office of Management and Budget (2017).

Table 102 in Appendix 7.2 maps 2017 NAICS codes and descriptions for construction industries onto the UK SIC 2007 codes and descriptions, enabling equivalent industries in the two countries to be compared. It is apparent that the two classifications have the same structure at the higher levels – the three-NAICS subsectors (codes 236, 237 and 238) are equivalent to Divisions F41, F42 and F43 in UK SIC 2007. Differences arise at the lower levels of classification because the UK SIC has only 35 construction categories whereas

NAICS has 73. This means that multiple NAICS categories map onto single UK SIC categories. This is most obvious with UK SIC 2007 code F43.99, 'Other specialised construction activities n.e.c.' which has eight unique 2017 NAICS categories mapping onto it, which reflects a more detailed breakdown within NAICS of specialised construction contractors.

1.3.4 US 2010 SOC

The 2010 edition of the United States SOC[10] is the most relevant to this project as the bulk of the papers that report data by SOC categories cover the period since then. The previous edition was published in 2000, and a further edition was published in 2018. Details of all editions are available at the US Bureau of Labor Statistics (BLS) website (www.bls.gov). Changes between editions reflect the evolution of the labour market, such as when the introduction of new technology creates new occupations and leads to others ceasing to exist.

A user guide for the 2010 edition is at https://www.bls.gov/soc/soc_2010_user_guide.pdf. Other supporting documents[11] include detailed definitions of occupations (U.S. Bureau of Labor Statistics, 2013).

The SOC classification of occupations is also constructed as a hierarchy, in this case of four levels. The 23 major groups are subdivided into 97 minor groups. The minor groups are broken into 461 broad groups. At the most specified level, there are 840 detailed occupations. This is the level at which an individual worker is classified, based on the tasks performed. Detailed occupations with similar job duties, and in some cases skills, education, and/or training, are grouped together.

The codes are constructed as six-digit numbers, often with a dash between the second and third digits. The four levels of the hierarchy are:

- **major groups**, which have codes ending with 0000, for example 47-0000 'Construction and extraction occupations'
- **minor groups**, which (with two exceptions that are not construction-related) have codes ending with 000, for example 47-1000 'Supervisors of construction and extraction workers'
- **broad occupations**, which have codes ending with 0, for example 47-2020 'Brickmasons, blockmasons, and stonemasons'
- **detailed occupations**, which have codes ending with a number other than 0, for example 47-2021 'Brickmasons and blockmasons and 47-2022 Stonemasons'

The nature of the hierarchy means that some categories within higher levels are not subdivided, so names are repeated until the detailed occupation level is reached. For example, 47-2110 'Electricians' has identical data to 47-2111 'Electricians' and there is no category 47-2112.

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[10] Standard Occupational Classification (SOC) System: U.S. Bureau of Labor Statistics (bls.gov)
[11] Standard Occupational Classification (SOC) System: U.S. Bureau of Labor Statistics (bls.gov)

Of particular interest for this project are major group 47-0000 ‘Construction and extraction occupations’, and within that group, minor group 47-2000 ‘Construction trades workers’. The minor group 47-5000 ‘Extraction workers’, which is the remainder of the major group, is not of interest as it is distinct from construction.

All 142 US 2010 SOC occupational groups identified as construction-specific or containing construction occupations are listed in Table 4. Of the 142 groups, eight were major groups, 15 were minor groups, 50 were broad groups and 69 were detailed occupations.

There are 113 distinct occupational descriptions and 29 that are duplicated. Groups that are specific to the construction sector are identified (110 of them) as are 32 groups that contain a mixture of construction-specific and non-construction lower level groups. These inevitably are more likely to be the higher level groups.

Table 4. US 2010 SOC codes for construction occupations

US 2010 SOC code	Group type	Occupation description	Construction -specific?
11-0000	Major	Management occupations	Contains
11-9000	Minor	Other management occupations	Contains
11-9020	Broad	Construction managers	Yes
11-9021	Detailed	Construction managers	Yes
11-9040	Broad	Architectural and engineering managers	Yes
11-9041	Detailed	Architectural and engineering managers	Yes
13-0000	Major	Business and financial operations occupations	Contains
13-1000	Minor	Business operations specialists	Contains
13-1050	Broad	Cost estimators	Contains
13-1051	Detailed	Cost estimators	Contains
17-0000	Major	Architecture and engineering occupations	Contains
17-1000	Minor	Architects, surveyors, and cartographers	Contains
17-1010	Broad	Architects, except naval	Contains
17-1011	Detailed	Architects, except landscape and naval	Yes
17-1020	Broad	Surveyors, cartographers, and photogrammetrists	Contains
17-1022	Detailed	Surveyors	Yes
17-2000	Minor	Engineers	Contains
17-2050	Broad	Civil engineers	Yes
17-2051	Detailed	Civil engineers	Yes
17-3000	Minor	Drafters, engineering technicians, and mapping technicians	Contains
17-3010	Broad	Drafters	Contains

US 2010 SOC code	Group type	Occupation description	Construction -specific?
17-3011	Detailed	Architectural and civil drafters	Yes
17-3020	Broad	Engineering technicians, except drafters	Contains
17-3022	Detailed	Civil engineering technicians	Yes
17-3030	Broad	Surveying and mapping technicians	Yes
17-3031	Detailed	Surveying and mapping technicians	Yes
19-0000	Major	Life, physical, and social science occupations	Contains
19-3000	Minor	Social scientists and related workers	Contains
19-3050	Broad	Urban and regional planners	Yes
19-3051	Detailed	Urban and regional planners	Yes
47-0000	Major	Construction and extraction occupations	Contains
47-1000	Minor	Supervisors of construction and extraction workers	Yes
47-1010	Broad	First-line supervisors of construction trades and extraction workers	Yes
47-1011	Detailed	First-line supervisors of construction trades and extraction workers	Yes
47-2000	Minor	Construction trades workers	Yes
47-2010	Broad	Boilermakers	Yes
47-2011	Detailed	Boilermakers	Yes
47-2020	Broad	Brickmasons, blockmasons, and stonemasons	Yes
47-2021	Detailed	Brickmasons and blockmasons	Yes
47-2022	Detailed	Stonemasons	Yes
47-2030	Broad	Carpenters	Yes
47-2031	Detailed	Carpenters	Yes
47-2040	Broad	Carpet, floor, and tile installers and finishers	Yes
47-2041	Detailed	Carpet installers	Yes
47-2042	Detailed	Floor layers, except carpet, wood, and hard tiles	Yes
47-2043	Detailed	Floor sanders and finishers	Yes
47-2044	Detailed	Tile and marble setters	Yes
47-2050	Broad	Cement masons, concrete finishers, and terrazzo workers	Yes
47-2051	Detailed	Cement masons and concrete finishers	Yes
47-2053	Detailed	Terrazzo workers and finishers	Yes
47-2060	Broad	Construction laborers	Yes
47-2061	Detailed	Construction laborers	Yes

US 2010 SOC code	Group type	Occupation description	Construction -specific?
47-2070	Broad	Construction equipment operators	Yes
47-2071	Detailed	Paving, surfacing, and tamping equipment operators	Yes
47-2072	Detailed	Pile-driver operators	Yes
47-2073	Detailed	Operating engineers and other construction equipment operators	Yes
47-2080	Broad	Drywall installers, ceiling tile installers, and tapers	Yes
47-2081	Detailed	Drywall and ceiling tile installers	Yes
47-2082	Detailed	Tapers	Yes
47-2110	Broad	Electricians	Yes
47-2111	Detailed	Electricians	Yes
47-2120	Broad	Glaziers	Yes
47-2121	Detailed	Glaziers	Yes
47-2130	Broad	Insulation workers	Yes
47-2131	Detailed	Insulation workers, floor, ceiling, and wall	Yes
47-2132	Detailed	Insulation workers, mechanical	Yes
47-2140	Broad	Painters and paperhangers	Yes
47-2141	Detailed	Painters, construction and maintenance	Yes
47-2142	Detailed	Paperhangers	Yes
47-2150	Broad	Pipelayers, plumbers, pipefitters, and steamfitters	Yes
47-2151	Detailed	Pipelayers	Yes
47-2152	Detailed	Plumbers, pipefitters, and steamfitters	Yes
47-2160	Broad	Plasterers and stucco masons	Yes
47-2161	Detailed	Plasterers and stucco masons	Yes
47-2170	Broad	Reinforcing iron and rebar workers	Yes
47-2171	Detailed	Reinforcing iron and rebar workers	Yes
47-2180	Broad	Roofers	Yes
47-2181	Detailed	Roofers	Yes
47-2210	Broad	Sheet metal workers	Yes
47-2211	Detailed	Sheet metal workers	Yes
47-2220	Broad	Structural iron and steel workers	Yes
47-2221	Detailed	Structural iron and steel workers	Yes
47-2230	Broad	Solar photovoltaic installers	Yes
47-2231	Detailed	Solar photovoltaic installers	Yes

US 2010 SOC code	Group type	Occupation description	Construction -specific?
47-3000	Minor	Helpers, construction trades	Yes
47-3010	Broad	Helpers, construction trades	Yes
47-3011	Detailed	Helpers--brickmasons, blockmasons, stonemasons, and tile and marble setters	Yes
47-3012	Detailed	Helpers--carpenters	Yes
47-3013	Detailed	Helpers--electricians	Yes
47-3014	Detailed	Helpers--painters, paperhangers, plasterers, and stucco masons	Yes
47-3015	Detailed	Helpers--pipelayers, plumbers, pipefitters, and steamfitters	Yes
47-3016	Detailed	Helpers--roofers	Yes
47-3019	Detailed	Helpers, construction trades, all other	Yes
47-4000	Minor	Other construction and related workers	Yes
47-4010	Broad	Construction and building inspectors	Yes
47-4011	Detailed	Construction and building inspectors	Yes
47-4020	Broad	Elevator installers and repairers	Yes
47-4021	Detailed	Elevator installers and repairers	Yes
47-4030	Broad	Fence erectors	Yes
47-4031	Detailed	Fence erectors	Yes
47-4040	Broad	Hazardous materials removal workers	Yes
47-4041	Detailed	Hazardous materials removal workers	Yes
47-4050	Broad	Highway maintenance workers	Yes
47-4051	Detailed	Highway maintenance workers	Yes
47-4060	Broad	Rail-track laying and maintenance equipment operators	Yes
47-4061	Detailed	Rail-track laying and maintenance equipment operators	Yes
47-4070	Broad	Septic tank servicers and sewer pipe cleaners	Yes
47-4071	Detailed	Septic tank servicers and sewer pipe cleaners	Yes
47-4090	Broad	Miscellaneous construction and related workers	Yes
47-4091	Detailed	Segmental pavers	Yes
47-4099	Detailed	Construction and related workers, all other	Yes
49-0000	Major	Installation, maintenance, and repair occupations	Contains
49-2000	Minor	Electrical and electronic equipment mechanics, installers, and repairers	Contains

US 2010 SOC code	Group type	Occupation description	Construction -specific?
49-2020	Broad	Radio and telecommunications equipment installers and repairers	Contains
49-2022	Detailed	Telecommunications equipment installers and repairers, except line installers	Yes
49-2090	Broad	Miscellaneous electrical and electronic equipment mechanics, installers, and repairers	Contains
49-2098	Detailed	Security and fire alarm systems installers	Yes
49-9000	Minor	Other installation, maintenance, and repair occupations	Contains
49-9010	Broad	Control and valve installers and repairers	Contains
49-9011	Detailed	Mechanical door repairers	Yes
49-9020	Broad	Heating, air conditioning, and refrigeration mechanics and installers	Yes
49-9021	Detailed	Heating, air conditioning, and refrigeration mechanics and installers	Yes
49-9040	Broad	Industrial machinery installation, repair, and maintenance workers	Contains
49-9044	Detailed	Millwrights	Yes
49-9050	Broad	Line installers and repairers	Yes
49-9051	Detailed	Electrical power-line installers and repairers	Yes
49-9052	Detailed	Telecommunications line installers and repairers	Yes
49-9090	Broad	Miscellaneous installation, maintenance, and repair workers	Contains
49-9096	Detailed	Riggers	Yes
51-0000	Major	Production occupations	Contains
51-2000	Minor	Assemblers and fabricators	Contains
51-2040	Broad	Structural metal fabricators and fitters	Yes
51-2041	Detailed	Structural metal fabricators and fitters	Yes
51-4000	Minor	Metal workers and plastic workers	Contains
51-4120	Broad	Welding, soldering, and brazing workers	Contains
51-4121	Detailed	Welders, cutters, solderers, and brazers	Yes
53-0000	Major	Transportation and material moving occupations	Contains
53-7000	Minor	Material moving workers	Contains
53-7020	Broad	Crane and tower operators	Yes
53-7021	Detailed	Crane and tower operators	Yes

US 2010 SOC code	Group type	Occupation description	Construction -specific?
53-7030	Broad	Dredge, excavating, and loading machine operators	Contains
53-7032	Detailed	Excavating and loading machine and dragline operators	Yes

Construction occupations identified from https://www.bls.gov/soc/2010/home.htm.

Table 103 in Appendix 7.2 maps the US 2010 SOC codes and occupation titles onto the equivalent UK SOC 2010 codes and group titles. This allows comparison of US data with UK data.

1.4 Relevant databases

1.4.1 HSE annual statistics from the Labour Force Survey (LFS)

The Office for National Statistics (ONS) is the body responsible for official statistics in Great Britain. It reports death statistics by occupation but does not collect data on non-fatal injuries. It refers enquires about non-fatal occupational injuries to HSE[12].

HSE publishes a wide range of statistics in relation to health and safety that are available on its website at Health and safety statistics (hse.gov.uk).

HSE commissions questions within the GB Labour Force Survey (LFS) carried out by the ONS. In 2022 the ONS was surveying around 36 000 households each quarter but has experienced recruitment problems since. The two modules that HSE commissions are included in the survey carried out within the first quarter of each calendar year. The modules are 'Self-reported Work-related Illness' (SWI) and 'Workplace Injury'. The analysis of the resultant data is carried out and reported by HSE. Further details are given at LFS technical note (hse.gov.uk).

The available LFS data on ill health are available via LFS - Labour Force Survey - Self-reported work-related ill health and workplace injuries: Index of LFS tables - HSE Statistics - Work-related ill health and occupational disease (hse.gov.uk). An annual summary of WRMSD statistics for GB is available at Work-related ill health and occupational disease in Great Britain - HSE. This contains breakdowns both by broad occupational groups and by broad industry groups across GB.

1.4.2 USA annual statistics from the Survey of Occupational Injuries and Illnesses

The Bureau of Labor Statistics (BLS) in the USA carries out an annual Survey of Occupational Injuries and Illnesses (SOII)[13], part of which asks for employer reports of OSHA recordable WRMSDs. Recordable cases involve days absent from work, days absent restricted or transferred, medical treatment beyond first aid or significant work-

[12] See, for example, Injury and death statistics by occupation - Office for National Statistics or Death or injury at work - Office for National Statistics

[13] https://www.bls.gov/opub/hom/soii/pdf/soii.pdf

related injuries or illnesses diagnosed by a licensed health care professional. The SOII is based on a stratified sampling strategy that takes into account industry, ownership, and establishment size. The sampled industries can vary from year to year, depending on the requirements of the participating states and US territories. The data are published on the BLS website (www.bls.gov).

2 Methods

2.1 Systematic review screening methods

The Cochrane Collaboration (www.cochrane.org) is well-known in the health field for providing guidance on suitable methodologies for systematically reviewing scientific literature, with an emphasis on the effectiveness of interventions (Cumpston *et al.*, 2024). Their definition of a systematic review is: 'A systematic review attempts to identify, appraise and synthesize all the empirical evidence that meets pre-specified eligibility criteria to answer a specific research question. Researchers conducting systematic reviews use explicit, systematic methods that are selected with a view aimed at minimizing bias, to produce more reliable findings to inform decision making.'

The Cochrane focus is on health and social care, but many of their recommendations can be applied when seeking to carry out a systematic review in relation to a health and safety question.

2.1.1 The scope of the review and eligibility criteria

The specific aim of the project was to link particular construction tasks and trades with increased risk of WRMSD. The focus of the review was therefore on retrieving epidemiological data linking individual construction trades and tasks to increases in risk of MSD. In other words, evidence was being sought that showed that different outcomes, such as absence from work due to low back pain, occurred in different construction trades and tasks. Epidemiological studies, ie studies that measure the incidence or prevalence of ill-health outcomes such as musculoskeletal disorders, were therefore the focus of the review.

2.1.2 Strategy for literature searches

An existing EndNote database in use within the Ergonomics team within Science Division contains a large number of items relating to MSDs. This was searched for items related to the construction industry. Searches were also carried out on external databases of peer-reviewed and other literature by the HSE Information Management Team. Some of these databases require subscriptions, which are paid for by HSE. It was requested that the search should be as extensive as possible with:

- no date restrictions
- no language restrictions. However, the suggested search terms were all in English so articles without English translations of at least the title were likely to be omitted
- no geographical restrictions

The suggested search strategy sent to the search team in late 2019 can be summarised as trying to find sources that relate to (musculoskeletal disorders) AND (the construction industry).

Terms related to the construction industry and to MSDs were identified and are listed in Appendix 7.1. These were grouped into sub lists of terms related to MSDs (Table 99), terms related to names of construction trades, descriptions of construction trades, names of construction equipment/plant and hand-held construction equipment/tools (Table 100), and terms related to construction materials, construction occupations and manual handling (Table 101).

The request to the search team was that the terms in the sub lists should be combined with the Boolean OR operator. The suggested searches were:

1. (Terms relating to musculoskeletal disorders) AND “construction”
2. (Terms relating to musculoskeletal disorders) AND (construction trade names)
3. (Terms relating to musculoskeletal disorders) AND (construction trade descriptions) AND (construction occupation descriptions)
4. (Terms relating to musculoskeletal disorders) AND (construction equipment/plant names) AND (construction occupation descriptions)
5. (Terms relating to construction materials) AND (terms relating to manual handling)
6. #1 OR #2 OR #3 OR #4 OR #5

It was expected that search #1 would generate most hits. Searches #2, #3 and #4 were suggestions of ways to search for information about MSDs in specific construction tasks and trades. Searches #3 and #4 sought to take account of the way that multiple terms are used to describe the workers who carry out specific tasks/operate particular items of equipment.

Results were returned by email in January 2020. The files were in RIS format, which permitted their easy import into a dedicated EndNote database in EndNote version X9. Relevant records in the existing local EndNote database focussed on musculoskeletal disorders were identified by searching for the term ‘construction’. A total of 2503 records were retrieved by searches of five sources and the breakdown from each source is given in Table 5.

Table 5. Numbers of records returned by the literature search.

Database(s)	Number of results
Ergonomics Abstracts	258
OSHUpdate	618
Proquest – Medline, Embase, Civil Engineering Abstracts, Conference Papers, Health and Safety Science Abstracts, ICONDA, NTIS, ANTE, EiCompendex, SciSearch	1037
Web of Science	364
Existing personal database on musculoskeletal topics	226
Total for import into the Construction MSD database	2503

The dedicated EndNote database was named 'Construction MSD' and the records from the five sources were added to it. Elimination of duplicate records and records that were clearly irrelevant to the project reduced the number of references of potential interest to 1708 (Table 6). The automatic FIND FULL TEXT option within EndNote downloaded available free full-text PDFs of articles within the database.

Table 6. Classification of the retrieved records

Total records retrieved by searches	2503			
Duplicate records not imported into EndNote		444		
Records for screening		2059		
Records later identified as duplicates or as irrelevant			351	
References for classification			1708	
References identified as in scope				576
References identified as out of scope				1132

2.1.3 Classification of records as in-scope or out-of-scope

The initial crude estimate was that the number of scientific publications concerning MSDs and the construction industry might be in the region of 1000. The number returned, after the automatic elimination of duplicates on import into EndNote was slightly more than twice this at 2059 documents.

Each team member had a personal copy of the EndNote database and worked independently to classify the 1708 papers left after removal of duplicates and irrelevant papers. The aim was to classify papers as in-scope of the study or out-of-scope and by the study type or topic under consideration. At this stage, the criterion for identifying a study as eligible to be included (ie within scope) was that it reported a study of musculoskeletal disorders in the construction industry with epidemiological data on individual construction trades or construction tasks. Studies that reported comparisons between the construction sector as a whole and other industries without any breakdown of the data within the sector were excluded. This was on the basis that it was already known that construction is high-risk compared to other sectors and the research question was about differentiating high-risk and low-risk groups within construction.

In-scope studies were classified into the 14 mutually exclusive study types in Table 7. They are ranked on the basis of the rigour of the study design (Greenhalgh, 1997, Guyatt *et al.*, 1995). The rigour of the design is linked to the strength of the ability to draw conclusions from such a study, with the most rigorous allowing the most-wide-ranging conclusions. Greenhalgh (1997) provides an overview of the range of study designs used in the biomedical literature.

Seven study types were different epidemiological study designs and two were different types of review. One category was descriptive articles, and one was expert opinion pieces. One category was recommendations for best practice, so derivative from other work. One category was secondary citations of other relevant studies and often these were already in the database. The final category was of papers that appeared from the title to be relevant, but for which it was not possible to find published abstracts, often due to being published in foreign-language journals or being conference abstracts.

Table 7. In scope study types sorted by epidemiological study quality

Quality order	Study type
1	Systematic reviews
2	Intervention studies
3	Dose-response studies
4	Cohort/prospective studies/randomised controlled trials
5	Registry/retrospective studies
6	Case-control studies
7	Cross-sectional studies
8	Case reports/series
9	Non-systematic reviews/research summaries
10	Descriptive/qualitative studies
11	Expert opinion pieces
NA	Best practice recommendations
NA	Secondary citations of other studies
NA	Title appears relevant but no abstract found

Systematic reviews are the highest value papers as they pull together and summarise evidence from many studies. They have the disadvantage that they tend to be focussed on narrow, tightly defined questions, and therefore are unlikely to answer the research question of interest.

Intervention studies are experimental studies, that would, in the context of MSDs in the construction sector, require groups of workers to be exposed in a controlled manner to different risk factors to measure the effects of different exposures. Dose-response studies examine the effect of systematically varied levels of exposure to risk factors and can be viewed as a subset of intervention studies. Both study types allow inferences to be drawn about the causal relationships between exposures and outcomes as the exposure is known before the outcome.

Cohort study and prospective study are interchangeable terms and refer to studies where groups (cohorts) with different profiles of exposure to risk factors are followed ‘prospectively’ or ‘longitudinally’, ie over time, so that any relationship between the exposure measurements at the start of the study and the MSD outcomes can be identified. Randomised controlled trials (RCTs) are a subset of prospective studies where the participants are randomly allocated to groups that are given different levels of exposure to risk factors, with the levels of exposure being controlled by the study team.

Registry (or retrospective) studies retrieve data from sources such as medical or workers' compensation insurance records ('registries') to identify cases of disease that have already occurred (so looking back over time, ie retrospectively). The registries used can include data for whole populations collected over many years so can have very large sample sizes. This study design allows inferences to be drawn about associations between exposure to risk factors and harmful outcomes but not about causation as the data before exposure are missing. Their other disadvantages include the fact that reliable exposure data may be lacking so job titles may have to be used instead.

In case-control studies, each case of disease, such as an MSD, that is identified is matched to one or more similar people (the controls) that does not have the MSD. The exposure of the cases to a particular risk factor can then be compared to the exposure of the controls to the same risk factor. As cases and controls are only identified after the problem has been detected, this is also a retrospective type of study. Again, inferences can only be made about associations between exposure and outcome, not about causation.

Cross-sectional studies measure the outcome status of groups at a single point in time and look for associations between current exposure and current status. They have the advantage of only needing to collect data at one point in time and are therefore inherently quicker than longitudinal studies.

Case reports or case series are reports of individual cases with a particular outcome, such as an MSD, that (often) a clinician has chosen to highlight as interesting. They cannot be generalised to groups or populations but can serve to identify issues of concern.

The categories in Table 8 were used to classify out-of-scope references by the topic under consideration, without any evaluation of the quality of the studies.

Studies related to both hand-arm vibration and whole-body vibration were excluded as, while they can both cause MSDs, they are treated as a separate topic within HSE. Epidemiological studies that related to MSDs, but not the construction sector, were excluded, as were other studies of MSDs that did not relate to construction. Biomechanical modelling studies, and laboratory and field studies were excluded as they did not provide epidemiological data. Similarly, a wide range of studies about methods and tools for risk assessment of MSD exposure and about exposure measurement, such as through the use of wearable devices were also excluded.

Unlike the in-scope study categories, there is potential for studies to be classified in more than one of the listed categories as they may cover topics in more than one category. Also, some of the chosen categories could be further broken down (such as by having separate categories for biomechanical modelling studies, laboratory field studies and field studies). However, the importance of any misclassifications will be low as the main purpose of the classification exercise was to remove out-of-scope studies from detailed consideration and to provide the ability to gain an overview of the variety of out-of-scope studies retrieved by the search strategy should this be useful at a later date.

Table 8. Categories for classifying out of scope references

Study topic
Barriers to implementing ergonomic changes
Biomechanical models/laboratory studies/field studies
Clinical cases/studies
Construction tools/equipment/control measures
Construction - not MSD
Ergonomic design
Fatigue/mental load/demands
General construction - not trade specific
Hand arm vibration
Health promotion/sick leave/rehabilitation/return to work
Heat illness
MSD - not construction
MSD epidemiology - not construction
News/guidance/policy/regulation/campaigns/textbooks
Not construction & not MSD
Office ergonomics/Display Screen Equipment
Opinion pieces/continuous professional development articles/ editorials/ outdated material
Risk assessment tools/methods
Wearables/exposure assessment/measurement techniques
Whole body vibration
Work and ageing

2.1.4 Selection of articles for detailed review

2.1.4.1 Introduction

Once the articles had been sorted by study type, the study team considered in more detail which articles should be included in the planned review. This was done by starting with the systematic reviews as being the highest quality type and then working down the study hierarchy until sufficient quality information was found that could be extracted that addressed the study question. The classifications of the three team members were compared in a table and differences between them were resolved in team meetings. At this stage, titles, abstracts and, where already available, the full papers, were taken into consideration. When on closer inspection it was realised that a paper had been misclassified it was assigned to the appropriate category. In a small proportion of cases, it was decided to obtain the full text of a paper before making a final decision on inclusion.

Where it was not already in the database, the full text of each article identified at this stage for further consideration was retrieved, either by downloading from journals that HSE had full-text access to, or from the document supply sources that the HSE Information Management specialists could access.

Table 9 gives the numbers of papers at the three main stages of data screening and extraction for the top six study types.

Table 9. Results of the screening and selection of studies

Study type	Papers identified by the three reviewers from the titles and abstracts	Papers chosen for full-text review	Papers chosen for data extraction
Systematic reviews	9	5	0
Intervention studies	150	8	0
Cohort studies	70	41 *	0
Registry studies	63	40	23
Case-control studies	16	NA	NA
Cross-sectional studies	190	NA	NA

* Initially, 39 were chosen for full text review. One was a recent protocol paper and led to two related papers published during 2020, ie after the initial searches. Inclusion of these resulted in the review of 41 papers.

Once a batch of papers of a particular study type had been identified as needing full review, each paper was allocated to two of the three team members. However, multiple papers that related to the same study were allocated as a single batch to the same two reviewers so that they could consider all the available information about the study.

2.1.4.2 Outcomes of assessing the systematic review papers

From Table 9 it can be seen that of the nine papers identified for consideration as systematic reviews, five were chosen for full-text reviews. These were Boschman *et al.* (2011), Rinder *et al.* (2008), Umer *et al.* (2018), Sobeih *et al.* (2006), and Makola and Genaidy (2006).

The Boschman *et al.* (2011) paper found that there was evidence for bricklayers linking physical demands on bricklayers and risk of low back pain and musculoskeletal complaints in the arms and legs. There was only limited evidence that construction supervisors were at any increased risk of MSDs.

Rinder *et al.* (2008) systematically reviewed studies of interventions in construction designed to improve musculoskeletal health among construction workers. They found of the eight studies they reviewed that the quality was at best ‘average’, with many details omitted. Only two papers reported outcomes relevant to MSDs. They concluded that there was an urgent need for more studies of interventions to reduce MSDs and that new studies needed to be much better quality studies.

Umer *et al.* (2018) systematically reviewed studies of the prevalence of musculoskeletal symptoms in construction workers. They were able to carry out a meta-analysis of 35 data sets of 12-month prevalence in different body regions but could not find sufficient information to carry out a comparison of different trades.

Sobeih *et al.* (2006) reviewed the epidemiological literature linking psychosocial work factors to musculoskeletal disorders among construction workers. They found only two cohort studies and six cross-sectional studies. All the studies reported associations between psychosocial factors and MSDs, and many associations were still significant after adjustment for the physical demands of the job. They noted lack of standardisation of the psychosocial factors measured.

It was found that the study by Makola and Genaidy (2006) focussed on whole-body vibration so it was not considered further.

Given the limited number of systematic reviews found, their heterogeneity, their limited conclusions and the lack of data on individual trades and tasks, the team agreed that it was necessary to proceed to reviewing the intervention studies identified in the search.

2.1.4.3 Outcomes of assessing the intervention study papers

As shown in Table 9, the three team members identified a total of 150 papers as possible intervention studies. Of these, only eight (Bernold *et al.*, 2001, Borstad *et al.*, 2009, Brandt *et al.*, 2015, Dasgupta *et al.*, 2016, Martinelli and Tarquini, 2012, Mirka *et al.*, 2000, Peters *et al.*, 2018, van der Molen *et al.*, 2009) were considered suitable for full review and possible data extraction. Of these, Martinelli and Tarquini (2012), which was published in Italian, was eliminated as it proved impossible for HSE to obtain the full text. Brandt *et al.* (2015) was eliminated as it was a protocol paper for a study where the results paper (Brandt *et al.*, 2018) had already been eliminated as not providing a breakdown of results by task or trade. Three (Bernold *et al.*, 2001, Dasgupta *et al.*, 2016, and Mirka *et al.*, 2000) were eliminated as they did not contain epidemiological data. This left three intervention studies with potentially useful information.

The study reported by Borstad *et al.* (2009) looked at the effect of a home exercise intervention in preventing shoulder-pain in construction apprentices in four trades requiring overhead work (sheet metal work, electrical work, plumbing, and pipe fitting). They found that the intervention was effective but there were no significant differences between the trades.

The study by van der Molen *et al.* (2009) found that the use of ergonomic measures by carpenters and pavers remained low over a 4.5-year period despite a large informational campaign. They did find that regular use of the majority of the ergonomic measures was associated, although not statistically significantly, with a lower likelihood of lower back or shoulder complaints.

Peters *et al.* (2018) evaluated a high-quality matched-pair cluster randomized controlled trial of an ergonomics program combined with health promotion. After one-month the intervention group had statistically significantly improved ergonomic practices and reduced incidences of pain and injury. After six months the intervention group had reduced physically demanding work, increased recreational physical activity and higher consumption of fruits and vegetables. However, the drop-out rate of the study was very high so lacked sufficient power at the six-month stage to detect significant changes in ergonomic practices or the incidences of pain and injury.

Given the very small number of useful intervention studies found, the study team agreed that it was necessary to proceed to reviewing the cohort/prospective studies identified as potentially useful.

2.1.4.4 Outcomes of assessing the cohort/prospective study/RCT papers

The three team members identified a total of 70 papers as potential cohort/prospective studies/RCTs (Table 9). Of these, 39 were identified as needing review of the full text. During the reading of these papers, one was identified as a recent protocol paper. It was then found that two papers from that study had been published during 2020, ie after the initial searches. These were therefore included in the study, giving a total of 41 papers that were subject to full review.

Related papers were grouped together, and each group/paper was allocated to two reviewers who independently extracted relevant information into Excel spreadsheets. The outcome of the review process is shown in Table 10 where the related papers are grouped together, with the larger groups listed first. Within the groups the papers are sorted by date and then author name.

A total of eleven papers from six different studies were identified as suitable for data extraction. Three other papers were classified as registry/retrospective studies; one was classified as a cross-sectional study. Of the included papers, three (Group 2 in Table 10) reviewed data from regular German occupational health examinations of construction workers. The three papers in Group 3 examined the risks of hip and knee osteoarthritis in different construction trades. Two papers (Group 9) studied occupational risk factors for low back pain in construction workers. The remaining three papers were unrelated (Group 11). One (van der Molen *et al.*, 2010) looked at the effect of ergonomic measures on low back complaints among construction workers. One (Boschman *et al.*, 2012) was an observational study of MSDs in bricklayers and supervisors over 12 months. The final included study (Boschman *et al.*, 2015) looked at the effect of a publicity campaign on the use of ergonomics measures by construction workers in nine trades.

The remaining 26 papers reported 13 studies and were all excluded from further consideration. Full papers could not be retrieved for two studies that were reported by single papers, so these were excluded. The remaining studies were excluded due to insufficient suitable data. Several reported data from single construction trades so were not useful for identifying which tasks or trades created MSD risk. One reported data from the construction sector in general without any breakdown by trade. Two were studies of the effectiveness of training. One had too small a sample size to be useful.

The consensus among the review team was that the six suitable studies were quite varied and, viewed overall, provided insufficient data to allow conclusions to be drawn about individual construction trades and tasks.

It was therefore agreed that the team should proceed to the review of the registry/retrospective studies rather than extract data from these six studies.

Table 10. Outcome of selection of cohort/prospective studies/RCTs

No.	Paper	Group	Overall decision
1	Riihimäki *et al.* (1981)	1	Paper not available
2	Riihimäki (1985)		Cross-sectional study
3	Wickström (1985)		Paper not available
4	Riihimäki *et al.* (1989)		Omit
5	Arndt *et al.* (1996)	2	Include
6	Rothenbacher *et al.* (1997)		Include
7	Arndt *et al.* (2005)		Include
8	Järvholm *et al.* (2008)	3	Include
9	Järvholm *et al.* (2014)		Include
10	Jackson *et al.* (2019)		Include
11	Jensen and Friche (2007)	4	Omit
12	Jensen and Friche (2008)		Omit
13	Jensen and Friche (2010)		Omit
14	Kincl *et al.* (2016)	5	Omit
15	Anton *et al.* (2020)		Cross-sectional study
16	Hess *et al.* (2020)		Omit
17	Welch *et al.* (1997)	6	Omit
18	Welch *et al.* (2010)		Omit
19	Welch *et al.* (2009)		Omit
20	Elders *et al.* (2003)	7	Omit
21	Elders and Burdorf (2004)		Omit
22	Hanvold *et al.* (2014)	8	Omit
23	Hanvold *et al.* (2015)		Omit
24	Latza *et al.* (2000)	9	Include
25	Latza *et al.* (2002)		Include
26	Lipscomb *et al.* (2009b)	10	Retrospective study
27	Schoenfisch *et al.* (2017)		Omit
28	Pietri-Taleb *et al.* (1994)	11	Omit

No.	Paper	Group	Overall decision
29	Pietri-Taleb *et al.* (1995)		Omit
30	Stubbs and Nicholson (1979)		Retrospective study
31	Akinmayowa (1987)		Retrospective study
32	Spielholz and Wiker (1996)		Omit
33	Wimmel *et al.* (2000)		Paper not available
34	Tüchsen *et al.* (2005)		Omit
35	Rytter *et al.* (2007)		Omit
36	van der Molen *et al.* (2010)		Include
37	Boschman *et al.* (2012)		Include
38	Dong *et al.* (2012)		Retrospective study
39	Boschman *et al.* (2015)		Include
40	Veiersted *et al.* (2015)		Paper not available
41	Egwuonwu *et al.* (2016)		Cross-sectional study

2.1.4.5 Outcomes of assessing the registry/retrospective study papers

Table 9 shows that the individual work of the project team members led to a total of 63 papers being considered for inclusion in the review as registry/retrospective studies. After reviewing the titles and abstracts, the project team agreed that the 40 papers listed in Table 11 should be retrieved for full-text review. As with Table 10, related papers are grouped together, with the larger groups listed first. Within the groups the papers are sorted by date and then author name.

Twenty-seven papers were placed into eight groups, ranging in size from eight to two papers, with 13 studies represented by single papers. Group 1 (8 papers) reported studies of unionised carpenters in Washington State in the USA. Group 2 (six papers) also reported studies from Washington State but covered all occupations included in the Washington State Workers' Compensation State Fund scheme. Group 3 (three papers) reported part of a wider series of studies of Finnish concrete reinforcement workers and house painters. Group 4 (two papers) reported Bureau of Labor Statistics (BLS) data about MSDs in the construction sector across the USA. Group 5 (two papers) reported population-wide data from Finland on disability retirements due to hip and knee osteoarthritis. Group 6 (two papers) reported ill-health data from the construction industry in Ireland. Group 7 (two papers) reported data on musculoskeletal problems in the construction industry in Germany. Group 8 (two papers) reported data on wrist problems among unionised Danish house painters.

Of the remaining 13 papers, three did not report data specific to construction trades, leaving ten single publication studies. One of these was an HSE-funded study of THOR data from the UK and of the other nine, four were from the USA, two from Canada, two from Scandinavia and one from Belgium. Of the nine studies from outside the UK, three analysed Workers' Compensation data; two analysed hospital records; two analysed data from national workforce surveys; one analysed referrals to Occupational Health physicians, and one was a case study of accident reports from a single large contractor.

The retrieval of full texts of papers led to four papers being excluded, reducing the total under consideration to 36. One of the four papers could not be retrieved; one was only a conference abstract, so lacked detail; the other two did not report data specific to construction trades.

After full-text review of the remaining 36 papers, another 13 were removed from consideration, leaving 23 that data were extracted from. Of the 13 excluded papers, four had too limited data to be useful; three did not report MSD data separately to other injury data; two reported data that were also reported in related papers; one did not report data specific to construction trades; one did not report injury rate data; one reported data from a single trade and in the final paper, the data were very old in an area (hand tools) that has seen significant design changes since the paper was published.

Data from tables and figures in each of the 23 chosen papers were copied into individual Excel workbooks and the incidence rates standardised. The approach in many of the papers included, particularly those from the USA, is to equate one 'Full-Time Equivalent' (FTE) worker to 2000 work hours per year, on the basis of a worker working eight hours per day for five days per week for 50 weeks of the year. This figure assumes ten days of paid leave per year, which is common in the USA[14]. In the UK, the current legal minimum for a full-time worker is 28 days paid leave, including bank holidays and public holidays[15]. This means the 2000 hours figure is higher than the annual working hours (excluding overtime) of full-time construction workers in the UK. However, it is a reasonable approximation that allows comparison with studies from different countries. Therefore, all incidence rates are reported as rates per 200 000 hours (100 FTE × 2000 annual hours).

Close examination of the data being extracted led to four papers being excluded from further consideration. The paper by Schoenfisch *et al.* (2014) was excluded as it did not offer additional insights or data beyond those of the related papers about unionised carpenters in Washington State (Group 1 in Table 11). Guidotti (1995) was excluded as the WC lost-time claims data reported did not separate cases of MSDs from other claims. The papers by Chiou *et al.* (2000) and Nurminen (1997) were both excluded due to lacking incidence data, making it impossible to compare the data with data from other studies.

Of the remaining 19 studies, four (Lipscomb *et al.*, 1997, Lipscomb *et al.*, 2008a, b, Lipscomb *et al.*, 2015) remained of the eight in Group 1 in Table 11. Five of the six papers in Group 2 remained (Silverstein *et al.*, 2002, Bonauto *et al.*, 2006, Schoonover *et al.*, 2010, Spector *et al.*, 2011, Anderson *et al.*, 2013). The two papers from Group 4 (Wang *et al.*, 2017, Dong *et al.*, 2019) and the two papers from Group 5 (Kontio *et al.*, 2018, Solovieva *et al.*, 2018) all remained. The other six remaining papers (Duguay *et al.*, 2001, Stocks *et al.*, 2011, Andersen *et al.*, 2012, Wahlström *et al.*, 2012, Memarian and

[14] The State of Paid Time Off in the U.S. in 2024 - Center for American Progress
[15] Holiday entitlement: Entitlement - GOV.UK

Mitropoulos, 2013, Dale *et al.*, 2015) were all single publications. No papers remained from Groups 3, 6, 7 and 8 of Table 11.

The data from the 19 individual Excel workbooks were combined into a single workbook for further analysis.

2.1.5 PRISMA flow diagram to summarise the searching and screening process

Figure 1 is a flow diagram summarising the results of the search and selection process, from the number of records identified in the search to the number of studies finally included in the review. It uses the format provided by Page *et al.* (2021) as part of the recommendations of the *Preferred Reporting Items for Systematic reviews and Meta-Analyses* (PRISMA) statement.

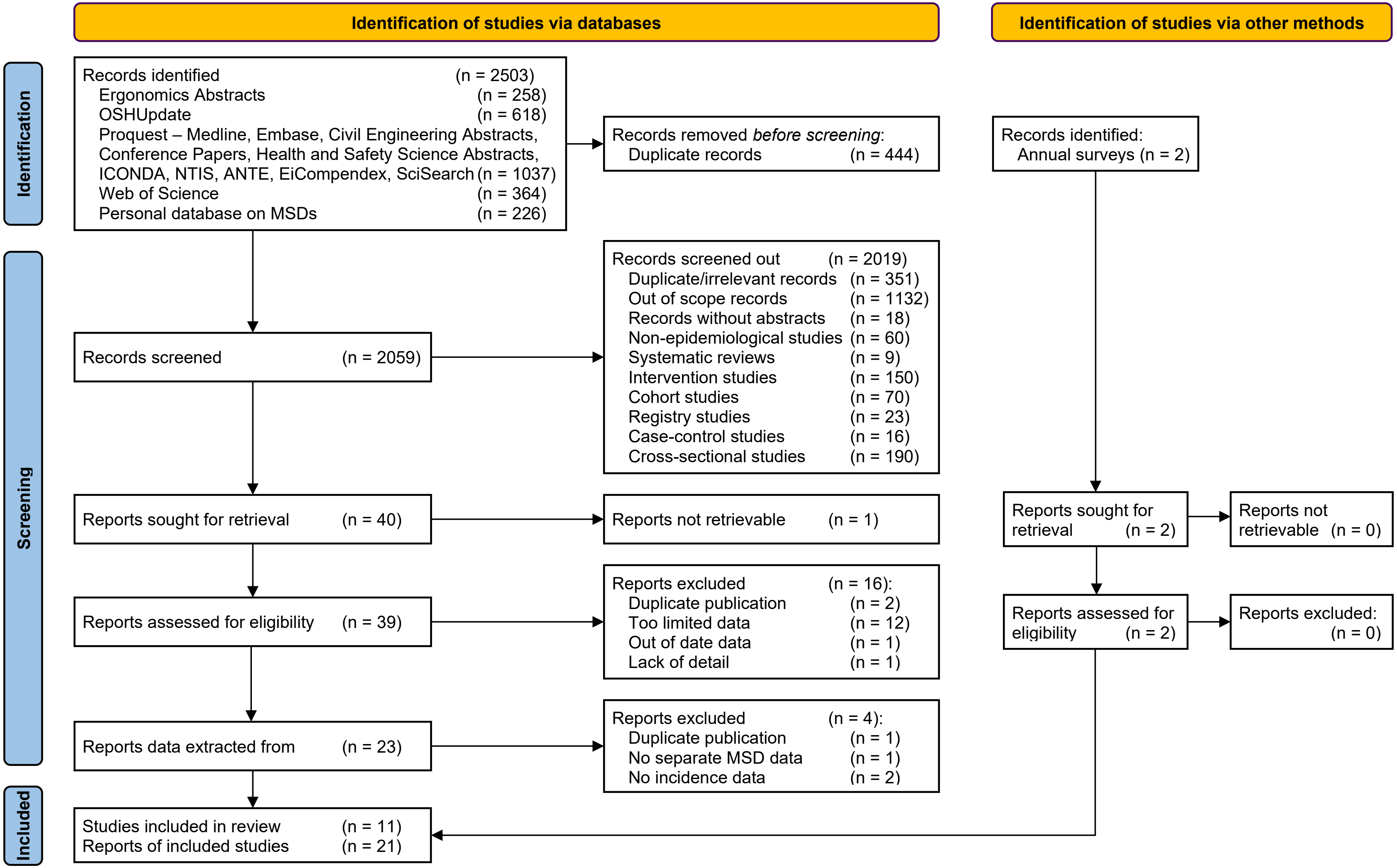
Table 11. Papers identified for review as registry/retrospective studies from titles and abstracts (N = 40)

No.	Paper	Group	Country	Outcome of full-text retrieval (N = 36)	Outcome of full-text review/ decision re data extraction (N = 23)	Data used (N = 19)
1	Lipscomb *et al.* (1996)	1	USA	Full text retrieved	Excluded – data available in related paper(s)	–
2	Lipscomb *et al.* (1997)			Full text retrieved	Data extracted	Yes
3	Lipscomb *et al.* (2008a)			Full text retrieved	Data extracted	Yes
4	Lipscomb *et al.* (2008b)			Full text retrieved	Data extracted	Yes
5	Lipscomb *et al.* (2009a)			Full text retrieved	Excluded – injury rate data not reported	–
6	Lipscomb *et al.* (2009b)			Full text retrieved	Excluded – data available in related paper(s)	–
7	Schoenfisch *et al.* (2014)			Full text retrieved	Data extracted	No
8	Lipscomb *et al.* (2015)			Full text retrieved	Data extracted	Yes
9	Silverstein *et al.* (2002)	2	USA	Full text retrieved	Data extracted	Yes
10	Bonauto *et al.* (2005)			Excluded – Paper not available	–	–
11	Bonauto *et al.* (2006)			Full text retrieved	Data extracted	Yes
12	Schoonover *et al.* (2010)			Full text retrieved	Data extracted	Yes
13	Spector *et al.* (2011)			Full text retrieved	Data extracted	Yes
14	Anderson *et al.* (2013)			Full text retrieved	Data extracted	Yes
15	Niskanen (1985)	3	Finland	Full text retrieved	Excluded – MSD data not reported separately	–
16	Wickström *et al.* (1985)			Full text retrieved	Excluded – limited data	–
17	Nurminen (1997)			Full text retrieved	Data extracted	No

No.	Paper	Group	Country	Outcome of full-text retrieval (N = 36)	Outcome of full-text review/ decision re data extraction (N = 23)	Data used (N = 19)
18	Wang *et al.* (2017)	4	USA	Full text retrieved	Data extracted	Yes
19	Dong *et al.* (2019)			Full text retrieved	Data extracted	Yes
20	Kontio *et al.* (2018)	5	Finland	Full text retrieved	Data extracted	Yes
21	Solovieva *et al.* (2018)			Full text retrieved	Data extracted	Yes
22	Brenner and Ahern (2000)	6	Ireland	Full text retrieved	Excluded – MSD data not reported separately	–
23	Brenner and Ahern (2005)			Full text retrieved	Excluded – MSD data not reported separately	–
24	Hartmann and Seidel (2003)	7	Germany	Full text retrieved	Excluded – limited data	–
25	Hartmann and Seidel (2008)			Full text retrieved	Excluded – limited data	–
26	Heilskov-Hansen *et al.* (2016)	8	Denmark	Full text retrieved	Excluded – single trade study	–
27	Thomsen *et al.* (2016)			Excluded – Conference abstract	–	–
28	Halewyck de Heusch (1980)		Belgium	Full text retrieved	Excluded – limited data	–
29	Klein *et al.* (1984)		USA	Excluded – Data not specific to construction trades	–	–
30	Myers and Trent (1988)		USA	Full text retrieved	Excluded – data outdated	–
31	Guidotti (1995)		Canada	Full text retrieved	Data extracted	No
32	Chiou *et al.* (2000)		USA	Full text retrieved	Data extracted	No
33	Duguay *et al.* (2001)		Canada	Full text retrieved	Data extracted	Yes

No.	Paper	Group	Country	Outcome of full-text retrieval (N = 36)	Outcome of full-text review/ decision re data extraction (N = 23)	Data used (N = 19)
34	Husberg *et al.* (2005)		USA	Excluded – Data not specific to construction trades	–	–
35	Silverstein and Adams (2006)		USA	Full text retrieved	Excluded – data not specific to construction trades	–
36	Stocks *et al.* (2011)		UK	Full text retrieved	Data extracted	Yes
37	Andersen *et al.* (2012)		Denmark	Full text retrieved	Data extracted	Yes
38	Wahlström *et al.* (2012)		Sweden	Full text retrieved	Data extracted	Yes
39	Memarian and Mitropoulos (2013)		USA	Full text retrieved	Data extracted	Yes
40	Dale *et al.* (2015)		USA	Full text retrieved	Data extracted	Yes

Figure 1. PRISMA 2020 flow diagram for the study



PRISMA flowchart design from Page *et al.* (2021), licensed under CC BY 4.0.

2.2 Systematic review analysis methods

2.2.1 Inclusion of Government statistics

Examination of the papers by Wang *et al.* (2017) and Dong *et al.* (2019) showed that their data formed a subset of the publicly available SOII data from the USA (see Section 1.4.2 for a description of the SOII and Section 3.3 for analysis of their data). It was therefore decided to include the full SOII dataset as a source of relevant data on prevalence and incidence of WRMSDs. It was also decided to use the HSE LFS survey as a source of similar data for Great Britain.

2.2.2 Analysis of HSE LFS data

HSE updates its published statistics annually and the data tables include data for previous years. The lfsillind.xlsx file (data analysed by UK SIC code) and the lfsillocc.xlsx file (data analysed by UK SOC code) were downloaded from the HSE statistics microsite, https://www.hse.gov.uk/statistics/index.htm on 02/11/2023. These contained data collected up to the end of the 2021/22 financial year, ie to the end of March 2022.

Copies of the downloaded Excel workbooks were examined and both prevalence/incidence data and prevalence ratio/incidence ratio data and their associated 95% Confidence Intervals were extracted for occupations with sufficiently large samples for HSE to provide estimates. Estimates of the numbers of FTE workers in each occupational class were calculated from the prevalence or incidence data and the associated rate data.

HSE rounds its estimates of prevalence and incidence to the nearest thousand. HSE also reports 95% Confidence Intervals for these rates, again rounded to the nearest thousand. The limits of the LFS sample size means that HSE does not provide estimates for subgroups where sample sizes are too small for the estimates to be reliable.

For the data classified by industry (ie the SIC code), it was decided to use annual averages over the three-year period from April 2016 to March 2019. For the data classified by occupation (the SOC code), the data used are annual averages over the later period from April 2017 to March 2020. This means that the two sets of data are for slightly different but overlapping periods of three UK financial years. These periods were selected as being recent but not significantly affected by the Coronavirus pandemic that started in early 2020.

The SIC data are broken down to the lowest level of industry group (see Table 1 in Section 1.3.1. The SOC data are broken down to the smallest occupational group (see Table 2 in Section 1.3.2).

2.2.3 Analysis of BLS SOII data

The BLS website makes available three data sets derived from the SOII:

- injury and illness rate per 10 000 full-time workers
- injury and illness cases

- median days lost

These are classified in two complementary ways:

- By the NAICS code classification of industries
- By the SOC code classification of occupations

It was decided to extract data from the 10-year period from 2011 to 2020 to allow analysis of data over a number of years.

It was found that construction industry data were available for this period from 35 NAICS codes within the construction sector code of 23XXXX. There are an additional six codes where no data are available. Of the 35 codes with data, 25 are at the lowest level of classification and ten are higher level classifications that include other codes from lower levels of classification. The analysis of these data reported in Section 3.3.1.

The US 2010 SOC codes were examined to identify construction occupations. The majority of these occupations had codes from 47-0xxx to 47-4xxx. There were related occupations in other top-level occupational groups, such as construction managers (SOC code 11-902x). A total of 86 occupational groups was selected. Of these, 19 were 'Broad Groups' identical to the 'Detailed Occupation' at the level below. One was a 'Minor Group' identical to the 'Broad Group' below. Data were extracted for the remaining 66 groups that had either more than one sub-group or were 'Detailed Occupations'. The analysis of these data is reported in Section 3.3.2.

Case and days absent data were available for all 66 occupations and for all 10 years for 44 occupations (67%). Between seven and nine years of data were available for 10 occupations (15%); 7 occupations (11%) had from four to six years of data. The remaining five occupations (8%) had between and three years of data. The total 'occupation-years' of data for cases and days absent were both 566. The mean years of case and days absent data per occupation was 8.6.

Rate data were not available for two of the 66 occupations. These were both 'all other' categories. There were slightly fewer occupation-year values available across the remaining occupations – a total of 539. The number of occupations with rate data for 10 years was 40 (61%) and the average years of data for each occupation was 8.2. An explanation has not been found in BLS publications explaining the lack of rate data where case data are available.

2.2.4 Analysis of Washington State Workers Compensation data

The state-run Workers' Compensation (WC) scheme[16] in place in Washington State is a no-fault insurance system that pays wage and medical benefits to employees who suffer on-the-job injuries or illnesses. It provides immunity for employers from lawsuits resulting from workplace injuries or illnesses suffered by their employees.

[16] Chapter 296-17 WAC, "General Reporting Rules, Audit and Recordkeeping, Rates and Rating System for Washington Workers' Compensation Insurance". Available at https://apps.leg.wa.gov/wac/.

The state WC scheme calculates the insurance premiums that employers pay by using the 'Washington Industrial risk Classification' (WIC) to group firms with similar risk profiles. "Each classification describes the types of businesses and operations it includes, and the classification is a blend of exposures and risks representing the combined work for all of the businesses in the classification"[17]. Unlike the SIC and SOC classifications, the WIC system does not appear to be hierarchical. The WIC risk classes grouped under the heading of 'Building Construction and Trades' in the list of insurance rates at https://lni.wa.gov/insurance/_docs/2023RatesBusTypeClassCode.xlsx range from 0301 'Landscape Construction and Renovation' to 0610 'Telephone and Electrical Alarm System Installation'. The risk classes under 'Miscellaneous Construction And Mining' range from 0101 'Excavation, Road Construction, Land Clearing, NOC' to 5206 'Construction/Logging/Trucking - Permanent Yard'. While no classes fall within more than one top-level grouping, the overlap of the class number ranges shows that the numbering system is not designed to separate the top-level groupings.

The WIC approach to risk classification appears to be unique to Washington State. There is no similar UK classification that it could be mapped to. Therefore, using information about WIC risk classes in the UK would have to rely on mapping class names onto UK construction practices rather than industries or occupations.

Such classification systems have to evolve over time to reflect changes in the jobs that exist and changes withing individual occupations. Therefore, class definitions change/are created/are removed over time. As a result, some of the risk classes reported in Sections 3.4.1 and 3.4.2 do not appear in the 2023 classification. For example, class 0109 'Reinforcing steel installation' in Table 49 is no longer used.

2.2.5 Correlation of incidence rates reported in different studies

Correlation coefficients (Pearson's r) were calculated in order to compare the rankings of prevalence/incidence rates reported by a number of studies. This was done by manual matching of job titles (and SOC codes where available) for each pair of studies in an Excel sheet and using the Excel CORREL function to return the value of Pearson's r. As positive relationships were expected, the associated one-tailed probabilities were then found from statistical tables. Scatter plots with best-fit regression equations were also created in Excel.

In order to give insights into how well the job titles could be matched, pairs of percentages were calculated from the numbers of WRMSD cases contributing to each correlation. So, if study A had occupations representing 90% of cases matched to occupations in Study B representing 80% of cases, this was recorded as '90.0%,80.0%.'

2.2.6 Presentation of injury and incidence rates

All rates included in this report have been standardised so that they are expressed as the number of injuries reported per 200 000 hours worked. This figure is equivalent to 100 full-

[17] Chapter 296-17 WAC, "General Reporting Rules, Audit and Recordkeeping, Rates and Rating System for Washington Workers' Compensation Insurance". Available at https://apps.leg.wa.gov/wac/.

time workers working 40 hours per week for 50 weeks in each year. It is a common metric in the papers included as it reflects a ‘standard’ working year in the USA. Using a standardised metric in this way allows direct comparison between studies.

This study sought to rank construction tasks and activities by risk of WRMSDs. This has been attempted before in Washington State in the USA (Section 3.4). Those studies used a Prevention Index to help prioritise enforcement activity. This averaged the rank of the injury rate with the rank of the number of cases reported, with the effect of increasing the rankings of large industries with relatively low injury rates. Doing so for this study would require data on worker population sizes for all the studies included, which were not always reported. Instead, simple incidence rates per 200 000 hours worked are used.

3 Results

3.1 UK studies of WRMSD rates in construction

3.1.1 HSE LFS data classified by industry (SIC code)

3.1.1.1 Detailed results

The industry data included within the detailed data file[18] made available by HSE are broken down to the lowest level of industry group. Because of the limits of the LFS sample size, many industry codes are marked as having sample numbers that are too small to provide reliable estimates. In the case of Section F of the UK SIC, only eight of the 35 construction industry codes (see Table 1) have sufficient data for any estimates to be provided in relation to MSDs. Of these eight, two are identical (F41.2 and F41.20 Construction of residential and non-residential buildings), leaving seven unique codes. Of the eight industry codes, two are at the lowest level of industry classes (F41.20 'Construction of residential and non-residential buildings' and F43.32 'Joinery installation'). The remaining codes are at Section, Division and Group levels.

Table 12, Table 13, Table 14, and Table 16 list data for the eight codes and for all industries. Table 12 reports estimates of 12-month prevalences and prevalence rates for all MSDs. Table 13 reports prevalences and prevalence rate estimates for the subset of MSDs mostly affecting the upper limbs and neck, including the shoulders. Table 14 reports prevalences and prevalence rates estimates for MSDs mostly affecting the back, so includes data for the lower and upper back combined, but not the neck or shoulders. Table 16 reports estimates of incidence and incidence rates for all MSDs. The HSE tables do not include incidence estimates for the upper limb/neck or back.

The prevalence and incidence rates and their associated 95% Confidence Intervals are given in these tables. They are expressed as rates per 200 000 hours, ie per 100 worker-years, using 2000 hours as a standard figure for the annual hours worked by a full-time worker. The numbers of full-time equivalent (FTE) workers in each SIC Code have been estimated by averaging estimates obtained from HSE's prevalence and rate data reported in these tables. This averages out errors introduced by the rounding of the figures that HSE report to the nearest thousand.

The data in Table 12 indicate that the prevalence rate of MSDs in the construction sector is 1.8 times (= 2.11/1.16) the prevalence rate averaged across all industries. Within the sector, the F43.3 'Building completion and finishing' group has twice (= 4.17/2.11) the rate of MSDs of the sector as a whole. In contrast, F43.2 'Electrical, plumbing and other construction installation activities' has a rate that is 90% (1.93/2.11) of the rate of the whole sector. Of the two industry classes, F41.20 'Construction of residential and non-residential buildings' has the second lowest prevalence rate in the construction sector codes listed, whereas F43.32 'Joinery installation' has the second highest rate in the table

[18] The lfsinjind.xlsx file available at https://www.hse.gov.uk/statistics/lfs/tables.htm.

at 3.68 reports per 200 000 hours worked. The rate that exceeds it is its parent group, F43.3 ‘Building completion and finishing’ at 4.17 reports per 200 000 hours. There are four other classes within F43.3, (F43.31 ‘Plastering’, F43.33 ‘Floor and wall covering’, F43.34 ‘Painting and glazing’ and F43.39 ‘Other building completion and finishing’). These classes are too small for HSE to estimate separate prevalences, but it can be shown that their combined prevalence rate is 4.49 reports per 200 000 hours.

As Table 13 and Table 14 report subsets of the total MSD reports in Table 12, some of the lower SIC classification levels no longer have sufficient numbers for reliable estimates of prevalence to be calculated. For the groups with sufficient numbers, there is increased uncertainty in the estimates, reflected by wider 95% Confidence Intervals. Despite this, Table 13 shows that the construction sector as a whole is at 1.7 times (= 0.87/0.51) the rate of upper limb/neck problems compared to all industries. No statistically significant differences could be detected within the construction sector but the group with the highest risk for upper limb or neck MSDs is F43.3, ‘Building completion and finishing’, which has a prevalence rate 1.9 times (= 1.61/0.87) that of construction as a whole.

The data in Table 14 for MSDs affecting the back show that F43.3 ‘Building completion and finishing’ is the worst construction group, with a rate 2.3 (= 1.71/0.74) times the rate of the whole construction sector. The lack of overlap of the 95% confidence intervals (1.010-2.410 and 0.550-0.940) shows that the difference is statistically significant at the 5% level.

Table 15 compares prevalences in the three main body regions of the upper limbs and neck, the back and the lower limbs. Across the whole construction industry, rates of reports in the upper limbs and neck were highest at 41%, with reports about the back being at 35% and the lower limbs at 24%. Across the whole economy the rates were 44%, 38% and 18%, respectively. In the few construction industry groups with sufficient data to be reported, rates in the upper limb and neck ranged from 35-46%, rates in the back ranged from 33-41% and in the lower limbs up to 27%.

The data in Table 16 show that the 12-month incidence of new cases of MSDs in Group F43.3 ‘Building completion and finishing’ is 2.4 times (= 1.61/0.660) the rate in the whole construction sector. Again, there are insufficient data for reliable estimates to be made for any industrial classes and for other groups.

3.1.1.2 Summary of results

Overall, the prevalence rate of MSDs in the construction sector is significantly higher (1.8 times) the rate averaged across all industries. Within the sector, F43.3 ‘Building completion and finishing’ is clearly the worst industrial group among the small subset of construction industries that the LFS has gathered sufficient data from which valid conclusions can be drawn.

For comparisons across major regions of the body, it can be concluded that reporting rates for back problems are somewhat less than for the upper limb and neck and lower limb reports make up a relatively small proportion of complaints. The precise proportions vary depending on the industry group, but the limitations of the data prevent detailed comparisons of the different levels of classification.

3.1.1.3 Data tables

Table 12. Prevalence and rates of self-reported MSDs caused or made worse by current or most recent job, by industry, for people working in the previous 12 months, GB, averaged over 2016/17-2018/19

UK SIC 2007 code *	Level	Industry description	Estimated FTE	Prevalence	95% CI	PR †	95% CI
0	All	All industries (current/most recent job)	32 907 000	383 000	360 000-405 000	1.160	1.090-1.230
F	Section	Construction	2 298 000	49 000	41 000-57 000	2.110	1.750-2.460
F41	Division	Construction of buildings	863 000	14 000	10 000-18 000	1.590	1.130-2.050
F41.2	Group	Construction of residential and non-residential buildings	760 000	13 000	9 000-17 000	1.670	1.170-2.170
F41.20	Class	Construction of residential and non-residential buildings	760 000	13 000	9 000-17 000	1.670	1.170-2.170
F43	Division	Specialised construction activities	1 070 000	33 000	26 000-40 000	3.070	2.420-3.710
F43.2	Group	Electrical, plumbing and other construction installation activities	466 000	9 000	5 000-12 000	1.930	1.220-2.640
F43.3	Group	Building completion and finishing	391 000	17 000	12 000-21 000	4.170	3.110-5.240
F43.32	Class	Joinery installation	163 000	6 000	4 000-9 000	3.680	2.170-5.200

MSDs; Musculoskeletal disorders; GB, Great Britain; UK SIC 2007, UK Standard Industrial Classification 2007 edition; FTE, Full-Time Equivalent; CI, Confidence Interval; PR, Prevalence Rate.

* All construction SIC codes where sample numbers are too small to provide any reliable estimates have been excluded.

† Rate per 200 000 hours worked in the previous 12 months.

Data derived from Table 2 of the lfsinjind.xlsx file available at https://www.hse.gov.uk/statistics/lfs/tables.htm.

Table 13. Prevalence and rates of self-reported UL MSDs caused or made worse by current or most recent job, by industry, for people working in the previous 12 months, GB, averaged over 2016/17-2018/19

UK SIC 2007 code *	Level	Industry description	Estimated FTE	Prevalence	95% CI	PR †	95% CI
0	All	All industries (current/most recent job)	32 907 000	167 000	152 000-182 000	0.510	0.460-0.550
F	Section	Construction	2 298 000	20 000	15 000-26 000	0.870	0.640-1.110
F41	Division	Construction of buildings	863 000	6 000	4 000-9 000	0.710	0.410-1.010
F41.2	Group	Construction of residential and non-residential buildings	760 000	6 000	4 000-9 000	0.810	0.470-1.160
F41.20	Class	Construction of residential and non-residential buildings	760 000	6 000	4 000-9 000	0.810	0.470-1.160
F43	Division	Specialised construction activities	1 070 000	13 000	8 000-18 000	1.220	0.790-1.650
F43.2	Group	Electrical, plumbing and other construction installation activities	466 000	‡	‡	‡	‡
F43.3	Group	Building completion and finishing	391 000	6 000	4 000-9 000	1.610	0.940-2.270
F43.32	Class	Joinery installation	163 000	‡	‡	‡	‡

UL MSDs; Musculoskeletal disorders mainly affecting the upper limbs or neck; GB, Great Britain; UK SIC 2007, UK Standard Industrial Classification 2007 edition; FTE, Full-Time Equivalent; CI, Confidence Interval; PR, Prevalence Rate.

* All construction SIC codes where sample numbers are too small to provide any reliable estimates have been excluded.

† Rate per 200 000 hours worked in the previous 12 months.

‡ Sample numbers are too small to provide reliable estimates.

Data derived from Table 3 of the lfsinjind.xlsx file available at https://www.hse.gov.uk/statistics/lfs/tables.htm.

Table 14. Prevalence and rates of self-reported back MSDs caused or made worse by current or most recent job, by industry, for people working in the previous 12 months, GB, averaged over 2016/17-2018/19

UK SIC 2007 code *	Level	Industry description	Estimated FTE	Prevalence	95% CI	PR †	95% CI
0	All	All industries (current/most recent job)	32 907 000	146 000	132 000-160 000	0.440	0.400-0.480
F	Section	Construction	2 298 000	17 000	13 000-22 000	0.740	0.550-0.940
F41	Division	Construction of buildings	863 000	‡	‡	‡	‡
F41.2	Group	Construction of residential and non-residential buildings	760 000	‡	‡	‡	‡
F41.20	Class	Construction of residential and non-residential buildings	760 000	‡	‡	‡	‡
F43	Division	Specialised construction activities	1 070 000	11 000	7 000-14 000	1.020	0.690-1.350
F43.2	Group	Electrical, plumbing and other construction installation activities	466 000	‡	‡	‡	‡
F43.3	Group	Building completion and finishing	391 000	7 000	4 000-10 000	1.710	1.010-2.410
F43.32	Class	Joinery installation	163 000	‡	‡	‡	‡

Back MSDs; Musculoskeletal disorders mainly affecting the back; GB, Great Britain; UK SIC 2007, UK Standard Industrial Classification 2007 edition; FTE, Full-Time Equivalent; CI, Confidence Interval; PR, Prevalence Rate.

* All construction SIC codes where sample numbers are too small to provide any reliable estimates have been excluded.

† Rate per 200 000 hours worked in the previous 12 months.

‡ Sample numbers are too small to provide reliable estimates.

Data derived from Table 4 of the lfsinjind.xlsx file available at https://www.hse.gov.uk/statistics/lfs/tables.htm.

Table 15. Comparison, by body region, of prevalences and rates of self-reported MSDs caused or made worse by current or most recent job, by industry, for people working in the previous 12 months, GB, averaged over 2016/17-2018/19

UK SIC 2007 code *	Level	Industry description	Estimated FTE	Prevalence	UL prevalence	Back prevalence	LL prevalence	UL %	Back %	LL %
0	All	All industries (current/most recent job)	32 907 000	383 000	167 000	146 000	70 000	44%	38%	18%
F	Section	Construction	2 298 000	49 000	20 000	17 000	12 000	41%	35%	24%
F41	Division	Construction of buildings	863 000	14 000	6 000	†	†	43%	†	†
F41.2	Group	Construction of residential and non-residential buildings	760 000	13 000	6 000	†	†	46%	†	†
F41.20	Class	Construction of residential and non-residential buildings	760 000	13 000	6 000	†	†	46%	†	†
F43	Division	Specialised construction activities	1 070 000	33 000	13 000	11 000	9 000	39%	33%	27%
F43.2	Group	Electrical, plumbing and other construction installation activities	466 000	9 000	†	†	†	†	†	†
F43.3	Group	Building completion and finishing	391 000	17 000	6 000	7 000	4 000	35%	41%	24%
F43.32	Class	Joinery installation	163 000	6 000	†	†	†	†	†	†

MSDs; Musculoskeletal disorders; GB, Great Britain; UK SIC 2007, UK Standard Industrial Classification 2007 edition; FTE, Full-Time Equivalent; UL, Upper limbs and neck; LL, Lower limbs.

* All construction SIC codes where sample numbers are too small to provide any reliable estimates have been excluded.

† Sample numbers are too small to provide reliable estimates.

Data derived from Table 2, Table 3 and Table 4 of https://www.hse.gov.uk/Statistics/lfs/lfsinjind.xlsx.

Table 16. Incidence and rates of self-reported MSDs caused or made worse by current or most recent job, by industry, for people working in the previous 12 months, GB, averaged over 2016/17-2018/19

UK SIC 2007 code *	Level	Industry description	Estimated FTE	Incidence	95% CI	IR †	95% CI
0	All	All industries (current/most recent job)	32 907 000	134 000	121 000-147 000	0.410	0.370-0.440
F	Section	Construction	2 298 000	15 000	11 000–20 000	0.660	0.480-0.850
F41	Division	Construction of buildings	863 000	‡	‡	‡	‡
F41.2	Group	Construction of residential and non-residential buildings	760 000	‡	‡	‡	‡
F41.20	Class	Construction of residential and non-residential buildings	760 000	‡	‡	‡	‡
F43	Division	Specialised construction activities	1 070 000	12 000	8 000-16 000	1.130	0.780-1.490
F43.2	Group	Electrical, plumbing and other construction installation activities	466 000	‡	‡	‡	‡
F43.3	Group	Building completion and finishing	391 000	6 000	4 000-9 000	1.610	0.940-2.270
F43.32	Class	Joinery installation	163 000	‡	‡	‡	‡

MSDs; Musculoskeletal disorders; GB, Great Britain; UK SIC 2007, UK Standard Industrial Classification 2007 edition; FTE, Full-Time Equivalent; CI, Confidence Interval; IR, Incidence Rate.

* All construction SIC codes where sample numbers are too small to provide any reliable estimates have been excluded.

† Rate per 200 000 hours worked in the previous 12 months.

‡ Sample numbers are too small to provide reliable estimates.

Data derived from Table 7 of the lfsinjind.xlsx file available at https://www.hse.gov.uk/statistics/lfs/tables.htm.

3.1.2 HSE LFS data classified by occupation (UK SOC 2010 code)

3.1.2.1 Detailed results

The detailed data file of LFS data classified by occupation[19] that HSE makes available reports data for occupational groups at all levels of the UK SOC hierarchy.

As with the SIC data discussed in Section 3.1.1, many occupational groups have sample numbers that are too small to provide reliable estimates. Of the 62 groups relevant to construction listed in Table 2, only 19 have sufficient data for any estimates to be provided in relation to MSDs. Of these, only three of the 33 unit groups, all from minor group 531 'Construction and building trades', have sufficient data. The only other minor group in construction with sufficient data is 524 'Electrical and electronic trades'. At the sub-major group level, the one construction-specific group – 53 'Skilled construction and building trades' – had sufficient data. Seven of the eight sub-major groups and all six of the major groups containing construction occupations also had sufficient data for reliable estimates. The pattern of most top-level groups having sufficient data and most lower level groups not doing so is a result of increased sample sizes as groups are combined.

Table 17 contains estimates of 12-month prevalences and prevalence rates for all MSDs for the 19 occupational groups that consist of or contain construction occupations. It also contains data for 'All occupations' across the GB workforce. Table 18, Table 19, Table 20, Table 22 and Table 23 list data for the three unit groups with reliable estimates and the parent minor group (531 'Construction and building trades'), sub-major group (53 'Skilled construction and building trades') and major group (5 'Skilled trades occupations'). These tables also include data for 'All occupations' for comparison purposes.

As with the SIC data in the previous section, these SOC tables differ in the MSD data presented: Table 18 reports estimates of 12-month prevalences and prevalence rates for all MSDs, replicating part of Table 17. Table 19 reports prevalences and prevalence rate estimates for the subset of MSDs mostly affecting the upper limbs and neck. Table 20 reports prevalences and prevalence rates estimates for MSDs mostly affecting the back. Table 22 reports estimates of incidence and incidence rates for all MSDs. The HSE tables do not include incidence estimates for the upper limb/neck or back.

Again, as with the SIC data, the numbers of full-time equivalent (FTE) workers in each SOC Code have been estimated by averaging estimates obtained from HSE's prevalence and rate data for the different outcomes reported in Table 18, Table 19, Table 20 and Table 22.

Of the major groups (single digit SOC codes) listed in Table 17, 5 'Skilled trades occupations', stands out as having the highest prevalence rate at 1.9 times the rate of 'All occupations'. It is noticeable that the non-manual/managerial occupations (codes 1-3) have lower prevalence rates than 'All occupations' and the manual occupations (codes 5, 8 and 9) have higher rates.

[19] The lfsinjocc.xlsx file available at https://www.hse.gov.uk/statistics/lfs/tables.htm.

At the sub-major group (two-digit SOC codes) level, group 53 ‘Skilled construction and building trades’ has the highest rate, the prevalence rate being 60% higher than the next highest rate, which occurs in group 91 ‘Elementary trades and related occupations’. Code 91 contains ‘elementary agricultural occupations’ (911) and ‘elementary process plant occupations’ (913) as well as ‘elementary construction occupations’ (912).

At the minor group level (three-digit SOC codes), group 531 ‘Construction and building trades’ has a rate slightly in excess of the parent sub-major group 53 ‘Skilled construction and building trades’. Group 531 has a prevalence rate three times the rate for ‘All occupations’. The other minor groups within group 53 are 532 ‘Building finishing trades’ and 533 ‘Construction and building trades supervisors’, neither of which has sufficient data to be reported. The three unit groups with sufficient data are all within minor group 531 and are discussed below in relation to Table 18.

Table 18 is the subset of data in Table 17 that relates specifically to construction occupations and their parent groups in the hierarchy. The three unit groups listed are all within minor group 531, along with four other skilled construction occupations that are not listed due to insufficient data. Unit group 531 has a prevalence rate of 3.36 reports per 200 000 hours worked. The occupation with the highest prevalence of MSDs is 5314 ‘Plumbers and heating and ventilating engineers’. The rate of 3.68 reports per 200 000 hours slightly exceeds that of group 531. The other two group, 5315 ‘Carpenters and joiners’ and 5319 ‘Construction and building trades n.e.c.’, both have lower rates (2.84 and 2.76 reports per 200 000 hours) than group 531.

The data for both upper limb and neck MSDs in Table 19 and for back MSDs in Table 20 indicate that the sample sizes for the three unit groups have become too small for reliable estimates to be found.

Table 21 compares the rates across the three major body regions of the upper limbs and neck, the back and the lower limbs. The precise proportions vary slightly, depending on the group being examined, but both the UL MSD and the Back MSD rates are about 40% of the rate for all MSDs across the four groups with sufficient data, leaving 20% of reports about the lower limbs.

Minor group 531 ‘Construction and building trades’, which is the smallest group with data available for UL MSDs has a prevalence rate 2.7 times (= 1.30/0.48) the rate for ‘All occupations’, which is similar to the situation for all MSDs in Table 18 where the rate for group 531 is 3.0 times (= 3.36/1.13) the rate for ‘All occupations’.

Group 531 in Table 20, has 3.1 (= 1.34/0.43) times the prevalence rate of ‘All occupations’, very close to the rate ratios for this group all MSDs and for UL MSDs.

The incidence data given in Table 22 show that the sample size for group 531 has become too small for reliable incidence estimates to be calculated for it. Looking at sub-major group 53, the rate ratio comparing it to ‘All occupations’ is 1.9 (=0.76/0.39). The prevalence rate ratio for the categories in Table 18 is 2.7 (= 3.10/1.13). The related 95%

confidence intervals in both tables indicate that skilled workers in construction and building trades are at significantly increased risk of MSDs than ‘All occupations’.

Table 23 reports data for days lost due to MSDs for the unit groups and their parent groups with sufficient data for reliable estimates of prevalences for all MSDs (Table 18). Again, the three unit groups lack sufficient data for reliable days lost estimates. However minor group 531 does have sufficient data, unlike in Table 22. The days lost rate ratio for this group compared to ‘All occupations’ is 3.3 (= 69.0/21.0), again indicating that the skilled workers in the ‘Construction and building trades’ minor group are at much higher risk from MSDs than the average across ‘All occupations’.

3.1.2.2 Summary of results

- Major group 5 ‘Skilled trades occupations’, stands out as having the highest prevalence rate at 1.9 times the rate of ‘All occupations’.
- Non-manual/managerial occupations (codes 1-3) have lower prevalence rates than ‘All occupations’ and the manual occupations (codes 5, 8 and 9) have higher rates.
- At sub-major group level, group 53 ‘Skilled construction and building trades’ has the highest rate.

At the minor group level, group 531 ‘Construction and building trades’ has a rate three times the rate for ‘All occupations’. Of the three unit groups with sufficient data for reliable estimates, the highest prevalence of MSDs is for 5314 ‘Plumbers and heating and ventilating engineers’.

The data sets for separate body parts (for example, the upper limb and neck) tend to be too small for reliable estimates for unit level groups to be found. Back and UL MSDs each make up about 40% of MSDs in SOC sub-major group 53, ‘Skilled construction and building trades’.

3.1.2.3 Data tables

Table 17. Prevalence of self-reported MSDs caused or made worse by current or most recent job, UK SOC 2010, people working in the previous 12 months, GB, averaged over 2017/18-2019/20

Group code * †	Group level	UK SOC 2010 group title	Estimated FTE	Prevalence	95% CI	PR ‡	95% CI
All	All	All occupations	33 714 000	379 000	356 000-403 000	1.130	1.060-1.200
1	Major	Managers, directors and senior officials	3 707 000	27 000	21 000-33 000	0.740	0.570-0.910
2	Major	Professional occupations	7 150 000	71 000	60 000-81 000	0.990	0.850-1.140
3	Major	Associate professional and technical occupations	4 872 000	42 000	34 000-49 000	0.850	0.700-1.000
5	Major	Skilled trades occupations	3 205 000	69 000	60 000-78 000	2.150	1.860-2.430
8	Major	Process, plant and machine operatives	1 991 000	35 000	27 000-42 000	1.720	1.370-2.070
9	Major	Elementary occupations	3 525 000	40 000	33 000-48 000	1.140	0.920-1.360
11	Sub-major	Corporate managers and directors	2 656 000	18 000	13 000-24 000	0.690	0.490-0.890
21	Sub-major	Science, research, engineering and technology professionals	2 059 000	16 000	11 000-21 000	0.790	0.540-1.050
24	Sub-major	Business, media and public service professionals	1 859 000	16 000	11 000-21 000	0.850	0.590-1.100
52	Sub-major	Skilled metal, electrical and electronic trades	1 141 000	19 000	14 000-24 000	1.640	1.210-2.080
53	Sub-major	Skilled construction and building trades	1 067 000	33 000	26 000-39 000	3.100	2.510-3.690
81	Sub-major	Process, plant and machine operatives	790 000	12 000	8 000-16 000	1.500	1.020-1.980
82	Sub-major	Transport and mobile machine drivers and operatives	1 209 000	22 000	16 000-28 000	1.870	1.380-2.360
91	Sub-major	Elementary trades and related occupations	510 000	10 000	6 000-13 000	1.960	1.230-2.700
524	Minor	Electrical and electronic trades	435 000	8 000	5 000-11 000	1.840	1.120-2.550
531	Minor	Construction and building trades	824 000	27 000	21 000-33 000	3.360	2.650-4.070
5314	Unit	Plumbers and heating and ventilating engineers	190 000	7 000	4 000-10 000	3.680	2.150-5.220

Group code * †	Group level	UK SOC 2010 group title	Estimated FTE	Prevalence	95% CI	PR ‡	95% CI
5315	Unit	Carpenters and joiners	211 000	6 000	3 000-9 000	2.840	1.590-4.100
5319	Unit	Construction and building trades n.e.c.	254 000	7 000	4 000-10 000	2.760	1.490-4.030

MSDs, Musculoskeletal disorders; GB, Great Britain; UK SOC 2010, UK Standard Occupational Classification 2010 edition; FTE, Full-time equivalents; CI, Confidence Interval; PR, Prevalence Rate; n.e.c., not elsewhere classified.

* UK SOC 2010 groups containing construction occupations were identified from SOC 2010 Volume 1, available at https://www.ons.gov.uk/.

† Occupational groups where sample numbers are too small to provide any reliable estimates have been omitted.

‡ Rate per 200 000 hours worked in the previous 12 months.

Data derived from Table 2 of the lfsinjocc.xlsx file available at https://www.hse.gov.uk/statistics/lfs/tables.htm.

Table 18. Prevalence of self-reported MSDs caused or made worse by current or most recent job, skilled construction occupations, people working in the previous 12 months, GB, averaged over 2017/18-2019/20

Group code * †	Group level	UK SOC 2010 group title	Estimated FTE	Prevalence	95% CI	PR ‡	95% CI
All	All	All occupations	33 714 000	379 000	356 000-403 000	1.130	1.060-1.200
5	Major	Skilled trades occupations	3 205 000	69 000	60 000-78 000	2.150	1.860-2.430
53	Sub-major	Skilled construction and building trades	1 067 000	33 000	26 000-39 000	3.100	2.510-3.690
531	Minor	Construction and building trades	824 000	27 000	21 000-33 000	3.360	2.650-4.070
5314	Unit	Plumbers and heating and ventilating engineers	190 000	7 000	4 000-10 000	3.680	2.150-5.220
5315	Unit	Carpenters and joiners	211 000	6 000	3 000-9 000	2.840	1.590-4.100
5319	Unit	Construction and building trades n.e.c.	254 000	7 000	4 000-10 000	2.760	1.490-4.030

MSDs, Musculoskeletal disorders; GB, Great Britain; UK SOC 2010, Standard Occupational Classification 2010 edition; FTE, Full-time equivalents; CI, Confidence Interval; PR, Prevalence Rate; n.e.c., not elsewhere classified.

* UK SOC 2010 groups containing construction occupations were identified from SOC 2010 Volume 1, available at https://www.ons.gov.uk/.

† Occupational groups where sample numbers are too small to provide any reliable estimates have been omitted.

‡ Rate per 200 000 hours worked in the previous 12 months.

Data derived from Table 2 of the lfsinjocc.xlsx file available at https://www.hse.gov.uk/statistics/lfs/tables.htm.

Table 19. Prevalence of self-reported UL MSDs caused or made worse by current or most recent job, skilled construction occupations, people working in the previous 12 months, GB, averaged over 2017/18-2019/20

Group code [*] [†]	Group level	UK SOC 2010 group title	Estimated FTE	Prevalence	95% CI	PR [‡]	95% CI
All	All	All occupations	33 714 000	162 000	147 000-176 000	0.480	0.440-0.530
5	Major	Skilled trades occupations	3 205 000	26 000	20 000-32 000	0.810	0.630-0.990
53	Sub-major	Skilled construction and building trades	1 067 000	13 000	9 000-17 000	1.220	0.840-1.600
531	Minor	Construction and building trades	824 000	11 000	7 000-14 000	1.300	0.850-1.760
5314	Unit	Plumbers and heating and ventilating engineers	190 000	§	§	§	§
5315	Unit	Carpenters and joiners	211 000	§	§	§	§
5319	Unit	Construction and building trades n.e.c.	254 000	§	§	§	§

UL MSDs, Musculoskeletal disorders mainly affecting the upper limbs or neck; GB, Great Britain; UK SOC 2010, Standard Occupational Classification 2010 edition; FTE, Full-time equivalents; CI, Confidence Interval; PR, Prevalence Rate; n.e.c., not elsewhere classified.

[*] UK SOC 2010 groups containing construction occupations were identified from SOC 2010 Volume 1, available at https://www.ons.gov.uk/.

[†] Occupational groups where sample numbers are too small to provide any reliable estimates have been omitted.

[‡] Rate per 200 000 hours worked in the previous 12 months.

[§] Sample numbers are too small to provide reliable estimates.

Data derived from Table 3 of the lfsinjocc.xlsx file available at https://www.hse.gov.uk/statistics/lfs/tables.htm.

Table 20. Prevalence of self-reported back MSDs caused or made worse by current or most recent job, skilled construction occupations, people working in the previous 12 months, GB, averaged over 2017/18–2019/20

Group code * †	Group level	UK SOC 2010 group title	Estimated FTE	Prevalence	95% CI	PR ‡	95% CI
All	All	All occupations	33 714 000	145 000	130 000-159 000	0.430	0.390-0.480
5	Major	Skilled trades occupations	3 205 000	27 000	21 000-33 000	0.850	0.670-1.030
53	Sub-major	Skilled construction and building trades	1 067 000	13 000	9 000-17 000	1.200	0.820-1.570
531	Minor	Construction and building trades	824 000	11 000	7 000-15 000	1.340	0.890-1.800
5314	Unit	Plumbers and heating and ventilating engineers	190 000	§	§	§	§
5315	Unit	Carpenters and joiners	211 000	§	§	§	§
5319	Unit	Construction and building trades n.e.c.	254 000	§	§	§	§

Back MSDs, Musculoskeletal disorders mainly affecting the back; GB, Great Britain; UK SOC 2010, Standard Occupational Classification 2010 edition; FTE, Full-time equivalents; CI, Confidence Interval; PR, Prevalence Rate; n.e.c., not elsewhere classified.

* UK SOC 2010 groups containing construction occupations were identified from SOC 2010 Volume 1, available at https://www.ons.gov.uk/.

† Occupational groups where sample numbers are too small to provide any reliable estimates have been omitted.

‡ Rate per 200 000 hours worked in the previous 12 months.

§ Sample numbers are too small to provide reliable estimates.

Data derived from Table 4 of the lfsinjocc.xlsx file available at https://www.hse.gov.uk/statistics/lfs/tables.htm.

Table 21. Comparison, by body region, of prevalences of self-reported MSDs caused or made worse by current or most recent job, skilled construction occupations, people working in the previous 12 months, GB, averaged over 2017/18-2019/20

Group code * †	Group level	UK SOC 2010 group title	Estimated FTE	Prevalence	UL prevalence	Back prevalence	LL prevalence	UL %	Back %	LL %
All	All	All occupations	33 714 000	379 000	162 000	145 000	72 000	43%	38%	19%
5	Major	Skilled trades occupations	3 205 000	69 000	26 000	27 000	16 000	38%	39%	23%
53	Sub-major	Skilled construction and building trades	1 067 000	33 000	13 000	13 000	7 000	39%	39%	21%
531	Minor	Construction and building trades	824 000	27 000	11 000	11 000	5 000	41%	41%	19%
5314	Unit	Plumbers and heating and ventilating engineers	190 000	7 000	‡	‡	‡	‡	‡	‡
5315	Unit	Carpenters and joiners	211 000	6 000	‡	‡	‡	‡	‡	‡
5319	Unit	Construction and building trades n.e.c.	254 000	7 000	‡	‡	‡	‡	‡	‡

MSDs, Musculoskeletal disorders; GB, Great Britain; UK SOC 2010, UK Standard Occupational Classification 2010 edition; FTE, Full-time equivalents; UL, Upper limbs and neck; LL, lower limbs; n.e.c., not elsewhere classified.

* UK SOC 2010 groups containing construction occupations were identified from SOC 2010 Volume 1, available from https://www.ons.gov.uk/.

† Occupational groups where sample numbers are too small to provide any reliable estimates have been omitted.

‡ Sample numbers are too small to provide reliable estimates.

Data derived from Table 2, Table 3 and Table 4 of https://www.hse.gov.uk/Statistics/lfs/lfsinjocc.xlsx.

Table 22. Incidence of self-reported MSDs caused or made worse by current or most recent job, skilled construction occupations, people working in the previous 12 months, GB, averaged over 2017/18-2019/20

Group code * †	Group level	UK SOC 2010 group title	Estimated FTE	Incidence	95% CI	IR ‡	95% CI
All	All	All occupations	33 714 000	132 000	118 000-145 000	0.390	0.350-0.430
5	Major	Skilled trades occupations	3 205 000	20 000	15 000-25 000	0.620	0.460-0.770
53	Sub-major	Skilled construction and building trades	1 067 000	8 000	5 000-11 000	0.760	0.470-1.040
531	Minor	Construction and building trades	824 000	§	§	§	§
5314	Unit	Plumbers and heating and ventilating engineers	190 000	§	§	§	§
5315	Unit	Carpenters and joiners	211 000	§	§	§	§
5319	Unit	Construction and building trades n.e.c.	254 000	§	§	§	§

MSDs, Musculoskeletal disorders; GB, Great Britain; UK SOC 2010, Standard Occupational Classification 2010 edition; FTE, Full-time equivalents; CI, Confidence Interval; IR, Incidence Rate; n.e.c., not elsewhere classified.

* UK SOC 2010 groups containing construction occupations were identified from SOC 2010 Volume 1, available at https://www.ons.gov.uk/.

† Occupational groups where sample numbers are too small to provide any reliable estimates have been omitted.

‡ Rate per 200 000 hours worked in the previous 12 months.

§ Sample numbers are too small to provide reliable estimates.

Data derived from Table 7 of the lfsinjocc.xlsx file available at https://www.hse.gov.uk/statistics/lfs/tables.htm.

Table 23. Days lost due to self-reported MSDs caused or made worse by current or most recent job, skilled construction occupations, people working in the previous 12 months, GB, averaged over 2017/18–2019/20

Group code * †	Group level	UK SOC 2010 group title	Estimated FTE	Days lost	95% CI	DLR ‡	95% CI
All	All	All occupations	33 714 000	5 581 000	4 646 000-6 516 000	21.0	18.0-25.0
5	Major	Skilled trades occupations	3 205 000	1 300 000	796 000-1 803 000	43.0	27.0-60.0
53	Sub-major	Skilled construction and building trades	1 067 000	605 000	314 000-896 000	60.0	31.0-88.0
531	Minor	Construction and building trades	824 000	535 000	253 000-816 000	69.0	33.0-105.0
5314	Unit	Plumbers and heating and ventilating engineers	190 000	§	§	§	§
5315	Unit	Carpenters and joiners	211 000	§	§	§	§
5319	Unit	Construction and building trades n.e.c.	254 000	§	§	§	§

MSDs, Musculoskeletal disorders; GB, Great Britain; UK SOC 2010, Standard Occupational Classification 2010 edition; FTE, Full-time equivalent; CI, Confidence Interval; DLR, Days Lost Rate; n.e.c., not elsewhere classified.

* UK SOC 2010 groups containing construction occupations were identified from SOC 2010 Volume 1, available at https://www.ons.gov.uk/.

† Occupational groups where sample numbers are too small to provide any reliable estimates have been omitted.

‡ Rate per 200 000 hours worked in the previous 12 months.

§ Sample numbers are too small to provide reliable estimates.

Data derived from Table 10 of the lfsinjocc.xlsx file available at https://www.hse.gov.uk/statistics/lfs/tables.htm.

3.1.3 Data reported to HSE via THOR

3.1.3.1 Detailed results

Table 24 contains data for UK reports of work-related MSDs experienced by skilled tradesmen and workers in construction-related occupations for the period from 2002 to 2008 reported by Stocks *et al.* (2011).

The underlying data source for Table 24 was a UK voluntary reporting system of cases of illness diagnosed as being caused or made worse by work known as THOR[20,21] (The Health and Occupation Reporting network).THOR is partly funded by HSE and HSE publishes the full statistics from THOR at Statistics - Index of tables (hse.gov.uk). The data extracted by Stocks *et al.* (2011) come from a sample of 1400 rheumatologists, occupational physicians and general practitioners. There are large variations in the rates of reports provided by the different specialisms. The rates of reporting MSDs attributed to construction are low – one report every 58 years by each rheumatologist; one report every 27 years by each occupational physician; and one report every four years by each General Practitioner.

Caution must be exercised in extrapolating this data set to the whole of the construction sector – the estimated annual total of MSD cases that the participating physicians would see is only 1539. Also, the referral mechanisms from GPs to rheumatologists and differences in availability of Occupational Physicians will result in non-random variation of the types of cases seen by the different types of clinicians. In other words, GPs will only refer more serious cases to rheumatologists but will treat simpler cases directly. They will not refer cases that they consider are likely to self-resolve quickly. They may also refer cases, particularly MSD cases, to other clinicians, such as physiotherapists. Stocks *et al.* (2011) noted that 'access to occupational health services is poor among construction workers', which will be related to the way that many construction workers are self-employed or employed by small businesses and therefore do not have contracts with OH providers. Therefore, it is likely that large construction employers are overrepresented within the figures for construction occupations.

Some of the occupations in Table 24 have very low estimated numbers of annual cases, which means the estimates of SRRs for them have very wide confidence intervals. Excluding occupations estimated to report fewer than 100 cases per year removes one occupation with a high SRR – 'Labourers other construction trades n.e.c.'. It also removes four occupations with SRRs of 1.4 to 2.0, of which three were not significantly different to the UK workforce. Finally, it removes two occupations where cases were so few that the SRRs could not be estimated. The remaining occupations are listed again in Table 25.

3.1.3.2 Summary of results

Despite significant methodological issues with this study, Table 25 shows that UK SOC 2000 unit group 8142 'Road construction operatives' had an SRR of 11.0 and was clearly at higher risk in this sample than any other occupation. The remaining occupations fell into

[20] See the sources.pdf file available at Statistics - Data Sources (hse.gov.uk)
[21] The Health and Occupation Research (THOR) network | The University of Manchester

two overlapping groups, with unit group 9121 ‘Labourers build and woodworking trades’ (SRR = 4.0) only in the higher risk group and unit group 5241 ‘Electricians and electrical fitters’ (SRR = 1.8) only in the lower risk group. Unit groups 5319 ‘Construction trades n.e.c.’, 5314 ‘Plumbing, heating and ventilating engineers’, 5315 ‘Carpenters and joiners’ and 5323 ‘Painters and decorators’ fell into both groups, with SRRs between 2.4 and 2.0.

3.1.3.3 Data tables

Table 24. Directly standardized incidence rate ratios (SRR) of reports of WRMSDs made to THOR Network for skilled tradesmen and construction-related occupations in the UK from 2002 to 2008

UK SOC 2000	Construction-related occupation	Est. male cases *	SRR †	95% CI	Sig. ‡	Groups of occupations §
8142	Road construction operatives	140	11.0	7.0–17.0	P<0.05	A
9129	Labourers other construction trades n.e.c.	7	6.5	3.6–11.5	P<0.05	A B
9121	Labourers build and woodworking trades	253	4.0	2.8–5.7	P<0.05	B C
5319	Construction trades n.e.c.	218	2.4	1.7–3.5	P<0.05	C D
5314	Plumbing, heating and ventilating engineers	162	2.3	1.6–3.5	P<0.05	C D
5315	Carpenters and joiners	242	2.1	1.5–3.0	P<0.05	C D
5323	Painters and decorators	126	2.0	1.2–3.2	P<0.05	C D
8149	Construction operatives n.e.c.	56	2.0	1.1–3.8	P<0.05	B C D
5241	Electricians and electrical fitters	175	1.8	1.2–2.7	P<0.05	D
5312	Bricklayers and masons	74	1.7	0.9–2.9	NS	C D
5313	Roofers, roof tilers and slaters	29	1.5	0.6–3.7	NS	B C D
5321	Plasterers	32	1.4	0.7–3.1	NS	C D
1122	Managers in construction	1	**	**	–	E
8141	Scaffolders, stagers and riggers	24	**	**	–	E
Estimate of male cases seen annually by the participating physicians		1539				

SRR, Standardised incidence rate Ratio; WRMSD, Work-related musculoskeletal disorders; THOR, The Health and Occupation Reporting network; UK SOC 2000, UK Standard Occupational Classification 2000; Est., Estimated; CI, Confidence Interval; Sig., Statistical significance n.e.c, Not elsewhere classified; P, Probability that the test result was due to chance; NS, Not statistically significant.

* Estimates of the annual numbers of male cases seen by the participating physicians.

† Standardised against estimates of the number of all UK workers from the Labour Force Survey 2005.

‡ Comparison with UK workforce.

§ Occupations with no statistical difference between them are grouped by letter.

** Insufficient cases to estimate SRR.

Data derived from Table 1 of Stocks *et al.* (2011).

Table 25. Directly standardized incidence rate ratios (SRR) of reports of WRMSDs made to THOR Network for skilled tradesmen and construction-related occupations in the UK from 2002 to 2008 – occupations with > 100 estimated male cases per year

UK SOC 2000	Construction-related occupation	Estimated male cases [*]	SRR [†]	95% CI	Sig. [‡]	Groups [§]
8142	Road construction operatives	140	11.0	7.0–17.0	P<0.05	A
9121	Labourers build and woodworking trades	253	4.0	2.8–5.7	P<0.05	C
5319	Construction trades n.e.c.	218	2.4	1.7–3.5	P<0.05	C D
5314	Plumbing, heating and ventilating engineers	162	2.3	1.6–3.5	P<0.05	C D
5315	Carpenters and joiners	242	2.1	1.5–3.0	P<0.05	C D
5323	Painters and decorators	126	2.0	1.2–3.2	P<0.05	C D
5241	Electricians and electrical fitters	175	1.8	1.2–2.7	P<0.05	D
Estimate of male cases seen annually by the participating physicians		1539				

SRR, Standardised incidence rate Ratio; WRMSD, Work-related musculoskeletal disorders; THOR, The Health and Occupation Reporting network; UK SOC 2000, UK Standard Occupational Classification 2000; CI, Confidence Interval; Sig., Statistical significance; n.e.c, Not elsewhere classified.

[*] Estimates of the annual numbers of male cases seen by the participating physicians.

[†] Standardised against estimates of the number of all UK workers from the Labour Force Survey 2005.

[‡] Comparison with UK workforce.

[§] Occupations with no statistical difference between them are grouped by letter.

Data derived from Table 1 of Stocks *et al.* (2011).

3.2 European studies of WRMSD rates in construction workers

3.2.1 Health examinations of Swedish construction workers

Table 26 gives data derived from Wahlström *et al.* (2012) for Swedish construction workers who had periodic health examinations between 1971 and 1992. Hospitalisation data were available for the 17-year period from 1987–2003. Cases were construction workers who were hospitalised for at least one day in that period as a result of lumbar disc disease. Lumbar disc disease was defined as a primary diagnosis of ICD–9 (1987–1996) code 722.1, 'Displacement of thoracic or lumbar intervertebral disc without myelopathy') or ICD–10 (1997–2003) code M51.1, 'Lumbar and other intervertebral disc disorders with radiculopathy'.

Table 26 shows that all the occupations apart from the reference occupations of white-collar workers and foremen formed one group with overlapping confidence intervals for the relative risks of hospitalisation. A subset of the occupations formed a group with the reference occupations due to not having an elevated risk of hospitalisation.

The case definition used in this study of at least one day's hospitalisation is much narrower than many studies that use insurance claims due to work loss (such as Dong *et al.* (2019), Section 3.3.1), or cases diagnosed by physicians (such as Stocks *et al.* (2011), Section 3.1.3). Incidence rates are therefore going to be lower than in such studies. This may have the effect of decreasing differences between occupations. It will only affect the ranking of professions if there are differences in the rates of hospitalisation between occupations that do not follow the rates of insurance claims or diagnosis.

In summary, this study found that white-collar workers and construction foremen were at less risk of being hospitalised for lumbar disc disease than all other construction workers. It did not have sufficient data to detect statistically significant differences between individual construction occupations.

Table 26. Occupation and risk of hospitalisation for lumbar disc disease in Sweden, 1987–2003

Occupation	Workers	Cases	Years worked	Incidence Rate *†	Rate Ratio † ‡	95% Confidence Interval	Statistical significance †	Groups of occupations §
Refrigerator technicians	1 196	17	17 655	0.096	1.98	1.21–3.26	$P < 0.05$	A
Floor layers	4 937	59	71 732	0.082	1.89	1.41–2.53	$P < 0.05$	A
Plumbers	21 962	235	315 583	0.074	1.68	1.39–2.02	$P < 0.05$	A
Roofers	1 210	13	17 684	0.074	1.60	0.91–2.80	NS	A B **
Crane operators	2 996	28	40 495	0.069	1.65	1.11–2.44	$P < 0.05$	A
Drivers	3 881	36	52 341	0.069	1.52	1.06–2.16	$P < 0.05$	A
Concrete workers	27 704	243	357 542	0.068	1.55	1.29–1.87	$P < 0.05$	A
Preparatory workers	9 859	89	132 088	0.067	1.50	1.17–1.93	$P < 0.05$	A
Bricklayers	8 167	72	111 183	0.065	1.52	1.16–1.99	$P < 0.05$	A
Machine operators	9 904	90	139 104	0.065	1.42	1.09–1.82	$P < 0.05$	A
Wood workers	57 700	526	839 923	0.063	1.40	1.19–1.64	$P < 0.05$	A
Sheet-metal workers	10 980	102	163 733	0.062	1.37	1.08–1.74	$P < 0.05$	A
Insulators	2 513	21	36 707	0.057	1.25	0.80–1.96	NS	A B
Rock workers	2 678	19	33 465	0.057	1.30	0.81–2.08	NS	A B
Repairers	2 429	19	33 523	0.057	1.60	0.91–2.06	NS	A B
Painters	20 681	169	302 818	0.056	1.27	1.03–1.55	$P < 0.05$	A
Asphalt workers	3 601	27	51 134	0.053	1.15	0.77–1.72	NS	A B
Glass workers	2 476	18	36 574	0.049	1.08	0.67–1.76	NS	A B
Electricians	33 938	248	507 423	0.049	1.08	0.89–1.30	NS	A B

Occupation	Workers	Cases	Years worked	Incidence Rate *†	Rate Ratio † ‡	95% Confidence Interval	Statistical significance †	Groups of occupations §
White-collar & foremen	34 717	208	479 839	0.043	1.00	1.00–1.00	NA	B

P, Probability that the test result was due to chance; NS, Not statistically significant; NA, Not applicable.

* Rate per 200 000 hours worked. 1 year worked = 2000 hours.

† Adjusted for age, height, weight, smoking, and time period.

‡ Compared to white-collar workers & foremen.

§ Occupations with no statistical difference between them are grouped by letter.

** Group B occupations are not significantly different to the reference group of white collar workers and foremen.

Data derived from Table 1 of Wahlström *et al.* (2012).

3.2.2 Danish comparison of floor and bricklayers with construction workers as a whole

3.2.2.1 Detailed results

Andersen *et al.* (2012) carried out a study of cases of surgery for hip and knee osteoarthritis (OA) in the Danish working population over the 11 years from 1996–2006. They could report data for a combined group of floor layers/bricklayers/pavers and for all construction workers because they were able to link occupation to individuals.

Table 27 gives the age-standardised incidence rates separated by sex and shows that the combined group of male floor layers, bricklayers and pavers had a rate of surgically treated hip OA 11% higher than all male construction workers and a rate of surgically treated knee OA 14% higher than all male construction workers. The number of cases among female floor and bricklayers was effectively zero, and the total cases among female construction workers was much lower than among men.

Table 28 gives hazard ratios for the different occupational groups compared to a reference group of office workers. It shows that construction workers in general were at increased risk of needing surgery for hip and knee OA. The subgroup of male floor layers, bricklayers and pavers were at even greater risk but were not at significantly more risk than the group of all construction workers.

Table 29 reports the hazard ratios stratified by cumulative years in the different occupations. Andersen *et al.* (2012) noted that the risk of OA generally increased with the years worked in the studied occupations, but the numbers of individuals decreased with cumulative years in occupation, which was especially pronounced for female construction workers.

3.2.2.2 Summary of results

This study showed that Danish construction workers were at increased of having surgery for hip or knee osteoarthritis, and the group of floor-layers, brick layers and pavers was at even higher risk. The risk of osteoarthritis increased with the number of years worked in these occupations, but there appears to be a survivor effect, with the number of individuals working dropping with seniority.

3.2.2.3 Data tables

Table 27. Age-standardised incidence rate per 200 000 hours worked of hip and knee OA according to occupation, stratified by gender, Denmark, 1996–2006

	Sex	Hip OA cases	Person-years worked	IR * †	Knee OA cases	Person-years worked	IR * †
Construction workers	Men	2 899	3 482 168	0.0899	1 700	3 448 815	0.0523
Floor- and bricklayers	Men	326	317 113	0.0995	194	317 856	0.0596
Construction workers	Women	139	272 675	0.0938	111	272 844	0.0705
Floor- and bricklayers	Women	0	5 651	0.0	1	5 647	0.0265

OA, Osteoarthritis; IR, Incident rate.

* Rate per 200 000 hours worked.

† Age standardised to the office worker population, for the period 1996-2006.

Data derived from Table 2 of Andersen *et al.* (2012).

Table 28. Hazard Ratios for surgically treated OA in the hip or knee according to occupational group and gender, Denmark, 1996–2006

	HR for men	95% CI	Sig. *	HR for women	95% CI	Sig. *
Hip OA †						
Office workers	1.00	1.00–1.00		1.00	1.00–1.00	
Construction workers	1.23	1.15–1.31	P < 0.05	1.21	1.03–1.43	P < 0.05
Floor- and bricklayers §	1.35	1.20–1.52	P < 0.05	n.e.	–	–
Knee OA ‡						
Office workers	1.00	1.00–1.00		1.00	1.00–1.00	
Construction workers	1.27	1.17–1.38	P < 0.05	1.37	1.14–1.64	P < 0.05
Floor- and bricklayers §	1.49	1.28–1.73	P < 0.05	n.e.	–	–

OA, Osteoarthritis; HR, Hazard Ratio; CI, Confidence Interval; Sig., Statistical significance; P, Probability that the test result is due to chance; n.e., not estimable.

* Compared to reference group of office workers.

† Adjusted for age (underlying timescale), calendar period, income and unemployment.

‡ Adjusted for age (underlying timescale), calendar period, income, unemployment and knee injury.

§ Floor layers, bricklayers and pavers formed a subgroup of construction workers. The group had too few women to make analysis possible.

Data derived from Table 3 of Andersen *et al.* (2012).

Table 29. Hazard Ratios for surgically treated OA in the hip or knee according to cumulative years in occupation among men and women, Denmark, 1996–2006

	HR for men	95% CI	Sig. *	HR for women	95% CI	Sig. *
Hip OA †						
Office workers	1.00	1.00-1.00		1.00	1.00-1.00	
Construction workers 1–5 years	1.05	0.97-1.13	NS	1.17	0.97-1.41	NS
Construction workers 6–10 years	1.18	1.08-1.29	P<0.05	1.21	0.78-1.88	NS
Construction workers > 10 years	1.83	1.68-2.00	P<0.05	1.57	0.97-2.52	NS
Floor- and bricklayers § 1–5 years	0.94	0.77-1.13	NS	n.e.	–	
Floor- and bricklayers § 6-10 years	1.44	1.21-1.72	P<0.05	n.e.	–	
Floor- and bricklayers § > 10 years	2.23	1.81-2.73	P<0.05	n.e.	–	
Knee OA ‡						
Office workers	1.00	1.00-1.00		1.00	1.00-1.00	
Construction workers 1–5 years	0.95	0.86-1.05	NS	1.19	0.95-1.47	NS
Construction workers 6–10 years	1.45	1.30-1.62	P<0.05	1.98	1.33-2.97	P<0.05
Construction workers > 10 years	1.96	1.75-2.20	P<0.05	2.06	1.26-3.37	P<0.05
Floor- and bricklayers § 1–5 years	1.04	0.81-1.34	NS	n.e.	–	
Floor- and bricklayers § 6-10 years	1.58	1.26-1.99	P<0.05	n.e.	–	
Floor- and bricklayers § > 10 years	2.27	1.75-2.95	P<0.05	n.e.	–	

OA, Osteoarthritis; HR, Hazard Ratio; CI, Confidence Interval; Sig., Statistical significance; P, Probability that the test result is due to chance; NS, Not statistically significant; n.e., not estimable.

* Compared to reference group of office workers.

† Adjusted for age (underlying timescale), calendar period, income and unemployment.

‡ Adjusted for age (underlying timescale), calendar period, income, unemployment and knee injury.

§ Floor layers, bricklayers and pavers formed a subgroup of construction workers. The group had too few women to make analysis possible.

Data derived from Table 4 of Andersen *et al.* (2012).

3.2.3 Rates of hip and knee osteoarthritis in skilled and unskilled Finnish construction workers

3.2.3.1 Introduction

A pair of papers (Solovieva *et al.*, 2018, and Kontio *et al.*, 2018) report nationwide register-based studies in Finland covering the risk of disability retirement due to hip (Solovieva *et al.*, 2018) and knee (Kontio *et al.*, 2018) osteoarthritis (OA) during the nine-year period from 2005 to 2013. Their outcome measure was temporary or permanent disability retirement. This is not simply related to the outcome of hip or knee replacement surgery due to OA in the Danish study of Andersen *et al.* (2012) (Section 3.2.2) as some individuals granted temporary disability retirement may have been able to return to work following joint replacement surgery.

Solovieva *et al.* (2018), and Kontio *et al.* (2018) used register data for a 70% random sample of the Finnish population aged 18-70 on 31 Dec 2004. They analysed data for 1.137 million adults employed in Finland aged 30-60 at the start of 2005, examining outcome data over the following nine years.

They considered a wide range of occupations, with construction workers reported in two groups. They use the description ‘Construction workers, electricians and plumbers’ for ISCO-88 code 71, ‘Extraction and building trades workers’. Their description is ‘Unskilled transport, construction, and manufacturing workers’ for ISCO-88 code 93, ‘Laborers in manufacturing and construction’. Their reference group was ‘Professionals’ (ISCO-88 codes 21, ‘Physical, mathematical and engineering science professionals’, 22 ‘Life science and health professionals’ and 24 ‘Other professionals’). ‘Teaching professionals’ (ISCO-88 code = 23) were excluded from their reference group.

The proportion of females in the full sample was 49.4%. The ‘Professionals’ group was 57.6% male. The construction occupations were heavily dominated by males with 95.6% of the skilled groups being male and 73.3% of the unskilled group being male. Nearly twice as many women as men (30.5% vs 16.7%) had been educated at tertiary level (further/higher education).

The results for hip OA (Solovieva *et al.*, 2018) are discussed in Section 3.2.3.2, with the results for knee OA (Kontio *et al.*, 2018) being discussed in Section 3.2.3.3.

3.2.3.2 Hip osteoarthritis

The data from Solovieva *et al.* (2018) in Table 30 show that the skilled construction workers (ISCO-88 code = 71) and unskilled construction workers (ISCO-88 code = 93) were both at increased risk of disability retirement due to hip OA compared to professionals (ISCO-88 codes 21, 22, 24). While the skilled construction workers had a 25% greater incident rate than the unskilled workers, the difference was not statistically significant. The number of female skilled construction workers was very low, and no differences were detected between men and women.

Table 31 demonstrates that statistical models that seek to identify the effect of the covariates of age, education and physical workload factors on the probability of retirement due to hip OA show that physical workload factors account for 43% and 58% of the cases in male and female unskilled construction workers respectively and 88% of the cases in male skilled construction workers. However, the lack of any significant Hazard Ratios in the models for female skilled construction workers meant that it was inappropriate to calculate the proportions explained.

Table 32 seeks to determine which physical risk factors contribute to the risk of disability retirement due to hip OA. The numbers of female skilled construction workers were too small for the models to work for them.

It indicates that kneeling and squatting was most strongly associated with this outcome (78.9%) among skilled construction workers (ISCO-88 code = 71). It is also clear that the contributions of the different physical factors overlap or interact as the totals across the five factors significantly exceed 100%. In other words, electricians who have to kneel or squat to carry out their work, are also very likely to have to carry out heavy physical work.

For unskilled construction workers (ISCO-88 code = 93), the strongest factor for both men and women was heavy physical work, accounting for only 44.3% and 37.8% of the risk, respectively.

3.2.3.3 Knee osteoarthritis

The data from Kontio *et al.* (2018) in Table 33 show that the skilled construction workers (ISCO-88 code = 71) and unskilled construction workers (ISCO-88 code = 93) were both at increased risk of disability retirement due to knee OA compared to professionals (ISCO-88 codes 21, 22, 24) but there was no statistical difference between the two groups of construction workers. Nor was there a statistical difference between men and women.

Table 34 shows that physical workload factors account for 51% and 76% of the risk of disability retirement due to knee OA of unskilled male and female construction workers, respectively. These factors accounted for 85% and 119% of the cases of the male and female skilled construction workers respectively, though the latter figure being bigger than 100% illustrates the limitations of the modelling methods used.

As would be expected, the models reduced the hazard ratios for each occupational group, but the construction workers were still at increased risk of having to retire due to knee OA than professionals, even after taking age, education and physical workload factors into account. There were no statistically significant differences between the skill levels or between men and women.

Table 35 seeks to determine which physical workload risk factors contribute to the risk of disability retirement due to knee OA. Heavy physical work was most strongly associated with this outcome among skilled female construction workers, being associated with 96% of disability among them. It was associated with for 70% of disability among the unskilled females. These figures were approximately twice those for males.

Despite heavy physical work being strongly associated with retirement among skilled female workers, heavy lifting was strongly negatively associated with it, as was standing or moving. Kontio *et al.* (2018) do not explore what these negative associations mean.

3.2.3.4 Summary of results

Skilled construction workers and unskilled construction workers were both at increased risk of disability retirement due to hip or knee osteoarthritis compared to professionals, with skilled workers having higher risks than unskilled workers. The differences were associated with differences in physical workload factors.

3.2.3.5 Data tables

Table 30. Age-adjusted IR and 95% CI of full disability retirement as a result of hip OA among 30- to 60-year-old men and women by occupational group, Finland, 2005–2013

ISCO-88 code	Occupation al groups	Sex	N	No. of events	IR*	95% CI
21, 22, 24	Professionals	M	77 600	26	0.004	0.002–0.008
71	Construction workers, electricians and plumbers	M	47 700	208	0.056	0.043–0.075
93	Unskilled transport, construction and manufacturing workers	M	18 400	86	0.045	0.029–0.075
21, 22, 24	Professionals	W	57 200	17	0.003	0.001–0.009
71	Construction workers, electricians and plumbers	W	2 200	3	0.011	0.002–0.081
93	Unskilled transport, construction and manufacturing workers	W	6 700	18	0.039	0.019–0.084

IR, Incidence Rate; CI, Confidence Interval; OA, Osteoarthritis; ISCO-88, International Standard Classification of Occupations 1988 version.

N, Number of workers; M, Men; W, Women.

* Rate per 200 000 hours

Data derived from Table S1 and Table 2 of Solovieva *et al.* (2018).

Table 31. HR and 95% CI of full disability retirement as a result of hip OA among 30- to 60-year-old men and women by occupational group, Finland, 2005–2013

				Model 1		Model 2			Model 3		
ISCO-88 code	Occupational groups	Sex	IR *	HR †	95% CI	HR †	95% CI	PRE † ‡	HR †	95% CI	PRE † §
21, 22, 24	Professionals	M	0.004	1.00	1.00–1.00	1.00	1.00–1.00	NA	1.00	1.00–1.00	NA
71	Construction workers, electricians and plumbers	M	0.056	12.70	8.44–19.70	6.74	4.35–10.40	50.9	1.70	0.75–3.84	87.8
93	Unskilled transport, construction and manufacturing workers	M	0.045	10.60	6.75–16.70	5.58	3.46–9.01	52.3	2.94	1.58–5.47	57.6
21, 22, 24	Professionals	F	0.003	1.00	1.00–1.00	1.00	1.00–1.00	NA	1.00	1.00–1.00	NA
71	Construction workers, electricians and plumbers	F	0.011	2.80	0.65–12.10	1.43	0.33–6.30	NA	0.68	0.14–3.29	NA
93	Unskilled transport, construction and manufacturing workers	F	0.039	8.51	4.42–16.40	4.12	2.10–8.10	58.5	2.78	1.33–5.78	42.9

Model 1, adjusted for age; Model 2, adjusted for age and education; Model 3, adjusted for age, education, and all physical workload factors.

HR, Hazard Ratio; CI, Confidence Interval; OA, Osteoarthritis; ISCO-88, International Standard Classification of Occupations 1988 version; IR, Incidence Rate; PRE, proportion explained (%); M, Men; NA: not applicable; W, Women.

* Rate per 200 000 hours.

† Reference group: professionals.

‡ PRE, Proportion explained by education—the percentage of attenuation of HR after adjustment for education in Model 2: (HRModel 2–HRModel 1)/(HRModel 1–1) × 100%.

§ PRE, Proportion explained by combined physical workload factors—the percentage of attenuation of HR after adjustment for all physical workload factors in Model 3: (HRModel 3–HRModel 2)/(HRModel 2–1) × 100%.

Data derived from Table S1, Table 2, Table 4 and Table 5 of Solovieva *et al.* (2018).

Table 32. The contribution of separate physical workload factors to full disability retirement as a result of hip OA among 30- to 60-year-old men and women by occupational group, Finland, 2005–2013

ISCO-88 code	Occupational groups	Sex	All * †	HPW * ‡	Kn/sq * ‡	HL * ‡	Sit * ‡	Sta/mv * ‡
21, 22, 24	Professionals	M	NA	NA	NA	NA	NA	NA
71	Construction workers, electricians and plumbers	M	87.8	55.4	78.9	28.7	35.9	31.5
93	Unskilled transport, construction and manufacturing workers	M	57.6	44.3	41.0	25.8	31.7	25.5
21, 22, 24	Professionals	W	NA	NA	NA	NA	NA	NA
71	Construction workers, electricians and plumbers	W	NA	NA	NA	NA	NA	NA
93	Unskilled transport, construction and manufacturing workers	W	42.9	37.8	13.8	-1.3 §	18.9	1.0

OA, osteoarthritis; ISCO-88, International Standard Classification of Occupations 1988 version; All, all workload factors tested; HPW, heavy physical work; Kn/sq, Kneeling or squatting; HL, Heavy lifting; Sit, Sitting; Sta/mv, Standing or moving; M, Men; NA: not applicable; W, Women HR, Hazard Ratio.

* Reference group: professionals.

† Proportion explained—the percentage of attenuation of HR after adjustment for all physical workload factors: (HRModel 3–HRModel 2)/(HRModel 2 –1) × 100%, where Model 2 is adjusted for age and education and Model 3 is adjusted for age, education and all physical workload factors.

‡ Proportion explained—the percentage of attenuation of HR after adjustment for a single physical workload factor: (HRModel X–HRModel 2)/(HRModel 2 –1) × 100%, where Model 2 is adjusted for age and education and Model X is adjusted for age, education, and the physical workload factor in question.

§ Negative sign indicates an increase in HR after adjustment.

Data derived from Table S1, Table 2, Table 4 and Table 5 of Solovieva *et al.* (2018).

Table 33. Age-adjusted IR and 95% CI of full disability retirement due to knee OA among 30- to 60-year-old men and women by occupational group, Finland, 2005–2013

ISCO-88 code	Occupational groups	Sex	N	IR *	95% CI
21, 22, 24	Professionals	M	77 600	0.008	0.005-0.013
71	Construction workers, electricians and plumbers	M	47 700	0.142	0.120-0.170
93	Unskilled transport, construction and manufacturing workers	M	18 400	0.104	0.076-0.148
21, 22, 24	Professionals	W	57 200	0.010	0.006-0.018
71	Construction workers, electricians and plumbers	W	2 200	0.087	0.034-0.247
93	Unskilled transport, construction and manufacturing workers	W	6 700	0.133	0.084-0.230

IR, Incidence Rate; CI, Confidence Interval; OA, Osteoarthritis; ISCO-88, International Standard Classification of Occupations 1988 version; N, Number of workers; M, Men; W, Women.

* Rate per 200 000 hours.

Data derived from Table 1 and Table 2 of Kontio *et al.* (2018).

Table 34. HRs and 95% CIs of full disability retirement due to knee OA among 30- to 60-year-old men and women by occupational group, Finland, 2005–2013

				Model 1		Model 2			Model 3		
ISCO-88 code	**Occupational groups**	**Sex**	**IR** *	**HR** †	**95% CI**	**HR** †	**95% CI**	**PRE** † ‡	**HR** †	**95% CI**	**PRE** † §
21, 22, 24	Professionals	M	0.008	1.00	1.00-1.00	1.00	1.00-1.00	NA	1.00	1.00-1.00	NA
71	Construction workers, electricians and plumbers	M	0.142	16.6	12.5-22.2	6.55	4.82-8.92	64.4	1.82	1.06-3.13	85.2%
93	Unskilled transport, construction and manufacturing workers	M	0.104	12.0	9.21-17.4	4.98	3.56-6.96	66.0	2.96	1.93-4.54	50.8%
21, 22, 24	Professionals	W	0.010	1.00	1.00-1.00	1.00	1.00-1.00	NA	1.00	1.00-1.00	NA
71	Construction workers, electricians and plumbers	W	0.087	6.52	3.60-11.8	2.04	1.56-5.17	81.2	0.80	0.41-1.54	119%
93	Unskilled transport, construction and manufacturing workers	W	0.133	9.99	6.93-14.4	4.09	2.80-5.95	65.6	1.74	1.15-2.63	76.1%

Model 1, adjusted for age; Model 2: adjusted for age and education; Model 3: adjusted for age, education and physical workload factors.

HR, Hazard Ratio; CI, Confidence Interval, OA, Osteoarthritis; ISCO-88, International Standard Classification of Occupations 1988 version; M, Men; NA, Not Applicable; W, Women.

* Rate per 200 000 hours.

† Reference group: professionals.

‡ PRE: proportion explained by education (%)—the percentage of attenuation of HR after adjustment for education: (HRModel 2−HRModel 1)/(HRModel 1−1)×100%.

§ PRE: proportion explained by all physical workload factors (%)—the percentage of attenuation of HR after adjustment for all physical workload factors: (HRModel 3−HRModel 2)/(HRModel 2−1)×100%.

Data derived from Table 1, Table 2 and Table 4 of Kontio *et al.* (2018).

Table 35. The contribution of separate physical workload factors to occupational differences in full disability retirement due to knee OA among 30- to 60-year-old men and women, Finland, 2005–2013

ISCO-88 code	Occupational groups	Sex	All * †	HPW * ‡	Kn/sq * ‡	HL * ‡	Sit * ‡	Sta/mv * ‡
71	Construction workers, electricians and plumbers	M	85.2	47.4	84.3	32.6	31.0	8.8
93	Unskilled transport, construction and manufacturing workers	M	50.8	38.2	46.5	29.9	27.9	7.3
71	Construction workers, electricians and plumbers	W	119	96.2	21.2	-53.8 §	10.6	-72.1 §
93	Unskilled transport, construction and manufacturing workers	W	76.1	70.2	13.9	6.5	29.4	19.4

OA, osteoarthritis; ISCO-88, International Standard Classification of Occupations 1988 version; All, All workload factors tested; HPW, heavy physical work; Kn/sq, Kneeling or squatting; HL, Heavy lifting; Sit, Sitting; Sta/mv, Standing or moving; M, Men; NA: not applicable; W, Women HR, Hazard Ratio.

* Reference group: professionals.

† Proportion explained—the percentage of attenuation of HR after adjustment for all physical workload factors: (HRModel 3–HRModel 2)/(HRModel 2 –1) × 100%, where Model 2 is adjusted for age and education and Model 3 is adjusted for age, education and all physical workload factors.

‡ Proportion explained—the percentage of attenuation of HR after adjustment for a single physical workload factor: (HRModel X–HRModel 2)/(HRModel 2 –1) × 100%, where Model 2 is adjusted for age and education and Model X is adjusted for age, education, and the physical workload factor in question. HR for Model X not shown.

§ Negative sign indicates an increase in HR after adjustment.

Data derived from Table 1 and Table 5 of Kontio *et al.* (2018).

3.3 US BLS studies of WRMSD rates in construction

3.3.1 Classification by industry sector (NAICS code)

3.3.1.1 Background to the NAICS WRMSD data

As discussed in Section 1.3, reports of WRMSD incidents can be classified by either the employment sector, ie the sector of the economy that the employer operates in, or the occupation of the employee. This allows a single incident to be examined in the context of both the kind of employer and the kind of occupational tasks and skills of employees.

This section uses the classifications of the 2017 North American Industrial Classification System (NAICS) (Section 1.3.3) to explore construction sector data from the USA. The sources used were Dong *et al.* (2019) and the US BLS dataset available at One-Screen Data Search (bls.gov) that underlies Dong *et al.* (2019).

3.3.1.2 Detailed results

Table 36 gives incidence rates for WRMSD cases in 17 NAICS construction subsectors in 2017 reported by Dong *et al.* (2019). The confidence intervals for the incidence rates are not reported, but the highest rate is over 8 times the lowest. The cases underlying Table 36 were obtained by the 2017 BLS Survey of Occupational Injuries and Illnesses (SOII)[22] asking for employer reports of OSHA recordable WRMSDs using the 2011 onwards definition of WRMSD.

Within the 17 subsectors reported by Dong *et al.* (2019), ten are classified using 5-digit codes, five using 4-digit codes and two using 3-digit codes. Codes 2361 and 2362 are subsets of code 236 and together account for 99.8% of the cases under code 236. Codes 2371 and 2373 are subsets of code 237 and together account for 83.7% of the cases under code 237. Within code 238, ‘Specialty trade contractors’, five 5-digit codes (23831, 23832, 23833, 23834, 23835) together account for 93.8% of cases listed under code 2383. Dong *et al.* (2019) do not report totals for codes 2381, 2382 and 2389 so the percentages accounted for by codes 23813 and 23814, by codes 23821 and 23822 and by code 23891 cannot be calculated from their figures.

Inspection on the BLS website of the SOII data used by Dong *et al.* (2019) using the One-Screen Data Search (bls.gov) confirmed the accuracy of the data they reported. They do not describe their criteria for selecting only 17 of the 35 construction sector codes for reporting, and their criteria are not apparent from inspection of the data.

Certain NAICS codes have no values reported for some years with no pattern to the missing data. The maximum number of codes with no data in one year is five; the minimum is one code with no data in 2017, which is the year selected by Dong *et al.* (2019). This appears to be due to the way, as discussed in Section 1.4.2, that the sampling strategy can vary from year to year. Table 37 shows the numbers of construction industries with different numbers of years of available SOII case data. This is done for all construction sectors, for different levels of classification, at the lowest level of classification

[22] https://www.bls.gov/opub/hom/soii/pdf/soii.pdf

(to 5 digits) and for the subsectors listed by Dong *et al.* (2019). The table shows that missing data constitute a relatively small proportion of the total, with 63% of codes having data for the full ten years and only 12% having fewer than eight years. Of the subsectors selected by Dong *et al.* (2019) to report 2017 data, only 3/17 (18%) had fewer than the full ten years of data.

Inspection of the raw SOII data showed high levels of variability in the annual median days lost within each code. Coefficients of variation over time within the NIACS codes reached as high as 154%. The case numbers and incidence rates were less variable, with maximum coefficients of variation of 89% and 87%, respectively.

Table 38 illustrates this with data from two construction subsectors. Over the ten-year period, the tile and terrazzo contractors had a median Days Away From Work (DAFW) as a result of a reportable incident that ranged from four days in 2017 to 180 days in 2012. The coefficient of variation for median DAFW is 135%, which is much higher than the value of 41% for the ‘Residential building construction’ category. The 2012 figure is very much an outlier as the next highest median DAFW is 31 days in 2011. In 2012 the number of cases was 70, whereas the number in 2011 was only 20 greater at 90. This suggests that DAFW is not a stable measure, which would make it very difficult to interpret any comparisons of NAICS codes made using it.

It is also noticeable that the value of 660 cases in 2017 (IR of 1.250 injuries per 200 000 hours) is an outlier among the data for the tile and terrazzo contractors, with the next highest value being only 230 cases in 2016 (IR of 0.473 injuries per 200 000 hours worked). This contributes to the coefficient of variation being 80%. Deleting the value of 660 brings the CV down to 40% and brings the mean down from 211 cases to 155 cases per year. This indicates that the variations in the data from year to year can have noticeable influence on the injury rates and hence rankings of the different subsectors.

Because of this discovery of the effect of outliers on the injury rates, the 2017 outlier for NAICS code 23834 ‘Tile and terrazzo contractors’ was excluded from the calculation of the mean injury rate for that classification, with 2017 treated as having missing data. The mean injury rates across the 10-year period from 2011–2020 were then compared with the data from 2017, which is the year that Dong *et al.* (2019) reported. Table 39 presents a summary of the SOII MSD case and rate data for all 35 subcategories within the construction sector, sorted by NAICS code. The mean Incidence Rate per 200 000 hours worked for each subcategory is given, averaged across the number of years data are available for. The rank order of each of the 35 subcategories is also given. For comparison, the differences from the 2017 IRs are given, along with the 2017 rank across all 35 subcategories.

Table 40 is a simplified version of Table 39, showing only the 2011-2020 data for 5-digit 2017 NAICS codes, ie at the level of individual industries and omitting the comparison with the 2017 data from Dong *et al.* (2019). This is sorted by incidence rate. Table 41 reports the same data sorted by the 2017 NAICS code.

For comparison with the data in Table 36 from Dong *et al.* (2019), Table 42 summarises the data from 2011–2020 for their 17 sectors, industry groups and industries, sorted by the 2017 incidence rate. Table 43 summarises the same data sorted by mean incidence rate.

The mean incidence rates range from 0.180 cases per 200 000 hours to 0.478 cases per 200 000 hours. For comparison, the 2017 incidence rates for the same 17 industries range from 0.145 to 1.250 cases per 200 000 hours. The correlation between the two sets of incidence rates is very low (adjusted $R^2 = 3.5\%$, $P > 0.05$).

Illustrating the effect of the outlying 2017 value, the mean IR for 23834 'Tile and terrazzo contractors' was 0.359, the 20th of 35 values, whereas the 2017 IR was the highest for that year at 1.250 cases per 200 000 hours. Code 23832 'Painting and wall covering contractors' had a mean IR of 0.267 and a 2017 IR of 0.752 cases per 200 000 hours, being second in 2017 and 13th averaged across the 10 years. The next largest change was for 23814 'Masonry contractors' who had a mean IR of 0.450 and a 2017 IR of 0.301 cases per 200 000 hours, a difference of 0.149. This moved them from sixth across the 10-year period to tenth in 2017.

3.3.1.3 Summary of results

It is apparent that missing data and other unknown sources of variation make the 2017 data reported by Dong *et al.* (2019) less reliable than the data from the 10-year period as a means of ranking construction industries by risk and therefore the mean IR rank order of Table 40 should be used in preference to the data in Table 36 extracted by Dong *et al.* (2019).

Table 40 shows that the four worst industries were 23835 'Finish carpentry contractors' (IR = 0.563 cases per 200 000 hours), 23833 'Flooring contractors' (IR = 0.561), 23813 'Framing contractors' (IR = 0.551) and 23817 'Siding contractors' (IR = 0.539). These industries map (Table 102) onto UK SIC 2007 codes F43.32 'Joinery installation', F43.33 'Floor and wall covering', F43.99 'Other specialised construction activities n.e.c.', and F43.99 'Other specialised construction activities n.e.c.', respectively.

The mean incidence rate for 23835 'Finish carpentry contractors', was 9.5 times the lowest rate of 0.059 cases per 200 000 hours for 23712 'Oil and gas pipeline construction'.

3.3.1.4 Data tables

Table 36. Number and rate of WRMSDs, selected construction subsectors, 2017

2017 NAICS code *	Construction subsector *	Number of cases	IR †
23834	Tile and terrazzo contractors	660	1.250
23832	Painting and wall covering contractors	1 290	0.752
2383	Building finishing contractors	3 840	0.551
23833	Flooring contractors	330	0.530
23835	Finish carpentry contractors	540	0.435
23813	Framing contractors	320	0.429
23822	Plumbing and HVAC contractors	4 100	0.416
2361	Residential building construction	2 760	0.414
23831	Drywall and insulation contractors	780	0.353
23814	Masonry contractors	380	0.301
236	Construction of buildings	4 200	0.294
23891	Site preparation contractors	740	0.239
2373	Highway, street, and bridge construction	720	0.230
23821	Electrical and wiring contractors	1 460	0.190
2362	Nonresidential building construction	1 430	0.188
237	Heavy and civil engineering construction	1 780	0.180
2371	Utility system construction	770	0.145

Source: U.S. Bureau of Labor Statistics, 2017 Survey of Occupational Injuries and Illnesses.

WRMSD, Work-related musculoskeletal disorder; 2017 NAICS, North American Industrial Classification System, 2017 revision; IR, Incidence Rate; HVAC, Heating, ventilation and air-conditioning.

* NAICS codes and sector names completed by reference to https://www.census.gov/naics/reference_files_tools/2017_NAICS_Manual.pdf.

† Rate per 200 000 hours worked.

Data derived from Chart 12 of Dong *et al.* (2019).

Table 37. Completeness of 2011–2020 SOII case data for 35 construction 2017 NAICS codes

Number of years	10	9	8	6	5	Total
All construction sector NAICS codes (Percentage)	22 (63%)	7 (20%)	2 6%	2 6%	2 6%	35 (100%)
3-digit NAICS codes (subsectors) (Percentage)	3 (100%)					3 (100%)
4-digit NAICS codes (industry groups) (Percentage)	8 (80%)	1 (10%	1 (10%)			10 (100%)
5-digit NAICS codes (industries) (Percentage)	11 (50%)	6 (27%)	1 (5%)	2 (9%)	2 (9%)	22 (100%)
Lowest level of classification to 5 digits (Percentage)	14 (52%)	7 (26%)	2 (7%)	2 (7%)	2 7%)	27 (100%)
Subsectors listed by Dong *et al.* (2019) (Percentage)	14 (82%)	1 (6%)		2 (12%)		17 (100%)

Source: U.S. Bureau of Labor Statistics, annual Survey of Occupational Injuries and Illnesses (SOII), 2011–2020.
2017 NAICS, North American Industrial Classification System, 2017 revision.

Data extracted from https://data.bls.gov/PDQWeb/cs.

Table 38. Examples of the variability of SOII data

NAICS code	23834			2361		
Industry	Tile and terrazzo contractors			Residential building construction		
Year	Cases	Incidence Rate *	Median DAFW	Cases	Incidence Rate *	Median DAFW
2011	90	0.258	31	1 650	0.336	10
2012	70	0.212	180	2 600	0.501	10
2013	130	0.339	10	1 930	0.351	10
2014	200	0.475	30	2 500	0.443	12
2015	220	0.517	14	2 300	0.382	23
2016	230	0.473	22	2 010	0.312	8
2017	660	1.250	4	2 760	0.414	14
2018				3 020	0.429	6
2019	210	0.368	20	2 020	0.277	7
2020	90	0.186	30	1 650	0.232	15
Range	70–660	0.186–1.250	4–180	1 650–3 020	0.232–0.501	6–23
Mean	211	0.453	38	2 244	0.368	12
SD	169	0.303	51	444	0.078	5
CV	80%	67%	135%	20%	21%	41%

Source: U.S. Bureau of Labor Statistics, annual Survey of Occupational Injuries and Illnesses (SOII), 2011–2020.

NAICS, North American Industrial Classification System; DAFW, Days Away From Work; SD, Standard Deviation; CV, Coefficient of Variation.

* Rate per 200 000 hours worked.

Data extracted from https://data.bls.gov/PDQWeb/cs.

Table 39. US SOII MSD case * and rate † data from 2011-2020 for construction subsectors, industry groups and industries, sorted by NAICS code

2017 NAICS code	Industry short title	Years of data	Mean annual cases *	Mean annual person years exposed	Mean IR †	Rank of mean IR †	Difference of mean IR † and 2017 IR †	Rank of 2017 IR †
236 ‡	Construction of buildings	10	3721	1330900	0.280	24	-0.014	18
2361 ‡	Residential building construction	10	2244	618170	0.363	19	-0.051	8
2362 ‡	Nonresidential building construction	10	1480	714810	0.207	32	0.019	28
237 ‡	Heavy and civil engineering construction	10	2098	949290	0.221	30	0.041	29
2371 ‡	Utility system construction	10	904	502630	0.180	34	0.035	32
23711	Water and sewer system construction	10	424	167880	0.253	28	0.092	31
23712	Oil and gas pipeline construction	10	96	161760	0.059	35	0.002	34
23713	Power and communication system construction	9	402	178611	0.225	29	0.024	26
2372 ‡	Land subdivision	8	73	37450	0.194	33	-0.080	20
2373 ‡	Highway, street, and bridge construction	10	918	302600	0.303	23	0.073	25
2379 ‡	Other heavy construction	9	231	106522	0.217	31	0.045	30
238 ‡	Specialty trade contractors	10	14269	3745620	0.381	14	0.029	12
2381 ‡	Building foundation and exterior contractors	10	2965	704650	0.421	10	0.086	15
23811	Poured concrete structure contractors	8	679	178825	0.380	16	0.034	14
23812	Steel and precast concrete contractors	9	244	73511	0.333	21	0.060	21
23813	Framing contractors	10	330	59860	0.551	3	0.122	6
23814	Masonry contractors	10	527	117230	0.450	8	0.149	17
23815	Glass and glazing contractors	9	253	54333	0.466	5	0.120	14
23816	Roofing contractors	9	627	154611	0.405	12	0.019	9

2017 NAICS code	Industry short title	Years of data	Mean annual cases *	Mean annual person years exposed	Mean IR †	Rank of mean IR †	Difference of mean IR † and 2017 IR †	Rank of 2017 IR †
23817	Siding contractors	5	144	26720	0.539	4		
23819	Other building exterior contractors	5	148	39220	0.377	17	0.269	33
2382 ‡	Building equipment contractors	10	6727	1824740	0.369	18	0.056	16
23821	Electrical and wiring contractors	10	2039	784690	0.260	27	0.070	27
23822	Plumbing and HVAC contractors	10	4191	908830	0.461	6	0.045	7
23829	Other building equipment contractors	10	495	130240	0.380	15	0.119	23
2383 ‡	Building finishing contractors	10	2788	649390	0.429	9	-0.122	3
23831	Drywall and insulation contractors	10	829	203360	0.408	11	0.055	11
23832	Painting and wall covering contractors	6	435	163033	0.267	26	-0.485	2
23833	Flooring contractors	10	336	59910	0.561	2	0.031	4
23834	Tile and terrazzo contractors	8	155	43125	0.359	20	-0.891	1
23835	Finish carpentry contractors	6	700	124300	0.563	1	0.128	5
23839	Other building finishing contractors	10	285	62910	0.453	7	0.088	10
2389 ‡	Other specialty trade contractors	10	1792	567160	0.316	22	0.051	22
23891	Site preparation contractors	10	779	290510	0.268	25	0.029	24
23899	All other specialty trade contractors	9	1073	267644	0.401	13	0.109	19

Source: U.S. Bureau of Labor Statistics, annual Survey of Occupational Injuries and Illnesses (SOII), 2011–2020.

IR, Incidence Rate; 2017 NAICS, North American Industry Classification System, 2017 revision; HVAC, Heating, ventilation and air-conditioning.

* Nonfatal injury and illness cases involving days away from work reported by private industry, All U.S.

† Rate per 200 000 hours worked.

‡ Combines data from lower level codes.

Data extracted from https://data.bls.gov/PDQWeb/cs.

Table 40. US SOII MSD case * and rate † data from 2011-2020 for construction subsectors, sorted by mean incidence rate †

5-digit 2017 NAICS code	Industry short title	Years of data	Mean annual cases *	Mean annual person years exposed	Mean IR †	Rank of mean IR †
23835	Finish carpentry contractors	6	700	124 300	0.563	1
23833	Flooring contractors	10	336	59 910	0.561	2
23813	Framing contractors	10	330	59 860	0.551	3
23817	Siding contractors	5	144	26 720	0.539	4
23815	Glass and glazing contractors	9	253	54 333	0.466	5
23822	Plumbing and HVAC contractors	10	4 191	908 830	0.461	6
23839	Other building finishing contractors	10	285	62 910	0.453	7
23814	Masonry contractors	10	527	117 230	0.450	8
23831	Drywall and insulation contractors	10	829	203 360	0.408	9
23816	Roofing contractors	9	627	154 611	0.405	10
23899	All other specialty trade contractors	9	1 073	267 644	0.401	11
23829	Other building equipment contractors	10	495	130 240	0.380	12
23811	Poured concrete structure contractors	8	679	178 825	0.380	13
23819	Other building exterior contractors	5	148	39 220	0.377	14
23834	Tile and terrazzo contractors	8	155	43 125	0.359	15
23812	Steel and precast concrete contractors	9	244	73 511	0.333	16
23891	Site preparation contractors	10	779	290 510	0.268	17
23832	Painting and wall covering contractors	6	435	163 033	0.267	18
23821	Electrical and wiring contractors	10	2 039	784 690	0.260	19
23711	Water and sewer system construction	10	424	167 880	0.253	20

5-digit 2017 NAICS code	Industry short title	Years of data	Mean annual cases *	Mean annual person years exposed	Mean IR †	Rank of mean IR †
23713	Power and communication system construction	9	402	178 611	0.225	21
23712	Oil and gas pipeline construction	10	96	161 760	0.059	22

Source: U.S. Bureau of Labor Statistics, annual Survey of Occupational Injuries and Illnesses (SOII), 2011–2020.

IR, Incidence Rate; 2017 NAICS, North American Industry Classification System, 2017 revision; HVAC, Heating, ventilation and air-conditioning.

* Nonfatal injury and illness cases involving days away from work reported by private industry, All U.S.

† Rate per 200 000 hours worked.

Data extracted from https://data.bls.gov/PDQWeb/cs.

Table 41. US SOII MSD case * and rate † data from 2011-2020 for construction industries, sorted by 2017 NAICS 5-digit code

5-digit 2017 NAICS code	Industry short title	Years of data	Mean annual cases *	Mean annual person years exposed	Mean IR †	Rank of mean IR †
23711	Water and sewer system construction	10	424	167880	0.253	20
23712	Oil and gas pipeline construction	10	96	161760	0.059	22
23713	Power and communication system construction	9	402	178611	0.225	21
23811	Poured concrete structure contractors	8	679	178825	0.380	13
23812	Steel and precast concrete contractors	9	244	73511	0.333	16
23813	Framing contractors	10	330	59860	0.551	3
23814	Masonry contractors	10	527	117230	0.450	8
23815	Glass and glazing contractors	9	253	54333	0.466	5
23816	Roofing contractors	9	627	154611	0.405	10
23817	Siding contractors	5	144	26720	0.539	4
23819	Other building exterior contractors	5	148	39220	0.377	14
23821	Electrical and wiring contractors	10	2039	784690	0.260	19

5-digit 2017 NAICS code	Industry short title	Years of data	Mean annual cases *	Mean annual person years exposed	Mean IR †	Rank of mean IR †
23822	Plumbing and HVAC contractors	10	4191	908830	0.461	6
23829	Other building equipment contractors	10	495	130240	0.380	12
23831	Drywall and insulation contractors	10	829	203360	0.408	9
23832	Painting and wall covering contractors	6	435	163033	0.267	18
23833	Flooring contractors	10	336	59910	0.561	2
23834	Tile and terrazzo contractors	8	155	43125	0.359	15
23835	Finish carpentry contractors	6	700	124300	0.563	1
23839	Other building finishing contractors	10	285	62910	0.453	7
23891	Site preparation contractors	10	779	290510	0.268	17
23899	All other specialty trade contractors	9	1073	267644	0.401	11

Source: U.S. Bureau of Labor Statistics, annual Survey of Occupational Injuries and Illnesses (SOII), 2011–2020.

IR, Incidence Rate; 2017 NAICS, North American Industry Classification System, 2017 revision; HVAC, Heating, ventilation and air-conditioning.

* Nonfatal injury and illness cases involving days away from work reported by private industry, All U.S.

† Rate per 200 000 hours worked.

Data extracted from https://data.bls.gov/PDQWeb/cs.

Table 42. Comparison of the 2017 MSD * incidence rates † for construction industries reported by Dong et al. (2019) with mean incidence rates † from 2011–2020, sorted by 2017 incidence rate †

2017 NAICS code	Industry short title	Years of data	Mean annual cases *	Mean annual person years exposed	2017 IR †	Mean IR †	Rank of mean IR †	Difference of mean IR † and 2017 IR †
23834	Tile and terrazzo contractors	8	155	43125	1.250	0.359	9	-0.891
23832	Painting and wall covering contractors	6	435	163033	0.752	0.267	13	-0.485

2017 NAICS code	Industry short title	Years of data	Mean annual cases *	Mean annual person years exposed	2017 IR †	Mean IR †	Rank of mean IR †	Difference of mean IR † and 2017 IR †
2383 ‡	Building finishing contractors	10	2788	649390	0.551	0.429	6	-0.122
23833	Flooring contractors	10	336	59910	0.530	0.561	2	0.031
23835	Finish carpentry contractors	6	700	124300	0.435	0.563	1	0.128
23813	Framing contractors	10	330	59860	0.429	0.551	3	0.122
23822	Plumbing and HVAC contractors	10	4191	908830	0.416	0.461	4	0.045
2361 ‡	Residential building construction	10	2244	618170	0.414	0.363	8	-0.051
23831	Drywall and insulation contractors	10	829	203360	0.353	0.408	7	0.055
23814	Masonry contractors	10	527	117230	0.301	0.450	5	0.149
236 ‡	Construction of buildings	10	3721	1330900	0.294	0.280	11	-0.014
23891	Site preparation contractors	10	779	290510	0.239	0.268	12	0.029
2373 ‡	Highway, street, and bridge construction	10	918	302600	0.230	0.303	10	0.073
23821	Electrical and wiring contractors	10	2039	784690	0.190	0.260	14	0.070
2362 ‡	Nonresidential building construction	10	1480	714810	0.188	0.207	16	0.019
237 ‡	Heavy and civil engineering construction	10	2098	949290	0.180	0.221	15	0.041
2371 ‡	Utility system construction	10	904	502630	0.145	0.180	17	0.035

Source: U.S. Bureau of Labor Statistics, annual Survey of Occupational Injuries and Illnesses (SOII), 2011–2020.

IR, Incidence Rate; 2017 NAICS, North American Industry Classification System, 2017 revision; HVAC, Heating, ventilation and air-conditioning.

* Nonfatal injury and illness cases involving days away from work reported by private industry, All U.S.

† Rate per 200 000 hours worked.

‡ Combines data from lower level codes.

Data extracted from https://data.bls.gov/PDQWeb/cs.

Table 43. Comparison of the mean MSD * incidence rates † from 2011–2020 for construction industries with incidence rates † for 2017 reported by Dong et al. (2019), sorted by mean incidence rate †

2017 NAICS code	Industry short title	Mean IR †	2017 IR †	Rank of 2017 IR †	Difference of mean IR † and 2017 IR †
23835	Finish carpentry contractors	0.563	0.435	5	0.128
23833	Flooring contractors	0.561	0.530	4	0.031
23813	Framing contractors	0.551	0.429	6	0.122
23822	Plumbing and HVAC contractors	0.461	0.416	7	0.045
23814	Masonry contractors	0.450	0.301	10	0.149
2383 ‡	Building finishing contractors	0.429	0.551	3	-0.122
23831	Drywall and insulation contractors	0.408	0.353	9	0.055
2361 ‡	Residential building construction	0.363	0.414	8	-0.051
23834	Tile and terrazzo contractors	0.359	1.250	1	-0.891
2373 ‡	Highway, street, and bridge construction	0.303	0.230	13	0.073
236 ‡	Construction of buildings	0.280	0.294	11	-0.014
23891	Site preparation contractors	0.268	0.239	12	0.029
23832	Painting and wall covering contractors	0.267	0.752	2	-0.485
23821	Electrical and wiring contractors	0.260	0.190	14	0.070
237 ‡	Heavy and civil engineering construction	0.221	0.180	16	0.041
2362 ‡	Nonresidential building construction	0.207	0.188	15	0.019
2371 ‡	Utility system construction	0.180	0.145	17	0.035

Source: U.S. Bureau of Labor Statistics, annual Survey of Occupational Injuries and Illnesses (SOII), 2011–2020.

IR, Incidence Rate; 2017 NAICS, North American Industry Classification System, 2017 revision; HVAC, Heating, ventilation and air-conditioning.

* Nonfatal injury and illness cases involving days away from work reported by private industry, All U.S.

† Rate per 200 000 hours worked.

‡ Combines data from lower level codes.

Data extracted from https://data.bls.gov/PDQWeb/cs.

3.3.2 Classification by occupation (SOC code)

This section explores occupation/trade data from the USA reported using the US 2010 Standard Occupational Classification (US SOC) as the basis of classification.

3.3.2.1 Detailed results

Wang *et al.* (2017) examined trends and patterns of WRMSDs among construction workers in the USA, using data from the annual BLS SOII, from 1992–2014. They found that the number of WRMSDs dropped significantly in the US construction industry, following overall injury trends, but the WRMSD rate in construction remained higher than in all industries combined. They reported WRMSD case numbers and incident rates for 19 construction occupations for the four years from 2011 to 2014. These are listed in Table 44. They list rate ratios (which they described as a 'risk index') of WRMSDs comparing each occupation to the whole construction sector across the USA.

Because they also reported 95% Confidence Intervals for the rate ratios, it has been possible to identify groups of occupations that are statistically distinct. These are identified by letters in the 'Groups of occupations' column in Table 44. These groups overlap in complex ways. These figures illustrate that very often the risks experienced by different occupations do not differ greatly but looking across the range of occupations it is clear there are occupations that have much higher rates than other ones.

Table 45 gives comparable data to the data in Table 44 from the following three-year period, ie 2015–2017, derived from Dong *et al.* (2019). While Wang *et al.* (2017) had included 19 occupations, Dong *et al.* (2019) included 20. Also, checking the data from Wang *et al.* (2017) and Dong *et al.* (2019) against the data available on the BLS website showed that there were minor differences between the occupational groups included in the two papers. These are noted in the footnotes to Table 45.

The relationships between the data reported in these two studies are explored in more detail in Section 3.6, which reports correlations between incidence rates reported in these two studies and with rates reported in other studies of construction occupations.

An existing data file (msd-construction-occ-2011-2017.xlsx) was found on the BLS website at https://www.bls.gov/iif/iif-data-requests/ containing data from 2011–2017 that were extracted from the BLS database in 2019. These data matched the 2011–2014 data reported by Wang *et al.* (2017) and the 2015–2017 data reported by Dong *et al.* (2019). The number of MSD cases that resulted in days absent from work were reported for each year for each selected occupation. The median days absent and the relative standard error, which appears to be for the number of cases of absence, were also reported.

The data for each year includes figures for 'All occupations'. The numbers of occupations reported varied from year to year, ranging from 114 in 2015 to 144 in 2012, with a total of 204 (including 'All occupations') included across the seven-year period. Of these, 84 (41%) had data for all seven years and 50 (25%) had data for only one year. A description of the origin and selection criteria for the occupations included in the file has not been found.

Many of the included occupations could not reasonably be considered part of the construction sector, though their services might be necessary for construction firms to operate (such as 11-1000 'Top Executives' and 37-2012 'Maids and Housekeeping Cleaners)'. Therefore, the occupations that clearly related to the construction sector were identified. SOC codes 47-0XXX to 47-4XXX were mostly included. Extraction occupations (47-5XXX) were excluded. A small number of occupations from other SOC Major groups were included, such as 11-9021 'Construction Managers' and 49-9021 'Heating- Air Conditioning- and Refrigeration Mechanics and Installers'.

Table 46 reports summary statistics (mean, standard deviation and coefficient of variation) for the SOII incident rate data of 66 construction occupations (see Section 2.2.3) over the 10-year period from 2011 to 2020. The occupations are sorted by incidence rate. The table illustrates the range of variability within the occupational groups, with two groups having coefficients of variation over 100% and 33 having coefficients of variation less than 50%.

Table 47 gives data on the incident rates per 200 000 hours worked, case numbers and days absent from work for these 66 occupations averaged over the 10 years from 2011 to 2020. The order occupations are listed in is the same as in Table 46, ie sorted by incidence rate. Table 47 also gives data on the case numbers and median days absent from work for each occupation.

The occupation with the highest rate, 47-2043 'Floor sanders and finishers', has three times the incidence rate of the next worst occupation, but the data are from only four years. It also has a very high coefficient of variation suggesting that either actual incidence rates are very variable or that the reported data are of limited reliability and therefore the position in the list may not be accurate. The fourth occupation in the list, 47-2142 'Paperhangers', has data from only one year, again suggesting that the high position in the list may not be accurate.

Looking solely at US 2010 SOC detailed occupations, ie ignoring occupations where the SOC code last digit is zero, the occupations with the highest incidence rates of work absences due to MSDs were 47-2043 'Floor sanders and finishers' (IR = 3.581 episodes per 200 000 hours),47-2042 'Floor layers, except carpet, wood and hard tiles' (IR = 1.119), 47-2142 'Paperhangers' (IR = 1.058), 47-2041 'Carpet installers' (IR = 0.966), 49-2022 'Telecommunications equipment installers and repairers, except line installers' (IR = 0.866), and 49-9021, 'Heating, air conditioning, and refrigeration mechanics and installers' (IR = 0.849).

Three of these occupations can be mapped (Table 103) to UK SOC 2010 code 5322 'Floorers and wall tilers', with the others mapping to 5323 'Painters and decorators', 5242, 'Telecommunications engineers' and 5225 'Air-conditioning and refrigeration engineers'

Table 48 lists 11 occupational groups where there were statistically significant trends in incidence rates over the ten years from 2011 to 2020. Of these, eight were 'detailed occupations', ie classified at the lowest level of classification. Groups were only included if data from at least seven years were available. In all the included groups the incidence rates decreased over time.

3.3.2.2 Summary of results

Correlations ranged between -0.70 and -0.93, so the amount of variability associated with the time trend ranged between 49% and 86%, indicating that these were consistent decreases in incidence rates. Such decreases over a 10-year period would suggest that longer-term trends are reducing MSD risks in these occupations.

3.3.2.3 Data tables

Table 44. Number and incidence rate of WRMSDs in construction, selected occupations, 2011—2014

US 2010 SOC code *	Occupation	No. of WRMSDs	IR †	95% CI	RR ‡	Groups of occupations §
47-3010	Helper	1 520	1.009	0.530–1.926	2.56	A
49-9021	Heating A/C mechanic	6 800	0.989	0.733–1.328	2.50	A B
47-2050	Cement mason	1 290	0.863	0.454–1.625	2.19	A B C
47-2211	Sheet metal	1 110	0.862	0.421–1.733	2.18	A B C D
47-2221	Ironworker	850	0.729	0.321–1.595	1.85	A B C D E
47-2152	Plumber	6 740	0.619	0.468–0.806	1.57	A B C D E
49-9051	Power line installer	390	0.611	0.173–1.809	1.55	A B C D E F
53-3030	Truck driver	2 300	0.531	0.337–0.807	1.34	A B C D E F
47-2031	Carpenter	10 370	0.488	0.393–0.599	1.24	A C D E F
47-2061	Construction labourer	15 490	0.474	0.395–0.563	1.20	A C D E F
47-2111	Electrician	6 190	0.468	0.357–0.603	1.18	A C D E F
47-2181	Roofer	1 740	0.398	0.241–0.620	1.01	A C D E F
47-2081	Drywall	990	0.319	0.166–0.556	0.81	A C D E F
47-1011	Foreman	4 110	0.317	0.231–0.423	0.80	D E F
47-2021	Brickmason	910	0.289	0.145–0.506	0.73	C D E F
47-2140	Painter	1 830	0.206	0.132–0.302	0.52	F
47-2073	Operating engineer	1 180	0.175	0.100–0.276	0.44	F
51-4121	Welder	400	0.156	0.052–0.328	0.39	E F G
11-9021	Construction manager	670	0.045	0.022–0.073	0.11	G
	All construction	82 670	0.395	0.361–0.430	1.00	D E F

Source: US Bureau of Labor Statistics, 2011—2014 Survey of Occupational Injuries and Illnesses; 2011—2014 Current Population Survey. Note: Only private wage-and-salary workers were included. Self-employed workers were not included.

WRMSDs, work-related musculoskeletal disorders; US SOC, US Standard Occupational Classification; IR, Incidence Rate; CI, Confidence Interval; RR, Rate Ratio; A/C, Air Conditioning; FTEs, full-time equivalent workers.

* From US 2010 SOC, available at https://www.bls.gov/soc/2010/home.htm.

† Rate per 200 000 hours worked. 2000 hours = 1 FTE.

‡ The WRMSD incidence rate for 'All construction' between 2011 and 2014 was used as the reference (rate ratio = 1).

§ Occupations with no statistical difference between them are grouped by letter.

Data derived from Table 3 of Wang *et al.* (2017).

Table 45. Number and rate of WRMSDs resulting in days away from work, selected construction occupations, sum of 2015 to 2017

US 2010 SOC code [*]	Construction occupation	No. of cases	IR [†]
47-3010	Helpers	1 280	0.897
47-2211	Sheet metal	1 390	0.801
47-2221	Ironworkers	670	0.510
53-3030	Truck drivers	2 380	0.450
47-2121	Glaziers	510	0.443
47-2050	Cement masons	640	0.437
49-9021	Heating	4 270	0.420
49-9050 [‡]	Line installers	390	0.414
47-2150 [§]	Plumbers	5 070	0.351
47-2181	Roofers	1 830	0.307
47-2061	Construction laborers	13 410	0.266
47-2080 [**]	Drywall	1 150	0.242
47-2031	Carpenters	7 040	0.207
47-2111	Electricians	3 200	0.189
47-2073	Operating engineers	1 309	0.155
51-4121	Welders	420	0.144
47-2020 [††]	Brickmasons	540	0.123
47-2040	Carpet and tile	480	0.118
47-2140	Painters	1 770	0.118
11-9021	Construction managers	1 960	0.070

Sources: U.S. Bureau of Labor Statistics, 2015–2017 Survey of Occupational Injuries and Illnesses; 2015–2017 Current Population Surveys. Calculations by the CPWR Data Center.

US 2010 SOC, US Standard Occupational Classification, 2010 edition; IR, Incidence Rate.

[*] From US 2010 SOC, available at https://www.bls.gov/soc/2010/home.htm

[†] Rate per 200 000 hours worked.

[‡] This is a different SOC code to the line installers included by Wang *et al.* (2017) (SOC 49-9051). SOC 49-9051 had 180 cases between 2015 and 2017.

[§] This is a different SOC code to the plumbers included by Wang *et al.* (2017) (SOC 47-2152). SOC 47-2152 had 4890 cases between 2015 and 2017.

[**] This is a different SOC code to the drywall installers included by Wang *et al.* (2017) (SOC 47-2081). SOC 47-2081 had 1080 cases between 2015 and 2017.

[††] This is a different SOC code to the brickmasons included by Wang *et al.* (2017) (SOC 47-2021). SOC 47-2021 had 480 cases between 2015 and 2017.

Data derived from Chart 13 of Dong *et al.* (2019) and checked against https://www.bls.gov/iif/iif-data-requests/msd-construction-occ-2011-2017.xlsx (last downloaded on 30/01/2023).

Table 46. Private industry incidence rates of episodes of days absent from work due to MSDs, all US, 2011–2020, by detailed construction occupation

US 2010 SOC code	Occupation	Data years	IR * mean	IR * SD	IR * CV
47-2043	Floor sanders and finishers	4	3.581	3.668	102%
47-4090	Miscellaneous construction and related workers	9	1.201	0.866	72%
47-2042	Floor layers, except carpet, wood, and hard tiles	9	1.119	0.839	75%
47-2142	Paperhangers	1	1.058	–	–
47-2041	Carpet installers	10	0.966	0.725	75%
49-2022	Telecommunications equipment installers and repairers, except line installers	10	0.866	0.215	25%
47-2040	Carpet, floor, and tile installers and finishers	9	0.860	0.495	58%
49-9021	Heating, air conditioning, and refrigeration mechanics and installers	10	0.849	0.290	34%
47-2044	Tile and stone setters	10	0.742	0.552	74%
47-3012	Helpers–carpenters	5	0.667	0.615	92%
49-9011	Mechanical door repairers	9	0.652	0.415	64%
47-2121	Glaziers	10	0.632	0.253	40%
47-2061	Construction laborers	10	0.615	0.124	20%
47-2131	Insulation workers, floor, ceiling, and wall	10	0.602	0.624	104%
47-2231	Solar photovoltaic installers	2	0.595	0.465	78%
47-2152	Plumbers, pipefitters, and steamfitters	10	0.584	0.166	28%
47-2031	Carpenters	10	0.567	0.134	24%
47-2053	Terrazzo workers and finishers	1	0.566	–	–
47-2150	Pipelayers, plumbers, pipefitters, and steamfitters	10	0.565	0.161	28%
47-2181	Roofers	10	0.550	0.193	35%
47-3016	Helpers–roofers	1	0.538	–	–
47-2022	Stonemasons	6	0.528	0.081	15%
47-2171	Reinforcing iron and rebar workers	6	0.524	0.472	90%
47-4021	Elevator and escalator installers and repairers	9	0.486	0.275	57%
47-2000	Construction trades workers	10	0.467	0.082	18%
47-2081	Drywall and ceiling tile installers	10	0.436	0.213	49%
47-2021	Brickmasons and blockmasons	10	0.424	0.165	39%
47-2211	Sheet metal workers	10	0.420	0.192	46%
47-0000	Construction and extraction occupations	10	0.419	0.069	17%

US 2010 SOC code	Occupation	Data years	IR * mean	IR * SD	IR * CV
47-2020	Brickmasons, blockmasons, and stonemasons	10	0.413	0.149	36%
47-2080	Drywall installers, ceiling tile installers, and tapers	10	0.407	0.180	44%
47-2221	Structural iron and steel workers	10	0.407	0.150	37%
47-2140	Painters and paperhangers	10	0.399	0.237	59%
47-2141	Painters, construction and maintenance	10	0.396	0.240	61%
47-2151	Pipelayers	8	0.386	0.282	73%
49-9096	Riggers	9	0.379	0.276	73%
47-2130	Insulation workers	10	0.362	0.273	75%
47-2111	Electricians	10	0.355	0.122	34%
47-4000	Other construction and related workers	10	0.352	0.147	42%
47-3011	Helpers–brickmasons, blockmasons, stonemasons, and tile and marble setters	10	0.321	0.193	60%
47-4031	Fence erectors	4	0.320	0.245	77%
49-9044	Millwrights	10	0.310	0.144	47%
47-3014	Helpers–painters, paperhangers, plasterers, and stucco masons	1	0.306	–	–
49-2098	Security and fire alarm systems installers	10	0.304	0.154	51%
51-4121	Welders, cutters, solderers, and brazers	10	0.304	0.127	42%
47-3015	Helpers–pipelayers, plumbers, pipefitters, and steamfitters	10	0.293	0.131	45%
47-3010	Helpers, construction trades	10	0.288	0.095	33%
47-2082	Tapers	9	0.286	0.181	63%
53-7021	Crane and tower operators	10	0.283	0.168	59%
47-2161	Plasterers and stucco masons	10	0.278	0.085	31%
47-1000	Supervisors of construction and extraction workers	10	0.276	0.048	18%
47-1011	First-line supervisors of construction trades and extraction workers	10	0.276	0.048	18%
47-2011	Boilermakers	6	0.252	0.223	88%
47-2051	Cement masons and concrete finishers	10	0.199	0.165	83%
47-2050	Cement masons, concrete finishers, and terrazzo workers	10	0.197	0.161	82%
47-2132	Insulation workers, mechanical	7	0.194	0.081	42%
53-7032	Excavating and loading machine and dragline operators	8	0.176	0.057	32%

US 2010 SOC code	Occupation	Data years	IR * mean	IR * SD	IR * CV
47-2073	Operating engineers and other construction equipment operators	10	0.173	0.049	29%
11-9021	Construction managers	10	0.172	0.152	88%
47-2070	Construction equipment operators	10	0.159	0.043	27%
47-3013	Helpers—electricians	10	0.103	0.063	61%
47-2071	Paving, surfacing, and tamping equipment operators	5	0.100	0.030	30%
47-4011	Construction and building inspectors	5	0.078	0.034	44%
47-4041	Hazardous materials removal workers	6	0.074	0.033	45%
47-3019	Helpers, construction trades, all other	0	–	–	–
47-4099	Construction and related workers, all other	0	–	–	–

MSD, Musculoskeletal Disorder, US 2010 SOC, US Standard Occupational Classification, 2010 edition; IR, Incidence rate; SD, Standard Deviation; CV, Coefficient of Variation.

* Rate per 200 000 hours worked

Data extracted from https://data.bls.gov/PDQWeb/cs.

Table 47. Private industry case numbers and median days absent from work due to MSDs, all US, 2011–2020, by detailed construction occupation

US 2010 SOC code	Occupation	Data years	Annual cases mean	Annual cases SD	Annual cases CV	Median DAFW mean	Median DAFW SD	Median DAFW CV
47-2043	Floor sanders and finishers	5	112	127	114%	20	23	116%
47-4090	Miscellaneous construction and related workers	10	272	176	65%	18	16	90%
47-2042	Floor layers, except carpet, wood, and hard tiles	9	104	66	63%	41	57	138%
47-2142	Paperhangers	3	57	55	97%	1	1	43%
47-2041	Carpet installers	10	219	192	88%	23	23	99%
49-2022	Telecommunications equipment installers and repairers, except line installers	10	1 692	554	33%	31	9	30%
47-2040	Carpet, floor, and tile installers and finishers	10	569	292	51%	25	21	85%
49-9021	Heating, air conditioning, and refrigeration mechanics and installers	10	1 996	424	21%	13	5	36%
47-2044	Tile and stone setters	10	199	121	61%	37	33	89%
47-3012	Helpers–carpenters	5	192	170	89%	24	43	179%
49-9011	Mechanical door repairers	9	122	82	67%	28	38	136%
47-2121	Glaziers	10	265	110	42%	18	16	90%
47-2061	Construction laborers	10	4 530	596	13%	11	4	32%
47-2131	Insulation workers, floor, ceiling, and wall	10	145	143	99%	29	51	178%
47-2231	Solar photovoltaic installers	2	25	7	28%	10	11	112%
47-2152	Plumbers, pipefitters, and steamfitters	10	1 972	407	21%	24	23	94%
47-2031	Carpenters	10	3 112	680	22%	14	3	21%
47-2053	Terrazzo workers and finishers	1	20	–	–	4	–	–

US 2010 SOC code	Occupation	Data years	Annual cases mean	Annual cases SD	Annual cases CV	Median DAFW mean	Median DAFW SD	Median DAFW CV
47-2150	Pipelayers, plumbers, pipefitters, and steamfitters	10	2 059	413	20%	24	21	89%
47-2181	Roofers	10	504	166	33%	14	7	52%
47-3016	Helpers–roofers	1	40	–	–	1	–	–
47-2022	Stonemasons	6	53	8	15%	20	22	109%
47-2171	Reinforcing iron and rebar workers	7	77	57	74%	23	21	91%
47-4021	Elevator and escalator installers and repairers	9	100	62	62%	25	19	77%
47-2000	Construction trades workers	10	15 996	1 299	8%	14	3	19%
47-2081	Drywall and ceiling tile installers	10	332	172	52%	27	30	111%
47-2021	Brickmasons and blockmasons	10	221	93	42%	26	20	78%
47-2211	Sheet metal workers	10	480	223	46%	26	20	75%
47-0000	Construction and extraction occupations	10	19 080	1 438	8%	14	2	16%
47-2020	Brickmasons, blockmasons, and stonemasons	10	255	97	38%	27	20	77%
47-2080	Drywall installers, ceiling tile installers, and tapers	10	372	177	48%	26	29	114%
47-2221	Structural iron and steel workers	10	243	75	31%	21	17	83%
47-2140	Painters and paperhangers	10	654	366	56%	21	9	46%
47-2141	Painters, construction and maintenance	10	638	365	57%	21	9	42%
47-2151	Pipelayers	8	110	79	71%	18	16	88%
49-9096	Riggers	9	62	35	56%	38	29	76%
47-2130	Insulation workers	10	180	135	75%	29	51	179%
47-2111	Electricians	10	1 827	435	24%	13	4	33%

US 2010 SOC code	Occupation	Data years	Annual cases mean	Annual cases SD	Annual cases CV	Median DAFW mean	Median DAFW SD	Median DAFW CV
47-4000	Other construction and related workers	10	617	231	37%	18	13	70%
47-3011	Helpers–brickmasons, blockmasons, stonemasons, and tile and marble setters	10	64	37	58%	31	51	164%
47-4031	Fence erectors	4	55	44	81%	65	82	127%
49-9044	Millwrights	10	126	52	41%	22	12	56%
47-3014	Helpers–painters, paperhangers, plasterers, and stucco masons	1	30	–	–	40	–	–
49-2098	Security and fire alarm systems installers	10	171	74	43%	13	10	78%
51-4121	Welders, cutters, solderers, and brazers	10	1 045	394	38%	16	8	51%
47-3015	Helpers–pipelayers, plumbers, pipefitters, and steamfitters	10	125	49-	39%	30	31	103%
47-3010	Helpers, construction trades	10	535	197	37%	18	22	128%
47-2082	Tapers	9	42	29	69%	22	15	67%
53-7021	Crane and tower operators	10	124	74	60%	37	24	66%
47-2161	Plasterers and stucco masons	10	53	22	42%	31	54	176%
47-1000	Supervisors of construction and extraction workers	10	1 325	124	09%	14	6	39%
47-1011	First-line supervisors of construction trades and extraction workers	10	1 325	124	09%	14	6	39%
47-2011	Boilermakers	7	39	32	83%	18	12	69%
47-2051	Cement masons and concrete finishers	10	255	168	66%	17	11	66%
47-2050	Cement masons, concrete finishers, and terrazzo workers	10	261	167	64%	16	11	67%
47-2132	Insulation workers, mechanical	7	46	19	42%	15	16	104%

US 2010 SOC code	Occupation	Data years	Annual cases mean	Annual cases SD	Annual cases CV	Median DAFW mean	Median DAFW SD	Median DAFW CV
53-7032	Excavating and loading machine and dragline operators	8	76	25	33%	22	33	146%
47-2073	Operating engineers and other construction equipment operators	10	496	156	31%	17	9	57%
11-9021	Construction managers	10	404	353	87%	15	24	155%
47-2070	Construction equipment operators	10	523	155	30%	17	9	56%
47-3013	Helpers—electricians	10	59	34	58%	21	29	136%
47-2071	Paving, surfacing, and tamping equipment operators	5	40	12	31%	53	73	138%
47-4011	Construction and building inspectors	5	34	21	61%	20	15	77%
47-4041	Hazardous materials removal workers	6	28	10	35%	40	40	99%
47-3019	Helpers, construction trades, all other	10	169	77	46%	14	13	93%
47-4099	Construction and related workers, all other	10	272	176	65%	18	16	90%

MSD, Musculoskeletal Disorder, SOC, Standard Occupational Classification; DAFW, Days Absent From Work; SD, Standard Deviation; CV, Coefficient of Variation.

[*] Rate per 200 000 hours worked

Data extracted from https://data.bls.gov/PDQWeb/cs.

Table 48. Statistically significant trends in IR from 2011–2020 in occupations with data from 7 or more years

US 2010 SOC code	SOC group level	Occupation	Years of rate data	2020 IR as % of 2011 IR	Correlation (r) for trend	Probability
49-9021	Detailed occupation	Heating, air conditioning, and refrigeration mechanics and installers	10	65%	-0.712	P < 0.05
47-2044	Detailed occupation	Tile and stone setters	10	16%	-0.742	P < 0.05
47-2061	Detailed occupation	Construction laborers	10	64%	-0.772	P < 0.01
47-2000	Minor group	Construction trades workers	10	65%	-0.926	P < 0.01
47-0000	Major group	Construction and extraction occupations	10	65%	-0.928	P < 0.01
47-2151	Detailed occupation	Pipelayers	8	*	-0.850	P < 0.01
47-2111	Detailed occupation	Electricians	10	58%	-0.734	P < 0.05
49-9044	Detailed occupation	Millwrights	10	28%	-0.831	P < 0.01
51-4121	Detailed occupation	Welders, cutters, solderers, and brazers	10	83%	-0.701	P < 0.05
47-1000	Minor group	Supervisors of construction and extraction workers	10	71%	-0.769	P < 0.01
47-1011	Detailed occupation	First-line supervisors of construction trades and extraction workers	10	71%	-0.769	P < 0.01

US 2010 SOC, US Standard Occupational Classification, 2010 edition; IR, Incidence rate; r, Pearson's r.

* No data were available for this occupation for 2020, so it was not possible to calculate the ratio.

Data extracted from https://data.bls.gov/PDQWeb/cs.

3.4 Studies of WRMSDs in Washington State, USA

A number of papers were identified as suitable for inclusion in this review that reported data from Washington State in the USA.

Data classified using the WIC by Silverstein *et al.* (2002) and Anderson *et al.* (2013) are reported in Sections 3.4.1 and 3.4.2 respectively.

Other studies reporting data from the Washington State WC scheme used NAICS codes (see Section 3.4.3 (Bonauto *et al.*, 2006), Section 3.4.4 (Anderson *et al.*, 2013), Section 3.4.5 (Schoonover *et al.*, 2010), and Section 3.4.6 (Spector *et al.*, 2011)).

Multiple papers reported data from the Carpenters' Trusts of Western Washington using data for WC insurance cover provided to members of the United Brotherhood of Carpenters and Joiners of North America (UBC). They classified data by the 'predominant type of work' carried out by the Union Local (the equivalent of a UK union branch) that the injured worker was a member of. The results are given in Section 3.4.7 (Lipscomb *et al.*, 1997), Section 3.4.8 (Lipscomb *et al.*, 1997, Lipscomb *et al.*, 2008a, b) and Section 3.4.9 (Lipscomb *et al.*, 2015).

3.4.1 Construction risk classes at high risk for WRMSDs of the neck, back, and upper extremity in Washington State, 1990–1998

3.4.1.1 Introduction

Silverstein *et al.* (2002) reported high-risk risk occupational classes for WRMSDs that resulted in a successful WC claim in Washington State in the 1990–1998 period, excluding less risky classes and less severe WRMSD cases. Their purpose was to assess the occurrence and direct cost of 'non-traumatic soft tissue' (NTST) disorders in the back, neck and upper limb. As part of this, they wanted to assess the occurrence and direct costs of the specific disorders of sciatica, rotator cuff syndrome, epicondylitis and carpal tunnel syndrome. They also wanted to identify high-risk industries for these disorders to allow better focussing of research and prevention efforts.

Data were extracted for claims from the State Fund WC scheme and from self-insured (ie large) employer WC schemes. They analysed data for "compensable" claims, ie absences of more than three days, that were claims for work-related injuries or occupational illnesses linked to specific diagnosis codes or appropriate 'Current Procedural Terminology' procedure codes. They also distinguished 'non-traumatic and traumatic onset' cases to differentiate 'cumulative' trauma exposures from acute exposures, such as slips, trips, falls, and struck by incidents.

They presented figures for the top 15 WIC classes, having sorted the data using a 'Prevention Index' (PI) that takes both injury rate and total number of cases reported into account[23]. (The PI was created to help prioritise enforcement activity in Washington State.)

[23] The Prevention Index is the average of the rank of the injury rate and the rank of the number of cases for the WIC class of interest. It is therefore a relative measure of risk because it is a single rank score for the WIC classes being examined.

They also included figures for other WIC classes that are in the top three for one but not both of injury rate and total cases. Their data include WIC classes from multiple sectors. Only those in the construction sector or closely related are included below. As a result, the WIC classes do not match completely across the tables below.

Data from this paper are presented using the absolute Claims Incidence Rate (CIR) per 100 FTE (per 200 000 hours worked) rather than the average rankings obtained using the Prevention Index, which are relative measures.

3.4.1.2 Detailed results

Combined data for the neck, back and upper extremity are presented in Table 49. As in all the following tables, the table is sorted by descending rate ratio. Data are also presented separately for the back (Table 50), upper extremity (Table 51) and neck (Table 52). The data for the back and upper extremity are subsets of the data in Table 49. The data for the neck have been calculated by subtracting figures for the back and upper extremity from the combined figures in Table 49. For the six WIC codes with data for complete data. back claims averaged 64% of the total for the neck, back and upper extremity. Upper extremity claims averaged 28% of the total cases. Neck claims averaged 8% of the total.

The seven WIC risk classes in Table 49 all have CIRs over three times the average CIR for all industries. The 95% Confidence Intervals for these classes do not include the average CIR value of 1.28, indicating a high degree of confidence that the rates in these risk classes are genuinely high. This indicates that they would be suitable for action to reduce the risks of back, neck and upper extremity non-traumatic MSDs.

It is noticeable that the first seven WIC risk classes for back problems in Table 50 are identical to the seven classes in Table 49 across the back, neck and upper extremity. This will be due largely to the claims for back problems being approximately 2/3 of the total claims. This suggests that the primary focus of prevention efforts should be focussed on back problems.

Comparing the CIRs and percentages of the total claims in Table 50 and Table 51 within risk classes shows that claims for back problems occur at up to about twice the rate of claims for upper extremity problems. Again, this suggests that the primary focus of prevention efforts should be focussed on back problems.

The reported data for the specific diagnosis of sciatica (Table 53) form only about 5% of the back pain cases in Table 50 but tend to be the most severe and long-lasting cases. While a history of back problems is a strong predictor of future back problems, risk assessment methods and hence suggested interventions are not currently capable of distinguishing between the risks of sciatica distinct from the risks of other forms of back pain. Also, the rankings of the four risk classes that appear in both Table 50 and Table 53 (0306 ‘Plumbing’, 0507 ‘Roofing’, 0510 ‘Wood frame building construction’ and 0515 ‘Wallboard installation’), are the same. This combination of factors suggests that it would be appropriate to focus on controlling risks for back problems in general rather than attempting to focus on sciatica specifically.

Table 54 contains data from the reports they received of rotator cuff syndrome, which is a specific injury to the tendons forming the capsule holding the shoulder in place, and that may need surgical repair. For the four risk classes that appear in both Table 54 and Table 51 (0507 ‘Roofing’, 0510 ‘Wood frame building construction’, 0515 ‘Wallboard installation’ and 0518 ‘Building construction, NOC’), it appears that rotator cuff problems constitute about 20-30% of the total upper extremity WC claims.

Table 55 contains data from the reports of epicondylitis, ie elbow problems. For the four risk classes where it has been possible to calculate percentages, the cases of epicondylitis range between 10% and 15% of the total upper extremity claims.

Table 56 contains data from the reports of carpal tunnel syndrome, which is a specific problem involving the wrist that causes weakness in the hand. For the four risk classes where it has been possible to calculate percentages, the cases of CTS range between 27% and 41% of the total upper extremity claims.

3.4.1.3 Summary of results

The fact that WIC risk classes 0515 ‘Wallboard installation’, 0518 ‘Building construction, NOC’ and 0510 ‘Wood frame building construction’ appear in the separate tables for sciatica, rotator cuff syndrome, epicondylitis and carpal tunnel syndrome indicates that all three create excessive demands on the whole body. This suggests that they would be appropriate areas for prioritisation.

Wallboard installation appears in all of the tables in this section, showing it to be a high-risk task.

Reinforcing steel installation appears as the most hazardous risk class for carpel tunnel syndrome. This is likely to be due to the practice of tying rebar together, which is known to be demanding on the wrists. Seeking to improve this practice would help to reduce the risks.

It should be born in mind that these data are from over 25 years ago and that practices may have improved. Therefore, consideration of current practices and later data should occur before making decisions on specific interventions.

3.4.1.4 Data tables

Table 49. Construction sector WA SF compensable non-traumatic soft tissue disorders in the neck, back, and upper extremity 1990–1998

WIC	Construction sector risk class *	Hours	N	CIR †	RR ‡	95% CI of CIR
0109	Reinforcing steel installation	1 170 742	103	17.60	13.7	14.36-21.34
0515	Wallboard installation	17 974 290	964	10.73	8.3	10.06-11.43
0507	Roofing	30 718 052	1 338	8.71	6.8	8.25-9.19
0102	Concrete construction	38 232 096	1 052	5.50	4.3	5.18-5.85
0510	Wood frame building construction	194 531 508	4 468	4.59	3.6	4.46-4.73
0301	Landscaping	67 457 555	1 431	4.24	3.3	4.03-4.47
0518	Building construction, NOC	87 932 579	1 775	4.04	3.1	3.85-4.23
	Combined total §	370 559 267	9700	5.24	-	-

WA SF, Washington State Fund; WIC, Washington Industrial risk Classification; N, Number of compensable disorders; CIR, Claims Incidence Rate; RR, Rate Ratio; CI, Confidence Interval; NOC, Not Otherwise Classified.

* Risk classes that had fewer than 100 000 hours worked per year were excluded from the analysis.

† Rate per 200 000 hours worked.

‡ Rate ratios are calculated by dividing by the rate for all industries combined.

§ Excluding 301 Landscaping.

Data derived from Table VI of Silverstein *et al.* (2002).

Table 50. Construction sector WA SF compensable non-traumatic soft tissue disorders in the back 1990–1998

WIC	Construction sector risk class *	N	CIR †	RR ‡	% of neck, back + UE claims
0109	Reinforcing steel installation	60	10.250	13.4	58%
0515	Wallboard installation	558	6.209	8.1	58%
0507	Roofing	877	5.710	7.4	66%
0102	Concrete construction	669	3.500	4.6	64%
0510	Wood frame building construction	2 884	2.965	3.9	65%
0301	Landscaping	904	2.680	3.5	63%
0518	Building construction, NOC	1 114	2.534	3.3	63%
0306	Plumbing	1 076	2.253	2.9	-
	Combined total §	6162	3.326	-	64%

WA SF, Washington State Fund; WIC, Washington Industrial risk Classification; N, Number of compensable disorders; CIR, Claims Incidence Rate; RR, Rate Ratio; UE, Upper Extremity; NOC, Not Otherwise Classified.

* Risk classes that had fewer than 100 000 hours worked per year were excluded from the analysis.

† Rate per 200 000 hours worked.

‡ Rate ratios are calculated by dividing by the rate for all industries combined.

§ Excluding 301 Landscaping and 306 Plumbing.

Data derived from Table VIIa of Silverstein *et al.* (2002).

Table 51. Construction sector WA SF compensable non-traumatic soft tissue disorders in the upper extremity 1990–1998

WIC	Construction sector risk class *	N	CIR †	RR ‡	% of neck, back + UE claims
0109	Reinforcing steel installation	41	7.004	17.0	40%
0515	Wallboard installation	300	3.338	8.1	31%
0507	Roofing	344	2.240	5.4	26%
0102	Concrete construction	281	1.470	3.6	27%
0518	Building construction, NOC	556	1.265	3.1	31%
0510	Wood frame building construction	1 210	1.244	3.0	27%
	Combined total	2732	1.475	-	28%

WA SF, Washington State Fund; WIC, Washington Industrial risk Classification; N, Number of compensable disorders; CIR, Claims Incidence Rate; RR, Rate Ratio; UE, Upper Extremity; NOC, Not Otherwise Classified.

* Risk classes that had fewer than 100 000 hours worked per year were excluded from the analysis.

† Rate per 200 000 hours worked.

‡ Rate ratios are calculated by dividing by the rate for all industries combined.

Data derived from Table VIIb of Silverstein *et al.* (2002).

Table 52. Construction sector WA SF compensable non-traumatic soft tissue disorders in the neck 1990—1998

WIC	Construction sector risk class *	N	CIR †	% of neck, back + UE claims
515	Wallboard installation	106	1.179	11%
507	Roofing	117	0.762	9%
102	Concrete construction	102	0.534	10%
510	Wood frame building construction	374	0.385	8%
109	Reinforcing steel installation	2	0.342	2%
518	Building construction, NOC	105	0.239	6%
	Combined total	806	0.435	8%

WA SF, Washington State Fund; WIC, Washington Industrial risk Classification; N, Number of compensable disorders; CIR, Claims Incidence Rate; UE, Upper Extremity; NOC, Not Otherwise Classified.

* Risk classes for which data was reported separately for the neck, back and upper extremity, the back, and the upper extremity.

† Rate per 200 000 hours worked.

Data derived from Table VI, Table VIIa and Table VIIb of 289 Silverstein et al (2002).

Table 53. Construction sector WA SF compensable claims for sciatica 1990—1998

WIC	Construction sector risk class *	N	CIR †	RR ‡	% of back claims
0201	Bridge construction	11	0.349	9.1	-
0515	Wallboard installation	30	0.334	8.7	5%
0507	Roofing	48	0.313	8.1	5%
0502	Floor covering installation	25	0.244	6.3	-
0518	Building construction, NOC	68	0.155	4.0	6%
0101	Road construction	74	0.140	3.6	-
0107	Underground utilities	27	0.137	3.5	-
0510	Wood frame building construction	124	0.127	3.3	-
0306	Plumbing	57	0.119	3.1	5%
0307	HVAC systems	49	0.115	3.0	-
0504	Painting	43	0.114	3.0	-

WA SF, Washington State Fund; WIC, Washington Industrial risk Classification; N, Number of compensable disorders; CIR, Claims Incidence Rate; RR, Rate Ratio; NOC, Not Otherwise Classified; HVAC, Heating, ventilation and air-conditioning; FTE, Full-Time Equivalent; 2000 hours = 1 FTE.

* Risk classes that had fewer than 100 000 hours worked per year were excluded from the analysis.

† Rate per 200 000 hours worked.

‡ Rate ratios are calculated by dividing by the rate for all industries combined.

Data derived from Table VIIIa of Silverstein *et al.* (2002).

Table 54. Construction sector WA SF compensable claims for rotator cuff syndrome 1990—1998

WIC	Construction sector risk class *	N	CIR †	RR ‡	% of UE claims
0524	Wallboard installation–discounted rate	21	1.315	14.7	-
0515	Wallboard installation	97	1.079	12.0	32%
0507	Roofing	77	0.501	5.6	22%
0504	Painting	123	0.327	3.6	-
0518	Building construction, NOC	133	0.303	3.4	24%
0510	Wood frame building construction	250	0.257	2.9	21%
0306	Plumbing	114	0.239	2.7	-

WA SF, Washington State Fund; WIC, Washington Industrial risk Classification; N, Number of compensable disorders; CIR, Claims Incidence Rate; RR, Rate Ratio; UE, Upper extremity; NOC, Not Otherwise Classified; FTE, Full-Time Equivalent; 2000 hours = 1 FTE.

* Risk classes that had fewer than 100 000 hours worked per year were excluded from the analysis.

† Rate per 200 000 hours worked.

‡ Rate ratios are calculated by dividing by the rate for all industries combined.

Data derived from Table VIIIb of Silverstein *et al.* (2002).

Table 55. Construction sector WA SF compensable claims for epicondylitis 1990—1998

WIC	Construction sector risk class *	N	CIR †	RR ‡	% of UE claims
0524	Wallboard installation–discounted rate	11	0.689	15.1	-
0515	Wallboard installation	44	0.456	10.0	15%
0201	Bridge construction	12	0.380	8.3	-
0302	Masonry construction	29	0.278	6.1	-
0507	Roofing	36	0.234	5.1	10%
0510	Wood frame building construction	186	0.191	4.2	15%
0518	Building construction, NOC	72	0.164	3.6	13%
0513	Interior finish carpentry	45	0.159	3.5	-
0504	Painting	53	0.144	3.1	-
0101	Road construction	64	0.121	2.7	-

WA SF, Washington State Fund; WIC, Washington Industrial risk Classification; N, Number of compensable disorders; CIR, Claims Incidence Rate; RR, Rate Ratio; UE, Upper extremity; NOC, Not Otherwise Classified; FTE, Full-Time Equivalent; 2000 hours = 1 FTE.

* Risk classes that had fewer than 100 000 hours worked per year were excluded from the analysis.

† Rate per 200 000 hours worked.

‡ Rate ratios are calculated by dividing by the rate for all industries combined.

Data derived from Table VIIIc of Silverstein *et al.* (2002).

Table 56. Construction sector WA SF compensable claims for carpal tunnel syndrome 1990—1998

WIC	Construction sector risk class *	N	CIR †	RR ‡	% of UE claims
0109	Reinforcing steel installation	17	2.904	18.8	41%
0515	Wallboard installation	82	0.912	5.9	27%
0504	Painting	165	0.438	2.8	-
0518	Building construction, NOC	188	0.428	2.8	34%
0510	Wood frame building construction	376	0.387	2.5	31%

WA SF, Washington State Fund; WIC, Washington Industrial risk Classification; N, Number of compensable disorders; CIR, Claims Incidence Rate; RR, Rate Ratio; UE, Upper extremity; NOC, Not Otherwise Classified; FTE, Full-Time Equivalent; 2000 hours = 1 FTE.

* Risk classes that had fewer than 100 000 hours worked per year were excluded from the analysis.

† Rate per 200 000 hours worked.

‡ Rate ratios are calculated by dividing by the rate for all industries combined.

Data derived from Table VIIId of Silverstein *et al.* (2002).

3.4.2 Compensable WC claims Washington State Fund, 2002–2010, by construction risk classes

3.4.2.1 Introduction

Anderson *et al.* (2013) followed the same approach as Silverstein *et al.* (2002) and used the Prevention Index to rank industries using the WIC (Table 57, Table 58 and Table 59) and NAICS codes (see Section 3.4.4). They used Washington State Fund compensable claims (over 3-days absence) data for injuries/illnesses occurring or starting during the nine-year period from 1st January 2002 to 31st December 2010. They analysed seven injury types responsible for 87.8% of compensable claims, 90% of claim costs and 92% of time lost. Two injury types are relevant to musculoskeletal disorders: 'WMSD' and 'Overexertion'. The other five were 'Struck by/Against', 'Fall on Same Level', 'Fall from Elevation', 'Caught In/Under/Between' and 'Motor Vehicle'.

They defined WMSD claims as being due to sprains, strains, or overexertion that could be clearly identified as the result of cumulative/repetitive injury. They separated them from overexertion claims, which they defined as resulting from events with clearly identifiable acute onset (for example fracture, hernia), plus the claims due to the other sprains, strains, or overexertions that were not clearly the result of cumulative/repetitive injury.

Anderson *et al.* (2013) do not compare their approach and findings to those reported by Silverstein *et al.* (2002). Their definition of 'WMSD' appears similar to the definition of non-traumatic soft-tissue MSDs (NTSTs) used by Silverstein *et al.* (2002), but this cannot be confirmed.

3.4.2.2 Detailed results

Table 57 lists CIRs for 'All injury types' within 15 construction sector WIC risk classes. This category includes data from the seven common injury types analysed.

The table is sorted by decreasing CIR. The data are derived from a table of the top 25 risk classes for 'All injury types' in Anderson *et al.* (2013). There are 320 risk classes currently listed on the Washington State Labor & Industries website[24]. Of these, a total of 49 are related to construction, 29 listed under 'Building Construction and Trades' and 20 of the 26 listed under 'Miscellaneous construction and mining'. In other words, 60% of the riskiest WIC classes are from a sector that constitutes 15% of the total classes. This indicates the overall severity of construction relative to other industries.

Within Table 57 it is noticeable that the largest CIR (0540 'Wallboard installation – discounted rate') is more than three times that of the lowest listed (0301 'Landscape construction and renovation').

Table 58 lists CIRs for WRMSDs (defined as due to cumulative/repetitive injury) within 13 construction sector WIC risk classes, again sorted by decreasing CIR. All 13 appear in the list of 15 risk classes in Table 57. The number of WRMSD claims in individual risk classes

[24] Rates for Workers' Compensation (wa.gov)

ranged from 30% to 52% of the claims for all injury types. Again, there was more than a 3 to 1 ratio between the CIRs for the worst risk class and the class at the bottom of the table.

Table 59 lists CIRs for overexertion injuries (defined as having clearly identifiable acute onset) within 13 construction sector WIC risk classes sorted by decreasing CIR. Twelve of the 15 risk classes appear in Table 57, and the thirteenth is 0513 'Interior Finish Carpentry'. Within the risk classes. the number of WRMSD claims ranged from 30% to 52% of the claims for all injury types, while the overexertion injuries ranged from 4% to 7% of them. This indicates that the 'acute onset'/overexertion injuries were only 10 to 15% of the cumulative/repetitive injury MSDs. Also, the days lost for overexertion claims (median days lost ranging from 29 to 54) were many fewer than those lost for cumulative/repetitive injury (median days lost ranged from 55 to 211).

Similar patterns of claim occur across Table 58 and Table 59, with the top four WIC risk classes being identical. WIC 0513 'Interior Finish Carpentry' is at the bottom of Table 59, but does not appear in Table 58 as it is not in the top 25 classes for all injury types. Therefore, it has not been possible to calculate the percentage of claims represented.

3.4.2.3 Summary of results

Table 60 compares the WIC Claims Injury Rates reported in Table 49 to Table 59, ie across injury types. Where there are CIRs from multiple WICs, these are averaged and the range given. It allows comparison of the importance of the different types of injury. The data for claims due to harm to individual body parts are from 1990 to 1998; the data for all claims, WRMSD claims, and overexertion claims are from 2002-2010. The data are from only nine WIC risk classes, so caution is needed in extrapolation. However, it does appear that non-traumatic soft tissue injuries are approximately twice as common in the back as in the upper limb.

3.4.2.4 Data tables

Table 57. Claims data for "All Injury Types" by construction sector risk class, 2002–2010, sorted by CIR

WIC	Construction sector risk class	FTE	No. of claims	CIR [*]	Median cost	Median days TL	Severity TL [†]	Severity cost
0540	Wallboard Installation – Discounted Rate	9 614	1 506	15.665	$15 606	125	5 466.1	$1 240 581
0507	Roofing Work – Construction and Repair	23 645	3 193	13.504	$10 579	82	3 589.4	$834 032
0510	Wood Frame Building Construction	98 996	9 181	9.274	$8 799	54	2 221.1	$471 040
0302	Masonry Construction	13 835	1 251	9.042	$12 070	82	2 704.7	$682 293
0511	Glass Installation: Buildings	12 686	1 035	8.158	$10 178	48	1 687.2	$395 350
0504	Painting: Building and Structures – Exterior Work	22 910	1 689	7.372	$12 231	88	2 354.6	$520 706
0516	Carpentry, N.O.C.	51 082	3 558	6.965	$12 006	76	1 986.0	$447 551
0512	Insulation Installation and Asbestos Abatement Work	12 668	867	6.844	$9 733	67	1 792.4	$438 606
0502	Floor Covering Installation	14 098	958	6.795	$9 505	61	1 839.3	$361 079
0101	Excavation and Grading, N.O.C.	61 182	3 855	6.301	$12 792	81	1 611.9	$448 383
0518	Non Wood Frame Building Construction	53 485	3 300	6.170	$15 742	145	1 631.6	$486 310
0217	Concrete Work – Foundations and Sidewalks	37 577	2 230	5.935	$8 178	57	1 438.8	$312 650
0307	HVAC Systems, Installation, Service and Repair	51 501	2 751	5.342	$8 850	46	1 078.0	$270 746
0306	Plumbing	61 227	3 209	5.241	$11 341	58	1 177.5	$309 452
0301	Landscape Construction and Renovation	38 604	1 907	4.940	$6 241	39	912.1	$181 309

WIC, Washington Industrial risk Classification; FTE, Full Time Equivalent; 1 FTE = 2000 hours; CIR, Claims Incidence Rate; TL, Time Lost in days; Severity TL, Time Lost in days per 200 000 hours; Severity cost, Total $/200 000 hours; N.O.C., Not otherwise classified; HVAC, Heating, ventilation and air-conditioning.

[*] Claims per 200 000 hours worked.

[†] Days lost per 200 000 hours worked.

Data derived from Table 25 of Anderson *et al.* (2013).

Table 58. Claims data for WRMSDs by construction sector risk class, 2002–2010, sorted by CIR

WIC	Construction sector risk class	FTE	No. of claims	% total claims *	CIR †	Median cost	Median days TL	Severity TL ‡	Severity cost
0540	Wallboard Installation – Discounted Rate	9 614	650	43%	6.761	$28 527	211	3 060.4	$657 781
0302	Masonry Construction	13 835	577	46%	4.170	$18 553	147	1 603.5	$380 061
0507	Roofing Work – Construction and Repair	23 645	976	31%	4.128	$13 097	103	1 244.6	$255 552
0511	Glass Installation: Buildings	12 686	450	43%	3.547	$13 105	63	891.9	$205 483
0502	Floor Covering Installation	14 098	495	52%	3.511	$12 152	88	1 092.0	$210 665
0510	Wood Frame Building Construction	98 996	2 710	30%	2.737	$12 547	83	885.7	$169 981
0217	Concrete Work – Foundations and Sidewalks	37 577	921	41%	2.451	$14 711	103	744.7	$158 335
0516	Carpentry, N.O.C.	51 082	1 246	35%	2.439	$15 093	97	856.4	$175 819
0518	Non Wood Frame Building Construction	53 485	1 242	38%	2.322	$24 555	205	813.4	$220 040
0307	HVAC Systems, Installation, Service and Repair	51 501	1 130	41%	2.194	$11 447	62	556.4	$126 603
0306	Plumbing	61 227	1 320	41%	2.156	$15 254	75	613.8	$148 109
0301	Landscape Construction and Renovation	38 604	769	40%	1.992	$8 189	55	485.4	$88 761
0101	Excavation and Grading, N.O.C.	61 182	1 184	31%	1.935	$18 596	116	614.6	$156 851

WIC, Washington Industrial risk Classification; FTE, Full Time Equivalent; 1 FTE = 2000 hours; CIR, Claims Incidence Rate; TL, Time Lost in days; Severity TL, Time Lost in days per 200 000 hours; Severity cost, Total $/200 000 hours; N.O.C., Not otherwise classified; HVAC, Heating, ventilation and air-conditioning.

* WRMSD claims as % of claims for all injury types.

† Claims per 200 000 hours worked.

‡ Days lost per 200 000 hours worked.

Data derived from Table 26 of Anderson *et al.* (2013).

Table 59. Claims data for “Overexertion” by construction sector risk class, 2002–2010, sorted by CIR

WIC	Construction sector risk class	FTE	No. of claims	% claims *	CIR †	Median cost	Median days TL	Severity TL ‡	Severity cost
0540	Wallboard Installation – Discounted Rate	9 614	64	4%	0.666	$8 723	53	120.98	$26 444
0302	Masonry Construction	13 835	83	7%	0.600	$9 082	43	133.92	$36 065
0507	Roofing Work – Construction and Repair	23 645	112	4%	0.474	$6 283	54	84.03	$16 377
0511	Glass Installation: Buildings	12 686	59	6%	0.465	$6 600	42	81.73	$17 856
0510	Wood Frame Building Construction	98 996	417	5%	0.421	$7 243	43	69.63	$14 435
0516	Carpentry, N.O.C.	51 082	171	5%	0.335	$6 869	38	52.38	$11 734
0518	Non Wood Frame Building Construction	53 485	173	5%	0.323	$6 799	54	38.41	$13 627
0217	Concrete Work – Foundations and Sidewalks	37 577	119	5%	0.317	$7 393	44	72.13	$13 843
0301	Landscape Construction and Renovation	38 604	111	6%	0.288	$6 657	39	38.18	$6 463
0306	Plumbing	61 227	173	5%	0.283	$7 990	38	38.02	$7 884
0307	HVAC Systems, Installation, Service and Repair	51 501	139	5%	0.270	$6 531	29	20.76	$6 363
0101	Excavation and Grading, N.O.C.	61 182	154	4%	0.252	$6 562	42	32.96	$7 784
0513	Interior Finish Carpentry	46 912	115	-	0.245	$7 803	35	46.44	$9 573

WIC, Washington Industrial risk Classification; FTE, Full Time Equivalent; 1 FTE = 2000 hours; CIR, Claims Incidence Rate; TL, Time Lost in days; Severity TL, Time Lost in days per 200 000 hours; Severity cost, Total $/200 000 hours; N.O.C., Not otherwise classified; HVAC, Heating, ventilation and air-conditioning.

* Overexertion claims as % of claims for all injury types.

† Claims per 200 000 hours worked.

‡ Days lost per 200 000 hours worked.

Data derived from Table 30 of Anderson *et al.* (2013).

Table 60. Comparison of CIRs for Washington State Fund compensable WRMSD claims by WIC class

WIC/Construction sector risk class	Neck, back & UE NTST *	Back NTST *	UE NTST *	Sciatica *	Rotator cuff syndrome *	Epicondylitis *	CTS *	All Injury Types †	WRMSDs †	Overexertion †
0301 Landscaping	4.24	2.68						4.94	1.99	0.29
0302 Masonry construction						0.28		9.04	4.17	0.60
0306 Plumbing		2.25		0.12	0.24			5.24	2.16	0.28
0307 HVAC systems				0.12				5.34	2.19	0.27
0502 Floor covering installation				0.24				6.80	3.51	
0507 Roofing	8.71	5.71	2.24	0.31	0.50	0.23		13.50	4.13	0.47
0510 Wood frame building construction	4.59	2.97	1.24	0.13	0.26	0.19	0.39	9.27	2.74	0.42
0513 Interior finish carpentry						0.16				0.25
0524 * & 0540 † Wallboard installation-discounted					1.32	0.69		15.67	6.76	0.67
Mean	5.85	3.40	1.74	0.18	0.58	0.31	0.39	8.73	3.46	0.41
Range	4.24-8.71	2.25-5.71	1.24-2.24	0.12-0.31	0.24-1.32	0.16-0.69		4.94-15.67	1.99-6.76	0.25-0.67
Number of values	3	4	2	5	4	5	1	8	8	8
Source	Table 49	Table 50	Table 51	Table 53	Table 54	Table 55	Table 56	Table 57	Table 58	Table 59

CIR, Claims Incidence Rate; WRMSD, Work-related musculoskeletal disorders; WIC, Washington Industrial risk Classification; NTST, Non-traumatic soft tissue disorders; UE, Upper extremity; CTS, Carpal tunnel syndrome; HVAC; Heating, ventilation and air conditioning.

* Data for the period from 1990-1998.

† Data for the period from 2002-2010.

Data derived from Silverstein *et al.* (2002), and Anderson *et al.* (2013).

3.4.3 Compensable WC claims WA SF, 1999–2003, by NAICS construction industry groups

3.4.3.1 Detailed results

Bonauto *et al.* (2006) report data from the Washington State WC system for the five years from 1999–2003 classified by industry grouping (NAICS code) rather than the occupational classification using the WIC used by Silverstein *et al.* (2002) and Anderson *et al.* (2013) discussed in Section 3.4.1 and Section 3.4.2. Again, the study used the Prevention Index, but the CIR is reported in this table as it is an absolute value rather than a ranked value.

They reported data from seven injury groups. The two relevant to this study are neck, back and upper-extremity WRMSDs ('WMSDs') and lower-extremity MSDs ('LE-MSDs'). They identified WRMSD claims using the definition developed by Silverstein *et al.* (2002). They defined LE-MSD claims as either 'overexertion' or 'bodily reaction' codes combined with a lower extremity body part code. They did not separate out the 'overexertion' category reported by Anderson *et al.* (2013) of events with clearly identifiable acute onset (for example fracture, hernia), plus other sprains, strains, or overexertions that were not clearly the result of cumulative/repetitive injury. They only included industry groups with ≥ 25 compensable claims and ≥ 100 FTE per year over the five years of the study.

Table 61 gives data from the five construction industry groups that appear in their list of the top 15 industry groups for all compensable claims during the five years of the study, ranked by decreasing CIR. Between them the five NAICS groups account for over 9% of all claims.

Table 62 gives data from the three construction industry groups within the top 15 industry groups for compensable claims for WRMSDs in the neck, back and upper extremity. These three groups are identical to the top three groups for all claims in Table 61. The WRMSD claims account for 35-38% of the claims within each industry group. Between them they account for 6.33% of the total claims across all 317 NAICS industry groups.

Table 63 gives data from the five construction industry groups within the top 15 industry groups for compensable claims for LE-MSDs. Four of these groups appear in the top groups for all claims in Table 61, but with slight variations in the sequence. The LE-MSD claims account for 7-8% of the claims within each industry group. NAICS 2382 'Building Equipment Contractors' appears in Table 63 but not in Table 61 so it has not been possible to calculate a figure for the % of all claims in that industry group. Between them they account for 11.75% of the total claims across all 317 NAICS industry groups.

3.4.3.2 Summary of results

It can be concluded that the identified industry groups in Washington State had elevated risks for back, neck and upper extremity WRMSDs and LE-MSDs. However, the back, neck and upper-extremity WRMSD are much more prevalent than lower-extremity MSDs. This indicates that the primary focus of WRMSD prevention in construction should be on neck, back and upper limb injuries, rather than lower limb injuries.

3.4.3.3 Data tables

Table 61. Claims data for all compensable claims for construction industry groups, sorted by CIR

4-digit NAICS code	Construction industry group [*]	FTE	No. of claims	CIR [†]	% total claims [‡]	Rate ratio [§]
2381	Foundation, Structure, and Building Exterior Contractors	127 900	9 594	7.501	3.77	1.76
2383	Building Finishing Contractors	72 100	4 438	6.153	1.75	1.44
2361	Residential Building Construction	85 700	5 196	6.065	2.04	1.42
2373	Highway, Street, and Bridge Construction	29 800	1 579	5.307	0.62	1.24
2389	Other Specialty Trade Contractors	45 100	2 278	5.056	0.90	1.18

NAICS, North American Industry Classification System; FTE, Full-Time Equivalent; 1 FTE = 2000 hours; CIR, Claims Incidence Rate.

[*] Of 317 NAICS industry groups, 274 met the study criteria of at least 100 FTE in each year of the study and ≥ 25 claims over the study period.

[†] Claims per 200 000 hours.

[‡] Total claims are across all 317 NAICS industry groups.

[§] Rate divided by mean compensable CIR across all 317 NAICS industry groups.

Data derived from Table 2 of Bonauto *et al.* (2006).

Table 62. Claims data for WRMSDs of the neck, back, and upper extremity, sorted by CIR

4-digit NAICS code	Construction industry group [*]	FTE	No. of claims	% claims in group [†]	CIR [‡]	% total claims [§]	Rate ratio [**]
2381	Foundation, Structure, and Building Exterior Contractors	127 900	3 317	35%	2.594	3.08	1.43
2383	Building Finishing Contractors	72 100	1 702	38%	2.360	1.58	1.30
2361	Residential Building Construction	85 700	1 797	35%	2.098	1.67	1.16

NAICS, North American Industry Classification System; FTE, Full-Time Equivalent; 1 FTE = 2000 hours; CIR, Claims Incidence Rate.

[*] Of 317 NAICS industry groups, 246 met the study criteria of at least 100 FTE in each year of the study and ≥ 25 claims over the study period.

[†] Percentage of claims within the same NAICS group.

[‡] Claims per 200 000 hours.

[§] Percentage of total claims across all 317 NAICS industry groups.

[**] Rate divided by mean compensable CIR across all 317 NAICS industry groups.

Data derived from Table 5 of Bonauto *et al.* (2006).

Table 63. Claims data for lower extremity WRMSDs, 1999–2003, sorted by CIR

4-digit NAICS code	Construction industry group [*]	FTE	No. of claims	% claims in group [†]	CIR [‡]	% total claims [§]	Rate ratio [**]
2383	Building Finishing Contractors	72 100	377	8%	0.523	1.96	1.62
2381	Foundation, Structure, and Building Exterior Contractors	127 900	655	7%	0.512	3.40	1.58
2361	Residential Building Construction	85 700	379	7%	0.442	1.97	1.37
2389	Other Specialty Trade Contractors	45 100	181	8%	0.402	0.94	1.24
2382	Building Equipment Contractors	184 000	670	-	0.364	3.48	1.13

NAICS, North American Industry Classification System; FTE, Full-Time Equivalent; 1 FTE = 2000 hours; CIR, Claims Incidence Rate.

[*] Of 317 NAICS industry groups, 131 met the study criteria of at least 100 FTE in each year of the study and ≥ 25 claims over the study period.

[†] Percentage of claims within the same NAICS group.

[‡] Claims per 200 000 hours.

[§] Percentage of total claims across all 317 NAICS industry groups.

[**] Rate divided by mean compensable CIR across all 317 NAICS industry groups.

Data derived from Table 8 of Bonauto *et al.* (2006).

3.4.4 Compensable WC claims Washington State Fund, 2002–2010, by NAICS industry groups

3.4.4.1 Detailed results

Section 3.4.2 contains WC claims data from Anderson *et al.* (2013) categorised by WIC risk class. This section contains the results of them also categorising their data by industry using NAICS four-digit industry group codes. They used inclusion criteria of at least 45 compensable claims over the 9 years of the study and at least 100 FTE in the group per year.

Table 64 lists claims data for the 10 NAICS construction industry groups that met the inclusion criteria, sorted by CIR. The highest CIR (NAICS 2381 'Foundation, Structure, and Building Exterior Contractors') is almost four times the lowest (NAICS 2372 'Land Subdivision').

Table 65 lists claims data, sorted by CIR, for the 8 NAICS construction industry groups that met the inclusion criteria. The WRMSD claims formed between 33% and 44% of the total claims across the seven injury types. There was a much smaller range in the CIRs than in the total claims (Table 64) due to NAICS 2372 'Land Subdivision not being included'.

Table 66 lists overexertion claims data for the seven NAICS construction industry groups that met the inclusion criteria, sorted by CIR. The overexertion claims formed between 4% and 5% of the total claims across the seven injury types.

3.4.4.2 Summary of results

Comparing the industry groups included in Table 64, Table 65 and Table 66, the two smallest by FTE have been omitted from the WRMSD figures in Table 65 and the three smallest have been omitted from the overexertion figures in Table 66, suggesting that they did not meet the inclusion criteria for those injuries. The only differences in rank order between the figures for all injury types in Table 64 and the figures for WRMSDs in Table 65 is that the second and fourth places for all injuries (2361 'Residential Building Construction' and 2382 'Building Equipment Contractors' respectively) have swapped for WRMSD claims. Comparing overexertion claims (Table 66) with all injury claims (Table 64) shows that the ranks of the top three industry groups (1st: 2381 'Foundation, Structure, and Building Exterior Contractors', 2nd: 2361 'Residential Building Construction', 3rd: 2383 'Building Finishing Contractors') are identical.

3.4.4.3 Data tables

Table 64. WA SF claims data for all injury types by NAICS construction industry group, 2002–2010, sorted by CIR

4-digit NAICS code	Construction industry group	FTE	No. of claims	CIR *	Median cost	Median days TL	Severity TL †
2381	Foundation, Structure, and Building Exterior Contractors	137 685	9 312	6.763	$13 196	68	1 611.6
2361	Residential Building Construction	186 292	9 792	5.256	$11 280	57	1 298.0
2383	Building Finishing Contractors	160 942	8 281	5.145	$13 697	71	1 369.5
2382	Building Equipment Contractors	276 061	12 495	4.526	$17 782	77	1 054.9
2389	Other Specialty Trade Contractors	123 197	5 456	4.429	$13 214	62	1 119.9
2373	Highway, Street, and Bridge Construction	45 004	1 880	4.177	$30 101	108	1 090.7
2371	Utility System Construction	57 242	2 147	3.751	$19 443	78	960.2
2379	Other Heavy and Civil Engineering Construction	15 018	543	3.616	$22 695	96	779.1
2362	Nonresidential Building Construction	108 886	3 580	3.288	$25 025	94	727.5
2372	Land Subdivision	12 860	223	1.734	$6 282	32	369.9

There were 10 industries in the Construction Sector that met the claim count and FTE inclusion criteria (≥45 compensable WC claims over the period of the study and ≥100 FTE per year).

WA SF, Washington State Fund; NAICS, North American Industry Classification Scheme; FTE, Full Time Equivalent; 1 FTE = 2000 hours; CIR, Claims Incidence Rate; TL, Time Lost in days; Severity TL, Time Lost in days per 200 000 hours.

* Claims per 200 000 hours worked.

† Days lost per 200 000 hours worked.

Data derived from Table 19 of Anderson *et al.* (2013).

Table 65. WA SF claims data for WRMSD Injuries by NAICS construction industry group, 2002–2010, sorted by CIR

4-digit NAICS code	Construction industry group	FTE	No. of claims	% claims *	CIR †	Median cost	Median days TL	Severity TL ‡
2381	Foundation, Structure, and Building Exterior Contractors	137 685	3 093	33%	2.246	$20 159	104	679.0
2382	Building Equipment Contractors	276 061	5 449	44%	1.974	$24 382	116	660.2
2383	Building Finishing Contractors	160 942	3 010	36%	1.870	$20 681	102	618.9
2361	Residential Building Construction	186 292	3 259	33%	1.749	$16 380	82	521.5
2389	Other Specialty Trade Contractors	123 197	1 937	36%	1.572	$18 085	97	487.4
2373	Highway, Street, and Bridge Construction	45 004	661	35%	1.469	$32 855	133	479.0
2371	Utility System Construction	57 242	778	36%	1.359	$22 614	97	412.9
2362	Nonresidential Building Construction	108 886	1 381	39%	1.268	$31 997	127	365.3

WA SF, Washington State Fund; NAICS, North American Industry Classification Scheme; FTE, Full Time Equivalent; 1 FTE = 2000 hours; CIR, Claims Incidence Rate; TL, Time Lost in days; Severity TL, Time Lost in days per 200 000 hours.

* WRMSD claims as % of claims for all injury types.

† Claims per 200 000 hours worked.

‡ Days lost per 200 000 hours worked.

Data derived from Table 10 of Anderson *et al.* (2013).

Table 66. WA SF claims data for "Overexertion" Injuries by NAICS construction industry group, 2002–2010, sorted by CIR

4-digit NAICS code	Construction industry group	FTE	No. of claims	% claims *	CIR †	Median cost	Median days TL	Severity TL ‡
2381	Foundation, Structure, and Building Exterior Contractors	137 685	425	5%	0.309	$9 134	46	50.4
2361	Residential Building Construction	186 292	474	5%	0.254	$7 922	42	40.5
2383	Building Finishing Contractors	160 942	379	5%	0.235	$8 453	42	35.6
2389	Other Specialty Trade Contractors	123 197	270	5%	0.219	$9 350	47	35.1
2362	Nonresidential Building Construction	108 886	190	5%	0.174	$7 983	32	16.1
2382	Building Equipment Contractors	276 061	472	4%	0.171	$8 428	34	22.3
2371	Utility System Construction	57 242	97	5%	0.169	$8 590	42	34.8

WA SF, Washington State Fund; NAICS, North American Industry Classification Scheme; FTE, Full Time Equivalent; 1 FTE = 2000 hours; CIR, Claims Incidence Rate; TL, Time Lost in days; Severity TL, Time Lost in days per 200 000 hours.

* Overexertion claims as % of claims for all injury types.

† Claims per 200 000 hours worked.

‡ Days lost per 200 000 hours worked.

Data derived from Table 14 of Anderson *et al.* (2013).

3.4.5 Construction occupations at high risk for WRMSDs in Washington State, 2003–2007, by NAICS industry groups

Table 67 contains data from the Washington State WC system for the period from 2003–2007 classified by industry grouping (NAICS code) (Schoonover *et al.*, 2010) These data therefore form a subset of the data for the 2002–2010 period in Section 3.4.4 reported by Anderson *et al.* (2013). The focus of the data reported by Schoonover *et al.* (2010) is on the severity of the compensation claim, as measured by the duration of time lost from work, whereas Anderson *et al.* (2013) report more broadly and in more detail.

Data from two tables in Schoonover *et al.* (2010) have been combined in Table 67 by extracting neck, back and upper limb WRMSD claims data and lower limb WRMSD claims data. They had an inclusion criterion of at least 1000 compensable claims over the five-year period analysed. While the severity (days lost) is reported for the WRMSD categories, they only report the CIR for 'all claims'.

As can be seen from Table 67, days lost rates varied significantly across the 10 industry groups analysed. The worst for neck, back and upper limb WRMSDs was 2381 'Foundation, Structure, and Building Exterior Contractors', and the worst for lower limb WRMSDs was 2383 'Building Finishing Contractors'.

Schoonover *et al.* (2010) note that neck, back and upper limb claims had the highest percentage of injury costs for all industry groups and lower limb claims had the lowest in all but one industry group. Lower limb claims comprised at most 21% of the neck, back and upper limb claims – for 2382 'Building Equipment Contractors'. This indicates that the primary focus of WRMSD prevention in construction should be on neck, back and upper limb injuries, and not on lower limb injuries.

Table 67. Compensable claims for ten NAICS construction industry groups, WA WC, 2003–2007, sorted by CIR

NAICS code	Construction industry group	All claims	CIR* for all claims	All claims severity†	Neck, back & UL WRMSD‡ severity†	LL WRMSD‡ severity†
2381	Foundation, Structure, and Building Exterior Contractors	9 008	6.71	1 255.9	463.7	55.6
2361	Residential Building Construction	5 226	5.34	925.3	329.1	51.5
2383	Building Finishing Contractors	4 342	5.22	1 144.1	436.1	61.8
2373	Highway, Street, and Bridge Construction	1 096	4.44	923.4	372.6	52.2
2389	Other Specialty Trade Contractors	2 528	4.32	792.1	303.7	44.4
2362	Nonresidential Building Construction	1 901	3.61	517.6	228.7	17.4
2379	Other Heavy and Civil Engineering Construction	525	3.43	584.9	231.4	§
2382	Building Equipment Contractors	5 937	3.27	476.8	193.2	40.0
2371	Utility System Construction	1 371	3.23	609.1	237.2	26.2
2372	Land Subdivision	156	1.73	331.9	156.7	§

NAICS, North American Industry Classification System; WA WC, Washington State Workers' Compensation; CIR, Claims Incidence Rate; UL, Upper limb; WRMSD, Work-related musculoskeletal disorder; LL, Lower limb; FTE, Full-Time Equivalent.

* Compensable claims per 200 000 hours worked; 2000 hours = 1 FTE.

† Time loss days per 200 000 hours worked.

‡ Non traumatic WRMSDs.

§ Did not meet the study inclusion criteria of ≥25 compensable workers' compensation claims and ≥100 FTE per year during the study period.

Data derived from Table 1 and Table 2 of Schoonover *et al.* (2010).

3.4.6 Washington State WC claims for knee WRMSDs, 1999–2007.

3.4.6.1 Detailed results

Spector *et al.* (2011) examined Washington State WC data to identify industries and occupations at highest risk for knee WRMSDs. They also assessed trends in incidence rates of knee WRMSDs over the period from 1999 to 2007. Their case definition was of non-traumatic soft tissue knee disorders caused or aggravated by work activities, such as frequent or heavy manual handling, awkward postures, or forceful or repetitive exertions. Claims had to have a knee body part code as well as an ICD-9 code relevant to knee disorders (for example, occupational bursitis).

Industry groups were only included in the analysis if they had an average of at least 50 FTE per year across the nine-year period studied.

Table 68 lists data for the five construction industry groups they identified as highest risk for all knee WRMSD claims that were accepted for WC payments. This included WC claims just for medical costs and claims for both medical costs and for wages lost due to over-3-day absences from work. Table 69 lists data for the subset of knee WRMSD claims that resulted in payment of WC for wages lost due to over-3-day absences. As can be seen from Table 69, the over-3-day claims were between 53% and 56% of the total in each industry group.

The first four industry groups in these tables are identical, with the fifth group, 2362 ‘Nonresidential building construction’, in Table 68 being replaced by 2389 ‘Other specialty trade contractors’ in Table 69.

Table 70 lists data for the four construction industry groups that were highest risk for cumulative trauma knee WRMSD claims that were accepted for WC payments. These groups are identical to the first four groups in both Table 68 and Table 69.

The cumulative trauma knee WRMSD claims in Table 70 are a subset of the knee WRMSD claims in Table 68. They ranged between 14% and 21% of the total claims within the four industry groups listed.

Table 71 lists data for the subset of cumulative trauma knee WRMSD claims (those in Table 70) that resulted in payment of WC for wages lost due to over-3-day absences. They ranged from 31% to 37% of the total cumulative trauma knee WRMSD claims (claims for just medical costs plus claims for both medical costs and lost wages).

3.4.6.2 Summary of results

The rankings of industry groups are identical across the first four rows of Table 68 and Table 69, and all rows of Table 70 and Table 71. This indicates consistency of risk ranking when the compensable claims were extracted and when the cumulative trauma claims were extracted. In other words, prioritising risk reduction in these groups will target the subgroups equally.

3.4.6.3 Data tables

Table 68. Construction industries in the top 10 for knee WRMSDs by PI, accepted WA SF claims, 1999–2007.

4-digit NAICS code	Construction industry group	Hours	Count	Lost days	CIR *	Rate ratio †	Severity rate *
2383	Building finishing contractors	258 391 446	782	101 830	0.605	2.85	78.8
2381	Foundation, structure, and building exterior contractors	448 080 678	1 315	159 243	0.587	2.76	71.1
2382	Building equipment contractors	624 936 450	1 718	395 722	0.550	2.58	126.6
2361	Residential building construction	323 788 612	822	96 646	0.508	2.39	59.7
2362	Nonresidential building construction	165 059 747	379	52 094	0.459	2.16	63.1

WRMSD, Work-related musculoskeletal disorder; PI, Prevention Index; WA SF, Washington State Fund; NAICS, North American Industrial Classification System; CIR, Claims Incidence Rate; FTE. Full-time equivalent; 2000 hours = 1 FTE.

* Incidence rates and severity rates (lost days) are per 200 000 hours worked.

† Rate ratios are calculated using the industry-wide rate.

Data derived from Table 2A of Spector *et al.* (2011).

Table 69. Construction industries in the top 10 for knee WRMSDs by PI, compensable WA SF claims, 1999–2007.

4-digit NAICS code	Construction industry group	Hours	Count	% of accepted claims *	Lost days	CIR †	Rate ratio ‡	Severity rate †
2383	Building finishing contractors	258 391 446	434	55%	101 826	0.340	3.52	78.8
2381	Foundation, structure, and building exterior contractors	448 080 678	712	54%	159 234	0.320	3.33	71.1
2382	Building equipment contractors	624 936 450	904	53%	395 711	0.290	3.03	126.6
2361	Residential building construction	323 788 612	461	56%	96 581	0.280	2.98	59.7
2389	Other specialty trade contractors	167 571 108	214	-	36 809	0.260	2.67	43.9

WRMSD, Work-related musculoskeletal disorder; PI, Prevention Index; WA SF, Washington State Fund; NAICS, North American Industrial Classification System; CIR, Claims Incidence Rate; FTE. Full-time equivalent; 2000 hours = 1 FTE.

* Compensable claims (over 3-day absence) as % of accepted claims (compensable claims + medical costs only claims).

† Incidence rates and severity rates (lost days) are per 200 000 hours worked.

‡ Rate ratios are calculated using the industry-wide rate.

Data derived from Table 2B of Spector *et al.* (2011).

Table 70. Construction industries in the top 10 for cumulative trauma knee WRMSDs by PI, accepted WA SF claims, 1999-2007.

4-digit NAICS code	Construction industry group	Hours	Count	% of all accepted claims *	Lost days	CIR †	Rate ratio ‡	Severity rate †
2383	Building finishing contractors	258 391 446	161	21%	4 387	0.125	7.89	3.4
2381	Foundation, structure, and building exterior contractors	448 080 678	207	16%	7 041	0.092	5.85	3.1
2382	Building equipment contractors	624 936 450	256	15%	5 067	0.082	5.19	1.6
2361	Residential building construction	323 788 612	113	14%	1 343	0.070	4.42	0.8

WRMSD, Work-related musculoskeletal disorder; PI, Prevention Index; WA SF, Washington State Fund; NAICS, North American Industrial Classification System; CIR, Claims Incidence Rate.

* Accepted cumulative trauma knee WRMSD claims as % of all accepted knee WRMSD claims.

† Incidence rates and severity rates (lost days) are per 200 000 hours worked; 2000 hours = 1 FTE.

‡ Rate ratios are calculated using the industry-wide rate.

Data derived from Table 2C of Spector *et al.* (2011).

Table 71. Construction industries in the top 10 for cumulative trauma knee WRMSDs by PI, compensable WA SF claims, 1999–2007.

4-digit NAICS code	Construction industry group	Hours	Count	% of accepted claims *	Lost days	CIR †	Rate ratio ‡	Severity rate †
2383	Building finishing contractors	258 391 446	60	37%	4 387	0.046	9.47	3.4
2381	Foundation, structure, and building exterior contractors	448 080 678	69	33%	7 041	0.031	6.28	3.1
2382	Building equipment contractors	624 936 450	80	31%	5 057	0.026	5.22	1.6
2361	Residential building construction	323 788 612	40	35%	1 343	0.025	5.04	0.8

WRMSD, Work-related musculoskeletal disorder; PI, Prevention Index; WA SF, Washington State Fund; NAICS, North American Industrial Classification System; CIR, Claims Incidence Rate.

* Compensable claims (over 3-day absence) as % of accepted claims (compensable claims + medical costs only claims).

† Incidence rates and severity rates (lost days) are per 200 000 hours worked; 2000 hours = 1 FTE.

‡ Rate ratios are calculated using the industry-wide rate.

Data derived from Table 2D of Spector *et al.* (2011).

3.4.7 WC claim rates for union carpenters, Washington State, 1989–1992

3.4.7.1 Introduction

A series of papers analysed WC data from carpenters in Washington State that were members of 'The United Brotherhood of Carpenters and Joiners of America' (UBC). The first paper (Lipscomb *et al.*, 1997) reported data from 1989–1992. Subsequent papers (Lipscomb *et al.*, 2008a, b) extended the analysis to the period from 1989–2003 (see Section 3.4.8). A third round of analysis (Lipscomb *et al.*, 2015) examined data from 1989–2008 (see Section 3.4.9).

The category of 'carpenter' in the USA encompasses a much broader range of craft skills than in the UK where it usually means a worker in wood. The UBC website Our Crafts • (carpenters.org) currently lists 'Carpenters (General)', ' Floor Coverers', 'Interior Systems Carpenters', 'Lathers', 'Millworkers & Cabinetmakers', 'Millwrights', 'Piledrivers' and 'Residential & Framing Carpenters' as the crafts they represent. (See the Glossary for their definitions.) The union is organised in 'Locals', which are geographically defined and often focus on representing workers from a single craft. It is therefore possible to group many of the Locals by the 'predominant type of work' carried out by the members.

Lipscomb *et al.* (1997) reported accepted WC claims from carpenters that were members of the UBC for at least three months from 1989 to 1992. The 16 musculoskeletal conditions they analysed were largely sprains but also included contusions, fractures, nerve conditions of the wrist/forearm and ill-defined back conditions. They classified claims by three body regions – the axial skeleton, ie the neck and trunk, the upper limb and the lower limb. They restricted their analysis to ANSI injury codes that had at least 50 claims over the four-year period. They carried out a separate analysis of lost-time claims, ie claims that resulted in payment for lost time from work, which happens after three days of absence. They categorised claims by the predominant types of carpentry work carried out by members of each Local and reported crude claims incidence rates and ratios of the rate within a predominant type of work compared to the mean rate.

Their eight categories of carpentry work (for example in Table 73) included 'light commercial' and 'heavy commercial'. Light commercial work involved construction on projects of up to three stories; heavy commercial work involved high-rise buildings and interstate and freeway work. The 'mixed types of work' category included Locals that did not have a predominant type of work.

Their cohort consisted of 10 935 active union carpenters who had worked at least three months of union hours during the four years from 1989 to 1992. The total union time worked by the cohort in this period was almost 39 million hours.

3.4.7.2 Detailed results

Data for eleven of the 16 different types of musculoskeletal conditions reported by Lipscomb *et al.* (1997) are given in Table 72. Five types of contusions and fractures have been omitted as these are likely to be caused by impacts. For the remaining 'non-traumatic' injuries, the numbers of claims, claim rate and percentages of the claims with paid lost time are included for each type of injury, along with totals across the whole body, and the three body regions. Also, to permit comparison with other data sets, values have been calculated for the back and for the combination of the upper extremity and neck. Claims for problems affecting both the neck and the back are therefore counted in each of these last two categories.

The figures show that 64% of claims related to the axial skeleton (the back and neck), 21% related to the upper extremity, excluding the neck, and 15% related to the lower extremity. This means that axial skeleton claims were three times more frequent than upper extremity claims and over four times more frequent than lower extremity claims. The comparison of back and upper limb + neck claims showed that 59% of claims related to the back and 36% related to the upper extremity and neck, meaning that back claims were 1.6 times more frequent than upper limb + neck claims. Claims relating to the neck were 16% of the total.

The data reported for the eight 'predominant types of work' showed that of the 16 injury types, only three (back sprain strain, back and neck sprain/strain and knee sprain/strain) had rates in excess of one claim per 200 000 hours worked. For each of these three disorders, Table 73 gives the numbers of claims, and the crude CIRs for each type of work. The Rate Ratios given have been calculated using the average across all types of work as the denominator. The table is sorted by the Rate Ratio for back sprain claims, so the rankings for the other two types of claim are slightly different.

It should be noted that the total number of workers and total hours worked are slightly smaller than the figures for the whole study, suggesting that some claims could not be assigned to specific Locals. It should also be noted that the numbers of workers and claims within the Millwright and Cabinet/fixture types of work are particularly low.

Table 74 reports the numbers of claims, the crude CIRs and the Rate Ratios after grouping the claims as affecting either the axial skeleton, the upper extremity or the lower extremity. It also reports these figures for all WRMSD claims. As in Table 73, they are sorted by the back sprain claim rates, resulting in slight changes in ranking between the different body parts. It is notable that the 'drywall' and 'residential' types of work have the two highest claim rates for the axial skeleton and the upper extremity. However, 'millwrights' have the second highest claim rate for lower extremity claims.

Using Poisson regression, Lipscomb *et al.* (1997) found statistically significant differences between types of work for back sprains (Table 75), back and neck sprains (Table 76), forearm sprains.(Table 77), and ankle sprains (Table 78).

Table 75 shows that drywall and light commercial work were associated with increased risk of successful claims for back sprains, but that piledriving work was associated with a reduced risk of making such a claim.

Table 76 shows that drywall work was associated with an increased risk of making a successful claim for a sprain involving both the back and neck. Piledriving was associated with a reduced risk of making such a claim. The number of workers predominantly involved in cabinet/fixture work (n = 72) and hence the number of claims were so low that a rate ratio could not be calculated for them.

Table 77 shows that the 'mixed' type of work was the only type of work associated with increased risk of successful claims for sprains of the forearm when compared to the mean.

Table 78 shows that drywall work was the only type of work associated with increased risk of successful claims for ankle sprains when compared to the mean.

The study also looked at the differences in claim rates between types of work when considering only the 38% of claims (N = 1162) that resulted in paid lost time from work. Only the seven injury types with more than 40 events were examined, using Poisson regression and only back sprain showed a difference between types of work. Drywall work was 1.8 times more likely than the mean to be associated with paid lost time claims for back sprain (Table 79).

3.4.7.3 Summary of findings

Excluding claims for contusions and fractures, claims related to the axial skeleton (ie the spinal column of the back and neck) accounted for 64% of total claims, with the upper extremity/upper limb accounting for 21% and the lower extremity/limb accounting for the remaining 15%. Claims related to the back accounted for 59% of claims, with 36% related to the upper extremity and neck.

Claims rates were highest from union Locals that predominantly did drywall work. They were followed by 'residential' carpenters and 'light commercial' carpenters. Piledrivers were clearly at reduced risk compared to the other types of work.

There were differences in claim rates in different types of carpentry work and different body parts.

3.4.7.4 Data tables

Table 72. Claims for musculoskeletal disorders among union carpenters in Washington State, 1989–1992

Body part/injury nature	Claims filed	Claims rate *	% with paid lost time	% of filed claims
Axial skeleton (back + neck)				
Back sprain/strain	1118	5.70	40.7%	36.7%
Back ill-defined symptoms	77	0.39	62.5%	2.5%
Neck sprain/strain	115	0.59	34.8%	3.8%
Back and neck sprain/strain	270	1.40	33.7%	8.9%
Upper extremity (shoulder to fingers)				
Shoulder sprain/strain	144	0.73	47.9%	4.7%
Elbow sprain/strain	92	0.47	31.5%	3.0%
Wrist/forearm sprain/strain	134	0.69	30.6%	4.4%
Hand/finger sprain/strain	66	0.34	27.3%	2.2%
Nerve condition of the wrist/forearm	78	0.40	69.2%	2.6%
Lower extremity (hip to toes)				
Knee sprain/strain	211	1.10	47.4%	6.9%
Ankle/lower leg sprain/strain	168	0.86	29.6%	5.5%
Totals				
MSD claims across all body parts	2473	12.67	41.4%	100.0%
Axial skeleton MSD claims	1580	8.08	42.1%	63.9%
Upper extremity MSD claims	514	2.63	41.1%	20.8%
Lower extremity MSD claims	379	1.96	39.1%	15.3%
Neck MSD claims	385	1.99	34.0%	15.6%
Back MSD claims	1465	7.49	42.7%	59.2%
Upper extremity and neck MSD claims	899	4.62	38.0%	36.4%

* Rate per 200 000 hours worked as a union carpenter

Data derived from Table I of Lipscomb *et al.* (1997).

Table 73. WC claim rates and rate ratios for the three most common musculoskeletal injury types by predominant type of work: Union carpenters, Washington State, 1989–1992

			Back sprain claims			Back/neck sprain claims			Knee sprain claims		
Predominant type of work	**No. of workers**	**Hours worked**	**No. of claims**	**Crude CIR ***	**RR †**	**No. of claims**	**Crude CIR ***	**RR †**	**No. of claims**	**Crude CIR ***	**RR †**
Drywall	1 525	5 695 264	245	8.60	1.52	71	2.50	1.85	37	1.30	1.22
Residential	282	516 021	22	8.50	1.51	3	1.20	0.89	0	—	—
Light commercial	2 831	10 131 169	299	5.90	1.05	66	1.30	0.96	61	1.20	1.13
Heavy commercial	3 922	15 045 437	391	5.20	0.92	83	1.10	0.82	75	1.00	0.94
Mixed types of work	960	3 496 215	75	4.30	0.76	25	1.40	1.04	17	0.97	0.91
Millwright	190	682 210	12	3.50	0.62	6	1.80	1.33	2	0.59	0.55
Piledriver	602	2 613 130	39	3.00	0.53	6	0.46	0.34	13	1.00	0.94
Cabinet/fixture	72	282 295	2	1.40	0.25	0	—	—	0	—	—
All types of work	10 384	38 461 741	1 085	5.64	—	260	1.35	—	205	1.07	—

WC; Workers' Compensation; CIR, Claims Incidence Rate; RR, Rate Ratio.

* Rate per 200 000 hours worked.

† Relative to the mean of all eight types of work.

Data derived from Table IV of Lipscomb *et al.* (1997).

Table 74. WC claim rates and rate ratios for musculoskeletal injuries in three body regions by predominant type of work: Union carpenters, Washington State, 1989–1992

			Axial skeleton claims			Upper extremity claims			Lower extremity claims			Claims for all WRMSDs		
Predominant type of work	**No. of workers**	**Hours worked**	**No. of claims**	**Crude CIR ***	**RR †**	**No. of claims**	**Crude CIR ***	**RR †**	**No. of claims**	**Crude CIR ***	**RR †**	**No. of claims**	**Crude CIR ***	**RR †**
Drywall	1 525	5 695 264	363	12.75	1.64	149	5.23	1.30	122	4.28	1.35	634	22.26	1.49
Residential	282	516 021	31	11.97	1.54	18	6.93	1.72	9	3.44	1.09	58	22.34	1.49
Light commercial	2 831	10 131 169	386	7.61	0.98	182	3.59	0.89	160	3.15	1.00	727	14.35	0.96
Heavy commercial	3 922	15 045 437	531	7.06	0.91	302	4.01	1.00	237	3.15	1.00	1 070	14.22	0.95
Mixed types of work	960	3 496 215	113	6.44	0.83	74	4.23	1.05	41	2.34	0.74	227	13.01	0.87
Millwright	190	682 210	20	5.89	0.76	11	3.25	0.81	12	3.56	1.13	43	12.70	0.85
Piledriver	602	2 613 130	53	4.07	0.52	34	2.58	0.64	28	2.15	0.68	115	8.80	0.59
Cabinet/fixture	72	282 295	3	2.11	0.27	4	2.82	0.70	0	—	—	7	4.93	0.33
All types of work	10 384	38 461 741	1 500	7.80	—	773	4.02	—	608	3.16	—	2 881	14.98	—

CIR, Claims Incidence Rate; RR, Rate Ratio.

* Rate per 200 000 hours worked.

† Relative to the mean of all eight types of work.

Data derived from Table IV of Lipscomb *et al.* (1997).

Table 75. Nonrejected back sprain claims (n = 1 118) filed by union carpenters, Washington State, 1989–1992

Predominant type of work	Rate ratio *	95% CI	Sig. *
Drywall	1.8	1.4–2.3	P < 0.05
Residential	1.5	0.92–2.3	NS
Light commercial	1.4	1.1–1.7	P < 0.05
Heavy commercial	1.2	0.95–1.5	NS
Mixed types of work	0.95	0.73–1.2	NS
Millwright	0.88	0.52–1.5	NS
Piledriver	0.72	0.51–1.0	P < 0.05
Cabinet/fixture	0.38	0.11–1.3	NS

CI, Confidence Interval, Sig., statistical significance; P, Probability that the test result is due to chance; NS, Not statistically significant.

* Relative to overall mean.

Data derived from Table V of Lipscomb *et al.* (1997).

Table 76. Nonrejected back and neck sprain claims (n = 270) filed by union carpenters, Washington State, 1989–1992

Predominant type of work	Rate ratio *	95% CI	Sig. *
Drywall	1.8	1.3–2.5	P < 0.05
Millwright	1.6	0.79–3.4	NS
Light commercial	1.2	0.84–1.6	NS
Mixed types of work	1.0	0.93–1.4	NS
Heavy commercial	0.83	0.61–1.1	NS
Residential	0.8	0.3–2.2	NS
Piledriver	0.43	0.21–0.89	P < 0.05
Cabinet/fixture	—	—	—

CI, Confidence Interval, Sig., statistical significance; P, Probability that the test result is due to chance; NS, Not statistically significant.

* Relative to overall mean.

Data derived from Table V of Lipscomb *et al.* (1997).

Table 77. Nonrejected forearm sprain claims (n = 134) filed by union carpenters, Washington State, 1989–1992

Predominant type of work	Rate ratio	95% CI	Sig. *
Millwright	2.0	0.72-5.7	NS
Light commercial	1.5	0.95-2.5	NS
Mixed types of work	1.4	1.2-1.7	$P < 0.05$
Drywall	1.2	0.67-2.0	NS
Heavy commercial	1.1	0.7-1.8	NS
Residential	0.57	0.1-1.6	NS
Piledriver	0.31	0.09-1.1	NS
Cabinet/fixture	—	——	—

CI, Confidence Interval, Sig., statistical significance; P, Probability that the test result is due to chance; NS, Not statistically significant.

* Relative to overall mean.

Data derived from Table VI of Lipscomb *et al.* (1997).

Table 78. Nonrejected ankle sprain claims (n = 168) filed by union carpenters, Washington State, 1989–1992

Predominant type of work	Rate ratio *	95% CI	Sig. *
Drywall	1.6	1.0-2.4	$P \leq 0.05$
Heavy commercial	1.2	0.85-1.8	NS
Light commercial	1.1	0.7-1.6	NS
Mixed types of work	0.96	0.81-1.2	NS
Residential	0.93	0.28-3.2	NS
Millwright	0.92	0.27-3.1	NS
Piledriver	0.57	0.26-1.3	NS
Cabinet/fixture	—	——	,,,,

CI, Confidence Interval, Sig., statistical significance; P, Probability that the test result is due to chance; NS, Not statistically significant.

* Relative to overall mean.

Data derived from Table VII of Lipscomb *et al.* (1997).

Table 79. Back sprain claims that resulted in paid lost time (n = 456) filed by union carpenters, Washington State, 1989–1992

Predominant type of work	Rate ratio *	95% CI	Sig. *
Drywall	1.8	1.2–2.5	$P < 0.05$
Light commercial	1.4	0.98–1.9	NS
Heavy commercial	1.3	0.91–1.8	NS
Millwright	1.2	0.54–2.5	NS
Mixed types of work	1.2	0.78–1.8	NS
Residential	0.98	0.43–2.2	NS
Piledriver	0.66	0.37–1.1	NS
Cabinet/fixture	0.51	0.09–2.9	NS

CI, Confidence Interval; Sig., statistical significance; P, Probability that the test result is due to chance; NS, Not statistically significant.

* Relative to overall mean.

Data derived from Table VIII of Lipscomb *et al.* (1997).

3.4.8 WC back injury claim rates for union carpenters, Washington State, 1989–2003

3.4.8.1 Introduction

Lipscomb *et al.* (1997) reported WC data for 16 types of musculoskeletal disorder from the four-year period from 1989–1992. Two subsequent papers (Lipscomb *et al.*, 2008a, b) had a narrower focus on WC data for back injuries in the same cohort, extended to the 15-year period from 1989–2003. Lipscomb *et al.* (2008a) examined differences between claims that did not result in paid lost time and claims resulting in paid list time. They also compared claims due to overexertion injuries to claims due to traumatic injuries. Lipscomb *et al.* (2008b) compared initial claims for injury ('incident' injuries in their terminology) and claims for subsequent ('recurrent') injuries suffered by the same individual.

Another difference between the first and the subsequent papers was that the predominant types of work categories were not identical – Lipscomb *et al.* (2008a, 2008b) did not use the 'Cabinet/fixture' category used by Lipscomb *et al.* (1997) (for example, in Table 79). They were unable to identify the type of work of carpenters affiliated with a Local outside the State of Washington so classified those results as 'Out of Washington' (Lipscomb *et al.*, 2008a) (for example, in Table 80), or 'Non-Washington' (Lipscomb *et al.*, 2008b). For consistency, the 'Out of Washington' terminology is used in this report for data from both papers.

The cohort for the later studies consisted of 18 768 carpenters (17 879, 97.4%, were male) who worked as union carpenters for at least three months in Washington State between 1989 and 2003. The number recorded in each year increased from 6190 in 1989 to 9961 in 2000 and then decreased to 8856 in 2003. The mean time observed was 45 months (median 23 months) The total hours worked over the 15 years were 134 199 143, with a total of 4138 injuries over that period.

3.4.8.2 Detailed results

Lipscomb *et al.* (2008a) reported that the annual injury rate ranged from 9.2 per 200 000 hours in 1990 and 1991 to 3.7 per 200 000 hours in 2002, showing a clear downward trend over time. Of the 4 138 injuries recorded, 2 457 (59.4%) did not result in paid lost time, with the remaining 1 681 (40.6%) resulting in paid lost time. Of the total, 3 042 (73.5%) were overexertion injuries and 1 095 (26.5%) were traumatic injuries.

Table 80 presents data split by predominant type of work for the back injury claims that did not result in paid lost time over the 15-year period. They are ranked by claim rate, as expressed in the adjusted Rate Ratio (aRR). This takes account (adjusts for) the effects of both age and time in the union on the claim rate – the claim rates decreased with both increasing age and increasing time in the union. The crude and adjusted Rate Ratios were calculated using the heavy commercial type of work as the reference category.

Table 80 shows that the drywall, residential and light commercial types of work had significantly increased claim rates compared to the heavy commercial reference category. Also, the piledriver type of work had a significantly lower claim rate.

Table 81 presents data for the 40.6% of back injury claims that resulted in paid lost time, again split by predominant type of work. The adjusted Rate Ratios also show that the drywall and residential types of work had significantly higher claim rates than the heavy commercial category and the piledriver type of work had a significantly lower claim rate.

Table 82 and Table 83 show results from the analysis of the 4 138 claims as either overexertion injuries or traumatic injuries. For the overexertion injuries (Table 82), drywall, residential and light commercial work had significantly higher injury rates than heavy commercial work; piledrivers were at significantly less risk. These results are very similar to the results for non-paid and paid lost time injuries in Table 80 and Table 81.

Table 83 shows a slightly different pattern for traumatic back injuries, with the residential, millwright and drywall categories being the most at risk. Again, piledrivers were at significantly less risk than the heavy commercial reference group. The mixed commercial category also had significantly lower risk than the reference group.

Table 84 and Table 85 contain data from Lipscomb *et al.* (2008b) for initial and subsequent back injury claims respectively. As with Table 80 to Table 83, the reference group was the heavy commercial category. There were 3 037 individuals who filed initial claims and 751 (24.7%) subsequently filed another claim. The maximum number of claims submitted by one individual was seven.

Table 84 shows the same pattern of results as the previous analyses, with the residential, light commercial and drywall types of work being at increased risk and piledrivers being at reduced risk of making an initial claim for a back injury.

Table 85 shows that only the drywall workers were at increased risk of making a claim for a recurrent back injury. The piledrivers were at reduced risk of making such a claim.

3.4.8.3 Summary of findings

Overall, the analyses in these two papers can be interpreted as indicating enhanced risk in workers performing drywall, residential and light commercial carpentry work when compared to other carpenters. This is largely consistent across considerations of severity (paid lost time vs no paid lost time), nature (overexertion vs traumatic injuries) and recurrence (initial vs recurrent injury). Piledrivers were consistently at lower risk than the other categories of carpenter.

3.4.8.4 Data tables

Table 80. Back injury claims without paid lost time made by union carpenters, Washington State 1989–2003 (n = 2 457)

Predominant type of work	Hours at risk	Injuries	Crude rate *	Crude RR †	aRR ‡	95% CI	Sig. §
Drywall	24 129 911	646	5.4	1.8	1.5	1.4-1.7	P < 0.05
Residential	1 675 730	47	5.7	1.8	1.5	1.2-2.0	P < 0.05
Light commercial	14 919 760	322	4.3	1.4	1.3	1.1-1.5	P < 0.05
Millwright	2 549 160	50	3.9	1.1	1.2	0.94-1.6	NS
Heavy commercial	20 253 804	339	3.3	1.0	1.0	1.0-1.0	NS
Out of Washington	1 826 138	29	3.2	1.0	0.93	0.65-1.3	NS
Mixed commercial	58 917 900	882	3.0	1.0	0.91	0.81-1.0	NS
Piledriver	8 171 203	81	2.0	0.6	0.62	0.5-0.78	P < 0.05

Crude RR, unadjusted Rate Ratio relative to the 'Heavy commercial' category; aRR, Adjusted Rate Ratio relative to the 'Heavy commercial' category; CI, Confidence Interval; Sig., statistical significance; P, Probability that the test result is due to chance; NS, Not statistically significant.

* Rate per 200 000 hours.

† Calculated using Poisson regression models.

‡ Adjusted for age, gender and time in the union.

§ Comparison with aRR = 1.

Data derived from Table III of Lipscomb *et al.* (2008a).

Table 81. Back injury claims leading to paid lost time made by union carpenters, Washington State 1989–2003 (n = 1 681)

Predominant type of work	Hours at risk	Injuries	Crude rate *	Crude RR †	aRR ‡	95% CI	Sig. §
Drywall	24 129 911	463	3.8	1.7	1.7	1.4-2.0	P < 0.05
Residential	1 675 730	38	4.6	2.0	1.7	1.2-2.4	P < 0.05
Out of Washington	1 826 138	27	3.0	1.3	1.3	0.85-1.9	NS
Millwright	2 549 160	32	2.5	1.1	1.1	0.77-1.6	NS
Light commercial	14 919 760	195	2.6	1.1	1.1	0.95-1.4	NS
Heavy commercial	20 253 804	232	2.3	1.0	1.0	1.0-1.0	NS
Mixed commercial	58 917 900	594	2.0	0.88	0.89	0.77-1.0	NS
Piledriver	8 171 203	36	0.9	0.38	0.40	0.28-0.56	P < 0.05

Crude RR, unadjusted Rate Ratio relative to the 'Heavy commercial' category; aRR, Adjusted Rate Ratio relative to the 'Heavy commercial' category; CI, Confidence Interval; Sig., statistical significance.

* Rate per 200 000 hours.

† Calculated using Poisson regression models.

‡ Adjusted for age, gender and time in the union.

§ Comparison with aRR = 1.

Data derived from Table III of Lipscomb *et al.* (2008a).

Table 82. Overexertion back injury claims made by union carpenters, Washington State 1989–2003 (n = 3 042)

Predominant type of work	Hours at risk	Injuries	Crude rate *	Crude RR †	aRR ‡	95% CI	Sig. §
Drywall	24 129 911	837	6.9	1.7	1.7	1.5-1.9	$P < 0.05$
Residential	1 675 730	59	7.1	1.8	1.6	1.2-2.0	$P < 0.05$
Light commercial	14 919 760	374	5.0	1.3	1.3	1.1-1.5	$P < 0.05$
Millwright	2 549 160	50	3.9	1.0	1.0	0.78-1.4	NS
Out of Washington	1 826 138	38	4.2	1.0	1.0	0.74-1.4	NS
Heavy commercial	20 253 804	407	4.0	1.0	1.0	1.0-1.0	NS
Mixed commercial	58 917 900	1 098	3.7	0.9	0.9	0.85-1.1	NS
Piledriver	8 171 203	87	2.1	0.5	0.5	0.45-0.69	$P < 0.05$

Crude RR, unadjusted Rate Ratio relative to the 'Heavy commercial' category; aRR, Adjusted Rate Ratio relative to the 'Heavy commercial' category; CI, Confidence Interval; Sig., statistical significance.

* Rate per 200 000 hours.

† Calculated using Poisson regression models.

‡ Adjusted for age, gender and time in the union.

§ Comparison with aRR = 1.

Data derived from Table IV of Lipscomb *et al.* (2008a).

Table 83. Traumatic back injury claims made by union carpenters, Washington State 1989–2003 (n = 1 095)

Predominant type of work	Hours at risk	Injuries	Crude rate *	Crude RR †	aRR ‡	95% CI	Sig. §
Residential	1 675 730	26	3.1	1.9	1.7	1.2-2.4	$P < 0.05$
Millwright	2 549 160	32	2.5	1.6	1.6	1.1-2.2	$P < 0.05$
Drywall	24 129 911	272	2.3	1.4	1.4	1.2-1.6	$P < 0.05$
Out of Washington	1 826 138	18	2.0	1.2	1.2	0.79-1.8	NS
Light commercial	14 919 760	143	1.9	1.2	1.2	0.98-1.4	NS
Heavy commercial	20 253 804	164	1.6	1.0	1.0	1.0-1.0	NS
Mixed commercial	58 917 900	378	1.3	0.79	0.8	0.69-0.94	$P < 0.05$
Piledriver	8 171 203	30	0.7	0.45	0.4	0.34-0.65	$P < 0.05$

Crude RR, unadjusted Rate Ratio relative to the 'Heavy commercial' category; aRR, Adjusted Rate Ratio relative to the 'Heavy commercial' category; CI, Confidence Interval; Sig., statistical significance.

* Rate per 200 000 hours.

† Calculated using Poisson regression models.

‡ Adjusted for age, gender and time in the union.

§ Comparison with aRR = 1.

Data derived from Table IV of Lipscomb *et al.* (2008a).

Table 84. Claims for initial back injuries made by union carpenters, Washington State 1989–2003 (n = 3 037)

Predominant type of work	Hours at risk	Injuries	Crude rate *	Crude RR †	aRR ‡	95% CI	Sig. §
Residential	1 439 915	69	9.7	2.0	1.7	1.3-2.2	P < 0.05
Drywall	18 584 830	724	7.8	1.6	1.5	1.4-1.7	P < 0.05
Light commercial	12 586 487	413	6.2	1.3	1.3	1.2-1.5	P < 0.05
Millwright	2 091 624	58	5.5	1.2	1.2	0.94-1.6	NS
Out of Washington	1 675 735	51	6.0	1.3	1.2	0.93-1.6	NS
Heavy commercial	17 278 765	390	4.8	1.0	1.0	1.0-1.0	NS
Mixed commercial	50 431 010	1 127	4.5	0.9	0.96	0.86-1.1	NS
Piledriver	7 302 610	99	2.7	0.6	0.6	0.49-0.74	P < 0.05

Crude RR, unadjusted Rate Ratio relative to the 'Heavy commercial' category; aRR, Adjusted Rate Ratio relative to the 'Heavy commercial' category; CI, Confidence Interval; Sig., statistical significance.

* Rate per 200 000 hours worked.

† Calculated using Poisson regression models.

‡ Adjusted for age, gender and time in the union.

§ Comparison with aRR = 1.

Data derived from Table 2 of Lipscomb *et al.* (2008b).

Table 85. Claims for recurrent back injuries made by union carpenters, Washington State 1989–2003 (n = 751)

Predominant type of work	Hours at risk	Injuries	Crude rate *	Crude RR †	aRR ‡	95% CI	Sig. §
Drywall	3 704 563	234	12.6	1.3	1.3	1.1-1.6	P < 0.05
Millwright	336 429	16	9.5	1.0	1.1	0.69-1.7	NS
Residential	189 935	12	12.6	1.3	1.0	0.61-1.7	NS
Light commercial	1 788 993	85	9.5	1.0	1.0	0.8-1.3	NS
Heavy commercial	2 279 369	110	9.7	1.0	1.0	1.0-1.0	NS
Mixed commercial	6 625 257	260	7.9	0.8	0.83	0.69-1.0	NS
Out of Washington	133 426	5	7.5	0.4	0.7	0.33-1.5	NS
Piledriver	756 0599	14	3.7	0.4	0.41	0.26-0.66	P < 0.05

Crude RR, unadjusted Rate Ratio relative to the 'Heavy commercial' category; aRR, Adjusted Rate Ratio relative to the 'Heavy commercial' category; CI, Confidence Interval; Sig., statistical significance; * Rate per 200 000 hours worked.

† Calculated using Poisson regression models.

‡ Adjusted for age, gender, and time in the union.

§ Comparison with aRR = 1.

Data derived from Table 2 of Lipscomb *et al.* (2008b).

3.4.9 WC claims for musculoskeletal disorders and injuries of union carpenters, Washington State, 1989–2008

3.4.9.1 Introduction

The data set reported in the papers by Lipscomb *et al.* (1997), Lipscomb *et al.* (2008a, 2008b) covered WC claims for the years from 1989 to 2003. A later paper by Lipscomb *et al.* (2015) extended the analysis to cover the 20-year period from 1989 to 2008. They used the same overall approach to analyse risk factors for upper extremity and knee MSD and injury claims. Again, they looked separately at all claims and at the subset of claims that resulted in paid lost time.

The increase in time covered increased the cohort used by Lipscomb *et al.* (2015) to 24 830 carpenters (97% of whom were male) who worked 192 371 021 union hours in Washington State between 1989 and 2008. They identified 3 753 upper extremity and 1 342 knee MSDs or injuries (MSDIs) in the WC claim records. The upper extremity claims were 13.6% of all claims and 20.9% of claims involving paid lost time from work (over 3-days absence). The knee claims were 5.0% of all claims and 10.2% of paid lost time claims. Approximately 50% (52.2% UE and 46.3% knee) of claims resulted from overexertion, bodily motion or repetitive use. Struck by/against or caught events accounted for 34.3% of UE claims and 24.3% of knee claims. Falls were associated with 11.8% of UE claims and 27.1% of knee claims. Claim rates declined steadily over the 20 years analysed, with the drop in knee MSDIs being greater than for the UE. Claim rates for struck by or fall events were greater than for overexertion events. They noted that the long-term fall in the burden of MSDIs in this cohort over 20 years was encouraging but acknowledged that it might partly have been due to a shift to seeking care outside the Workers' Compensation system (Schoenfisch *et al.*, 2014).

One difference in the analysis from the earlier papers was that they changed the reference predominant type of work to the light commercial group, whereas previously they had made comparisons with the heavy commercial group. The reason for the change is not stated.

3.4.9.2 Detailed results

Table 86 show the differences between the different predominant types of work on the risk of upper extremity MSDI claims. The drywall carpenters had a significantly higher rate of claims than the light commercial group. The heavy commercial, out of Washington and piledriver carpenters had significantly lower rates.

The data in Table 87 for the subset of paid lost time upper extremity MSD and upper extremity injury claims show that only the drywall category was at elevated risk and only the piledriver category at reduced risk compared to the light commercial category.

Looking at the data for all claims for knee MSDIs (Table 88) shows no statistically significant differences between types of work, except that piledrivers were at reduced risk. In the subset of paid lost time knee claims (Table 89), the only statistically significant difference was that the heavy commercial carpenters were at reduced risk.

3.4.9.3 Summary of results

Table 80 to Table 85 indicate a tendency for the light commercial group to have higher claim rates than the heavy commercial group for back claims. This is also apparent for upper extremity and knee claims in Table 86 to Table 89.

3.4.9.4 Data tables

Table 86. All upper extremity MSD and injury claims (n = 3 753) made by union carpenters, Washington State 1989–2008

Predominant type of work	Hours at risk	Claims	Claim rate *	aRR †	95% CI	Sig. ‡
Drywall	36 673 255	964	5.3	1.3	1.1-1.5	P < 0.05
Millwright	3 497 881	74	4.2	1.1	0.83-1.4	NS
Light commercial	18 336 177	364	4.0	1.0	1.0-1.0	NS
Mixed commercial	43 141 929	808	3.7	0.94	0.83-1.1	NS
Residential	3 077 068	65	4.2	0.93	0.71-1.2	NS
Heavy commercial	39 571 780	695	3.5	0.87	0.77-0.99	P < 0.05
Out of Washington	34 921 611	607	3.5	0.86	0.76-0.98	P < 0.05
Piledriver	11 275 835	115	2.0	0.52	0.42-0.64	P < 0.05

MSD, Musculoskeletal disorders; aRR, adjusted Rate Ratio relative to the 'Light commercial' category; CI, Confidence Interval; Sig., statistical significance.

* Rate per 200 000 hours worked.

† Adjusted for age, gender and time in the union.

‡ Comparison with aRR = 1.

Data derived from Table III of 208 Lipscomb et al (2015).

Table 87. Paid lost time upper extremity MSD and injury claims (n = 1 053) made by union carpenters, Washington State 1989–2008

Predominant type of work	Hours at risk	Claims	Claim rate *	aRR †	95% CI	Sig. ‡
Drywall	36 673 255	326	1.8	1.9	1.5-2.4	P < 0.05
Millwright	3 497 881	22	1.3	1.3	0.78-2.0	NS
Mixed commercial	43 141 929	224	1.03	1.1	0.83-1.4	NS
Light commercial	18 336 177	90	0.98	1.0	1.0-1.0	NS
Out of Washington	34 921 611	161	0.92	0.92	0.71-1.2	NS
Heavy commercial	39 571 780	172	0.87	0.88	0.68-1.1	NS
Residential	3 077 068	11	0.72	0.68	0.36-1.3	NS
Piledriver	11 275 835	25	0.44	0.45	0.29-0.7	P < 0.05

MSD, Musculoskeletal disorders; aRR, adjusted Rate Ratio relative to the 'Light commercial' category; CI, Confidence Interval; Sig., statistical significance.

* Rate per 200 000 hours worked.

† Adjusted for age, gender and time in the union.

‡ Comparison with aRR = 1.

Data derived from Table III of 208 Lipscomb et al (2015).

Table 88. All knee MSD and injury claims (n = 1 342) made by union carpenters, Washington State 1989–2008

Predominant type of work	Hours at risk	Claims	Claim rate *	aRR †	95% CI	Sig. ‡
Drywall	36 673 255	305	1.7	1.2	0.94-1.4	NS
Residential	3 077 068	24	1.6	1.0	0.65-1.6	NS
Mixed commercial	43 141 929	313	1.5	1.0	0.82-1.2	NS
Light commercial	18 336 177	134	1.5	1.0	1.0-1.0	NS
Out of Washington	34 921 611	235	1.3	0.93	0.75-1.2	NS
Millwright	3 497 881	23	1.3	0.89	0.57-1.4	NS
Heavy commercial	39 571 780	235	1.2	0.81	0.65-1.0	NS
Piledriver	11 275 835	55	0.97	0.68	0.49-0.93	$P < 0.05$

MSD, Musculoskeletal disorders; aRR, adjusted Rate Ratio relative to the 'Light commercial' category; CI, Confidence Interval; Sig., statistical significance.

* Rate per 200 000 hours worked.

† Adjusted for age, gender and time in the union.

‡ Comparison with aRR = 1.

Data derived from Table III of 208 Lipscomb et al (2015).

Table 89. Paid lost time knee MSD and injury claims (n = 517) made by union carpenters, Washington State 1989–2008

Predominant type of work	Hours at risk	Claims	Claim rate *	aRR †	95% CI	Sig. ‡
Millwright	3 497 881	13	0.74	1.3	0.68-2.3	NS
Drywall	36 673 255	125	0.68	1.2	0.89-1.7	NS
Mixed commercial	43 141 929	131	0.61	1.1	0.77-1.5	NS
Light commercial	18 336 177	53	0.58	1.0	1.0-1.0	NS
Out of Washington	34 921 611	79	0.45	0.79	0.56-1.1	NS
Residential	3 077 068	7	0.45	0.76	0.35-1.7	NS
Piledriver	11 275 835	22	0.39	0.68	0.42-1.1	NS
Heavy commercial	39 571 780	78	0.39	0.67	0.47-0.95	$P < 0.05$

MSD, Musculoskeletal disorders; aRR, adjusted Rate Ratio relative to the 'Light commercial' category; CI, Confidence Interval; Sig., statistical significance.

* Rate per 200 000 hours worked.

† Adjusted for age, gender and time in the union.

‡ Comparison with aRR = 1.

Data derived from Table III of 208 Lipscomb et al (2015).

3.4.10 Summaries of studies of union carpenters

It is important to be aware that the ability of statistical tests to detect differences increases with sample size. Therefore, when looking at subsets of subsets, such as paid lost time knee MSDI claims, it will be harder to detect real differences than when looking at larger data sets such as all MSDI claims across all body parts. Looking at the consistency of the ranking of the predominant types of work will help with judgments about the importance of detected differences.

Table 90 compares the rankings of ten measures of WRMSD risk of unionised carpenters in Washington State in the USA reported by Lipscomb *et al.* (2008a, 2008b), Lipscomb *et al.* (2015). Because of the differences in the outcomes reported it was not appropriate to calculate correlation coefficients so comparing rank orders was chosen to gain an understanding of how the risk order varied between the studies of the eight predominant types of work. Table 90 shows that workers whose predominant type of work was 'drywall' were at greatest risk as measured across these ten outcomes (mean rank = 1.5). 'Residential' carpentry work, 'millwright' work and 'light commercial' work had very similar rankings (mean ranks from 3.2 to 3.6). The 'out of Washington', 'mixed commercial' and 'heavy commercial' groups formed another group (mean ranks from 5.2 to 5.9). 'Piledriver' operators were consistently at lowest risk (mean rank = 7.9).

Table 90. Comparison of ranks of aRRs for ten measures of WRMSD risk

Predominant type of work	aRR rank: back injuries without PLT *	aRR rank: back injuries with PLT *	aRR rank: overexertion back injuries †	aRR rank: traumatic back injuries †
Drywall	1.5	1.5	1	3
Residential	1.5	1.5	2	1
Millwright	4	4.5	5	2
Light commercial	3	4.5	3	4.5
Out of Washington	6	3	5	4.5
Mixed commercial	7	7	7	7
Heavy commercial	5	6	5	6
Piledriver	8	8	8	8
Total WC claims	2 457	1 681	3 042	1 095
Predominant type of work	**aRR rank: incident back injury claims ‡**	**aRR rank: recurrent back injury claims ‡**	**aRR rank: all UE MSDI claims §**	**aRR rank: PLT UE MSDI claims §**
Drywall	2	1	1	1
Residential	1	4	5	7
Millwright	4.5	2	2	2
Light commercial	3	4	3	4
Out of Washington	4.5	7	7	5

Predominant type of work	aRR rank: back injuries without PLT *	aRR rank: back injuries with PLT *	aRR rank: overexertion back injuries †	aRR rank: traumatic back injuries †
Mixed commercial	7	6	4	3
Heavy commercial	6	4	6	6
Piledriver	8	8	8	8
Total WC claims	3 037	751	3 753	1 053
Predominant type of work	**aRR rank: all knee MSDI claims §**	**aRR rank: PLT knee MSDI claims §**	**Mean rank of aRRs**	**Range of aRR ranks**
Drywall	1	2	1.5	1–3
Residential	3	6	3.2	1–7
Millwright	6	1	3.3	1–6
Light commercial	3	4	3.6	3–5
Out of Washington	5	5	5.2	3–7
Mixed commercial	3	3	5.4	3–7
Heavy commercial	7	8	5.9	4–8
Piledriver	8	7	7.9	7–8
Total WC claims	1 342	517	–	–

aRR, adjusted rate ratio; MSDI, musculoskeletal disorder and injury; PLT, Paid lost time; UE, Upper extremity; WC, Workers' compensation; WRMSD, work-related musculoskeletal disorders.

* Data shown by PLT status are from Table 80 and Table 81 above, derived from Table III of Lipscomb *et al.* (2008a).

† Data shown by injury type are from Table 82 and Table 83 above, derived from Table IV of Lipscomb *et al.* (2008a).

‡ Data shown by recurrence status are from Table 84 and Table 85 above, derived from Table 2 of Lipscomb *et al.* (2008b).

§ Data shown for MSDI claims are from Table 86, Table 87, Table 88 and Table 89 above, derived from Table III of Lipscomb *et al.* (2015).

Data derived from studies by Lipscomb *et al.* (2008a, 2008b), Lipscomb *et al.* (2015).

3.5 Other studies from North America

3.5.1 Low back injuries covered by the Quebec Workers' Compensation Scheme

Duguay *et al.* (2001) reported successful compensation claims from 1995 made in Quebec in relation to back injuries in the construction sector. Quebec has a system where entry to the construction industry is legally controlled. Contractors have to be licenced and have to be able to demonstrate professional competency. Individual construction workers have to have competency certificates demonstrating that they have vocational qualifications in the trades or occupations they wish to work in. The legal system also makes provision for wages and working conditions to be negotiated across the whole of Quebec. It is overseen by the *Commission de la construction du Québec*[25] (CCQ) under the *Act Respecting Labour Relations, Vocational Training and Workforce Management in the Construction Industry (Act R-20)*. They also oversee related regulations, and the collective agreements that are in force. The *Commission des normes, de l'équité, de la santé et de la sécurité du travail* (CNESST)[26] regulates occupational health and safety in Quebec and administers the Workers' Compensation system for injuries or illnesses. Duguay *et al.* (2001) refer to CNESST by its previous name of the *Commission de la santé et de la sécurité du travail* (CSST).

Duguay *et al.* (2001) used CSST injury data and CCQ data on hours worked in regulated construction occupations in 1995 to calculate incidence rates by occupation. They did not analyse the 15% of claims that occurred among workers not directly carrying out construction activities. These excluded occupations included office workers, managers and engineers. This resulted in them reporting data from 1237 compensated spinal injuries.

They reported incidence rate as four categories (I to IV) because they were concerned about data inaccuracies biasing incidence rates. It has proved possible to calculate actual incidence rates from their data. Both ways of describing incidence are presented in Table 91. They had grouped smaller occupations by similarity and the footnotes to their tables do not give a complete breakdown of the groupings. This limits the comparability of their data to data from other jurisdictions. The occupations in Table 91 are sorted by incidence rate. Table 92 gives the severity data (mean days absent per compensated injury) for these occupations. In this table, the occupations are sorted by severity.

They noted that the least skilled occupation (labourers) had the highest incidence rate. They also noted that the groups with the highest mean days lost were interior finishing workers, followed by carpenter-joiners and that these had much lower incidence rates than the labourers. They therefore hypothesised that the occupations with greatest exposure to risk experience a greater diversity of risks, particularly risks of minor injuries, so are more likely to take shorter periods of sickness absence.

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[25] Application of Act R-20 (ccq.org)

[26] Home | Commission des normes de l'équité de la santé et de la sécurité du travail - CNESST (gouv.qc.ca)

Table 91. Incidence of back injuries in the construction sector in Quebec in 1995

Occupations * ranked by IR †	Workers	No. of CBI	IR †	RR ‡	Incidence level §
Labourers	11 494	313	7.37	1.96	I
Other occupations and trades	5 914	103	4.89	1.30	II
Tinsmiths	2 921	60	4.74	1.26	II
Carpenter-joiners and interior systems installers	20 172	239	3.98	1.06	III
Pipefitters, refrigeration mechanics and boiler makers	8 059	158	3.94	1.05	III
Workers at height	7 684	105	3.77	1.00	III
Interior finishing workers	8 079	76	3.35	0.89	III
Mechanics	2 985	35	2.08	0.55	IV
Electricians	10 816	100	2.01	0.53	IV
Operators of cranes, heavy equipment and mechanical shovels	8 229	48	1.48	0.39	IV

CBI, Compensable Back Injuries; IR, Incidence rate; RR, Rate ratio.

* The occupational groupings were determined from the information entered on CSST reimbursement request notice (ADR) forms, Interior finishing workers include, for example, painters, plasterers and flooring installers. Workers at height include, in particular, masons, roofers and reinforcing steel erectors. Other occupations and trades include, among others, iron workers, welders, service men and storekeepers.

† Rate per 200 000 hours.

‡ Relative to mean.

§ Corresponding to: (I) > 5.4; (II) 4.4–5.3; (III) 3.4–4.3 and (IV) 1.4–3.3 incidents per 200 000 hours worked.

Data derived from Tables 1 & 2 of Duguay *et al.* (2001).

Table 92. Severity of back injuries in the construction sector in Quebec in 1995

Occupations * ranked by severity †	Workers	No. of CBI	Severity †	RR ‡
Interior finishing workers	8 079	76	153.9	1.41
Carpenter-joiners and interior systems installers	20 172	239	139.4	1.28
Operators of cranes, heavy equipment and mechanical shovels	8 229	48	130.5	1.20
Workers at height	7 684	105	116.1	1.07
Other occupations and trades	5 914	103	102.8	0.94
Mechanics	2 985	35	102.6	0.94
Labourers	11 494	313	101.2	0.93
Electricians	10 816	100	100.3	0.92
Tinsmiths	2 921	60	80.8	0.74
Pipefitters, refrigeration mechanics and boiler makers	8 059	158	65.8	0.60

CBI, Compensable Back Injuries; RR, Rate ratio.

* The occupational groupings were determined from the information entered on CSST reimbursement request notice (ADR) forms, Interior finishing workers include, for example, painters, plasterers and flooring installers. Workers at height include, in particular, masons, roofers and reinforcing steel erectors. Other occupations and trades include, among others, iron workers, welders, service men and storekeepers.

† Days absent/injury.

‡ Relative to mean.

Data derived from Tables 1 & 2 of Duguay *et al.* (2001).

3.5.2 US construction workers specialised in masonry tasks

3.5.2.1 Detailed results

Memarian and Mitropoulos (2013) carried out detailed analysis of 141 recordable incidents that occurred over the three years from 2007-2009 in a large masonry contractor in the USA. Their aim was to identify activities with high frequency and severity, identify causal events and identify the risks to different roles in masonry crews. The events were identified from insurance claim records.

Table 93 categorises the incidents by the type of event. Table 94 categorises them by the type of work activity being undertaken when the incident occurred. In both tables, injury severity is measured by days absent and/or days with modified tasks.

The most frequent events (44/141 = 31%) were related to over-exertion, but significant proportions involved ‘struck by’ (26%) and ‘contact with’ (19%) events. As the results include non-WRMSD incidents, their applicability is limited.

Table 95 categorises injuries by the roles performed by the different members of a crew of workers. It is normal for one labourer to support two or three masons laying concrete masonry units or bricks. Again, the data are for all injury events.

Table 96 gives separate incident rates for the different crew roles and the various activities for all types of incident/injury. Of the activities listed, material handling, scaffolding, grouting, mixing mortar and block laying are likely to involve significant manual handling. Block cutting and grinding are likely to involve the use of large hand-held power tools.

The table illustrates that the activities and hence the risks depend on the role; for example, masons and foremen do not mix mortar.

Table 97 separates the incidents involving overexertion by worker role and the construction activity being undertaken. It shows that block laying is the largest cause of overexertion injuries for masons and that material handling is the largest cause of overexertion injuries for labourers.

3.5.2.2 Summary of results

Memarian and Mitropoulos (2013) concluded that their study had identified that scaffold erection and dismantling is a high-risk activity, not just due to the risk of falling from height. They also concluded that the labourers in the masonry crews were at significantly higher risk of injury than the other positions of masons, foremen and FLT operators.

Overall, the data from this study are of limited value to this project due to its limited scope and small scale. However, the study illustrates well the interaction between job role and the need to carry out particular manual handling operations.

3.5.2.3 Data tables

Table 93. Frequency and severity of 141 recordable incidents from 2007–2009 at a large US construction masonry contractor, grouped by incident event type

Event type	No. of incidents	IR *	DAW	DMT	TWD
Over-exertion	44	8.51	23	521	544
Struck by object	36	6.96	75	481	556
Contact with object	27	5.22	121	193	314
Slip/trip/fall on same level	18	3.48	276	241	517
Fall from elevation	10	1.93	71	202	273
Other events	6	1.16	0	0	0
Total	141	27.27	566	1 638	2 204

IR, Incidence Rate; DAW, Days away from work; DMT, Days with modified tasks; TWD, Total workdays affected.

* Rate per 200 000 hours worked.

Data derived from Table 2 of Memarian and Mitropoulos (2013).

Table 94. Frequency and severity of 139 * recordable incidents from 2007–2009 at a large US construction masonry contractor, grouped by work activity

Activity being undertaken	No. of incidents	IR *	DAW per incident	DMT per incident	TWD per incident
Scaffolding	22	4.3	9.5	17.9	27.4
Block cutting	8	1.5	0.5	20.3	20.8
Walking/climbing scaffold	9	1.7	2.4	17.1	19.6
Grouting	8	1.5	8.6	8.4	17.0
Block laying	27	5.2	2.8	12.6	15.4
Grinding	6	1.2	10.3	4.5	14.8
Other activities	12	2.3	0.0	12.8	12.8
Material handling	22	4.3	4.8	7.8	12.5
Layout	2	0.4	0.0	10.0	10.0
Rebar	11	2.1	0.4	6.9	7.3
Mixing mortar	3	0.6	0.0	6.7	6.7
Activity not specified	9	1.7	0.0	3.2	3.2

IR, Incidence Rate; DAW, Days away from work; DMT, Days with modified tasks; TWD, Total workdays affected.

* Two material handling incidents involving workers who were not part of masonry crews have been removed from the data set.

† Rate per 200 000 hours worked.

These figures are for all recorded work injuries to masonry crew members, not just overexertion injuries.

Data derived from Table 3 of Memarian and Mitropoulos (2013).

Table 95. Recordable incident rate from 2007–2009 at a large US construction masonry contractor, grouped by worker position

Position	No. of incidents	Hours worked	IR *	RR †
Laborers	58	868 560	13.4	1.71
Foremen	13	248 160	10.5	1.34
Masons	68	1 737 120	7.8	1.00
FLT operator	0	248 160	0.0	–
Other ‡	2	0	0.0	–
Total	141	3 102 000	9.1	–

IR, Incident rate; RR, risk ratio.

* Rate per 200 000 hours.

† Relative to rate for masons.

‡ Not part of the immediate masonry crew.

Data derived from Table 4 of Memarian and Mitropoulos (2013).

Table 96. Recordable incident rates from 2007–2009 at a large US construction masonry contractor, grouped by work activity and worker position

Activity being undertaken	IR * of laborers (No. of incidents)	IR * of masons (No. of incidents)	IR * of foremen (No. of incidents)	IR * of other workers (No. of incidents)	IR * of all workers (No. of incidents)
Material handling	3.9 (17)	0.5 (4)	0.8 (1)	1.6 (2)	1.5 (24)
Scaffolding	3.5 (15)	0.6 (5)	1.6 (2)	–	1.4 (22)
Other activities	1.4 (6)	0.3 (3)	2.4 (3)	–	0.8 (12)
Rebar	0.9 (4)	0.8 (7)	–	–	0.7 (11)
Walking/climbing scaffold	0.9 (4)	0.1 (1)	3.2 (4)	–	0.6 (9)
Grouting	0.7 (3)	0.3 (3)	1.6 (2)	–	0.5 (8)
Mixing mortar	0.7 (3)	–	–	–	0.2 (3)
Activity not specified	0.7 (3)	0.7 (6)	–	–	0.6 (9)
Block cutting	0.5 (2)	0.6 (5)	0.8 (1)	–	0.5 (8)
Grinding	0.2 (1)	0.6 (5)	–	–	0.4 (6)
Block laying	–	3.1 (27)	–	–	1.7 (27)
Layout	–	0.2 (2)	–	–	0.1 (2)
Total by activity	13.4 (58)	7.8 (68)	10.5 (13)	0.7 (2)	9.1 (141)

IR, Incidence rate.

* Rate per 200 000 hours worked.

Data derived from Table 5 of Memarian and Mitropoulos (2013).

Table 97. Recordable overexertion incidents for masons and labourers from 2007–2009 at a large US construction masonry contractor, grouped by work activity

Activity being undertaken	Overexertion incidents of masons	Overexertion incidents of laborers	Overexertion IR * of masons	Overexertion IR * of laborers
Block laying	12		1.4	
Rebar	2	2	0.2	0.5
Material handling	2	11	0.2	2.5
Cutting block	1	1	0.1	0.2
Grouting	1	1	0.1	0.2
Scaffold		4		0.9
Mixing mortar		1		0.2
Total by activity	18	20	2.1	4.6

IR, Incidence rate.

* Rate per 200 000 hours worked.

Data derived from Section 4.3 of Memarian and Mitropoulos (2013).

3.6 Correlations of incidence rates of different studies

3.6.1.1 Introduction

As described in Section 2.2.5, correlation coefficients (Pearson's r) were calculated to compare the rankings of prevalence/incidence rates reported by studies where job titles/SOC codes could be matched. The data in Table 98 were derived by matching occupational titles in five studies with suitable data. Of the 20 incidence rates reported by Wang *et al.* (2017) (Table 44), 18 could be matched with 18 of the 20 job titles reported by Dong *et al.* (2019) (Table 45). Nine could be matched with nine of the 10 job titles reported by Duguay *et al.* (2001) (Table 91). Only eight of the 14 job titles reported by Stocks *et al.* (2011) (Table 24) could be matched with the Wang *et al.* (2017) data. One of these (Managers in construction) had insufficient data to allow its incident rate ratio to be estimated, leaving seven data pairs to be correlated. Eleven job titles could be matched out of the 20 reported by Wahlström *et al.* (2012) (Table 26).

Nine job titles were matched between Dong *et al.* (2019) and Duguay *et al.* (2001). Seven were matched between Dong *et al.* (2019) and Stocks *et al.* (2011). Twelve were matched between Dong *et al.* (2019) and Wahlström *et al.* (2012).

Only five job titles could be matched between Duguay *et al.* (2001) and Stocks *et al.* (2011). Seven job titles were matched between Duguay *et al.* (2001) and Wahlström *et al.* (2012) and seven between Stocks *et al.* (2011) and Wahlström *et al.* (2012).

3.6.1.2 Detailed results

The percentages of the cases contributing to the correlations were as high as 93.7% and 98.0% for the comparison of Wang *et al.* (2017) and Dong *et al.* (2019). This reflects the fact that they both drew from the same source of data. Sixteen occupations were matched, the highest number achieved, and the correlation was statistically significant at the $P < 0.005$ level. By contrast, the lowest percentages were 63.5% and 49.3% for the comparison of Duguay *et al.* (2001) and Wahlström *et al.* (2012). The correlation was not significant and only five occupations were matched between the two studies.

Three pairs of studies had statistically significant correlations at $P < 0.005$ and one at $P < 0.01$. The scatter plots and regression lines for these four studies are shown in Figure 2 to Figure 5. Three of these four pairs of studies included Stocks *et al.* (2011), though the numbers of paired job titles ranged from eight down to only five of the 14 job titles that Stocks *et al.* (2011) reported.

Figure 2 shows the correlation between the WRMSD incidence rates in Table 44 reported by Wang *et al.* (2017) and in Table 45 reported by Dong *et al.* (2019). Both sets of data come from the SOII for the periods from 2011 to 2014 and 2015 to 2017, respectively, ie from consecutive stages of the same study, so a high correlation is to be expected. The actual correlation coefficient ($r = 0.856$) shows that over 73% ($R^2 = 73.3\%$) of the variability in one set of data is accounted for by variability in the other set. This shows that the rankings of tasks in Table 44 and Table 45 are stable over the period of the two studies (2011–2017). In other words, construction occupations such as 'helpers' and sheet metal workers continued to have high incidence rates throughout this period and occupations such as painters and welders continued to have low rates.

Figure 3 shows the correlation between the WRMSD incidence rates in Table 44 reported by Wang *et al.* (2017) and Table 24 reported by Stocks *et al.* (2011). The actual correlation coefficient ($r = 0.847$) shows that nearly 72% ($R^2 = 71.7\%$) of the variability in one set of data is accounted for by variability in the other set. In other words, there was a strong relationship between the injury rates in the UK and in matched occupations in the USA. This suggests that US data could be a useful resource when identifying priorities for action.

Figure 4 shows the correlation between the WRMSD incidence rates in Table 45 reported by Dong *et al.* (2019) and Table 24 reported by Stocks *et al.* (2011). The actual correlation coefficient ($r = 0.876$) shows that nearly 77% ($R^2 = 76.8\%$) of the variability in one set of data is accounted for by variability in the other set. It is also noticeable that the 'helpers' category ('labourers other construction trades n.e.c.' in Stocks *et al.* (2011)) is separated from the cluster of other occupations. This partly reflects the much higher rates reported for this pairing of occupations and the difficulty of matching job descriptions from different studies. Removing this category from the data set would reduce the correlation within the cluster of other occupations with lower rates.

The good correlations between the UK study reported by Stocks *et al.* (2011) and both US studies (Wang *et al.* (2017) and Dong *et al.* (2019)) reflect the high correlation between the two US studies.

Figure 5 shows the correlation between the WRMSD SRR in Table 24 reported by Stocks *et al.* (2011) and the Incidence Rates in Table 91 reported by Duguay *et al.* (2001). The very high correlation coefficient ($r = 0.969$) shows that 94% ($R^2 = 94.0\%$) of the variability in one set of data is accounted for by variability in the other set. However, it was only possible to match five job titles of the 10 reported by Duguay *et al.* (2001) and the 14 reported by Stocks *et al.* (2011). As a result, only 71.6% and 62.2% respectively of the cases reported by the two studies were included (Table 98).

Table 98. Correlation matrix of five studies reporting incidence rates of WRMSDs

	Duguay *et al.* (2001) (10 occupations)	**Stocks *et al.* (2011) (14 occupations)**	**Wahlström *et al.* (2012) (20 occupations)**	**Wang *et al.* (2017) (20 occupations)**
Dong *et al.* (2019) (20 occupations)	r = 0.619, R^2 = 38.3%	r = 0.876, R^2 = 76.8%	r = 0.285, R^2 = 8.1%	r = 0.856, R^2 = 73.3%
DF = N-2	7	5	10	16
% data included	47.9%, 91.7%	66.2%, 58.1%	55.6%, 87.5%	93.7%, 98.0%
Probability	P < 0.05	P < 0.005	NS	P < 0.005
Duguay *et al.* (2001) (10 occupations)	NA	r = 0.969, R^2 = 94.0%	r = 0.292, R^2 = 8.5%	r = 0.540, R^2 = 29.2%
DF = N-2		3	5	7
% data included		71.6%, 62.2%	63.5%, 49.3%	50.4%, 91.7%
Probability		P < 0.005	NS	NS
Stocks *et al.* (2011) (14 occupations)		NA	r = -0.400, R^2 = 16.0%	r = 0.847, R^2 = 71.7%
DF = N-2			5	5
% data included			61.7%, 66.9%	60.5%, 58.1%
Probability			NS	P < 0.01
Wahlström *et al.* (2012) (20 occupations)			NA	r = 0.467, R^2 = 21.8%
DF = N-2				9
% data included				52.9%, 86.7%
Probability				NS

DF, degrees of freedom; N, number of pairs of values being correlated; NS, not statistically significant.
% data included, percentages of the WRMSD cases in the two data sets that could be correlated (row, col.)
P, one-tailed probability that the correlation is due to chance; r, Pearson's correlation coefficient.

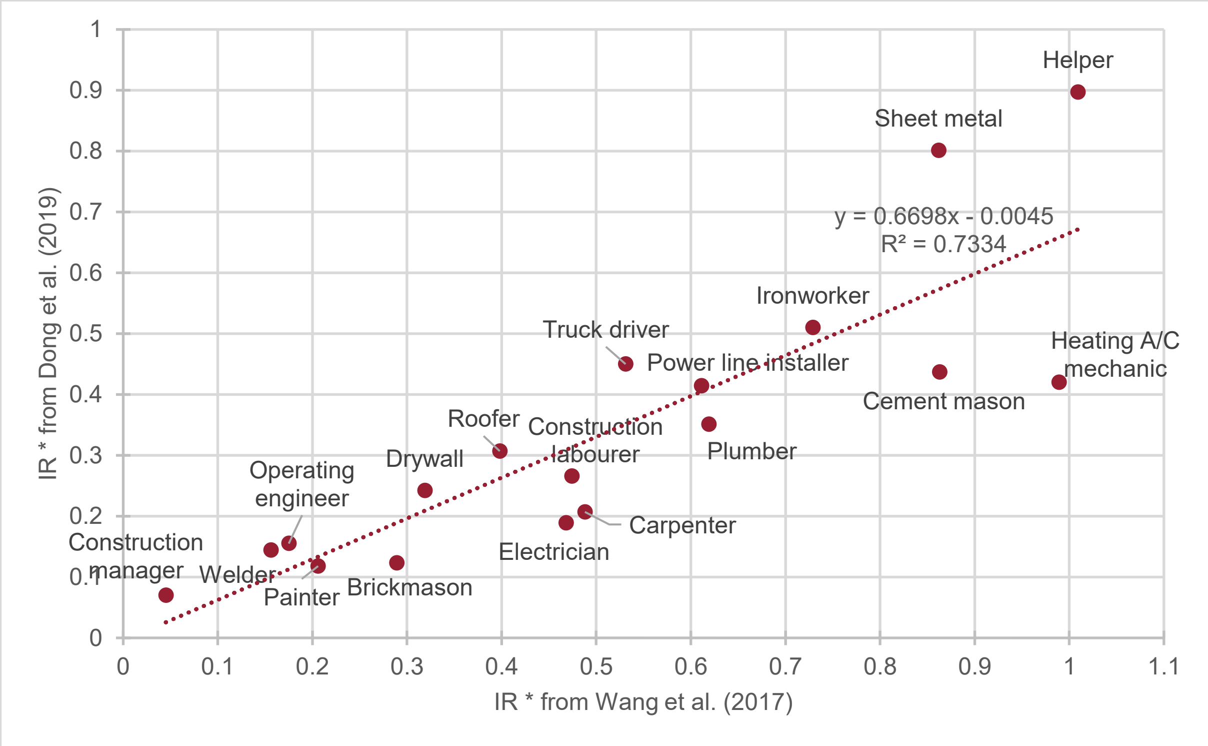
3.6.1.3 Summary of results

Matching occupational titles in five reports of studies of the construction sector from different countries had variable success. A number of factors contributed to this, including different selections of occupations reported, and different methods of grouping or not grouping occupations. Correlations between incidence rates reported by the five studies ranged from very high (R^2 > 90%) to very low (R^2 < 10%). Percentages of reported MSD cases in occupations that could be matched ranged from 98% down to 48%.

It was possible to demonstrate a strong relationship between the injury rates in the UK and in matched occupations in the USA. This suggests that with careful selection of data and matching of occupations, US data could be used effectively to help identify UK occupations that are likely to be high risk for MSDs.

3.6.1.4 Scatter plots

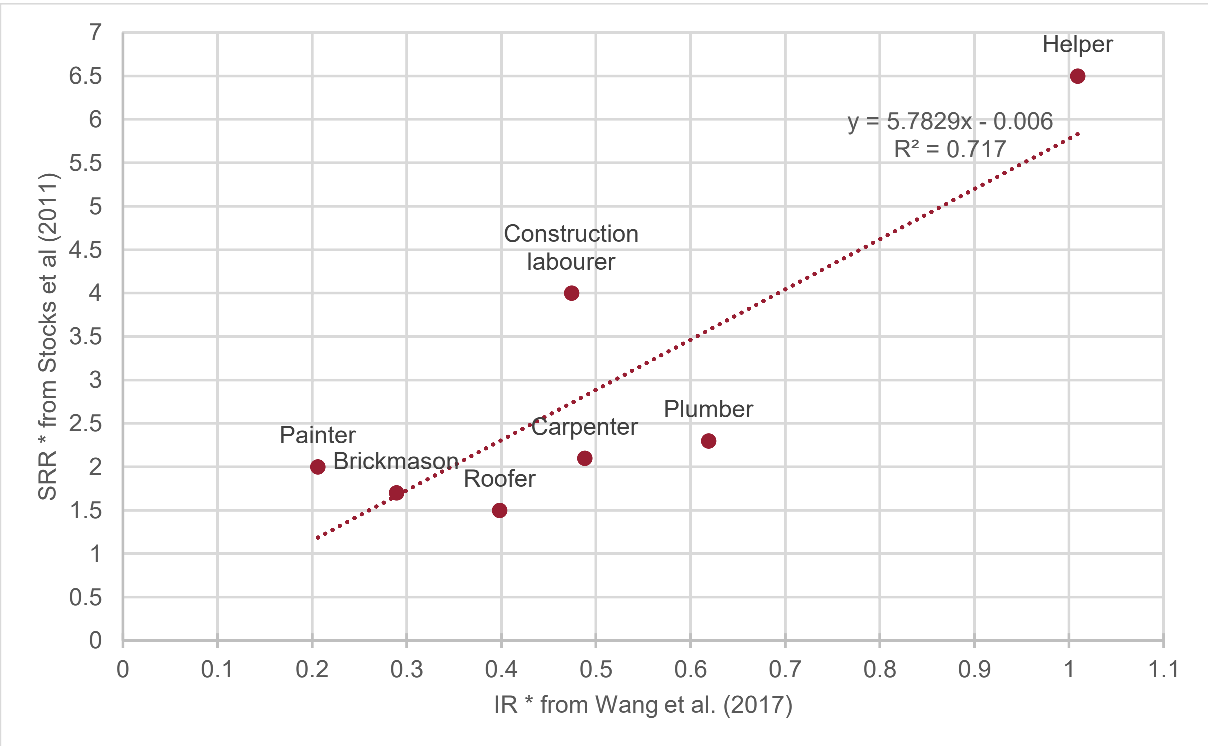
Figure 2. Scatter plot for Wang *et al.* (2017) and Dong *et al.* (2019)



IR, Incidence rate.

* Rate per 200 000 hours.

Figure 3. Scatter plot for Wang *et al.* (2017) and Stocks *et al.* (2011)

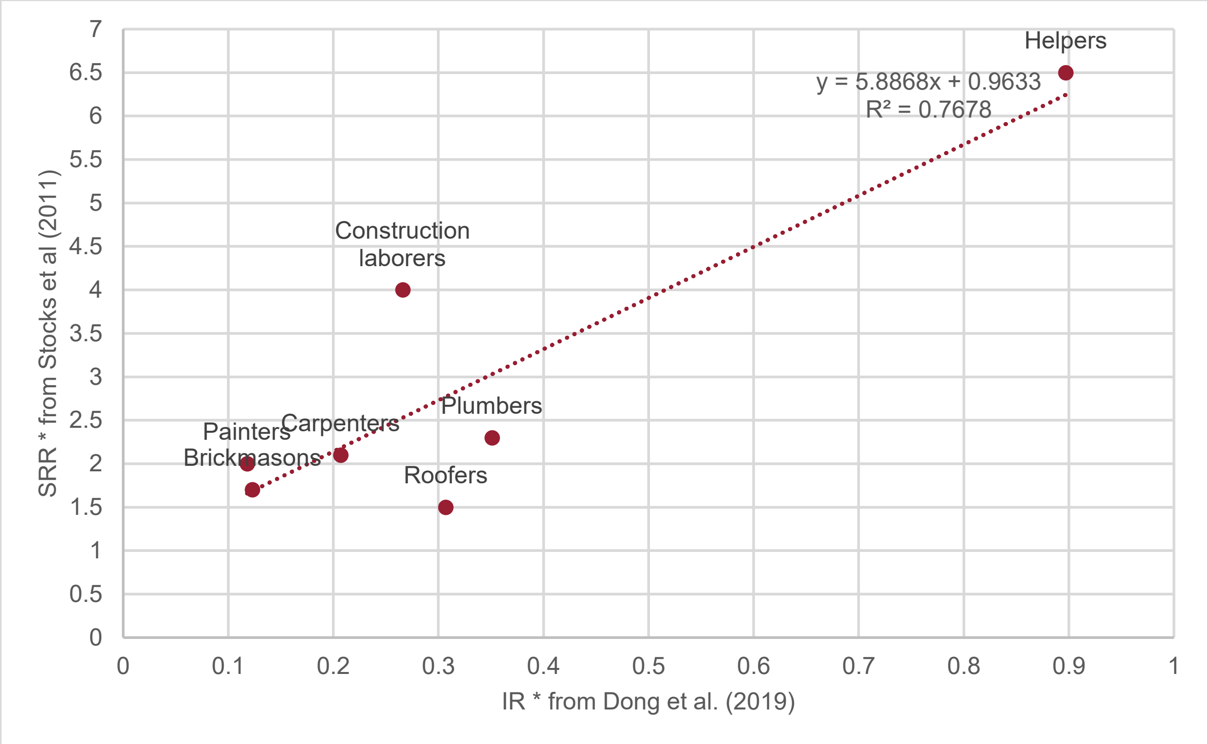


The ‘Managers in construction’ job title reported by Stocks *et al.* (2011) had insufficient data for them to calculate an incidence rate.

IR, Incidence Rate; SRR Standardised incidence Rate Ratio.

* Rate per 200 000 hours.

Figure 4. Scatter plot for Dong *et al.* (2019) and Stocks *et al.* (2011)

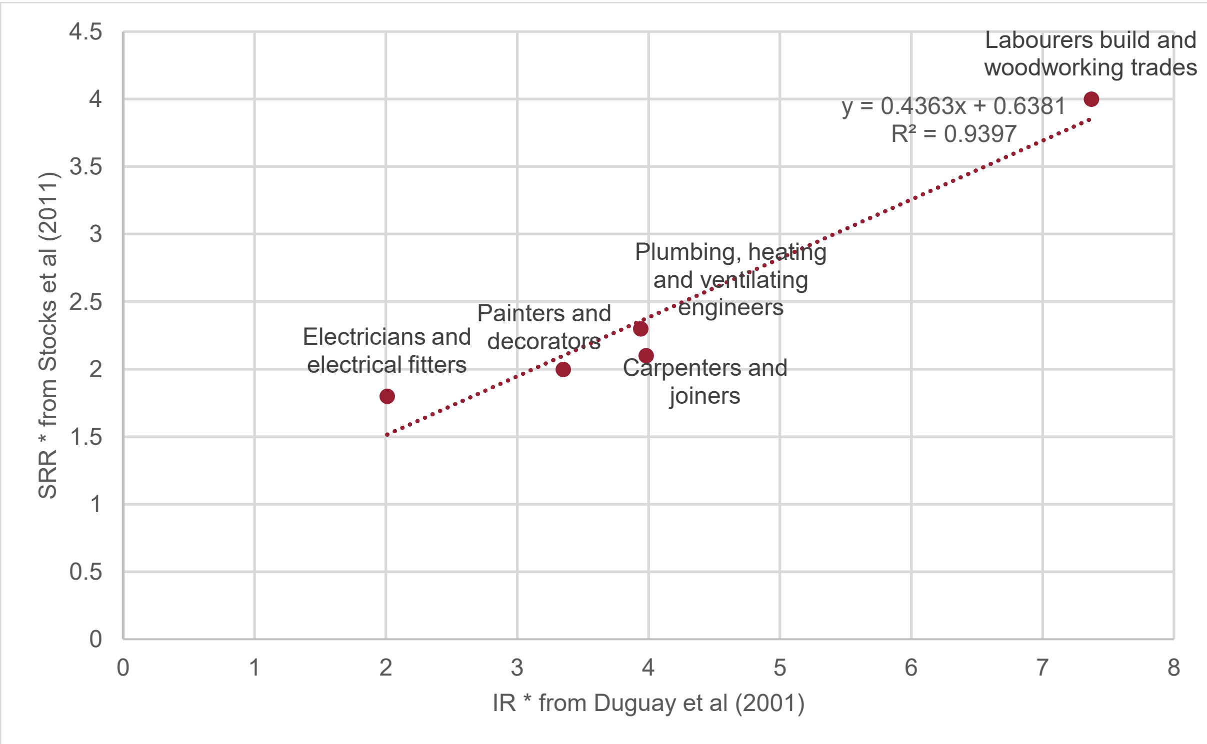


The 'Managers in construction' job title reported by Stocks *et al.* (2011) had insufficient data for them to calculate an incidence rate.

IR, Incidence Rate; SRR Standardised incidence Rate Ratio.

* Rate per 200 000 hours.

Figure 5. Scatter plot for Stocks *et al.* (2011) and Duguay *et al.* (2001)



IR, Incidence Rate; SRR Standardised incidence Rate Ratio.

* Rate per 200 000 hours.

4 Conclusions

4.1 General

1. A large number of registry/retrospective studies have been identified (Table 11 and Figure 1 in Section 2.1.5) that report longitudinal WRMSD data for construction industry groups and construction trades that are useful for HSE's purpose of trying to identify construction trades and occupations at increased risk of WRMSDs. Of the 19 scientific reports and two annual survey databases, 14 were from the USA, two from the UK and two from Finland. There were single studies from Canada, Sweden and Denmark. Nine of the 14 studies from the USA came from Washington State.
2. WRMSD reporting systems vary between countries. In countries with insurance-based Workers' Compensation systems, the usual data reported are Claims Incidence Rates, ie rates at which claims are made. Such reports will exclude uninsured workers who are not covered by the compensation system and are likely to exclude low-severity incidents.
3. Different studies report different outcomes; studies from the USA tend to report claim rates due to WRMSDs. Some European studies report hospitalisation rates for specific problems such as 'lumbar disc disease' or hip or knee osteoarthritis. This makes international comparisons more challenging.
4. The data identified are insufficient to provide comprehensive overviews of the risks of MSDs to different parts of the construction industry/construction occupations but do give some indications of how severity varies between industries and between occupations/trades.
5. Rates of injury are unrelated to the size of the construction industry group/trade concerned (see Table 41 in Section 3.3.1). In other words, both small and large groups of workers may have low injury rates or may have high injury rates. Therefore, targeting large industries or occupations will not result in change in small high risk industries or occupations.
6. Days absent from work due to WRMSDs are unrelated to both the size of the construction industry group/trade and to the injury rate for that construction industry group/trade (see Table 47 in Section 3.3.2).
7. As workers in different construction trades perform different activities, the MSD risks they experience differ. For example, one study reported that bricklayers/masons and their foremen do not mix the mortar that is used, since that task is delegated to labourers on the building sites (Section 3.5.2). That same study showed that block laying was the largest cause of overexertion injuries for the masons and handling of materials was the largest cause for the labourers working for them.
8. In order to aid prioritisation of interventions, some studies from Washington State in the USA have reported a 'Prevention Index' (see Section 3.4.1.1) that averages across industries the rank order for injury/claim rates and the rank order for the absolute number of claims. This creates a rank order of priority for intervention that seeks to balance injury rates and industry size by increasing the rankings of large industries with

relatively low injury rates. This approach has not been used in this report. Doing so would require data on worker numbers from the countries represented by the studies. Instead, simple incidence rates per 200 000 hours worked are used.
9. The studies that report data from multiple industries or occupations, show that there can be a wide range of incidence rates across them. Ranking them by incidence shows that the differences in risk between adjacent groups are often small and clear clusters or boundaries don't occur.

4.2 MSD risk in construction as a whole

While studies that reported MSD risk for the construction sector as a whole without any breakdown were excluded from the review, the HSE LFS survey data clearly confirmed (Sections 3.1.1 and 3.1.2) that construction as a whole is significantly more hazardous than the average across all industries.

4.3 Types of MSD reported

The evidence is clear (Section 3.4.2) that cumulative/repetitive injury MSDs are much more common and more disabling than 'acute onset' or overexertion injuries. Therefore, prevention efforts should be focussed on reducing long-term exposures to MSD risk factors, such as lifting heavy weights, while not ignoring risk factors for acute injuries, such as extreme loads.

There is evidence (e.g. Table 40 in Section 3.3.1, Table 46 in Section 3.3.2) that some industries or trades have higher rates of musculoskeletal problems than the construction sector or construction workers as a whole. This evidence extends to increased rates of osteoarthritis surgery (such as hip replacements) among floor layers, brick layers and pavers (Section 3.2.2.2). Similar evidence was found for osteoarthritis-related disability (Section 3.2.3), with skilled construction workers, such as electricians and plumbers having higher rates of hip OA than a group of unskilled transport, construction and manufacturing workers. It was also shown that combining kneeling and squatting and heavy physical work increased the risks of hip OA. This suggests that preventative strategies could focus on the risks of heavy physical work combined with awkward postures.

Comparisons of the rates at which different body parts are affected by WRMSDs can be made using the data from a number of the studies reviewed, though this is complicated by differing outcome measures. The HSE LFS data for construction (Sections 3.1.1 and 3.1.2) show that about 40% of all self-reported MSDs were in the neck and upper limb, 35-40% in the back and 20-25% in the lower limbs.

Data from Washington State in the USA (Table 49, Table 50 and Table 51 in Section 3.4.1) shows that averaged across six WIC high-risk risk classes with sufficient data for the 1990-1998 period, 64% of successful WC claims for 'non-traumatic soft tissue' disorders affecting the neck, back and upper extremity related to the back, 28% to the upper extremity and 8% to the neck. As a result, claims for back problems occurred at 2.3 times the rate of claims for the upper extremity and 7.6 times the rate for neck problems.

A separate analysis of Washington State WC data from 1989-1992 focussed on claims made by unionised carpenters. Table 72 in Section 3.4.7 shows that WC claims for non-traumatic soft-tissue injuries to the axial skeleton (the back and neck) occurred at three times the rate of claims for injuries to the upper limb excluding the neck and four times the rate for lower limb claims. As 59% related to the back and 36% related to the upper limb and neck, claims for back problems occurred at 1.6 times the rate for upper limb and neck claims.

Without further data it is not possible to be certain why UK LFS reports of UL MSDs are slightly more frequent than reports of back MSDs but US WC claims for the back were at least 1.6 times more common as upper limb and neck claims. As WC claims are associated with costs and self-reports may not be, the preponderance of back claims over UL claims does suggest that interventions should be prioritised accordingly. Within the category of back problems, the most severe cases tend to be due to sciatica, but current risk assessment and control methods are not capable of distinguishing between the risk of this and less severe cases of back pain. This suggests a focus on controlling risks to the low back in general, rather than on an attempt to focus on sciatica specifically.

4.4 UK evidence about higher risk groups

HSE pays the ONS to ask questions annually about work-related ill-health and workplace injuries as part of the LFS (Section 1.4.1). Examination of HSE published data (Section 3.1.1) reveals that the sample size is too small to allow reliable estimates to be made of prevalences of MSDs for 20 of 22 SIC industry classes and six of nine industry groups. Even one construction industry division (F41 'Civil Engineering') is too small for reliable data to be published by HSE. The same problems inevitably occur with the SOC system (Section 3.1.2) with only three of 33 construction-related unit groups having sufficient data. It was also apparent that the sample size did not allow detailed analysis of reports of MSDs by affected body parts.

Despite these limitations, the sample is sufficiently large to indicate from the SIC data (Table 12 in Section 3.1.1.3) that industry group F43.3 'Building completion and finishing' has the highest prevalence rate of all MSDs at 4.17 cases per 200 000 hours worked, which is twice the rate for the whole construction sector. The one class within it with sufficient data, F43.32 'Joinery installation', has the second highest rate at 3.68 cases per 200 000 hours. However, the other four completion and finishing classes within F43.3, ie F43.31 'Plastering', F43.33 'Floor and wall covering', F43.34 'Painting and glazing' and F43.39 'Other building completion and finishing', on average have a rate that is higher at 4.49 cases per 200 000 hours. This indicates that HSE should consider a focus on the building completion and finishing group of industries as a whole.

Classifying the same data by occupation using the UK SOC 2010 (Table 17 in Section 3.1.2.3) showed that the LFS sample is big enough to identify that non-manual/managerial occupations have lower prevalence rates than 'All occupations', and that manual occupations have higher rates, which was an expected result. SOC major group 5 'Skilled trades occupations', stands out as having the highest prevalence rate at 1.9 times the rate of 'All occupations'. It was possible to identify three occupational unit groups within sub-major group 53 'Skilled construction and building trades' as having high rates of MSDs, the highest being 5314 'Plumbers and heating and ventilating engineers', with the others being 5315 'Carpenters and joiners' and 5319 'Construction and building trades n.e.c.'. However, unit group 5319 contains a significant number of diverse trades which makes it more difficult to identify specific activities for interventions within it.

Analysis of the THOR data reported to HSE (Section 3.1.3 and Table 25) shows that despite significant methodological issues, UK SOC 2000 unit group 8142 'Road construction operatives' with a standardised rate ratio (SRR) of 11.0 was at highest risk in the sample, with the next highest risk unit group being 9121 'Labourers build and woodworking trades' with an SRR = 4.0.

4.5 US evidence about higher risk groups

4.5.1 BLS data

Available data from the US BLS annual SOII (Section 3.3) showed that averaged over the 10 years from 2011 to 2020, the four worst construction industries for MSD reports (Table 40) were NAICS codes 23835 'Finish carpentry contractors' (IR = 0.563 absences per 200 000 hours), 23833 'Flooring contractors' (IR = 0.561), 23813 'Framing contractors' (IR = 0.551) and 23817 'Siding contractors' (IR = 0.539). These industries map (Table 102) onto UK SIC 2007 codes F43.32 'Joinery installation', F43.33 'Floor and wall covering', F43.99 'Other specialised construction activities n.e.c.', and F43.99 'Other specialised construction activities n.e.c.', respectively.

The same data also showed (Table 47) that the six worst construction occupations over that period were 47-2043 'Floor sanders and finishers' (IR = 3.581 absences per 200 000 hours),47-2042 'Floor layers, except carpet, wood and hard tiles' (IR = 1.119), 47-2142 'Paperhangers' (IR = 1.058), 47-2041 'Carpet installers' (IR = 0.966), 49-2022 'Telecommunications equipment installers and repairers, except line installers' (IR = 0.866), and 49-9021, 'Heating, air conditioning, and refrigeration mechanics and installers' (IR = 0.849).

Three of these occupations can be mapped (Table 103) to UK SOC 2010 code 5322 'Floorers and wall tilers', with the others mapping to 5323 'Painters and decorators', 5242, 'Telecommunications engineers' and 5225 'Air-conditioning and refrigeration engineers'

4.5.2 Data from Washington State

Data from 2002-2010 from the Washington State WIC risk classification system (Table 58, Section 3.4.2) indicate that WIC classes 0540 'Wallboard installation – Discounted Rate', 0302 'Masonry Construction', and 0507 'Roofing Work – Construction and Repair' are the three construction sector classes most likely to result in compensation claims for absences (of over three days) due to WRMSDs. When the same WC data were classified using

NAICS 4-digit codes (Table 65, Section 3.4.4), the most hazardous construction industry groups for WRMSDs of the neck, back and upper extremity were 2381 ‘Foundation, Structure, and Building Exterior Contractors’, 2382 ‘Building Equipment Contractors’, 2383 ‘Building Finishing Contractors’ and 2361 ‘Residential Building Construction’. These NAICS codes map (Table 102) onto the UK SIC codes F43.99 ‘Other specialised construction activities n.e.c.’, F43.2 ‘Electrical, plumbing and other construction installation activities’, F43.3 ‘Building completion and finishing’, and F41.2 ‘Construction of residential and non-residential buildings’.

Studies of WC claims between 1989 and 1992 made by unionised carpenters in Washington State (summarised in Table 90 in Section 3.4.10) indicated the highest risk was to workers performing drywall work. Residential and light commercial carpentry work were also at increased risk when compared to other carpenters. This is largely consistent across considerations of severity (paid lost time (Table 81) vs no paid lost time (Table 80)), nature (overexertion (Table 82) vs traumatic injuries (Table 83)) and recurrence (initial (Table 84) vs recurrent (Table 85) injury). Piledrivers were consistently at lower risk than the other categories of carpenter. Millwrights (installers of industrial machinery) and residential carpenters were much fewer in number than drywall carpenters and carpenters doing light, heavy, or mixed commercial work.

Data from 1990-1998 showed (Section 3.4.1) that certain construction activities were high risk for multiple body parts, suggesting that they were creating excessive demands on the whole body. These were WIC risk classes 0515 ‘Wallboard installation’, 0518 ‘Building construction, NOC’ and 0510 ‘Wood frame building construction’. Risk class 0109 Reinforcing steel installation was the most hazardous class for carpal tunnel syndrome, suggesting the practice of rebar tying could be an issue, due to it being known to place significant demands on the wrists.

4.6 Evidence from other countries about higher risk groups

Evidence from Sweden for the period from 1971-1992 (Section 3.2.1) showed that white-collar workers and construction foremen were at less risk of being hospitalised for lumbar disc disease than all other construction workers, suggesting that physical workload is a key risk factor.

The Danish finding from data between 1996 and 2006 (Section 3.2.2.2) suggests that kneeling is an occupation-specific risk factor for lower-limb osteoarthritis. Construction workers were at increased of having surgery for hip or knee osteoarthritis, and the group of floor-layers, brick layers and pavers was at even higher risk.

The findings from Finland for the period 2005-2013 (Section 3.2.3.4) support this interpretation. It identified that all construction workers were at increased risk of disability retirement due to hip or knee osteoarthritis compared to professionals, and that skilled workers had higher risks than unskilled workers. This was associated with differences in physical workload factors.

A study of data collected in Quebec during 1995 (Section 3.5.1) found that the least skilled occupation (labourers) had the highest MSD incidence rate. The groups with the highest mean days lost were interior finishing workers, followed by carpenter-joiners but they had much lower incidence rates than the labourers. The study hypothesised that the occupations with the greatest exposure to risk experience a greater diversity of risks, particularly risks of minor injuries, so are more likely to take shorter periods of sickness absence.

4.7 Correlations of incidence rates

Correlation of incidence rates from studies from the USA (Dong *et al.*, 2019, Wang *et al.*, 2017) with data from the UK (Stocks *et al.*, 2011) (Table 98, Figure 3 and Figure 4 in Section 3.6) indicated that there was a strong relationship between rates in the two countries, even though it was possible to test this on only a limited number of occupations. This indicates that it may be possible to use rankings from the US in the absence of comparable UK data.

Similarly, comparing data from the UK study (Stocks *et al.*, 2011) with a study from Quebec (Duguay *et al.*, 2001) (Table 98, Figure 5 in Section 3.6) showed a very high correlation between incidence rates for the small number of occupations where comparable workers could be identified. This further indicates that if adequate data can be identified for comparable construction occupations from other countries, then HSE will be able to gain useful insights into relative UK risks.

However, caution will be needed as the limitations of the data sets examined make this conclusion tentative. Also, there are differences in construction techniques between countries, which may be due to differences in design due to climate differences or differences in the availability of various materials. Also, the detailed work carried out by workers in the same nominal trade may differ due to different cultural norms.

4.8 Trends in MSD reporting

Analysis of BLS data from the USA identified clear trends in reduction of MSD reporting incidence rates over the ten years from 2011 to 2020 (Table 48 in Section 3.3.2). This occurred across the US economy, not just the construction sector. Data from Washington State for unionised carpenters showed a similar trend over the period from 1989 to 2008 (Section 3.4.9), but it was acknowledged that it might have been affected by workers shifting from seeking care from the WC system to other health provision.

The rates of reduction from 2011 to 2020 (Table 48 in Section 3.3.2) varied between occupations, suggesting that specific factors have reduced risk differentially. This may be factors such as changes in working practices that are specific to occupations, changes in methods of handling building materials, or improved hand tool design.

It is less easy to observe such a trend in Great Britain. The annual HSE report of the historical picture of health and safety statistics in Great Britain shows a clear downward trend in total fatalities from approximately 1940. It also shows a long-term downward trend in non-fatal injury rates from 1986/7. The data for WRMSDs are much less complete, with annual data only starting in 2003/4, but again, there is a downward trend in the rate after that.

5 Methodological issues identified during the review

Some of the studies that data were extracted from had limitations in their methodologies. This made it very difficult to draw generalisable conclusions from them. For instance, Stocks *et al.* (2011) (Section 3.1.3) drew data from clinical reports of work-related illness. The voluntary reporting system that provided the data appears not to have been extensive enough to provide either a suitably large or representative sample of the construction industry, especially given that it appeared occupational health access is largely only available via large employers.

Another issue arises in studies such as Wahlström *et al.* (2012) who used a very restrictive case definition of hospitalisation for at least a day due to lumbar disc disease (Section 3.2.1). This will result in lower incidence rates than in surveys like Dong *et al.* (2019) (Section 3.3) that include cases of MSDs with less severe outcomes, such as work loss.

Studies such as Wahlström *et al.* (2012) (Section 3.2.1) that use construction sector-wide, or even population databases to identify clinical outcomes have the advantage of comprehensive coverage of the at-risk population. This means they don't rely on employer surveys such as the BLS SOII (Section 3.3) that may suffer from differential reporting rates by different employers.

Some studies, such as Dong *et al.* (2019) (Section 3.3), report data from a limited set of construction sectors or occupations without clear explanation of how they selected the data to report. This leaves the issue of the risk to unlisted sectors or occupations as an unknown.

It was also apparent that the BLS SOII data used by Dong *et al.* (2019) (Section 3.3) were quite variable from year to year. Data averaged over multiple years give a more reliable method of comparing construction industry groups and occupations, rather than the single year "snapshot" for 2017 that Dong *et al.* (2019) reported.

Another issue arises with the reliability of different types of data. It became apparent from analysis of the BLS SOII data (Section 3.3) that reported 'days absent from work' is a highly variable measure from year to year even with the same industry subsectors. In contrast, the numbers of cases reported and hence injury rates were much more stable. This leads to the conclusion that injury rates are the preferable measure when comparing industries and occupations.

A factor to be borne in mind when comparing data over time is that classification systems for occupations and industries evolve over time to reflect changes in the economy and in individual occupations, with some decreasing in importance and new ones growing.

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7 Appendix

7.1 Search terms

Table 99. Musculoskeletal Disorders

General MSD terminology	Low back terminology	ULD terminology	Lower limb disorders terminology
Arthritis	Back ache	Acromio-clavicular affection	Compartment syndrome
Bursitis	Back pain	Acromioclavicular syndrome	Iliotibial band friction syndrome
Compression neuropathy	Back spasms	Adhesive capsulitis	Meniscal tear
Entrapment neuropathy	Cauda equina	Anterior interosseous syndrome	Meniscal lesions
Fibromyalgia	Degenerative disc disease	Carpal ganglion	Meniscal damage
MSD	Disc degeneration	Carpal tunnel syndrome	Patellofemoral syndrome
MSK	Disc herniation	Cervical degenerative disc disease	Shin splints
Muscular skeletal	Dorsalgia	Cervical radiculopathy	Stress fracture
Musculo skeletal	Herniated disc	Cervical syndrome	Stress reaction injury
Musculoskeletal	LBP	Cervico-brachial syndrome	Varicose veins
Musculo-skeletal	Low back pain	Cervico-cranial syndrome	
Myalgia	Lower back pain	Compression neuropathy	
Osteoarthritis	Lumbago	Costo-clavicular syndrome	
Repetition Strain Injury	Lumbalgia	Cramp of the hand or forearm	
Repetitive Strain Injury	Nerve root pain	CTS	

General MSD terminology	Low back terminology	ULD terminology	Lower limb disorders terminology
Repetitive Stress Injury	Prolapsed disc	Cubital tunnel syndrome	
Rheumatoid arthritis	Radiculopathy	De Quervain's disease	
RSI	Ruptured disc	Digital neuritis	
Spondyloarthritis	Sciatica	Dupuytren's contracture	
Tendinitis	Slipped disc	Dystonia	
Tendinopathy	Spondylolisthesis	Epicondylitis	
Tendonitis	Spondylitis	Extensor indicis proprius syndrome	
Tenosynovitis	Spondylosis	Extra-costal syndrome	
ULD		Flexor carpi radialis tendonitis	
Upper limb disorders		Flexor carpi ulnaris tendonitis	
WMSD		Frozen shoulder	
Work-related musculoskeletal disorders		Hand-arm vibration syndrome	
Work-related upper limb disorders		HAVS	
WRMSD		Hyper-abduction syndrome	
WRULD		Median nerve entrapment	
		Neck pain	
		Nerve compression	
		Nerve entrapment	
		Non-specific arm pain	
		Non-specific diffuse forearm pain	
		Occupational overuse syndrome	

General MSD terminology	Low back terminology	ULD terminology	Lower limb disorders terminology
		Overuse syndrome	
		Periarthritis humero-scapularis	
		Peripheral nerve entrapment	
		Peripheral nerve entrapment	
		Peritendinitis	
		Peritendinitis crepitans	
		Plantar fasciitis	
		Posterior interosseus nerve entrapment	
		Pronator syndrome	
		Radial nerve compression at the wrist	
		Radial nerve entrapment	
		Radial nerve syndrome	
		Radial tunnel syndrome	
		Rotator cuff disease	
		Rotator cuff syndrome	
		Rotator cuff tendinitis	
		Scalenus syndrome	
		Severe cramp	
		Shoulder capsulitis	
		Stenosing tenosynovitis	

General MSD terminology	Low back terminology	ULD terminology	Lower limb disorders terminology
		Stenosing teno-vaginitis	
		Tension neck	
		Thoracalgia	
		Thoracic outlet syndrome	
		Trapped nerve	
		Trigger digit	
		Trigger finger	
		Ulnar nerve entrapment	
		Ulnar neuritis	
		Ulnar tunnel syndrome	
		Ulnar wrist extensor tendonitis	
		Vibration White Finger	
		Wartenburg's syndrome	

Table 100. Construction related search terms

Construction trade names	Construction trade descriptions	Construction equipment/ plant names	Hand-held construction equipment/tools
Bench joiner	Air-conditioning	Asphalt planer	Angle grinders
Boilermaker	Bathroom	Back actor	Chipping hammer
Brickie	Bitumen	Back hoe loader	Circular saw
Bricklayer	Canal repair	Backhoe	Cut-off saws
Brickmason	Carpet	Boom lift	Demolition hammer

Construction trade names	Construction trade descriptions	Construction equipment/ plant names	Hand-held construction equipment/tools
Builder	Cavity insulation	Boring machine	Impact driver
Canal liner	Ceiling	Bucket truck	Jackhammer
Canal trimmer	Cement	Bulldozer	Nail gun
Carpenter	Concrete	Cement mixer	Pavement breaker
Cement Mason	Concrete consolidation	Chip spreader	Plate compactor
Cladder	Concrete reinforcement	Cold milling machine	Pneumatic breaker
Concrete finisher	Construction	Cold planer	Pneumatic drill
Concrete pourer	Demolition	Compactor	Pneumatic hammer
Construction diver	Dry lining	Concrete boom pump	Pneumatic jackhammer
Curtain waller	Drywall	Concrete pump	Pneumatic pavement breaker
Decorator	Electrical	Construction plant	Power drill
Demolition topman	Emulsion	Crane	Router
Dry liner	Fence	Digger	Sander
Electrician	Fencing	Dozer	Saw
Engineering construction craftworker	Floor	Drilling machine	Screwdriver
Fencer	Flooring	Excavator	Spanner
Flat roofer	Flue	Grader	Wacker plate
Formworker	Formwork	Heavy equipment	Wrench
Glazier	Framer	Hoe loader	
Ground worker	Framework	Hoe ram	
Insulator	Gas installation	Hoe rammer	

Construction trade names	Construction trade descriptions	Construction equipment/ plant names	Hand-held construction equipment/tools
Iron worker	Gas mains	Hoist	
Joiner	Gas maintenance	Hydraulic breaker	
Labourer	Gas networks (main laying)	Lightning conductor	
Mason	Gas service	Loader	
Masonry	Geotechnical	Loader back hoe	
Mason tender	Glass	Micro tunnel system	
Painter	Heating	Micro-tunnelling	
Painter and decorator	Heating and ventilation	Milling machine	
Pipelayer	Highways	Motor grader	
Pipework lagger	HVAC	Paver	
Plasterer	Insulating	Payloader	
Plumber	Insulation	Pile	
Rigger	Iron	Piling	
Rodbuster	Kitchen	Power line	
Roofer	Landscaper	Power shovel	
Scaffolder	Mechanical maintenance	Reach forklift	
Slater	Paint	Rear actor	
Steeplejack	Painting	Road breaker	
Stone mason	Pipe	Road grader	
Thatcher	Plastering	Road planer	
Tiler	Plumbing	Roller	

Construction trade names	Construction trade descriptions	Construction equipment/ plant names	Hand-held construction equipment/tools
Wallpaper hanger	Pouring concrete	Roller-compactor	
Waterproofer	Rebar	Scissor lift	
Welder	Refrigeration and air-conditioning	Scraper	
Wood worker	Road construction	Side boom	
	Rod	Skid steer	
	Roofing	Skid-loader	
	Scaffolding	Skid-steer loader	
	Sheet metal	Spider lift	
	Slip form	Steam roller	
	Steel	Tar sprayer	
	Thermal insulation	Telehandler	
	Water distribution	Teleporter	
	Water leakage	Telescopic handler	
	Water network	Tipper	
	Water network service	Tipper lorry	
	Winch	Tip-trailer	
	Window	Tip-truck	
		Track	
		Track hoe	
		Tractor-scraper	
		Trench roller	

Construction trade names	Construction trade descriptions	Construction equipment/ plant names	Hand-held construction equipment/tools
		Trencher	
		Truck	

Table 101. Other categories of search terms

Construction materials	Construction materials (continued)	Construction occupations	Manual handling terms
Aggregate	Masonry	Driver	Manual handling
Ballast	Metal	Engineer	Manual materials handling
Blocks	Mortar	Erector	Lifting
Bricks	Paving slabs	Finisher	Lowering
Cable	Plaster	Fitter	Putting down
Cement	Plasterboard	Fixer	Pushing
Ceramic	Plastics	Installer	Pulling
Cladding	Render	Labourer	Carrying
Clay	Roofing	Layer	Holding
Composites	Roof trusses	Maker	Transporting
Concrete	Rolled steel joist	Mechanic	Supporting
Doors	RSJ	Operative	
Flags	Sand	Operator	
Flashing	Sanitary ware	Specialist	
Flooring	Sheet materials	Sprayer	
Glass	Slate	Technician	
Glazing	Steel beams	Worker	
Insulation	Stone		
Kerbs	Tiles		
Kerbstones	Timber		
Lead	Window frames		
Lintels	Wood		

7.2 Equivalent UK and US industrial and occupational classifications

Table 102. Mapping of 2017 NAICS codes and titles to UK SIC 2007 codes and titles

2017 NAICS code	2017 NAICS short title	UK SIC 2007 code	UK SIC 2007 description
23	Construction	F	Construction
236	Construction of buildings	F41	Construction of buildings
2361	Residential building construction	F41.2	Construction of residential and non-residential buildings
23611	Residential building construction	F41.20	Construction of residential and non-residential buildings
236115	New single-family general contractors	F41.20	Construction of residential and non-residential buildings
236116	New multifamily general contractors	F41.20	Construction of residential and non-residential buildings
236117	New housing for-sale builders	F41.20	Construction of residential and non-residential buildings
236118	Residential remodelers	F41.20	Construction of residential and non-residential buildings
2362	Nonresidential building construction	F41.2	Construction of residential and non-residential buildings
23621	Industrial building construction	F41.20	Construction of residential and non-residential buildings
236210	Industrial building construction	F41.20	Construction of residential and non-residential buildings
23622	Commercial building construction	F41.20	Construction of residential and non-residential buildings
236220	Commercial building construction	F41.20	Construction of residential and non-residential buildings
237	Heavy and civil engineering construction	F42	Civil engineering
2371	Utility system construction	F42.2	Construction of utility projects
23711	Water and sewer system construction	F42.21	Construction of utility projects for fluids
237110	Water and sewer system construction	F42.21	Construction of utility projects for fluids
23712	Oil and gas pipeline construction	F42.21	Construction of utility projects for fluids

2017 NAICS code	2017 NAICS short title	UK SIC 2007 code	UK SIC 2007 description
237120	Oil and gas pipeline construction	F42.21	Construction of utility projects for fluids
23713	Power and communication system construction	F42.22	Construction of utility projects for electricity and telecommunications
237130	Power and communication system construction	F42.22	Construction of utility projects for electricity and telecommunications
2372	Land subdivision	F43.12	Site preparation
23721	Land subdivision	F43.12	Site preparation
237210	Land subdivision	F43.12	Site preparation
2373	Highway, street, and bridge construction	F42.1	Construction of roads and railways
23731	Highway, street, and bridge construction	F42.11	Construction of roads and motorways
237310	Highway, street, and bridge construction	F42.11	Construction of roads and motorways
2379	Other heavy construction	F42.9	Construction of other civil engineering projects
23799	Other heavy construction	F42.12	Construction of railways and underground railways
237990	Other heavy construction	F42.99	Construction of other civil engineering projects n.e.c.
238	Specialty trade contractors	F43	Specialised construction activities
2381	Building foundation and exterior contractors	F43.99	Other specialised construction activities n.e.c.
23811	Poured concrete structure contractors	F43.99	Other specialised construction activities n.e.c.
238110	Poured concrete structure contractors	F43.99	Other specialised construction activities n.e.c.
23812	Steel and precast concrete contractors	F43.99	Other specialised construction activities n.e.c.
238120	Steel and precast concrete contractors	F43.99	Other specialised construction activities n.e.c.
23813	Framing contractors	F43.99	Other specialised construction activities n.e.c.
238130	Framing contractors	F43.99	Other specialised construction activities n.e.c.

2017 NAICS code	2017 NAICS short title	UK SIC 2007 code	UK SIC 2007 description
23814	Masonry contractors	F43.99	Other specialised construction activities n.e.c.
238140	Masonry contractors	F43.99	Other specialised construction activities n.e.c.
23815	Glass and glazing contractors	F43.32	Joinery installation
238150	Glass and glazing contractors	F43.32	Joinery installation
23816	Roofing contractors	F43.91	Roofing activities
238160	Roofing contractors	F43.91	Roofing activities
23817	Siding contractors	F43.99	Other specialised construction activities n.e.c.
238170	Siding contractors	F43.99	Other specialised construction activities n.e.c.
23819	Other building exterior contractors	F43.99	Other specialised construction activities n.e.c.
238190	Other building exterior contractors	F43.99	Other specialised construction activities n.e.c.
2382	Building equipment contractors	F43.2	Electrical, plumbing and other construction installation activities
23821	Electrical and wiring contractors	F43.21	Electrical installation
238210	Electrical and wiring contractors	F43.21	Electrical installation
23822	Plumbing and HVAC contractors	F43.22	Plumbing, heat and air-conditioning installation
238220	Plumbing and HVAC contractors	F43.22	Plumbing, heat and air-conditioning installation
23829	Other building equipment contractors	F43.29	Other construction installation
238290	Other building equipment contractors	F43.29	Other construction installation
2383	Building finishing contractors	F43.3	Building completion and finishing
23831	Drywall and insulation contractors	F43.31	Plastering
238310	Drywall and insulation contractors	F43.31	Plastering

2017 NAICS code	2017 NAICS short title	UK SIC 2007 code	UK SIC 2007 description
23832	Painting and wall covering contractors	F43.34	Painting and glazing
238320	Painting and wall covering contractors	F43.34	Painting and glazing
23833	Flooring contractors	F43.33	Floor and wall covering
238330	Flooring contractors	F43.33	Floor and wall covering
23834	Tile and terrazzo contractors	F43.33	Floor and wall covering
238340	Tile and terrazzo contractors	F43.33	Floor and wall covering
23835	Finish carpentry contractors	F43.32	Joinery installation
238350	Finish carpentry contractors	F43.32	Joinery installation
23839	Other building finishing contractors	F43.39	Other building completion and finishing
238390	Other building finishing contractors	F43.39	Other building completion and finishing
2389	Other specialty trade contractors	F43.9	Other specialised construction activities
23891	Site preparation contractors	F43.1	Demolition and site preparation
238910	Site preparation contractors	F43.12	Site preparation
23899	All other specialty trade contractors	F43.99	Other specialised construction activities n.e.c.
238990	All other specialty trade contractors	F43.99	Other specialised construction activities n.e.c.

2017 NAICS, North American Industrial Classification System; SIC, Standard Industrial Classification; n.e.c., Not elsewhere classified.

Construction industry NAICS codes from Office of Management and Budget (2017) mapped onto nearest industry codes from the UK SIC 2007 classification (Prosser, 2009)

Table 103. Mapping of US 2010 SOC codes to UK SOC 2010 codes

US 2010 SOC code *	US 2010 SOC Occupation title	UK SOC 2010 code †	UK SOC 2010 Group title
11-0000	Management occupations	1	Managers, directors and senior officials
11-9000	Other management occupations	11	Corporate managers and directors
11-9020	Construction managers	1122	Production managers and directors in construction
11-9021	Construction managers	1122	Production managers and directors in construction
11-9040	Architectural and engineering managers	2435	Chartered architectural technologists
11-9041	Architectural and engineering managers	2435	Chartered architectural technologists
13-0000	Business and financial operations occupations	24	Business, media and public service professionals
13-1000	Business operations specialists	242	(Business, research and administrative professionals)
13-1050	Cost estimators	2433	Quantity surveyors
13-1051	Cost estimators	2433	Quantity surveyors
17-0000	Architecture and engineering occupations	21	Science, research, engineering and technology professionals
17-1000	Architects, surveyors, and cartographers	243	Architects, town planners and surveyors
17-1010	Architects, except naval	2431	Architects
17-1011	Architects, except landscape and naval	2431	Architects
17-1020	Surveyors, cartographers, and photogrammetrists	243	Architects, town planners and surveyors
17-1022	Surveyors	2434	Chartered surveyors
17-2000	Engineers	212	Engineering professionals
17-2050	Civil engineers	2121	Civil engineers
17-2051	Civil engineers	2121	Civil engineers

US 2010 SOC code *	US 2010 SOC Occupation title	UK SOC 2010 code †	UK SOC 2010 Group title
17-3000	Drafters, engineering technicians, and mapping technicians	311	Science, engineering and production technicians
17-3010	Drafters	3122	Draughtspersons
17-3011	Architectural and civil drafters	3121	Architectural and town planning technicians
17-3020	Engineering technicians, except drafters	31	Science, engineering and technology associate professionals
17-3022	Civil engineering technicians	3114	Building and civil engineering technicians
17-3030	Surveying and mapping technicians	312	Draughtspersons and related architectural technicians
17-3031	Surveying and mapping technicians	312	Draughtspersons and related architectural technicians
19-0000	Life, physical, and social science occupations	211	(Natural and social science professionals)
19-3000	Social scientists and related workers	2114	(Social and humanities scientists)
19-3050	Urban and regional planners	2432	Town planning officers
19-3051	Urban and regional planners	2432	Town planning officers
47-0000	Construction and extraction occupations	53	Skilled construction and building trades
47-1000	Supervisors of construction and extraction workers	533	Construction and building trades supervisors
47-1010	First-line supervisors of construction trades and extraction workers	533	Construction and building trades supervisors
47-1011	First-line supervisors of construction trades and extraction workers	5330	Construction and building trades supervisors
47-2000	Construction trades workers	531	Construction and building trades
47-2010	Boilermakers	5214	Metal plate workers, and riveters
47-2011	Boilermakers	5214	Metal plate workers, and riveters

US 2010 SOC code *	US 2010 SOC Occupation title	UK SOC 2010 code †	UK SOC 2010 Group title
47-2020	Brickmasons, blockmasons, and stonemasons	5312	Bricklayers and masons
47-2021	Brickmasons and blockmasons	5312	Bricklayers and masons
47-2022	Stonemasons	5312	Bricklayers and masons
47-2030	Carpenters	5315	Carpenters and joiners
47-2031	Carpenters	5315	Carpenters and joiners
47-2040	Carpet, floor, and tile installers and finishers	5322	Floorers and wall tilers
47-2041	Carpet installers	5322	Floorers and wall tilers
47-2042	Floor layers, except carpet, wood, and hard tiles	5322	Floorers and wall tilers
47-2043	Floor sanders and finishers	5322	Floorers and wall tilers
47-2044	Tile and marble setters	5322	Floorers and wall tilers
47-2050	Cement masons, concrete finishers, and terrazzo workers	5321	Plasterers
47-2051	Cement masons and concrete finishers	5321	Plasterers
47-2053	Terrazzo workers and finishers	5322	Floorers and wall tilers
47-2060	Construction laborers	912	Elementary construction occupations
47-2061	Construction laborers	9120	Elementary construction occupations
47-2070	Construction equipment operators	822	Mobile machine drivers and operatives
47-2071	Paving, surfacing, and tamping equipment operators	8142	Road construction operatives
47-2072	Pile-driver operators	8229	Mobile machine drivers and operatives n.e.c.
47-2073	Operating engineers and other construction equipment operators	8229	Mobile machine drivers and operatives n.e.c.
47-2080	Drywall installers, ceiling tile installers, and tapers	5321	Plasterers

US 2010 SOC code *	US 2010 SOC Occupation title	UK SOC 2010 code †	UK SOC 2010 Group title
47-2081	Drywall and ceiling tile installers	5321	Plasterers
47-2082	Tapers	5321	Plasterers
47-2110	Electricians	5241	Electricians and electrical fitters
47-2111	Electricians	5241	Electricians and electrical fitters
47-2120	Glaziers	5316	Glaziers, window fabricators and fitters
47-2121	Glaziers	5316	Glaziers, window fabricators and fitters
47-2130	Insulation workers	8149	Construction operatives n.e.c.
47-2131	Insulation workers, floor, ceiling, and wall	8149	Construction operatives n.e.c.
47-2132	Insulation workers, mechanical	8149	Construction operatives n.e.c.
47-2140	Painters and paperhangers	5323	Painters and decorators
47-2141	Painters, construction and maintenance	5323	Painters and decorators
47-2142	Paperhangers	5323	Painters and decorators
47-2150	Pipelayers, plumbers, pipefitters, and steamfitters	5216	Pipe fitters
47-2151	Pipelayers	5216	Pipe fitters
47-2152	Plumbers, pipefitters, and steamfitters	5216	Pipe fitters
47-2160	Plasterers and stucco masons	5321	Plasterers
47-2161	Plasterers and stucco masons	5321	Plasterers
47-2170	Reinforcing iron and rebar workers	5319	Construction and building trades n.e.c.
47-2171	Reinforcing iron and rebar workers	5319	Construction and building trades n.e.c.
47-2180	Roofers	5313	Roofers, roof tilers and slaters

US 2010 SOC code *	US 2010 SOC Occupation title	UK SOC 2010 code †	UK SOC 2010 Group title
47-2181	Roofers	5313	Roofers, roof tilers and slaters
47-2210	Sheet metal workers	5213	Sheet metal workers
47-2211	Sheet metal workers	5213	Sheet metal workers
47-2220	Structural iron and steel workers	5311	Steel erectors
47-2221	Structural iron and steel workers	5311	Steel erectors
47-2230	Solar photovoltaic installers	5241	Electricians and electrical fitters
47-2231	Solar photovoltaic installers	5241	Electricians and electrical fitters
47-3000	Helpers, construction trades	814	Construction operatives
47-3010	Helpers, construction trades	9120	Elementary construction occupations
47-3011	Helpers--brickmasons, blockmasons, stonemasons, and tile and marble setters	9120	Elementary construction occupations
47-3012	Helpers--carpenters	9120	Elementary construction occupations
47-3013	Helpers--electricians	9120	Elementary construction occupations
47-3014	Helpers--painters, paperhangers, plasterers, and stucco masons	9120	Elementary construction occupations
47-3015	Helpers--pipelayers, plumbers, pipefitters, and steamfitters	9120	Elementary construction occupations
47-3016	Helpers--roofers	9120	Elementary construction occupations
47-3019	Helpers, construction trades, all other	9120	Elementary construction occupations
47-4000	Other construction and related workers	5319	Construction and building trades n.e.c.
47-4010	Construction and building inspectors	3565	Inspectors of standards and regulations
47-4011	Construction and building inspectors	3565	Inspectors of standards and regulations

US 2010 SOC code *	US 2010 SOC Occupation title	UK SOC 2010 code †	UK SOC 2010 Group title
47-4020	Elevator installers and repairers	5241	Electricians and electrical fitters
47-4021	Elevator installers and repairers	5241	Electricians and electrical fitters
47-4030	Fence erectors	5319	Construction and building trades n.e.c.
47-4031	Fence erectors	5319	Construction and building trades n.e.c.
47-4040	Hazardous materials removal workers	8149	Construction operatives n.e.c.
47-4041	Hazardous materials removal workers	8149	Construction operatives n.e.c.
47-4050	Highway maintenance workers	8142	Road construction operatives
47-4051	Highway maintenance workers	8142	Road construction operatives
47-4060	Rail-track laying and maintenance equipment operators	8143	Rail construction and maintenance operatives
47-4061	Rail-track laying and maintenance equipment operators	8143	Rail construction and maintenance operatives
47-4070	Septic tank servicers and sewer pipe cleaners	8126	Water and sewerage plant operatives
47-4071	Septic tank servicers and sewer pipe cleaners	8126	Water and sewerage plant operatives
47-4090	Miscellaneous construction and related workers	5319	Construction and building trades n.e.c.
47-4091	Segmental pavers	8142	Road construction operatives
47-4099	Construction and related workers, all other	5319	Construction and building trades n.e.c.
49-0000	Installation, maintenance, and repair occupations	5	Skilled trades occupations
49-2000	Electrical and electronic equipment mechanics, installers, and repairers	524	Electrical and electronic trades
49-2020	Radio and telecommunications equipment installers and repairers	5242	Telecommunications engineers

US 2010 SOC code *	US 2010 SOC Occupation title	UK SOC 2010 code †	UK SOC 2010 Group title
49-2022	Telecommunications equipment installers and repairers, except line installers	5242	Telecommunications engineers
49-2090	Miscellaneous electrical and electronic equipment mechanics, installers, and repairers	5249	Electrical and electronic trades n.e.c.
49-2098	Security and fire alarm systems installers	5249	Electrical and electronic trades n.e.c.
49-9000	Other installation, maintenance, and repair occupations	5319	Construction and building trades n.e.c.
49-9010	Control and valve installers and repairers	5319	Construction and building trades n.e.c.
49-9011	Mechanical door repairers	5319	Construction and building trades n.e.c.
49-9020	Heating, air conditioning, and refrigeration mechanics and installers	5314	Plumbers and heating and ventilating engineers
49-9021	Heating, air conditioning, and refrigeration mechanics and installers	5225	Air-conditioning and refrigeration engineers
49-9040	Industrial machinery installation, repair, and maintenance workers	5223	Metal working production and maintenance fitters
49-9044	Millwrights	5223	Metal working production and maintenance fitters
49-9050	Line installers and repairers	5249	Electrical and electronic trades n.e.c.
49-9051	Electrical power-line installers and repairers	5249	Electrical and electronic trades n.e.c.
49-9052	Telecommunications line installers and repairers	5242	Telecommunications engineers
49-9090	Miscellaneous installation, maintenance, and repair workers	5319	Construction and building trades n.e.c.
49-9096	Riggers	8141	Scaffolders, stagers and riggers
51-0000	Production occupations	8	Process, plant and machine operatives
51-2000	Assemblers and fabricators	52	Skilled metal, electrical and electronic trades

US 2010 SOC code *	US 2010 SOC Occupation title	UK SOC 2010 code †	UK SOC 2010 Group title
51-2040	Structural metal fabricators and fitters	5311	Steel erectors
51-2041	Structural metal fabricators and fitters	5311	Steel erectors
51-4000	Metal workers and plastic workers	521	Metal forming, welding and related trades
51-4120	Welding, soldering, and brazing workers	5215	Welding trades
51-4121	Welders, cutters, solderers, and brazers	5215	Welding trades
53-0000	Transportation and material moving occupations	82	Transport and mobile machine drivers and operatives
53-7000	Material moving workers	812	Plant and machine operatives
53-7020	Crane and tower operators	8221	Crane drivers
53-7021	Crane and tower operators	8221	Crane drivers
53-7030	Dredge, excavating, and loading machine operators	8229	Mobile machine drivers and operatives n.e.c.
53-7032	Excavating and loading machine and dragline operators	8229	Mobile machine drivers and operatives n.e.c.

(), UK SOC 2020 Group titles in brackets do not contain UK construction occupations; SOC, Standard Occupational Classification; n.e.c., Not elsewhere classified.

* In the US 2010 SOC, codes ending in -0000 are Major groups; codes ending in -x000 are Minor groups; codes ending in -xxx0 are Broad groups; codes ending in -xxxx are Detailed occupations.

† In the UK SOC 2010, single digit codes are Major groups; two digit codes are Sub-major groups; three digit codes are Minor groups; four digit codes are Unit groups.

Construction occupations from U.S. Bureau of Labor Statistics (2013) mapped onto nearest occupations from Office for National Statistics (2010)

8 Glossary

Acute illness/injury
In medicine, an 'acute' injury or disease occurs rapidly or suddenly and is likely to have a duration of a few weeks at most. The term does not relate to the intensity or severity of the problem.

Carpal tunnel syndrome
Compression neuropathy causing muscular weakness in the hands. Caused by compression of the median nerve in the carpal tunnel in the wrist.

Carpenters (general)
General carpenters provide the crucial foundation for concrete, exteriors, roofs, infrastructure, and scaffolding while also crafting fine trim and finish work. These professionals work with a variety of materials in every kind of structure; they are responsible for bringing blueprints to life. Source: Carpenters (General) • (carpenters.org)

Chronic illness
In medicine, a chronic illness, injury or disease is long-lasting, perhaps life-long.

Coefficient of variation
The ratio of the standard deviation of a set of data to its arithmetic mean, usually expressed as a percentage. It is a measure of the variability of a data set.

Epicondyles
A pair of bony protuberances on the sides of the elbow where tendons of muscles in the forearm originate. The medial epicondyle is on the side of the elbow nearer the trunk. The lateral epicondyle is on the outside of the elbow. Epicondylitis is a clinical condition involving inflammation of one or both of the epicondyles.

Floor coverers
Floor coverers install a wide variety of flooring materials, including carpet, resilients, wood, laminates, and sport surfaces. Source: Floor Coverers • (carpenters.org)

Interior systems carpenters
Interior systems carpenters specialize in assembling complex systems such as acoustical ceilings, computer-access flooring, metal framing, wall partitions, and office furniture. Source: Interior Systems • (carpenters.org)

Lateral epicondylitis
Inflammation of the wrist extensor tendons of the forearm where they originate on the lateral epicondyle of the elbow. Also known as 'tennis elbow'.

Lathers
Lathers build structural frameworks for plaster and other materials, creating such wonders as theme park attractions and ornamental ceilings. While lathers once worked with

wooden strips called lath, they now mostly employ wire and metal mesh to create structures of various shapes. Source: [Lathers • (carpenters.org)]

Lower extremity/lower limb
The leg from the toes to the hip.

Mean/arithmetic mean
A summary statistic for a set of data that shows the "average". It is the sum of all the values divided by the number of values.

Medial epicondylitis
Inflammation of the wrist flexor tendons of the forearm where they originate on the medial epicondyle of the elbow. Also known as 'golfer's elbow'.

Median
A summary statistic for a set of data that shows the "average". It is the middle value of a sorted list of the values.

Millworkers and cabinetmakers
Custom architectural millwork requires the work of an expert—a skilled professional who can craft fine woodwork, cabinetry, and décor in commercial, residential, institutional, and retail structures. Cabinetmakers and millworkers fabricate and install decorative and functional elements, including trim and molding, cabinetry, ceiling treatments, doors, windows, exposed columns and beams, displays, mantels, staircases, and more. Source: [Millworkers & Cabinetmakers • (carpenters.org)]

Millwrights (US terminology)
"Millwrights install, maintain, diagnose, and repair equipment such as compressors, pumps, conveyors, gas and steam turbines, monorails, and extruders." Source: [Millwrights • (carpenters.org)]

Musculoskeletal disorders (MSDs)
Musculoskeletal disorders are injuries or disorders of the muscles, nerves, ligaments, tendons, joints, cartilage, and spinal discs.

Non-traumatic soft tissue disorders
Disorders of the soft tissues (muscle, ligaments, nerves) not caused by traumatic injuries or wounds.

Overexertion injuries
A musculoskeletal injury clearly of traumatic/acute onset or a sprain strain or overexertion injury that cannot be clearly identified as the result of cumulative/repetitive injury.

Piledrivers
Pile drivers drive steel, concrete, or wood piling into the earth during the early stages of construction. Skill is crucial to both a project's success and the safety of workers, since the piling is necessary to hold back the earth during excavations; to set up the foundation of skyscrapers, highways, and bridges; and to build docks and wharfs. Source: [Pile Drivers • (carpenters.org)]

Poisson Regression
Poisson regression is a statistical method that can be used to test whether differences in numbers of events between different groups are statistically significant. Hence it can be used to compare rates of events in different groups.

Prevention Index (PI)
An index developed in Washington State to rank industries for urgency of intervention. It averages the rank of the injury rate and the rank of number of incidents in an industry or risk group. This allows both the injury rate and the size of the industry to be taken into account.

Residential and framing carpenters
The residential carpenter is an all-around carpenter with experience in nearly every aspect of residential construction. These UBC professionals work expertly and efficiently to assemble and erect the framework of homes, apartments, and condos. They install flooring, windows, doors, interior trim, cabinetry, roofing, siding, insulation, drywall, and more. Source: Residential & Framing • (carpenters.org).

Rotator cuff syndrome
Inflammation, degeneration or mechanical damage to the tendons surrounding the shoulder capsule that holds the head of the humerus in place.

Sciatica
Pain radiating down the back of the leg to below the knee due to compression of the sciatic nerve where it exits the spinal column in the low back. Usually caused by herniation of the intervertebral disc between the L5 and S1 vertebrae.

Standard deviation
A measure of the variability of a set of data. It has the same units as the underlying data.

Trauma
A wound or injury.

Upper extremity/upper limb
The arm from the fingertips to the shoulder but excluding the neck.

WIC (Washington Industrial risk Classification)
The Washington State WC scheme calculates the insurance premiums that employers pay using the WIC. This uses both industry and occupation to group workplaces with similar risks of workers' compensation loss. Thus a painter and an electrician within the same construction company that has a single NAICS code will be in different WIC risk classes (Anderson *et al.*, 2013). "Each classification describes the types of businesses and operations it includes, and the classification is a blend of exposures and risks representing the combined work for all of the businesses in the classification"[27].

[27] Chapter 296-17 WAC, "General Reporting Rules, Audit and Recordkeeping, Rates and Rating System for Washington Workers' Compensation Insurance". Available at https://apps.leg.wa.gov/wac/.

Workers' Compensation
Insurance based payments to workers unable to work because of injury or illness. Typically, the payments cover direct medical costs and wage replacement costs when a person is absent from work for over three days.

Work-related musculoskeletal disorders (WRMSDs) are a major cause of pain, lost working time and economic cost in Great Britain. Construction workers are particularly affected. HSE commissioned this research to better understand which construction jobs and tasks carry the greatest risk.

The research systematically reviewed epidemiological studies of MSD outcomes associated with trades and tasks. It also analysed long-term data from the UK Labour Force Survey and US Survey of Occupational Injuries and Illnesses. Evidence from multiple countries and datasets shows:

- Construction workers experience higher WRMSD risk than the wider workforce, but this greatly varies across trades.
- Finishing trades like floor layers, plasterboard installers, plasterers and joiners, plumbers, and labourers are identified as high-risk groups.
- Back disorders and upper-limb injuries dominate the claims burden.
- High risk activities involve cumulative physical load or physical stresses for the whole body, heavy materials handling, awkward postures, kneeling and repetitive wrist-intensive tasks.
- International data strongly aligns with UK patterns and can support GB-specific interventions where domestic data are limited.

This evidence provides a robust basis for prioritising preventative actions to reduce risks and feeds into HSE's regulatory approaches.

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