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REVIEW ARTICLE

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Differences between men and women in their risk of work injury and disability: A systematic review

Aviroop Biswas PhD[1,2] | Shireen Harbin RN, BScN[1] | Emma Irvin BA[1] | Heather Johnston MSc, PhD[1,3] | Momtaz Begum MPH[1] | Maggie Tiong MA, MI[1] | Dorothy Apedaile MPH[2] | Mieke Koehoorn PhD[1,4] | Peter Smith PhD[1,2,5]

[1]Institute for Work & Health, Toronto, Ontario, Canada

[2]Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada

[3]School of Kinesiology and Health Science, York University, Toronto, Ontario, Canada

[4]School of Population and Public Health, University of British Columbia, Vancouver, British Columbia, Canada

[5]Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Victoria, Australia

Correspondence

Aviroop Biswas, PhD, 400 University Ave., Suite 1800, Toronto, ON, M5G 1S5, Canada.
Email: abiswas@iwh.on.ca

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Abstract

Background: Health responses associated with occupational exposures can vary between men and women.

Aims: This study reviewed the work injury and disability risks associated with similar types of occupational exposures for men and women within and across occupations.

Materials & Methods: A systematic review was undertaken of observational studies published between 2009 and 2019. Studies were required to empirically compare men and women for associations between occupational exposures and work injury or disability outcomes. Included studies were appraised for methodological quality and medium to high rated studies were compared for risk differences between men and women.

Results: Of 14,006 records identified, 440 articles were assessed for methodological quality, and 33 medium to high rated studies were included and reviewed. Among all occupations, the association between physical exposures, job demands, noise, and repetitive tasks, and injury risk were stronger among men. The relationship between repetitive tasks and sickness absence was stronger among women. Most studies examining psychological exposures found no risk differences for men and women across occupations. Men were at higher injury risk in certain occupations in primary and secondary industry sectors involving physical exposures and some chemical/biological exposures. Women were at higher injury risk for the physical demands and repetitive tasks of health care and aluminum production occupations.

Conclusion: This review found that men and women can have different work injury and disability risks, both across and within the same occupations, for some physical exposures and to a lesser extent for some chemical and biological exposures. These differences might be a result of occupation-specific task differences.

KEYWORDS

gender, occupational exposures, sex, systematic review, work disability, work injury

This study was performed at the Institute for Work & Health, Toronto, ON, Canada.

1 | INTRODUCTION

Differences in gender (sociocultural constructs) and sex (biological factors) can affect the occupational health and safety of men and women in different ways. First, men and women have, on average, some biological differences (e.g., body size and shape, muscle anatomy and function, the metabolism of toxic compounds, hormones, and immunological responses), and their associations with occupational health outcomes have not been fully explored.[1,2] Second, both sex and gendered roles and expectations results in differential participation of men and women in different occupations in the labor market, which in turn lead to differences in occupational exposures.[3,4] Third, men and women in the same occupations do not always perform the same work tasks or can perform the same tasks differently.[2,5] Fourth, men and women can have different health responses associated with the same job assignments due to the interaction of their work environments with sex-based biological differences.[2,3,6] For example, differences in the average size and strength capacity between men and women within work environments designed for the anthropometric average man might explain the higher risk of musculoskeletal injury for women in some studies.[7–9] Fifth, gender differences in work-family demands, position in the occupational hierarchy, and gendered expectations for job performance can contribute to an unequal distribution of occupational exposures and attenuate occupational health risks.[10,11]

Occupational health research that is sensitive to sex/gender differences (hereinafter the interconnected dimensions of sex/gender will also be referred to as "men and women," unless otherwise specified) has the potential to expand our understanding of the health determinants of workers and is strongly recommended for targeted and inclusive work modification and hazard prevention strategies.[2,12] Yet, amidst the considerable amount of occupational health research examining sex/gender differences, existing reviews on the scope of potential differences in work injury and work disability in men and women are limited. A systematic review of mostly cross-sectional studies by Campos-Serna et al.[11] reporting on the prevalence of work-related health outcomes had found that women were at higher risk of poor physical and mental health than men. Two other review studies also reported that different psychosocial and work organization exposures based on the gender compositions of different occupations were associated with a higher risk for women of poor mental health,[13] and injury, illness and mortality.[14] However, these reviews were focused on a narrow field of physical and psychosocial occupational exposures related to work-related injury and disability. Accordingly, knowledge gaps remain on differences in risk of work injury and work disability for men and women with the same occupational exposures, including some associations that may not have been studied or reported. Furthermore, previous reviews had only examined sex and gender differences in occupational exposure-related outcomes according to the gendered segregation of the labor force (across occupations) but did not compare differences in occupational health outcomes of men and women within the same occupations. We can hypothesize that men and women in the same occupation are more similar in terms of work-related gender roles. Therefore, if differences in work exposures and health outcomes persist among different occupational groups, these are less likely to be due to gendered roles and expectations in relation to the labor market. By comparing the work injury and work disability outcomes of men and women for the same types of exposures, research can better inform where preventive policies and practices might be required to address occupational health disparities.

The objective of this systematic review was to synthesize evidence from research studies from the last decade that examined differences between men and women in their risks of work injury and work disability-related outcomes associated with the same types of occupational exposures both across occupations and within the same occupations.

2 | METHODS

This systematic review used a process developed by the Cochrane Collaboration which was adapted by the Institute for Work & Health (IWH) Systematic Review Program[15] and IWH's stakeholder collaboration model.[16] The review was registered on PROSPERO on August 8, 2019 (Registration number: CRD42019137010) and adheres to the 2020 *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) statement.[17]

2.1 | Identifying the research question

A series of meetings were held with a committee of stakeholder advisors comprised of five individuals with diverse and knowledgeable perspectives on occupational health and safety and sex/gender-based health research (the director of health and safety at a national union, the president of an industry association, the assistant director of a gender, sex, and health research institute, and a representative from the funder). The stakeholder advisors provided input on the research questions to ensure they were relevant and answerable within the project timeframe, helped refine the search strategy, and recommended studies relevant to the review.

2.2 | Identifying relevant studies

Eight electronic databases (MEDLINE [Ovid], Embase+Embase Classic [Ovid], PsycINFO [Ovid], Business Source Premier [EBSCO], EconLit [EBSCO], ABI Inform [Proquest], Social Services Abstracts [Proquest], Sociological Abstracts [Proquest]) were searched for peer-reviewed studies published from January 1, 2009 to May 1, 2019. The inclusion of studies was not limited by language. The search strategies were created by a research librarian (M. T.) and used a P.I.C.O. structure (Population, Intervention, Comparison, and Outcome). After the initial search strategy was developed, the

reviewers consulted with the stakeholder advisors to discuss the relevance of the terms and identify any missing terms. As controlled vocabularies differ significantly in the electronic databases, search terms were customized as needed. Terms within each category were combined with a Boolean OR operator and the main categories were then combined using a Boolean AND operator. In this way, the searches captured only studies that mentioned at least one term within each of the categories. The search terms used for the MEDLINE database are provided in Supporting Information: File 1. The reviewers and stakeholders were also solicited for studies that were in press (accepted by a journal but not yet published) or articles that were not captured by the formal search strategy but could be important for the review. Reference lists of included studies and relevant review articles were also scanned for references not previously captured. EndNote® was used to store references from all literature searches. Duplicates were removed and references loaded into DistillerSR®, an online systematic review management software designed specifically for the screening, quality appraisal, and data extraction phases of a systematic review.

2.3 | Study selection

Table 1 summarizes the inclusion criteria used to select relevant peer-reviewed studies. The following criteria were applied at the title/abstract and full-review stages: The population of interest were workers aged 18 and up to retirement who were described as employed at a workplace at the time of occupational exposure. Relevant occupational exposures were any work characteristics that could explain differences in work-related injury or work disability outcomes, including their indicators (e.g., sickness absence). Sex-specific reproductive health outcomes (e.g., miscarriage and menstruation rates, ovarian and prostate cancers) were not included in the search. Case–control (with rare outcomes), retrospective cohort, and prospective cohort study designs were accepted. Cross-sectional studies were excluded as it was not possible to determine a temporal relationship between exposure and outcome in these studies. Studies were required to provide a numerical comparison of the work injury and disability risks associated with occupational exposures for men and women (e.g., a comparison of odds ratios, relative risks, hazard ratios, incidence ratios). Studies were removed if they provided no direct statistical tests as they were uninformative to the research question.

Regular meetings were held with all reviewers to monitor the review process, address questions, and troubleshoot difficulties in assessing the studies. Non-English language studies were examined by the reviewers and their contacts who were fluent in the language. Only studies in Romanian, Hungarian, and Icelandic (four studies) were not reviewed as translators could not be found for these languages. Gender was treated as a simplistic binary definition as this is the way it is primarily reported in the work and health literature. The search strategy did not include terms to examine findings for participants' where their gender identity was different than assigned to them at birth or for nonbinary participants.

Reviewers were not blinded to the authors of the studies, but they did not screen or extract data from any of their own studies. Standardized relevance screening forms were created in DistillerSR® software to ensure that the reviewers uniformly applied the inclusion/exclusion criteria. The selection of relevant studies took place in two stages. In the first stage, the titles and abstracts of identified references were reviewed based on the inclusion/exclusion criteria. In the second stage, full texts were retrieved for those studies that: (i) were assessed by two reviewers as meeting the inclusion criteria or (ii) there was insufficient information based on the title and abstract to determine relevance.

TABLE 1 Summary of inclusion and exclusion criteria

Category	Inclusion	Exclusion
Population	Is the population (18 and up to retirement) tied to a current or previous workplace setting?	Exclude sex workers, housewives, and occupations that are generally not regulated under workers' compensation systems
Intervention/ Exposure	Does the article examine exposures related to working conditions (occupational exposures)?	Nonoccupational exposures
Comparison	Have the effects for men and women; males/females been reported separately? Have studies made assertions about differences between men and women (males/females); or stratified their analyses for men and women (males/females)?	Results presented for an overall sample of men and women/males and females together. Results presented only for men or only for women; only males or females
Outcomes	Does the article examine work-related injury, work-related disability and work-related sickness absence as outcomes?	Other work-related health outcomes for example, cardiovascular disease, mental health episodes, cancer. Outcomes linked indirectly to health; health behaviors; dimensions of wellbeing. For example, physical inactivity, presenteeism, return on investment, diet quality, job satisfaction, happiness, indicators of education/social status, and so forth. Reproductive health outcomes specific to a sex, for example, ovarian and testicular cancers

Due to the large number of studies retrieved by the search, the artificial intelligence (AI) feature of the DistillerSR® software was used, pairing a human reviewer with the AI feature to double-review each reference at the title/abstract and full-text stages of relevance screening. This required "training" the AI on a portion of studies reviewed by two humans at both stages so that the AI "learned" which types of studies were relevant to the review before "running" the AI as a second reviewer to the single human reviewer. Disagreements between the human and AI feature were reviewed by a third (human) reviewer until consensus was achieved.

2.4 | Quality appraisal

Studies were appraised for methodological quality using the Newcastle-Ottawa Scale (NOS) for Cohort Studies and Case-Control Studies.[18] The scales assess studies on three broad perspectives: the selection of the study groups; the comparability of the groups; and the ascertainment of either the exposure or outcome of interest for case–control or cohort studies, respectively. The instrument is scored by awarding a point for each answer that is marked with an asterisk on the NOS guide (Supporting Information: File 2). Possible points are four points for selection, two points for comparability, and three points for outcomes. With the NOS tool, all the study components were summed for a score from 0 (poorest quality) to the highest possible score of 9. No points were given to studies based on their treatment of sex/gender variables. To have confidence in the study findings, only studies with a moderate to high-quality score from 5 to 9 proceeded to the data extraction and evidence synthesis steps.

A pilot test of the NOS quality assessment forms was completed to ensure consistent interpretation by reviewers. Ten percent of studies were double reviewed by the review team as per AMSTAR guidelines[19]; conflicts were resolved by discussion. Once consensus was reached on the reviewing process, the remaining studies were reviewed by individual reviewers for quality appraisal. Review team members did not appraise studies that they consulted on, authored, or co-authored. Conflicts were resolved through discussion.

2.5 | Data extraction

A data extraction form was created in the DistillerSR® software based on input from review members and the project funder. Studies were characterized according to the last name of the first author, year of publication, country where the study was conducted, sample size and proportion/percentage of women participants, type of occupational exposures, type of occupation associated with the exposures, work-related injury and disability outcomes, relevant effect estimates for men and women, and a summary of the relevant findings (including relevant effect estimates for men and women). For studies where the work characteristic was unclear (e.g., reporting workers' socioeconomic status or work precarity), reviewers read the full text to see if a specific occupational exposure could be inferred. If it was not possible to infer an occupational exposure, the study was excluded from the review (25 studies). Occupational exposures were grouped on the basis of the major categories of the CSA Z1000-14 standard: psychological/psychosocial, physical, biological, and chemical.[20] Supporting Information: File 3 provides examples of occupational exposures that were included within the three broad exposure categories.

2.6 | Evidence synthesis

Effect size estimates were extracted from each study's fully adjusted statistical models. In cases where occupation variables were included as covariates; effect estimates were extracted from the partially adjusted statistical model where the occupation variable was removed. The analysis of differences within the same occupations was based on effect estimates extracted from studies that stratified or matched their results by occupation for men and women. Although a meta-analysis was initially planned in the protocol, it was precluded due to heterogeneity between studies in study samples, occupational exposures, statistical approaches, and the reported findings. Based on heterogeneity in the reporting of effect estimates, if studies reported separate effect estimates for men and women, the research team compared whether the effect estimates in one group indicated a greater risk or if there was no statistically significant risk difference based on the difference in means estimated at the 5% level.[21,22] It was possible that even if a study's effect estimates stratified among men or women (i.e., comparing men and women separately) showed only one sex at independent risk of work injury or disability, no statistically significant difference in risk might be found when formally comparing the effect estimates between men and women.

3 | RESULTS

3.1 | Study characteristics

Figure 1 outlines the systematic review search process. The search identified 9474 references, of which 1983 studies made it to full text relevance screening. An additional 28 studies from other sources and from a manual search of the reference lists of 9 systematic reviews were also added. Of the full study texts reviewed, 33 studies were identified as relevant to the study questions and included in the review of evidence.

Study characteristics and relevant effect estimates for men and women for all reviewed studies are provided in Supporting Information: File 4. Studies examining physical occupational exposures were mostly from Finland (four studies), Canada (four studies), France and the USA (both with three studies). Most studies examining psychological/psychosocial occupational exposures were from Finland (four studies) and Norway (three studies). Two studies examined biological and chemical occupational exposures, one from Norway and the other from Denmark. Women made up 50% or more of the study sample for 42% studies (14 of 33 studies), with the study with the lowest proportion of women at 10%[23] and highest proportion of women at 89%.[24]

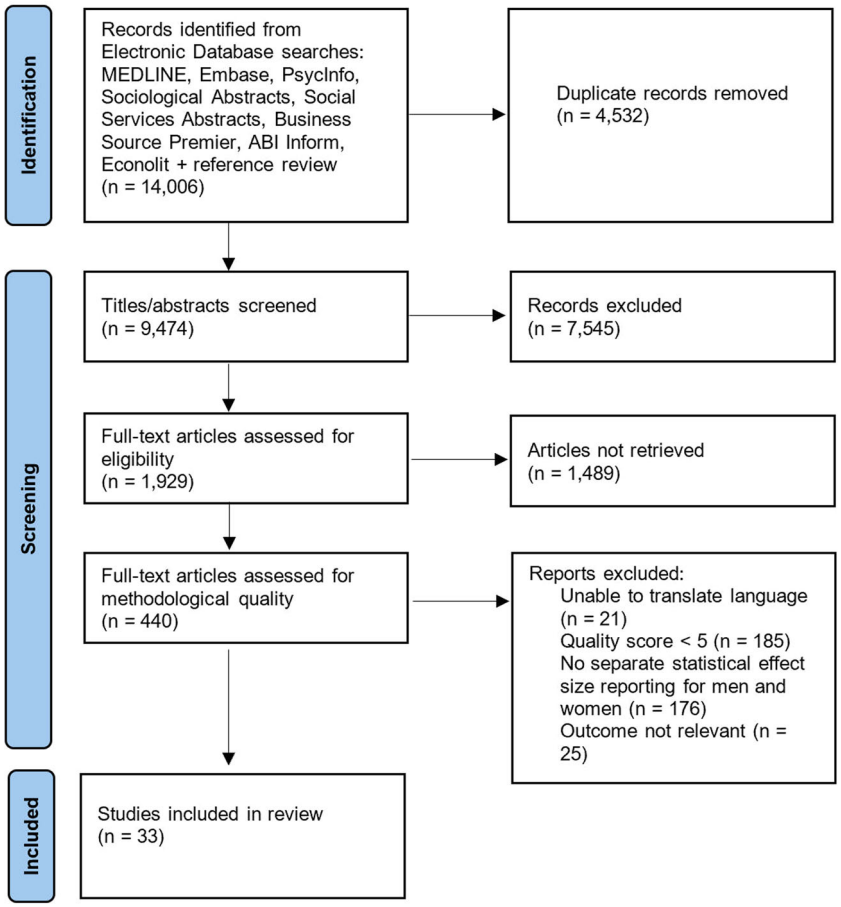

FIGURE 1 Flowchart outlining systematic review process

Reviewed studies reported the following terms related to work-related injury and disability outcomes: work injuries from all causes, musculoskeletal work injuries, short- and long-term disability claims, long-term work-related injuries, work-related sickness absence, work-related musculoskeletal pain, work-related disability pension, and retirement because of a work-related disability. Outcomes were measured using self-reported survey questions,[25–38] administrative workers' compensation claims data,[24,39–43] administrative data from social insurance or sickness benefit registries,[44–49] hospital registries,[50,51] company incident surveillance systems,[23,52] and a combination of physician-assessment and self-report.[53]

Tables 2–4 to compare men and women on the relationships between different occupational exposures and the risk of work injury or disability. The following sections describe the independent risks for men and women across occupations and in the same occupations and describe comparisons of the effect estimates between men and women (Table 2).

3.1.1 | Physical occupational exposures

3.1.1.1 | *Physical demands and risks for men and women across occupations*

Four studies reported associations between a broadly defined physical work demands exposure and MSDs,[28,30–32] with two studies reporting that both men and women were at increased risk of musculoskeletal pain but no differences in risk between men and women, and two studies reporting no increased risk of pain with physical work demands for men or women.[28,31] Four studies reported associations between physical work demands and disability and sickness absence.[34,41,48,51] All four studies reported that both men and women were at higher risk of disability or sickness absence associated with physical demands, but three studies reported no differences in the risk between men and women,[34,48,51] and one study reported a higher risk of sickness absence related to back pain in men compared to women.[41] One study also reported a risk of sickness absence associated with physical violence and sexual assault, with both men and women at risk, but no differences in risks between men and women.[34] Two studies examined associations between physical work demands and work injury risk,[38,43] with both reporting men and women as at higher risk of injury, but one reporting men at higher risk than women when exposed to heavy strength requirements[43] and the other study reporting no differences in the risk between men and women.[38]

Three studies reported associations between exposures to repetitive physical work tasks and MSDs.[29,36,53] One study reported that both men and women were at increased risk of shoulder pain from prolonged arm elevations, but women were at higher risk compared to men.[29] Another study reported that men and women were at risk of elbow-specific lateral epicondylitis from repetitive

TABLE 2 Studies comparing men and women in the association between physical occupational exposures and work-related injury and work disability (n = 22 studies), both across and within occupations

Physical occupational exposures	Outcomes	Difference in effect estimates between men and women			Study (year)	Nos.
		Higher risk in men only	Higher risk in women only	No difference[a]		
Noise	Long-term sickness absence (SA)		X		Clausen (2013)[26]	6
Noise	Injuries	X				
Physical demands	Disability retirement			X	Emberland (2017)[51]	6
Physical demands	Injuries (fire and emergency)	X			Gray (2017)[40]	5
Physical demands	Neck/shoulder pain			X	Hallman (2017)[28]	6
Physical demands	Musculoskeletal pain			X	Herin (2014)[30]	7
Physical demands	Chronic neck pain			X	Kääriä (2012)[31]	6
Physical demands	Low back pain			X	Lallukka (2017)32	9
Physical demands	SA (unskilled labor, semi-professional work, technical positions)	X			Liebers (2013)[41]	5
Physical demands	Injuries	X			Smith (2013)[43]	5
Physical demands	Injuries from falls from elevation (janitors)	X			Smith (2017)[42]	5
Physical demands	Long-term SA			X		
Physical demands	Injuries (smelting workers)		X		Taiwo (2009)[23]	7
Physical demands	Injuries (smelting workers)		X		Tessier-Sherman (2014)[52]	6
Physical demands	Injuries			X	Wong (2014)[38]	6
Physical strain	Disability pension			X	Falkstedt (2014)[44]	
Physical violence/sexual assault and physical demands	SA			X	Lesuffleur (2014)[34]	5
Prolonged arm elevation	Shoulder pain		X		Hanvold (2015)[29]	5
Prolonged sitting/standing	Injuries		X			
Repetitive tasks	Musculoskeletal injuries (healthcare workers)		X		Alamgir (2009)[24]	6
Repetitive tasks	Injuries (sales and service occupations)			X	Fan (2012)[39]	7
Repetitive tasks	Injury from lateral epicondylitis			X	Herquelot (2013)[53]	6
Repetitive tasks	Back-related MSDs			X	Prakash (2017)[36]	5
Repetitive tasks	Disability			X	Prakash (2017)[37]	5
Repetitive tasks	Long-term SA			X	Sterud (2014)[48]	8
	Injuries (admin and professional occupations, trades/transport/construction, natural resources, and manufacturing/utilities)	X				
	Injuries (healthcare)		X			
	Injuries (first responders)	X				
	Low back pain (engineers, managers, professional service occupations)			X		

(Continues)

TABLE 2 (Continued)

Physical occupational exposures	Outcomes	Difference in effect estimates between men and women			Study (year)	Nos.
		Higher risk in men only	Higher risk in women only	No difference[a]		
	Degenerative MSDs			X		
	Injuries from being struck by/against (janitors)	X				
	Injuries from falls from the same level (janitors)			X		
	MSDs (janitors)			X		

Abbreviations: MSD, musculoskeletal disorders; NOS, Newcastle Ottawa Scales for Cohort and Case-Control Studies; OA, osteoarthritis; SA, sickness absence.

[a]The no difference column can represent studies with increased risks, decreased risks, or no/null risks among both men and women.

exertion but no difference in the risk for men and women.[53] The third study reported no differences between men and women on their risk of back or degenerative MSDS from highly repetitive work tasks.[36] One study also reported that although both men and women were at risk of injury from occupational noise exposure, men were at higher risk than women.[26]

Three studies reported associations between repetitive work tasks and long-term sickness absence.[36,44,48] Two of these three studies reported that both men and women exposed to repetitive work tasks were at increased risk of long-term sickness absence[36,44] while the third study reported that only women but not men were at risk.[48]

3.1.1.2 | Physical work demands and risks for men and women in similar occupations

Two studies reported that women reporting physically demanding work in aluminum production and smelting were at higher injury risk than men in the same occupations.[23,52] Two studies examined the risks of repetitive work tasks for men and women working in healthcare occupations[24,39] and found that women in these occupations were at higher risk of all-cause injuries,[39] while women who were in physically demanding and repetitive work in care aid occupations were at higher risk than men in these occupations for MSDs.[24] Another study found that men in administrative and professional occupations generally, or occupations in the primary or secondary industry sectors (natural resources, manufacturing, or construction), were at higher injury risk from different repetitive work tasks than women in these occupations and industries, but that there were no differences in work injury risk between men and women in sales and service occupations.[39] Another study found that men in occupations described as involving unskilled labor, semiprofessional work, and technical positions were at higher risk of sickness absence than women in the same occupations, while men and women employed as engineers, managers, and in other professional service occupations had no differences in risk.[41]

Among a study of janitorial workers, men were at higher risk of injuries from falls from elevation and from being struck by or against something, compared to women.[42] The same study found no difference between men and women janitorial workers in their risk of MSDs and injuries from falls from the same level.[42] One other study examined injury risk associated with the physical demands among fire and emergency workers and first responders, finding that men were at higher risk of injury than women within these occupations[40] (Table 3).

3.1.2 | Psychological/Psychosocial occupational exposures

3.1.2.3 | *Psychological/Psychosocial demands and risks for men and women across occupations*

Four studies reported associations between work stress and sickness absence,[34,35,48,49] with two studies finding that men and women were at increased risk for sickness absence,[48,49] and two studies finding no risks for men and women.[34,35] All four studies reported no differences in the injury risks for men and women. Three studies reported associations between psychosocial exposures and work disability,[36,44,51] with one study reporting that both men and women were at increased risk associated with low levels of job control,[44] one study reporting that men were at increased risk when experiencing passive work and high job strain and women when experiencing high job strain,[36] and the final study reporting no increased risks for men and women experiencing job strain.[51] However, when comparing the effect estimates between men and women, all three studies reported no differences in injury risks.

Three studies reported associations between work stress and work-related injuries,[25,46,47] with one study reporting that men and women were at increased risk of injury from psychosocial exposures, in particular work stress and little organizational support[25], and two studies reporting that neither men or women were at increased risk of injury when experiencing high job stress[46] or a combination of

TABLE 3 Studies comparing men and women in the association between psychosocial/psychological occupational exposures and work-related injury and work disability ($n = 17$ studies), both across and within occupations.

Psychosocial/Psychological occupational hazards	Outcomes	Difference in effect estimates between men and women			Study (year)	Nos.
		Higher risk in men only	Higher risk in women only	No difference[a]		
Bullying	Chronic neck pain					
Bullying	Sickness absence			X		
Bullying	Sickness absence			X		
Burnout	Injuries (forestry workers)	X			Ahola (2013)[50]	8
Effort-reward imbalance	Injuries			X		
Job control	Disability pension			X	Falkstedt (2014)[44]	8
Job strain	Injuries			X	Baidwan (2019)[25]	5
Job strain	Disability pension			X	Emberland (2017)[51]	6
Job strain	Chronic neck pain			X	Kääriä (2012)[31]	6
Job strain	Lower back-related musculoskeletal injuries		X		Lapointe (2009)[33]	5
Job strain	Sickness absence			X	Lesuffleur (2014)[34]	5
Job strain	Sickness absence			X	Mortensen (2017)[35]	8
Job strain	MSDs			X	Prakash (2017)[36]	5
Job strain	Disability			X	Prakash (2017)[37]	5
Job strain	Sickness absence			X	Sterud (2014)[48]	8
Job strain	Sickness absence			X	Stromholm (2015)[49]	6
Organizational support	Injuries			X		
Organizational support	Sickness absence			X		
Organizational support	Sickness absence			X		
Work demands	Musculoskeletal pain			X	Herin (2014)[30]	7
Work stress	Sickness absence			X	Heo (2015)[65]	5
Work stress	Injuries and sickness absence			X	Julia (2013)[46]	6
Work stress	Injuries and sickness absence			X	Julia (2016)[47]	6
Work stress and traumatic conditions	Injuries (ambulance officers and paramedics)	X			Gray (2017)[40]	5
Work stress and traumatic conditions	Injuries (fire and emergency workers)			X		
	Upper limb-related musculoskeletal injuries	X				

[a]The no difference column can represent studies with increased risks, decreased risks, or no/null risks among both men and women.

psychosocial job exposures (social support, quality of leadership, poor definition of roles and functions, lack of adequate information).[47] However, all three studies reported no differences in the injury risks between men and women.

Four studies reported associations between job strain and MSDs,[30,31,33,37] in particular higher risks for women for shoulder and neck-related MSD injuries[33] and upper-limb MSD pain,[30] higher risks for men for chronic neck pain,[31] and no risk of all MSDs for either men or women.[37] One study also reported that men were at risk of sick leave when experiencing high job demands.[49] No statistically differences between men and women in their risks for MSDs were found in the five studies.

3.1.2.4 | *Psychological/Psychosocial demands and risks for men and women across occupations*

Two studies described the risks of work injury associated with psychological/psychosocial demands for men and women in similar occupations, with one study reporting that the stressful and

TABLE 4 Studies comparing men and women in the association between chemical and biological occupational exposures and work-related injury and work disability ($n = 2$ studies) across occupations

Chemical and biological occupational exposures	Outcomes	Difference in effect estimates between men and women			Study (year)	Nos.
		Higher risk in men only	Higher risk in women only	No difference[a]		
Animal-derived agents	Respiratory-related disability	X			Fell (2016)[27]	5
Cleaning agents	Disability pension			X	Feveile (2009)[45]	6
Metalworking fluids	Respiratory-related disability		X			
Motor exhaust	Respiratory-related disability		X			
Molds/bio-aerosols	Respiratory-related disability	X				
Reactive agents/cleaning agents	Respiratory-related disability		X			

[a]The no difference column can represent studies with increased risks, decreased risks, or no/null risks among both men and women.

traumatic work conditions for ambulance officers and paramedics were associated with a higher risk of injury among men compared to women in these occupations. The risks for fire and emergency workers were also studied, but no differences were found in the risks of injury for men and women in these occupations.[40] A second study also reported that men working in forestry occupations who reported experiencing burnout were at higher risk of severe injury than women (Table 4).[50]

3.1.3 | Biological and chemical occupational exposures

3.1.3.5 | *Biological and chemical exposures and risks for men and women across occupations*

One study on biological and chemical exposures reported that men were at risk of respiratory-related work disability associated with exposure to mixed agricultural work, molds, and other bio-aerosols, but that women were at risk associated with exposure to reactive agents, cleaning agents, metalworking fluids, vehicle/motor exhaust, and contact with cleaning agents. While both men and women shared a high risk for the same exposures, the risks for women were greater than men for respiratory work disability from animal-derived agents. No differences between men and women were observed for other biological and chemical exposures.[27] Another study examined the relationship between exposure to cleaning agents and risk of work disability, reporting no differences between men and women in their risk.[45]

3.1.3.6 | *Biological and chemical exposures and risks for men and women in similar occupations*

No studies were identified that compared men and women on their risks of work injury and disability associated with exposure to biological and chemical exposures within the same occupation.

4 | DISCUSSION

This systematic review provides evidence of observed differences between men and women in work injury and work disability outcomes for physical, chemical, and biological occupational exposures. Most studies did not find differences based on psychosocial/psychological exposures across occupations, although men and women were independently at risk of work injury and disability from these exposures. Studies providing direct comparisons of men and women in the same occupation were sparse and variable in terms of illuminating differences between men and women, which speaks to the need for more research on sex/gender differences within occupations to advance our understanding.

As men and women across occupations were compared based on the same types of exposures, the increased risks for men and women might be explained by occupation-specific task differences. The interaction between biological and social determinants is also

important when considering gender-based differences. For example, the increased work injury risks for men compared to women when exposed to certain chemical and biological exposures might be related to cellular and sex hormone differences.[54] Several studies reported that both men and women were at risk of work injury resulting from high levels of psychosocial/psychological occupational exposures. These exposures might be related to the type of work, position in the occupational hierarchy, horizontal and vertical discrimination, sexual harassment at work, and as is generally the case for women, the stressors of long work hours from paid and unpaid work.[55] It was also found that most of the reviewed studies reported no differences in work injury or work disability risk when comparing the effect estimates between men and women. This finding might reflect how psychosocial/psychological occupational exposures are not defined by a gendered distribution of the labor force but are more ubiquitously experienced across different occupations.

Although there were only few studies, we found differential work injury and disability risks for men and women in the same occupations, which might be a result of women and men not always performing the same tasks. For example, women carrying out physically demanding work are more likely to perform repetitive tasks whereas men are more likely to perform heavy lifts within the same occupation.[56,57] Anthropometric differences between men and women in their average size and strength capacity within work environments often designed for the anthropometric average man might explain why women were at increased risk of MSDs and injury in some studies [58] Women can also experience an increased risk of upper limb MSDs from engaging in more repetitive work within the same occupation or across occupations, which may be compounded by the double burden of unpaid work from increased work-life demands (e.g., family responsibilities)[10], potentially attenuating the health risks of work-related stress and biomechanical strain. Men are also more likely to work in jobs higher up in the occupational hierarchy than women (i.e., vertical segregation).[11] Hence, gender segregation within the same occupation can contribute to an unequal distribution of working conditions and exposure to different physical and psychological risks between men and women in the same workplace. Disparities in work injury and disability outcomes within the same occupations could also be explained by gendered differences in the self-reporting of injuries, especially if reporting is influenced by the experience with, as well as the anxiety about, a risk factor.[59]

While gender and sex are mentioned in research studies, they are often not the primary focus of research findings, which can lead to the potentially mistaken perception that the relationship between work and health does not differ for men and women, even in situations where it does. While there will be cases where studies are underpowered, or chance findings occur, a starting point for future occupational health studies might be to test for differences in exposure–outcome relationships between men and women before combining male and female samples. We acknowledge as a limitation of this review that the occupational exposures and associated work injury and disability risks attributed to men or women might be a result of lack of power to detect important differences. For example, because women are generally underrepresented in occupational health studies and particularly in occupations dominated by men, there may not be adequate numbers of events among women to detect differences in exposure–outcome relationships. Accordingly, it is important that occupational health researchers aim for adequate recruitment through stratified sampling approaches to detect a priori defined important differences in exposure/outcome relationships between men and women. While not a focus of this review, beyond stratifying samples based on men and women, it is important to also consider the intersectionality of gender differences according to ethnicity, culture, social class, family type, age and other variables that impact the relationship between occupational exposures and work-related health outcomes. These interactions could be studied empirically by linking existing data across disciplinary sources or collecting primary data that describes intersectional experiences and identities, incorporating multiple social categories and understanding their combined effects, and oversampling underrepresented groups to draw statistically valid conclusions.[60,61]

5 | STRENGTHS AND LIMITATIONS

The strengths of this review include a very rigorous approach, an a priori protocol, a comprehensive search strategy, a focus on prospective studies of medium-to-high quality to assess some degree of temporality between exposure and outcome, and a formal comparison of the magnitude of statistically significant effect estimates. There were also limitations that should be considered. First, although this review focused on synthesizing medium-to-high quality observational studies, it is also possible that some of the estimates were inflated because of measurement biases in the assessment of occupational exposure and outcomes. Sampling bias may have influenced the reported estimates as 45% (18 out of 33) of studies sampled more men than women. As stated in the previous section, these studies might be insufficiently powered to detect important differences in exposure–outcome relationships between men and women. Second, given the breadth of the occupational health research literature, it is possible that our search strategy did not capture all relevant studies that have been published in the field over the search period of 2009 to 2019. We incorporated variations of the search terms “sex,” “gender,“ “exposure,” and “hazard” to broadly capture sex/gender differences in occupational exposures but did not include the names of specific occupational exposures. Accordingly, this review might have been more effective at identifying common occupational exposures but might not have captured all possible occupational exposures such as those with specific chemical and biological names. To mitigate missing important studies, we involved a research librarian and stakeholders knowledgeable about sex and gender differences in occupational health research in the development of the search strategy. We also included studies in several different languages to the best of our ability. It also

is important to note that several potentially relevant studies might have been published since the literature search was completed, including the health impacts to the labor force related to the COVID-19 pandemic. Third, although this review synthesized estimates based on occupational title, this may not have been sufficient to assess task-related risk. Fourth, because of the heterogeneity across studies, we were unable to formally pool studies in a meta-analysis and compare the overall risks of work injury and disability outcomes for men and women.

Over 160 million people globally suffer from work-related injuries every year.[62] Furthermore, women now constitute over 40% of the global workforce. Accordingly, understanding how primary prevention interventions and policies can be tailored, where relevant, is essential to promoting safer and healthier workplaces for all workers. To address gender and sex disparities in occupational health and safety, the implementation of protective and preventive measures should consider the characteristics of female and male dominated occupations, the specific features of the occupations (who does what, when, how, and for how long), female and male biological differences in exposures and health outcomes, and the different responsibilities men and women have outside of work. The highlighting of a growing body of evidence on the less obvious risks of women's work is an important outcome of this review. Women are predominantly in occupations generally considered as safe but are exposed to a number of hazardous occupational exposures (e.g., emotionally demanding work, and in nail salon work - ortho-phthalate esters and organophosphate esters [63]). Accordingly, the design of occupational health and safety policies and legislation should not be restricted to protecting workers in visibly dangerous jobs associated with high levels of work-related injuries (where men are more likely than women to work); but more attention should be paid to less visible hazards that are more common in occupations where women predominate. While gender-neutral occupational health and safety policies may apply in situations where there appears to be no differences in the work injury risks between men and women, policies should be periodically reviewed to determine whether men and women react differently to the same occupational risks because of their exposure differences, differences in their biological makeup, working conditions, and gender roles. As has been previously described,[2,59,64] there is still a need for accurate measurement methods that are sensitive to the similarities and differences between men and women in occupational exposures and the associated health risks across the labor force and within occupations. Future research studies also will benefit from clarifying the potential mechanisms that create differences in work injury and disability for men and women, including better measures of the relevant dimensions of gender.

In conclusion, this systematic review found that men and women can have different work injury and work disability risks, for the same types of exposures across occupations, for physical occupational exposures and to a lesser extent for chemical and biological occupational exposures. As men and women were compared based on the same types of exposures within the same occupation, these differences might be explained by occupation-specific task differences. In contrast, while both men and women were at risk of work injury and work disability from exposure to psychological/psychosocial occupational exposures, most studies did not report statistically significant differences between the risks of men and women, suggesting that these occupational exposures are experienced similarly by sex/gender. While evidence was sparse and variable comparing exposures and risks within the same occupations (or in some cases, industries), men working as first responders, janitorial workers, and occupations within certain primary and secondary industry sectors were at higher injury risk than women, while women in healthcare and aluminum production were at higher work injury risk than men. These findings also suggest differences in work injury and disability risks between men and women were more likely for physical and chemical/biological occupational exposures than for psychological/psychosocial occupational exposures. To advance occupational health research, future studies should include investigations of gender/sex-based differences in exposure and health risks within the same occupations to inform modifiable prevention practices.

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AUTHOR CONTRIBUTIONS

Aviroop Biswas, Peter Smith, Mieke Koehoorn, and Emma Irvin received funding for the study and led the study conception and hypothesis generation. Aviroop Biswas, Emma Irvin, Shireen Harbin, Heather Johnston, Momtaz Begum, Maggie Tiong, and Dorothy Apedaile conducted the screening of articles and quality assessment. Aviroop Biswas wrote the first draft of the manuscript and all authors contributed to the interpretation of the data. All authors read and approved the final manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the supplementary material of this article. Any additional data requests are available from the corresponding author upon reasonable request.

ORCID

Aviroop Biswas http://orcid.org/0000-0002-0393-6280
Heather Johnston https://orcid.org/0000-0003-3357-3166
Maggie Tiong https://orcid.org/0000-0001-9708-1756
Dorothy Apedaile http://orcid.org/0000-0003-4663-8459
Mieke Koehoorn https://orcid.org/0000-0002-5376-7489
Peter Smith https://orcid.org/0000-0001-8286-4563

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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