NSW GOVERNMENT

The link between workplace stressors and physical injury: A cross sectional study

Centre for WHS

University of South Australia

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Executive Summary

Given the human, industrial and societal costs of Musculoskeletal Disorders (MSDs), the aim of this project was to (i) provide up to date prevalence estimates of MSDs among NSW employees in 2020-2021, (ii) estimate the associations of physical, psychosocial, and demographic factors with MSDs among NSW employees, specifically evaluating the Psychosocial Safety Climate (PSC) as a distal cause of MSD outcomes, and (iii) utilise the longitudinal strengths of the Australian Workplace Barometer survey to evaluate prospective physical and psychosocial process paths to MSDs in a wider population of employed Australians based on matched data from NSW, WA and Victoria with a lag of 6 years.

Data on MSDs and associated treatment, together with potential demographic and workplace risk factors were collected via telephone interview data from 628 NSW employees. Workplace risk factors included psychosocial risks (e.g., job demands, job control, social support, harassment, bullying), PSC, and physical risks (e.g., moving/lifting heavy loads, repetitive actions, rapid and continuous physical activity, working for long periods with head/ body or arms in physically awkward positions). Psychological distress was assessed in terms of burnout and depressive symptoms.

We focused on three main MSD specific outcomes; (i) pain, (ii) doctor diagnosed MSDs (e.g., carpal tunnel syndrome, chronic back pain, rotator cuff problem), and (iii) workplace injury.

Statewide and industry specific prevalence estimates of MSDs and associated outcomes were weighted for age and sex, using weights and estimates generated from the NSW sample in the 2016 ABS census and the Household, Income and Labour Dynamics in Australia (HILDA) panel survey.

In a cross-sectional analysis we estimated associations of a broad range of risk factors with MSDs. We then investigated poor PSC as a distal cause of MSDs via three paths using regression models:

- Path 1: PSC is negatively related to physical demands that in turn positively relate to MSDs (physical mechanism);
- Path 2: PSC is negatively related to psychosocial risk factors that in turn positively relate to MSDs (psychosocial mechanism); and,
- Path 3: PSC is negatively related to psychosocial risk factors that in turn positively relate to psychological distress and in turn MSDs (psychosocial extended).

We then repeated this investigation in a longitudinal path analysis again testing the hypothesis of poor PSC as a distal cause of MSDs in 432 Australians employed over 6 years.

Across the sample of 628 NSW employees one quarter (26%) of respondents reported being in a lot of pain in at least one body area, and only 21% reported no pain in any area. Around 20% of women and 22% of men indicated they had received a lifetime doctor diagnosis of any of the common chronic MSDs, and half (49%) of those reported being in a lot of pain. The most common doctor diagnosed MSD for both men and women was chronic back pain or sciatica (6%) and osteoarthritis in women (6%). Injuries in the past year were reported by 11% (70/628), and of these 31% (22/70) were work related. Around 2.5% of employees had made a worker's compensation claim in the past year.

The different methods of assessing MSDs and related symptoms produce different results for both prevalence and risk analysis.

For MSD related pain, NSW industries with the highest estimated prevalence of employees reporting a lot of pain from MSDs were Retail Trade, Electricity Gas and Waste Services (both around 35%), and Financial/Insurance, and Professional Scientific/Technical Services (both > 25%). Fewer than 15% of employees in Mining, Construction, Education, Public Administration, and IT reported high pain levels.

For doctor diagnosed MSDs, the industry variability in prevalence was lower, with no statistically significant differences between them and a range of 10-23%.

For 12 month work-related injury, there was a low prevalence 4% (22/628) and not surprisingly there were no significant differences between industries, although the prevalence was 10% or higher in Electricity Gas Water and Waste Services, Transport, Postal and Warehousing, and Wholesale Trades industries, and less than 1% in Finance.

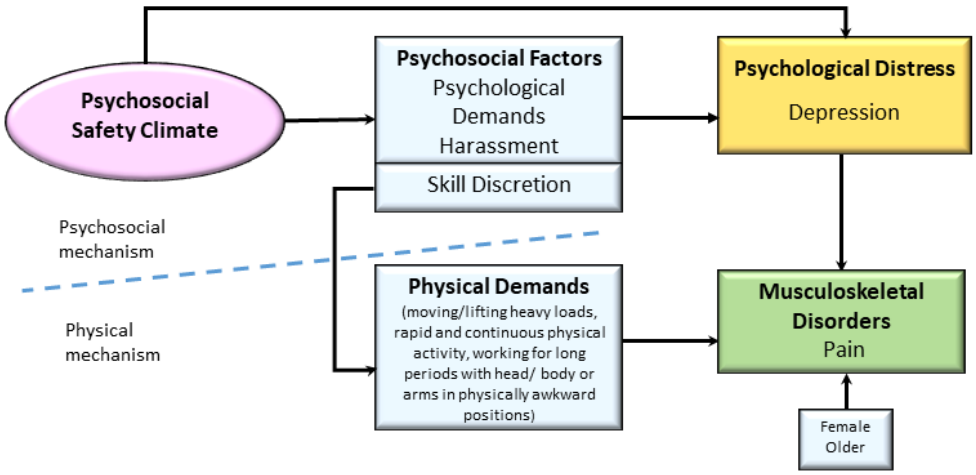
Taking into consideration the results from both cross-sectional and longitudinal analysis (considering the effects of risks over 6 years) it is clear that workplace physical risk factors are negatively associated with MSDs. Over and above these effects, there was some support for a psychosocial mechanism. Cross-sectionally psychosocial factors such as psychological demands (work pressure) and workplace harassment were positively related to psychological distress (depression) that in turn related positively to MSD pain. Burnout was directly related to work injury. Longitudinally workplace autonomy (skill discretion and decision latitude) emerge as more important factors for predicting future pain and workplace injury. A novel finding was that skill discretion appeared linked to MSD pain via physical demands, highlighting a new mechanism – how psychosocial mechanisms relate to physical mechanisms. Since PSC was

related to the psychosocial factors and distress, and sometimes directly related to MSDs there is some support for the proposition that PSC is an indicator of MSDs. The plausible risk factors for MSD pain (as an exemplar) are summarised in the figure below.

Some demographic factors were also significant risks: MSD diagnosis was more common among older workers, MSD pain more common among women workers.

Given the important role of physical demands we tested longitudinal models predicting future physical workplace risks. In this analysis since we were predicting future work conditions, we included only workers (n = 269) who were in the same organization at both T1 and T2. As expected, physical demands predicted future physical demands. Autonomy in the form of skill discretion was negatively related to future physical demands work, after controlling for baseline physical demands. Psychological distress (burnout, depressive symptoms) was not related to future exposure to physical demands. This is an important point since it gives more weight to these working conditions, rather than an overall negative view of individual worker, as explanation for future exposures.

Plausible Risks for Musculoskeletal Disorder Pain



In sum, the emergence of MSDs in the workplace are difficult to predict. The impact of high workplace physical demands, low PSC, skill discretion, decision authority and psychological health status many years earlier are variable depending on MSD outcomes. High levels of workplace physical risks are easier to predict and the most consistent risk factor for these is psychosocial - lower levels of autonomy at work. In occupations where workers are exposed to low skill discretion and decision authority, this may imply that local actions cannot be taken by employees to reduce or manage physical demands (less agency), resulting in increased risk for MSDs.

Given the impact of workplace factors on MSDs and that some risks identified are preventable or modifiable, action should be taken to target these. Physical demands should be reduced or controlled. Action should be taken to improve PSC, improve skill discretion, reduce harassment, and reduce work pressure. Although we have identified some factors that are associated with MSDs and psychological health the predictive effects are small and targeting each will have only a small effect. However, across employees over a whole NSW state this could have some reasonable population effects.

Duty holders under WHS laws should consider plans to implement control strategies for the physical and psychosocial risks identified. The finding that psychosocial factors play a substantive role in MSDs supports emerging research and requires a fresh preventive approach. A novel intervention not yet tried to improve MSD status among employees would be to focus on improving PSC. Since PSC is antecedent to many risk factors, focusing on improving PSC would be an efficient focus, and is achievable in a short period (Dollard & Bailey, 2021), and would have the added benefit of increasing workplace mental health.

Our research suggests that interventions focused on the following industry sectors reporting the most MSD pain in this study might be beneficial: Retail Trade, Electricity Gas and Waste Services, Financial/Insurance, Professional Scientific/Technical Services, Rental Hiring and Real Estate Services, Agriculture and Fishing, and Administrative and Support Services.

In conclusion, MSDs represent a complex issue for workplaces and workplace research. When assessing MSDs in an organisational context our multidimensional approach highlights huge variability in prevalence and risks depending upon how MSDs are conceptualised and measured. The low prevalence of MSDs in some physically demanding industries such as mining may reflect good work health and safety practices, or alternatively may not be indicative of incidence but rather represents people with MSDs leaving these industries (healthy worker effect).

This study shows that pain linked to MSDs is a very common symptom in NSW employees, regardless of occupation, and is associated with a range of physical and psychosocial risks, potentially mediating the effects of a poor corporate climate for worker psychological health (PSC).

Theoretically the results suggest that both physical and psychosocial mechanisms impact upon MSD and both must be considered in combination to fully understand the manifestations of MSDs.

Keywords: MSDs, workplace psychosocial risks, workplace physical risks, psychosocial safety climate, physical injuries

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Introduction

Musculoskeletal disorders (MSDs) are a fundamental problem in the workplace with tremendous costs for both individuals and organisations (Hassard et al., 2014; Oakman, Macdonald, Bartram, Keegel, & Kinsman, 2018; Safe Work Australia, 2021). MSDs refer to 'a range of conditions that affect joints, spinal vertebrae and intervertebral discs, the synovium, muscles, tendons and related tissues, soft tissues, and connective tissues' (Safe Work Australia, 2016; p. 4).

Injury and MSDs accounted for 87% of serious workers compensation claims during 2018–19 (Safe Work Australia, 2021). Workplace injuries and musculoskeletal disorders are the leading cause of medical conditions and disability to work in the Australian workforce. In NSW during the last 12 months, 93,930 workers compensation claims were lodged with 92.3% for serious workplace musculoskeletal disorder and 7.7% for psychological injuries claims, costing around four billion dollars to Australian society (NSW State Insurance Regulatory Authority [SIRA], 2021). Musculoskeletal disorders (MSDs) and related injuries are the most prevalent type of severe occupational injury and disease worldwide. In many countries the second most common type is stress-related mental health disorders (Safe Work Australia, 2015).

Aetiology: What We Know

Over the past two decades, there has been a substantial body of literature supporting the complex and multifactorial aetiology of work-related musculoskeletal disorders (MSDs) due to exposure to a range of risk factors in the workplace.

Hernandez and Peterson (2013) characterised those risk factors into three broad categories including: 1) physical or biomechanical risk factors related to physical activities or ergonomic characteristics in the workplace (such as repetitive movements, improper postures, heavy lifting, frequent bending, twisting, and vibration) that put an individual at increased risk of MSD development; 2) psychosocial risk factors (such as high job demand, low control, poor support from co-worker and/or manager); and 3) individual risk factors (such as gender, age, body mass index, lifestyle, and other personal characteristics).

In understanding the aetiology of MSDs two process pathways have been theorised. First is a physical pathway which posits that physical demands are antecedent to MSDs. Second is a psychosocial pathway which theorises that psychosocial factors are important precursors to MSDs. There is substantial evidence which links physical demands to MSDs. Although less widely recognised, psychosocial risk factors are argued to also be a significant contributor to adverse MSD outcomes (Leka, Van Wassenhove, & Jain, 2015; Macdonald & Oakman, 2015). Substantial

evidence is growing linking psychosocial risk factors to the prevalence of musculoskeletal disorders among workers (Robertson, Jayne, & Oakman, 2021; Zare, Choobineh, Hassanipour, & Malakoutikhah, 2021). Thus, contemporary evidence has established the dual aetiological paths involving both psychosocial and physical risk factors in developing MSDs (McLinton et al., 2018; Eatough et al., 2012; Gerr et al., 2014 a; b; Robertson, Jayne, & Oakman, 2021). Next, we review the evidence for the link between physical and psychosocial factors and MSD and the potential underlying mechanisms.

Physical Risk Factors: Current Evidence and Mechanisms Leading to MSDs

Risk of developing MSDs due to exposure to physical/biomechanical factors in the workplace has been established though a wealth of epidemiological and biomechanical studies. For low back disorder, one of the most common MSDs, it was found that the condition is highly associated with heavy lifting, frequent bending and twisting, and whole-body vibration. In a review reported to the US Congress on MSDs and the workplace, a panel of experts reviewed 43 publications that measured the association between physical factors and the occurrence of back disorders. The factors that were significant in almost all studies were lifting and/or carrying of loads (risk estimates of between 1.1 and 3.5), whole-body vibration (risk estimates: 1.3 to 9.0), frequent bending and twisting (risk estimates: 1.3 to 8.1) and heavy physical work (risk estimates: 1.5 to 3.7). More recently, in a meta-analysis of the effect of lifting during work on low back pain pooling data from eight longitudinal studies, Coenen and colleagues found the pooled estimates of ORs of 1.11 (1.05 to 1.18) per 10 kg lifted, 1.09 (1.03 to 1.15) per 10 lifts/day. They also found that lifting loads over 25kg and lifting at a frequency of over 25 lifts/day would increase the annual incidence of low back pain by 4.32% and 3.50%, respectively.

In regard to upper extremity disorders, such as carpal tunnel syndrome, hand-arm vibration syndrome, tendonitis, bone/joint-related conditions, the US National Research Council and Institute of Medicine Panel on Musculoskeletal Disorders and the Workplace 2001 reported significant positive association between upper extremity musculoskeletal disorders and exposure to repetitive tasks, forceful tasks, the combination of repetition and force, the combination of repetition and cold, and hand vibration. In their review, they found nine studies reported the outcome as carpal tunnel syndrome, with 18 estimates of risk based on various degrees of work exposure. Of these, 12 were significant and greater than 2.0 (ranging between 2.3 and 39.8); four were greater than 2.0 but non-significant; and two were between 1.7 and 2.0 but also non-significant. With hand-arm vibration syndrome and other vibration disorders, the panel found significant associations with vibration exposures in 12 of 13 studies, with increased risk of 2.6 to 84.5 times. Hoozemans and colleagues conducted a systematic review of studies on the association between pushing/pulling activities on the risk of upper extremity symptoms. In all four

prospective cohort studies included, they found positive significant relationships with upper extremity symptoms with effect sizes between 1.5 and 4.9. In a longitudinal study on the effect of physical risks on MSD among manufacturing workers, Gerr et al (2014) found consistent positive adjusted associations between hand/arm symptoms (HR = 1.73, 95% CI: 0.99 to 3.04) and disorders (HR=1.93, 95% CI: 0.85 to 4.40) with a higher strain index category (a combination rating of physical exposures including intensity of exertion, hand-wrist posture, exertions per minute, percentage duration of exertion, speed of work and duration per day).

For other MSDs in other body regions such as neck, shoulder, knee, foot, and ankle with conditions such as pain, tenderness, stiffness, intermittent muscle spasms, bursitis (inflammation of the fluid-filled pads at joints), there is also evidence that these conditions are positively associated with exposure to repetitive movement, improper static postures, awkward positions (such as kneeling, squatting), and/or heavy lifting.

Mechanisms Leading to MSDs Related to Exposure to Physical Factors

The link between workplace physical demands, such as high muscular load, awkward and static postures, harsh work environment, exposure to vibration or substances and lack of access to ergonomic equipment and physical injuries is well established in the literature (Wahlström, 2005; Welch, Haile, Boden, & Hunting, 2009). Evidence shows that MSD symptoms, such as neck pains and back pains result from the physical demands and work involving physical labour such as construction where continuing exposure and strain on muscles and the skeletal system can happen (Welch et al., 2009). These hazards also exist in less overtly physical jobs such as computer-based work in which increased mouse usage, and poor seated posture are identified as risk factors in MSD development (Wahlström, 2005).

Evidence of the links between exposure to physical factors and development of MSDs are often explored in basic biology and biomechanical studies and re-enforce findings from epidemiological studies. The mechanism of low back disorders due to heavy lifting, for instance, involves the transition of spinal loading to tissue injury within the intervertebral discs, especially when the loading is repeated and/or continuous. The subsequent physiological and cellular responses can lead to either biological adaptation or chronic pathology. The variation pattern includes inflammatory changes with fibrosis in the paratenon, with evidence of degenerative changes in the tendon, specifically oedema, collagen disorganisation, and fibrosis. The damage may be initially mediated by inflammatory activity and microtrauma.

Regarding the perception of pain, this can be highly complex, since there is no exact definition and is only perceived by the suffering individual. There is a wide network of pain receptors

distributed in the tissues of the body that is stimulated by mechanical factors, extremes of temperature (cold or hot) or chemical substances. Through the peripheral nerves, pain is transmitted to the spinal cord and to the brain. Efforts from biochemical studies found certain work exposure (such as heavy lifting) have a possible link to specific patterns of spine structure loading. Such loading patterns can lead to damage to the pain sensing structures of the spine, including the disc, vertebral body, joints, and ligaments, and subsequently lead to the perception of pain.

Psychosocial Risk Factors: Current Evidence and Mechanisms Leading to MSDs

In addition to physical risk factors, there has been increasing evidence showing the risk of developing MSDs resulting from exposure to psychosocial factors. For back and low back disorders, the US panel for MSD and workplace (National Research Council and Institute of Medicine, 2001) reviewed 21 prospective studies and found strong evidence of a positive association due to exposure to low job satisfaction, poor social support at work, monotonous work, high perceived stress, high perceived job demand and perceived ability to return to work. In another review, Hauke and colleagues (2011) pooled data from 27 prospective studies and found that low back disorders were significantly associated with low job satisfaction (OR=1.59, 95% CI: 1.29 to 1.97), low skill discretion (OR=1.40, 95% CI: 1.01 to 1.92), high job strain (OR=1.40, 95% CI: 1.10 to 1.80), low job control (OR=1.37, 95% CI: 1.01 to 1.84), high job demand (OR=1.34, 95% CI: 1.15 to 1.58), and low social support (OR=1.22, 95% CI: 1.07 to 1.38). In 2012, also using a systematic review and meta-analysis approach, Lang et al. found similar findings along with some additional psychosocial factors, including low supervisor support (OR=1.37, 95% CI: 1.19 to 1.58) and low job security (OR=1.43, 95% CI: 1.16 to 1.76). More recently, Buruck and colleagues (2019) reviewed evidence on the relationship of psychosocial areas of work-life and chronic low back pain. Pooling data from 18 studies, it was found that chronic low back pain was significantly associated with workload (OR=1.32, 95% CI: 1.20 to 1.46), overall job control (OR=0.81, 95% CI: 0.70 to 0.94), and decision authority (OR=0.82, 95% CI: 0.59 to 0.87).

Regarding upper extremity disorders, reviewing results from 28 studies, the US panel for MSD and workplace (2001) found that high job demand and low job control are consistently associated with disorders in all parts of upper extremity, including upper arm, elbow, arm, forearm, and wrist (National Research Council and Institute of Medicine, 2001). Factors that are also positively associated with symptoms in one or more parts of the upper extremities are low social support, and non-work-related worry/tension/psychological stress. In Hauke et al.'s review and meta-analysis of 14 studies, psychosocial risks factors identified are psychological distress (OR=1.71, 95% CI: 1.31 to 2.23), low decision authority (OR=1.67, 95% CI: 1.04 to 2.69), low job satisfaction (OR=1.19, 95% CI: 1.03 to 1.38), low social support (OR=1.18, 95% CI: 1.06 to 1.32), and high job demands

(OR=1.18, 95% CI: 1.06 to 1.32). In addition to the factors found in previous reviews, Lang et al also found that highly monotonous work is also positively associated with MSDs of the upper extremities (OR=1.57, 95% CI: 1.28 to 1.93).

In addition to evidence of psychosocial factors associated with increased risk of developing back and upper extremity disorders, reviews, and meta-analyses by Hauke et al and Lang et al also show that these psychosocial factors are also antecedents of MSDs in neck and/or shoulder, lower extremity, and multiple body region.

Mechanism Leading to MSDs Related to Exposure to Workplace Psychosocial Risk Factors

The development of MSDs due to exposure to psychosocial risk factors at work is commonly described as a process that involves physical/biomechanical and psycho-physiological pathways. Regarding the physical/biomechanical pathway, psychosocial risk factors contribute to increased load (e.g., spinal load in the case of low back symptoms, extra-neural pressure in the carpal tunnel in the case of wrist/hand symptoms). The increased load would then result in physical strains, which would subsequently lead to MSDs. With the psycho-physiological pathway, psychosocial stressors at work were found to be the trigger for physiological reactions, including biochemical stress responses potentially giving rise to increased muscle tension, co-activation, and load on the musculoskeletal system (Bongers, Ijmker, Van den Heuvel, & Blatter, 2006), decreased blood supply in the extremities (Vissera & van Dieëna, 2006), and prohibition of muscle repair (Theorell, Hasselhorn & Music Norrtälje Study Group, 2002).

There is also evidence from research showing that psychosocial stressors make muscle fibres become more susceptible to injuries, likely by permanently activating low-threshold motor units. All these responses are contributors to the development of MSDs in the long-term.

A potential mechanism linking psychosocial factors to these postulated stress responses is the erosion of personal resources. For instance, bullying at work has a detrimental impact on employee resources that leads to a decrease in personal energy (Tuckey & Neall, 2014). It may be that exposure to bullying, harassment, and violence affects an employee's capacity to act in a safe manner or feel supported by safety systems, thus leading to more strain and accidents at work.

Another psychosocial mechanism is that exposure to high work demands leads to emotional exhaustion, a state of mental weariness, fatigue, or tiredness, which then impacts physical health (Yulita, Idris, & Dollard, 2014). Psychosocial risk factors can also impact work-related injury causation and rehabilitation (Bailey et al., 2015). For example, workers with less social support

often express prolonged recovery time after superficial acute musculoskeletal injuries. Over time a lack of opportunity for recovery could lead to MSDs.

What is the Gap

It is necessary to understand both psychosocial and physical factors in the work environment and mechanisms that could be detrimental to worker physical health to prevent work-relate injuries. Yet with few exceptions an integrative theoretical framework linking the dual pathways (physical and psychosocial) is missing. Also missing is an effort to establish the cause of the dual process pathways, the 'cause of the causes' of physical and psychosocial risks. Although aspects such as leadership and organisational climate are implicated (Christensen, Nielsen, Finne, & Knardah, 2018) these factors are largely considered as co-occurring proximal work factors rather than potential distal determinants of MSD physical and psychosocial risk factors at work, leaving a gap in our explanation about what causes MSDs. Without optimal information about aetiology, efforts to prevent MSDs may be misguided. Given the prevalence and costs of MSD, the aim of this paper is to understand the distal and proximal causes of MSDs via the dual process paths.

Distal: Psychosocial Safety Climate as a Common Sources of MSD Causes

We propose that Psychosocial Safety Climate (PSC) is a common cause of the dual process paths. PSC theory is an innovation in the field (Dollard & Bakker, 2010; Dollard & Karasek, 2010; Law, Dollard, Tuckey, & Dormann, 2011) and refers to the corporate climate for worker psychological health and safety. PSC is defined as 'policies, practices and procedures for the protection of worker psychological health and safety' (Dollard & Bakker, 2010, p. 579). It incorporates management commitment and priority, organisational communication, and organisational participation and involvement, specifically in relation to psychosocial factors and worker health and safety. PSC theory has gained prominence nationally and internationally and is a unifying construct that has promoted interdisciplinarity integrating work stress and safety science research. The construct is empirically distinct from related constructs such as team psychological climate, organisational social support, and safety climate (Idris, Dollard, Coward, & Dormann, 2012). Whereas the safety climate construct is used to predict safety behaviour and accidents and injuries (Griffin & Curcuruto, 2016), PSC instead is used to predict psychosocial risks in work design and work conditions and their relationship to worker health. Previous research also suggests that PSC is a leading indicator for psychosocial factors that impact MSDs and physical health outcomes (Bailey, Dollard, McLinton & Richards, 2015; Garrick et al., 2014; Yulita et al., 2014).

PSC as a Predictor of Causal Pathways

Research has supported the PSC psychosocial mechanism showing that psychosocial factors influenced MSDs (physical health) and in turn rates of workers' compensation claims for physical

injuries (Bailey et al., 2015). The Australian study evaluated dual pathways in a longitudinal study of 1095 workers who completed a telephone interview on two occasions 12 months apart. Results confirmed the physical mechanism longitudinally, that physical demands were related to MSDs, which in turn predicted workers' compensation claims (Bailey et al., 2015). Over and above this, the study established a psychosocial mechanism, that psychosocial risk factors such as work pressure, harassment, bullying, and violence, preceded by PSC were significantly cross-sectionally related to emotional exhaustion, which in turn related to MSDs, and over time, predicted workers' compensation claims for physical injuries. The results showed that cross-sectionally emotional exhaustion mediates the relationship between job demands and MSDs, that in turn has a significant longitudinal impact on compensation claims for physical injury. The evidence supported the proposition that the PSC extended health erosion pathway (Dollard & Bakker, 2010) of the Job Demands Resources Model (Demerouti, Bakker, Nachreiner, & Schaufeli, 2001) is a predictor of psychological health, and revealed an expanded function of it as a potential predictor for physical injuries at work via emotional exhaustion. In other PSC research, physical health outcomes have also been investigated, including musculoskeletal issues, work-related injuries, and workers' compensation claims (Loh, Zadow & Dollard, 2020).

The significance of these contributions was mirrored in later research from The Netherlands, which also integrated physical and psychosocial mechanisms in explanation of MSDs in a cross-sectional study of 8,671 employees working in 177 health care settings (Bronkhorst & Vermeeren, 2016). They investigated the relationship between organisational safety climate (PSC and physical safety climate) and organisational health performance outcomes (i.e. absenteeism, presenteeism, health care utilization) mediated by individual worker health (MSDs and emotional exhaustion). Three pathways were tested: a physical pathway commencing with physical safety climate and mediated by MSDs; a psychosocial pathway commencing with PSC and mediated by emotional exhaustion, and a pathway commencing with PSC and mediated by an emotional exhaustion → MSDs effect. Their findings did not support the physical pathway because *physical* safety climate was not related to MSDs. The psychosocial pathway was supported in relation to health outcomes (absenteeism and presenteeism). The combined physical and psychosocial pathway explained differences in the third outcome: health care utilization. The findings confirmed a psychosocial process path, PSC → emotional exhaustion → MSDs.

A recent systematic literature review of 47 studies focused on the associations between psychosocial risk factors and the risk of musculoskeletal disorders (MSD) at work. James, Austin, and Bezzina's (2021) review across 4999 workers from various industries found that low job control, low job decision authority and low job satisfaction were significantly associated with an increase in the risk of MSD. Moreover, they have found psychosocial risk factors like inadequate

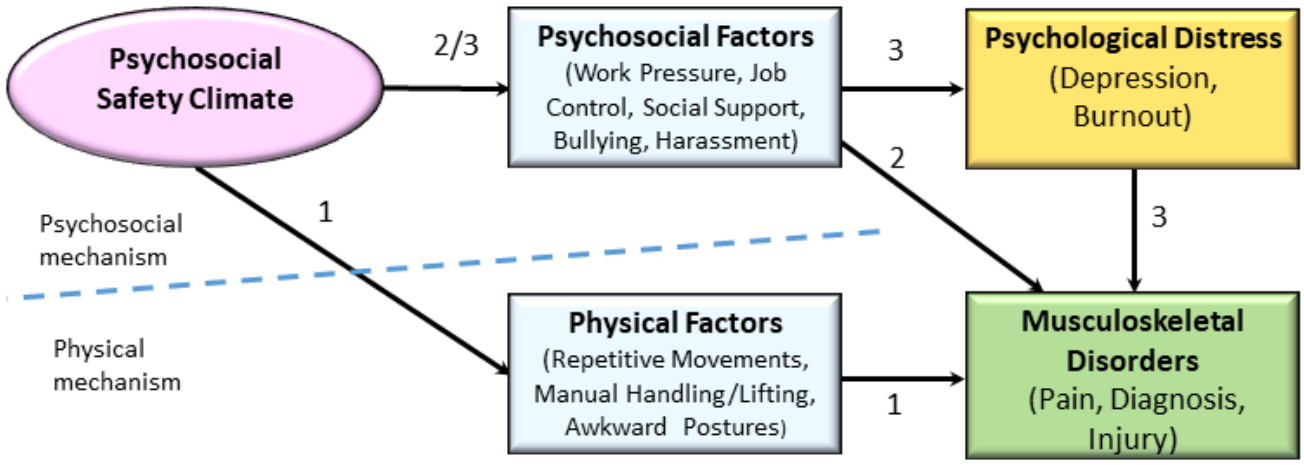
social support and lack of collaboration at work associated with the increased risk of MSD. Thus, there was a bi-directional relation between the psychosocial risk factors and a range of MSD conditions. However, despite the role of psychosocial factors in this relationship, the magnitude and direction of causal impact were influenced by further individual and organisational stressors and risks.

The Current Study

In this study, we focused on MSDs through the lens of psychosocial and physical mechanisms. We proposed that PSC, as a likely upstream determinant, influences both the psychosocial and physical mechanisms. Thus, high PSC is likely an antecedent to the dual combination of well-recognised psychosocial and physical mechanisms that precipitate psychological and physical injuries. Consequently, in this theoretical model of MSD causation, we highlighted the role of psychosocial factors (e.g., work pressure, job control, social support, bullying and violence) and physical factors (e.g., physical demands, high muscular load, and awkward and static postures). In our study, we operationalised physical demands in terms of physical effort, moving heavy loads, rapid activity, and awkward body positions, and MSD symptoms in terms of pain in the neck, back, arms or legs and muscle soreness. We included mental ill health such as emotional exhaustion (Bailey et al., 2015) along with depressive symptoms and anxiety, they have a significant role in mediating the association of both psychosocial and physical risk factors with low back pain, and neck and/or shoulder pain (Zamri, Moy & Hoe, 2017).

As shown in Figure 1, we introduced the following dual-process framework to examine MSDs, with PSC as a lead indicator. The potential paths involve a (1) a physical mechanism, and (2) psychosocial mechanism.

Figure 1. Proposed Study Framework with Process Paths



Method

Three process paths are proposed as outlined in Figure 1:

- Path 1: PSC relates to physical factors that in turn relate to MSDs (physical mechanism).
- Path 2: PSC relates to psychosocial factors that in turn relate to MSDs (psychosocial mechanism).
- Path 3: PSC relates to psychosocial factors that relate to psychological health and in turn MSDs (extended psychosocial mechanism).

Study Design

The project comprised three linked studies.

Study 1. An analysis of the prevalence of MSDs and risk factors in NSW employees

Study 2. A cross-sectional study assessing the association between risks and MSDs.

Study 3. A cohort study, the AWB, to evaluate prior psychosocial risks for (i) MSDs and (ii) reported workplace physical risk factors in workers continuously employed in the same organisation in three states – NSW, WA and Victoria

Ethics

This project was approved by the University of South Australia's Human Research Ethics Committee (protocol number 203003).

Participants

Sampling Method 1 (New Participants)

Data were supplied through the Edith Cowan University Survey Research Centre who obtained a population-based sample from a directory of phone numbers (See Appendix, Table 1A). The sample was provided to them by a sample broker who obtains personal information from government and non-government third party data suppliers such as this from BitData, to enable market research clients to use the data management services. The sample broker sought contractual commitments from all third-party data suppliers that the information has been collected and held by them in accordance with Australian Privacy Laws. Interview data was gathered from 468 new participants from NSW across a wide range of industries and organisations.

Sampling Method 2 (Recontacts)

We recontacted participants ('recontacts') who had previously participated in the AWB study. In 2009 a population-based sampling approach was used to ensure a representative sample of workers (18-65 year) across a range of organisations and industries. Participants were recruited randomly from the Australian Electronic White Pages and a directory of Australian mobile phone numbers. Prospective participants received letters/SMS informing them of the study's purpose and the interview procedure. This cohort was evaluated again in 2014/2015, with cohort enrichment and 432 follow up telephone interviews were completed in 2020/2021.

Sample Sizes

Prevalence Estimates and Cross-sectional Analysis

The total sample for the NSW prevalence analysis was 628 which comprised 468 new participants combined with 160 AWB recontact NSW employee participants.

Longitudinal analysis

The longitudinal analysis sought to shine light on questions of MSD 'causes' which is a general question and does not require an NSW specific sample. As noted in the recontacts sampling method, there were 432 recontacts across NSW, WA and Victoria yielding matched data to 2014/2015.

Survey Method

Data for both samples were gathered using Computer Assisted Telephone Interviews (CATI). Evidence suggests that this method provides quality data by comparison to online self-report techniques (Kurniawan, 2018; Szolnoki & Hoffmann, 2013). CATI is the method used in the high-quality Australian Bureau of Statistics and The Household, Income and Labour Dynamics in Australia (HILDA) surveys due to the comparatively low response bias and good generalisability compared to the web- or social media-based surveys (Szolnoki & Hoffmann, 2013). The method of accessing participants away from their worksites is preferable to interviews being conducted with employees at their workplaces as the latter can lead to exclusions and both sampling and response biases.

Measures

Survey tool

We used the AWB survey tool as the base survey. The AWB survey tool has been referenced extensively and has been used to establish national Australian and New Zealand benchmarks on a range of psychosocial risk factors and outcomes, including MSDs (Bailey et al., 2015), and

informing policy responses nationally, by jurisdiction, and at the enterprise level (Potter et al., 2017).

Relevant questions from the AWB survey tool were combined with additional questions determined during the co-design phase in consultation with representatives from the NSW Centre for WHS (The Centre). The AWB survey tool measures a range of psychosocial and physical risk factors, MSDs and mental health. The measures used were standardised and well validated psychometric scales. All reliability scores are from 2020/2021 NSW data.

Potential Risk Factors for MSDs

The range of potential risk factors assessed was developed in collaboration between the researchers and The Centre based upon a priori hypotheses and previous research.

Demographics

These included age, gender, income, education, family, employment type and duration, industry and occupation as used previously in the AWB.

Psychosocial risk factors

Psychosocial Safety Climate (PSC) was assessed with the PSC-12 (Hall, Dollard, & Coward, 2010). The PSC-12 consisted of four subscales, each with three items: (1) management commitment (e.g., "Senior management considers employee psychological health to be as important as productivity"); (2) management priority (e.g., "Senior management clearly considers the psychological health of employees to be of great importance"); (3) organisational communication (e.g., "There is good communication here about psychological safety issues which affect me") and (4) organisational participation (e.g., "Employees are encouraged to become involved in psychological safety and health matters"). Responses were on a Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*); α =.95.

Psychological Demands. Work pressure (psychological demands) was assessed using the five-item job demands scale from the new Job Content Questionnaire (JCQ 2.0; Karasek et al., 1998, www.jcqcenter.org). An example item is "My job requires working very hard". All items were measured on a Likert scale, ranging from 1 (*strongly disagree*) to 4 (*strongly agree*); α =.65.

Workplace Harassment. We used seven items from Richman et al.'s (1996) measure of organisational harassment to assess harassment (e.g., "I have been sworn and/or yelled at" and "I have been humiliated in front of others") and physical violence (i.e. "I have experienced being physically assaulted/threatened"). Responses were on a 5-point scale, from 1 (*very rarely/never*) through to 5 (*very often/always*); α =.70.

Workplace Bullying. We assessed bullying using an amended version of the QPSNordic Bullying Questionnaire (Dallner et al., 2000): "To label something as bullying, the offensive behaviour has to occur repeatedly over a period, and the person confronted has to experience difficulties defending him or herself. The behaviour is not bullying if two parties of approximate equal 'strength' are in conflict or the incident is an isolated event" (Lindström et al., 2000, p. 52). Participants were asked 'Have you been subjected to bullying at the workplace during the last six months?'

Job Control. Scales from the JCQ 2.0 were used to measure two job control constructs; *skill discretion* (6 items, e.g., "I have an opportunity to develop my own special abilities") α = .73; and *decision authority* (3 items, e.g., "My job allows me to make a lot of decisions on my own"); α = .76. A Likert response format was used for all items, with responses ranging from 1 (*strongly disagree*) to 4 (*strongly agree*).

Social Support. The JCQ 2.0 scales were used to measure *supervisor social support* (3-item scale, e.g., "My supervisor/manager is helpful in getting the job done"); α =.85, and *co-worker social support* (3-item scale, e.g., "I am treated with respect by my co-workers"); α =.83. Responses ranged from 1 (*strongly disagree*) to 4 (*strongly agree*) on both supervisor social support and co-worker social support scales.

Physical risk factors

Physical job demands were measured using a five-item physical demands subscale adopted from the JCQ-2.0 (Karasek et al., 1998, www.jcqcenter.org). These assessed as physical demands, moving/lifting heavy loads, rapid and continuous physical activity, working for long periods with head/ body or arms in physically awkward positions. An example item is "My job requires lots of physical effort". Responses were measured on a Likert scale, ranging from 1 (*strongly disagree*) to 4 (*strongly agree*); α =.80.

This was assessed with five items adapted from the physical demands measure (Macdonald et al., 2007). Items assessed aspects such as repeating the same movements, lift or carry heavy things, and working in twisted or awkward postures. Responses ranged from 1 (*almost never*) to 4 (*almost always*); α = .69.

MSD outcomes

These were evaluated using a multi-dimensional approach.

Pain was assessed with 3 items from the Nordic Musculoskeletal Questionnaire (NMQ; Kuorinka et al., 1987), including symptoms related to back pain, neck pain, muscle soreness, pains in arms,

legs, or joint areas like knee or hips, with an example item "[During the past 7 days] how much were you bothered by back or neck pain?". Responses were on a Likert scale, ranging from 1 (*not at all)*, 2 (*a little*), 3 (*some*) to 4 (*a lot*), α = .68. From the four-point scale from 1 (*not at all*), 2 (*a little*), 3 (*some*) to 4 (*a lot*) we constructed three pain levels, "*Not at all*", "*Some or a little*", and "*A lot*". We did this by defining: "*A lot*" as a respondent reporting this across any responses to neck or back, limb or joint or muscle soreness pain; "*Not at all*" by a match across all responses; and "*Some or little*" by any other match.

Doctor diagnosed Musculoskeletal Disorders. A list of common MSD conditions was designed to measure MSDs by asking the participants "Has a doctor EVER told you that you have a musculoskeletal condition?" If yes: "what was it?". Thirteen common MSDs like "Carpal Tunnel Syndrome", "Tendonitis", "Muscle and or Tendon and/or Ligament Strain", were provided with "*yes"* (1), "*no"* (0) responses. The number of MSDs diagnosed were added as total score for this measure. Participants reporting a doctor diagnosed MSD were then asked about medication used regularly in the last four weeks, and whether the MSD had caused them to change their work or take sickness absence in the past 12 months with "*yes"* (1), "*no"* (0) responses.

Medications. The participants were initially asked, "Have you taken any medications, vitamins or supplements regularly over the last four weeks?" with "*yes"* (1), "*no"* (0) responses. If yes, they were presented with a list of 17 common medications used by people with MSDs such as "Aspirin", "Nurofen", "Codeine", "Valium", "antidepressants" and "sleeping tablets" with "*yes"* (1), "*no"* (0) responses.

Self-reported 12-month Injuries were assessed with two non-exclusive questions asking, "Have you had a significant physical injury in the past 12 months?" (a) inside and/or (b) outside of the workplace.

Physical Treatments. Participants reporting any 12-month injury were then asked about physical treatments. Treatments received in the past 12 months were computed by asking the participants "Have you received any treatment for any of these physical injuries in the past 12 months?". If yes, "Have you had any treatment for this physical Injury/Injuries more than once in the past 4 weeks?" with a range of 6 multiple-choice answers such as "Physiotherapy", "Hydrotherapy" and "Osteopathy" and these were combined to indicate the number of treatments.

Workers' Compensation Claims were assessed with questions "Have you ever put in a workers' compensation claim?", "whether this was made in the past 12 months", and "whether the most recent claim was for a stress or psychological injury?" or "physical injury?" each with dichotomous

"*yes*"(1), "*no*"(0) responses. Thus, the compensation claims for psychological and physical injuries were aggregated to compute the total scores.

Data Handling and Analysis

Upon receipt of the data, the assumptions for normal distribution and parametric testing were checked and any non-normal distribution was fixed. Scale reliability was assessed, and distinct constructs were confirmed.

Study One: Estimation of prevalence of work-related psychosocial and physical risk factors and MSDs for workers across organisations in NSW in 2020-2021.

Accurate point prevalence estimation relies on gathering a random sample representative of the larger population sampling frame. Assumptions of generalisability were tested against NSW government and HILDA data for basic demographics and occupation. The prevalence of the risks and outcomes were then estimated as the number of people with the factor in the sample/ total number in the sample. Statistical weights were applied to ensure that the sample characteristics matched the population.

To evaluate the prevalence of psychosocial risk factors for MSD aetiology across industries in NSW we repeated and present results by industry, at the 2-digit level of ANZSCO 2006. Multilevel poststratification was used to generate estimates for each major industry category, adjusted for age and sex. To generate a representative sample we first converted industry categories to 2006 ANZSIC categories. Then we modelled MSD in the survey sample, using the industry, age and sex of the survey participants as independent variables. We used this model to generate the *sample* prevalence and the *adjusted* prevalence (by age and sex) of MSD. Next, we imported the NSW population data from the ABS (2016 Census), and then applied the model to the population data to estimate the number of people with MSD per industry in NSW and calculate the prevalence of MSD in NSW.

This method provides the observed MSD proportion (%) in the sample (% obs. = sample MSD n / sample N); the adjusted MSD proportion in the sample (% *adj*: MSD = age + sex + industry); and finally the estimated MSD prevalence in the NSW population (% estimate = NSW MSD n / NSW N), based on the distribution of each age and sex category per industry.

The model is built from the sample data and then applied to the population data, thus the variables in both the cross-sectional sample dataset and NSW population dataset must be equivalent.

Study Two: Cross-sectional relations between psychosocial and physical factors with MSDs in NSW workers

We determined bivariate associations of each risk factor and individual and composite measures of MSD outcomes. To assess multivariate association between workplace factors (psychosocial and/or physical) with MSDs, we used logistic regression model, adjusting for potential confounders. We modelled the processes by which factors affect MSD using structural equation modelling to address to what extent and how physical risk factors relate to MSDs (i.e. does PSC have a direct effect on MSDs or is the path mediated via psychosocial risks)?

For each outcome, univariate and multivariate effects were tested.

To test the process paths in the Directed Acyclic Graph (DAG) depicted above (Figure 1), the effect of each component in the DAG was tested in a series of multivariate regression models. The list of models, the risk factors assessed (and the Likelihood Ratio Test (LRT) comparison model) is shown below:

Model 0: PSC score (vs intercept-only)

Model I: PSC score + physical risk factors (LRT vs Model 0)

Model II: PSC score + psychosocial risk factors (LRT vs Model 0)

Model III: PSC score + psychosocial risk factors + distress (LRT vs Model II)

Model IV: PSC score + physical risk factors + psychosocial risk factors + sociodemographic factors (LRT vs Model II)

Model V: PSC score + physical risk factors + psychosocial risk factors + distress + sociodemographic factors (LRT vs Model IV)

Each cross-sectional model included controls (e.g., gender) indicated by the univariate results.

Study Three: Workplace Physical and Psychosocial Risk Factors associated with MSDs in NSW workers (Longitudinal)

The repeat panel nature of the cohort data enabled examining the relationships across time. Our 2020/2021 sample comprised 158 NSW, 169 WA, and 105 Victorian employees who had matched data to 2014/2015. Average time lag is 6 years. We examined bivariate relationships between each risk factor at Time 1 (2014/2015) with MSD outcomes at Time 2 (2020/2021). We used regression models (ordinal when the outcome was pain, logistic when the outcome was diagnosed MSD). Testing for *MSD outcomes*, models were the same as outlined in Study 2. We added Model V1 for the MSD pain only, where we had a baseline T1 estimate of the outcome and here we controlled for T1 MSD pain.

Model V1: MSD T1 + PSC T1 + physical demands and risks + psychosocial risks T1 + psychological distress T1 + demographics T1.

Physical hazard and risk outcomes. We explored predictors of future physical hazards and risks. In this we controlled for baseline levels because we were trying to predict future work environment from prior work environment. We selected into the sample only workers who worked in the same organisation 6.5 years later (n = 269). In predicting future physical hazard outcomes we controlled for Time 1 physical hazards. All models were the same as in Study 2.

Results

Study One. Estimation of prevalence of work-related psychosocial and physical risk factors and MSDs for workers across organisations in NSW in 2020-2021

Here we present the characteristics of the 628 NSW employee sample. We compared our sample to the NSW employed sample from the 2019 HILDA survey (latest release) to evaluate the representativeness of our sample with respect to four groups of potential risk factors (See Appendix, Table 2A):

- Socio-demographic (Table 1),
- Industry and occupation (Table 2 and 3),
- Workplace risk factors (Table 4), and
- Distress and compensation (Table 5).

Demographics

Relative to NSW employed respondents in the HILDA survey, the participants were more likely to be female, and older (over 40), more educated, higher earning, less single and more divorced, with fewer recent negative life events such as the victim of physical violence, serious personal injury and/or illness to self and death of spouse or child (see Table 1).

Table 1. Socio-demographics of Sample and Comparison to HILDA

Characteristic	AWB/ECU, N = 628[1]	HILDA, N = 3,158[1]	p-value[2]
Female	*359 / 623 (58%)*	*1,562 / 3,158 (49%)*	*<0.001*
Male	*264 / 623 (42%)*	*1,596 / 3,158 (51%)*	
Age category			
15 - 24	*15 / 627 (2.4%)*	*482 / 3,158 (15.3%)*	*<0.01*
25 - 34	*79 / 627 (13%)*	*826 / 3,158 (26%)*	
35 - 44	*150 / 627 (24%)*	*626 / 3,158 (20%)*	
45 - 54	*163 / 627 (26%)*	*564 / 3,158 (18%)*	
55 - 64	*161 / 627 (26%)*	*516 / 3,158 (16%)*	
65 - 74	*59 / 627 (9.5%)*	*144 / 3,158 (4.5%)*	
Education			*<0.001*
Did not finish Year 12	*14 / 620 (2.3%)*	*446 / 3,157 (14%)*	
High school	*301 / 620 (49%)*	*1,543 / 3,157 (49%)*	
University	*305 / 620 (49%)*	*1,168 / 3,157 (37%)*	
Income level			*<0.001*
Up to - $20,000	*24 / 598 (2.8%)*	*619 / 3,158 (19.5%)*	
$20,001 - $30,000	*24 / 598 (4.0%)*	*222 / 3,158 (7.0%)*	
$30,001 - $40,000	*34 / 598 (5.7%)*	*228 / 3,158 (7.2%)*	
$40,001 - $50,000	*54 / 598 (9.0%)*	*306 / 3,158 (9.7%)*	
$50,001 - $60,000	*63 / 598 (11%)*	*352 / 3,158 (11%)*	
$60,001 - $80,000	*107 / 598 (18%)*	*474 / 3,158 (15%)*	
$80,001 - $100,000	*88 / 598 (15%)*	*343 / 3,158 (11%)*	
$100,001 - $150,000	*141 / 598 (24%)*	*426 / 3,158 (13%)*	
$150,001 - $200,000	*37 / 598 (6.2%)*	*105 / 3,158 (3.3%)*	
More than $200,000	*26 / 598 (4.3%)*	*83 / 3,158 (2.6%)*	
Marital status			*<0.001*
Single	*94 / 620 (15%)*	*738 / 3,157 (23%)*	
Married/de facto	*433 / 620 (70%)*	*2,192 / 3,157 (69%)*	
Separated/divorced	*76 / 620 (12%)*	*202 / 3,157 (6.4%)*	
Widowed	*17 / 620 (2.7%)*	*25 / 3,157 (0.8%)*	
Employment status			
Permanent full-time	*410 / 628 (65%)*	*1,780 / 3,158 (56%)*	
Permanent part-time	*110 / 628 (18%)*	*492 / 3,158 (16%)*	
Fixed-term contract	*19 / 628 (3.0%)*	*232 / 3,158 (7.3%)*	
Casual/temporary	*76 / 628 (12%)*	*648 / 3,158 (21%)*	
Other (specify)	*13 / 628 (2.1%)*	*6 / 3,158 (0.2%)*	
Negative events in past year			*<0.001*
0	*491 / 628 (78%)*	*2,489 / 2,836 (88%)*	
1	*104 / 628 (17%)*	*304 / 2,836 (11%)*	
2 or more	*33 / 628 (5.2%)*	*43 / 2,836 (1.5%)*	
Good events in past year			*0.9*
0	*560 / 628 (89%)*	*2,548 / 2,842 (90%)*	
1	*67 / 628 (11%)*	*286 / 2,842 (10%)*	
2 or more	*1 / 628 (0.2%)*	*8 / 2,842 (0.3%)*	

Note: [1] n / N (%), [2] Pearson's Chi-squared test; Fisher's exact test. Where numbers do not add up to total sample this indicates missing responses

To compare the employment characteristics to NSW data, the occupation and industry categories in the survey sample were converted to ANZSCO 2006 and ANZSIC 2006 categories. For details of the conversion, see Appendix Study 1 Sample and Prevalence. Overall, the sample represented all industries and the differences were not statistically significant but there were > 5% difference in education (more in the study) and fewer in Professional, Scientific and Technical Services. As expected from the demographic differences the participants were more likely to be in professional and managerial occupations and less likely to come from blue collar occupations (see Table 2 and 3).

Table 2. Industry Categories of Study Sample and HILDA (ANZSIC 2006)

Industry (ANZSIC 2006)	AWB/ECU, N = 628	HILDA, N = 3,158
Agriculture, Forestry and Fishing	*15 / 628 (2%)*	*56 / 3158 (2%)*
Mining	*19 / 628 (3%)*	*46 / 3158 (1%)*
Manufacturing	*32 / 628 (5%)*	*215 / 3158 (7%)*
Electricity, Gas, Water and Waste Services	*19 / 628 (3%)*	*28 / 3158 (1%)*
Construction	*28 / 628 (5%)*	*263 / 3158 (8%)*
Wholesale Trade	*11 / 628 (2%)*	*91 / 3158 (3%)*
Retail Trade	*32 / 628 (5%)*	*285 / 3158 (9%)*
Accommodation and Food Services	*25 / 628 (4%)*	*213 / 3158 (7%)*
Transport, Postal and Warehousing	*38 / 628 (6%)*	*120 / 3158 (4%)*
Information Media and Telecommunications	*22 / 628 (4%)*	*63 / 3158 (2%)*
Financial and Insurance Services	*48 / 628 (8%)*	*143 / 3158 (5%)*
Rental, Hiring and Real Estate Services	*3 / 628 (<1%)*	*48 / 3158 (2%)*
Professional, Scientific and Technical Services	*11 / 628 (2%)*	*254 / 3158 (8%)*
Administrative and Support Services	*8 / 628 (1%)*	*104 / 3158 (3%)*
Public Administration and Safety	*67 / 628 (11%)*	*181 / 3158 (6%)*
Education and Training	*104 / 628 (17%)*	*342 / 3158 (11%)*
Health Care and Social Assistance	*123 / 628 (20%)*	*522 / 3158 (17%)*
Arts and Recreation Services	*5 / 628 (1%)*	*56 / 3158 (2%)*
Other Services	*17 / 628 (3%)*	*112 / 3158 (4%)*

Table 3. Occupational Categories (ANZSCO 2006)

Occupation (ANZSCO 2006)	AWB/ECU, N = 623	HILDA, N = 3,158
Managers	*186 / 623 (30%)*	*474 / 3158 (15%)*
Professionals	*225 / 623 (36%)*	*857 / 3158 (27%)*
Technicians and Trades Workers	*37 / 623 (6%)*	*377 / 3158 (12%)*
Community and Personal Service Workers	*20 / 623 (3%)*	*400 / 3158 (13%)*
Clerical and Administrative Workers	*49 / 623 (8%)*	*370 / 3158 (12%)*
Sales Workers	*15 / 623 (2%)*	*243 / 3158 (8%)*
Machinery Operators and Drivers	*7 / 623 (1%)*	*194 / 3158 (6%)*
Labourers	*24 / 623 (4%)*	*243 / 3158 (8%)*

Prevalence of Workplace Risk

Median values and interquartile range (IQR) of the median for the workplace physical and psychosocial risks are shown in Table 4.

Table 4. Workplace Risk Factors Median and Interquartile Range

Risk Factors	Median (Interquartile Range)
Psychological demands	*13.00 (12.00, 15.00)*
Physical demands	*6.00 (4.00, 7.00)*
Physical risk factors	*7.00 (5.00, 9.00)*
Skill discretion	*18.00 (16.00, 20.00)*
Decision authority	*9.00 (8.00, 10.00)*
Supervisor support	*9.00 (9.00, 11.00)*
Coworker support	*9.00 (9.00, 12.00)*
Psychosocial safety climate (PSC)	*45 (36, 49)*
Harassment in the past six months	*4.18 (4.00, 5.22)*
Bullying during the last six months?	*57 (9.1%)†*

Note: †, n (%); N = 628.

Prevalence of Psychological Distress and Compensation

Although 1 in 5 had put in a lifetime workers compensation claim, only 2.5% (16) had done so in the past year (fewer than the number who had reported a workplace injury) (see Table 5). The median depression score on the PHQ-9 of 3 (interquartile range (IQR) of the median is 1-7) is indicative of a normal population where the majority do not have significant depressive symptoms.

Table 5. Psychological Distress and Compensation

Variable	n (%)
Have you ever put in a worker's compensation claim?	
Yes	*119 (19%)*
No	*509 (81%)*
Refused	*0 (0%)*
Did you lodge this claim in the last 12 months?	
Yes	*16 (2.5%)*
No	*103 (16%)*
Refused	*0 (0%)*
(Not applicable)	*509 (81%)*
Psychological distress	
Burnout	*16 (10, 23)*[†]
Depressive symptoms	*3 (1, 7)*[†]

Note: [†]Median (Interquartile range); N = 628

Prevalence of Different Aspects of Musculoskeletal Disorders

Pain. The self-reported level of pain in each of three body areas is shown in Table 6.

Table 6. Pain Level by Location/Type (frequency)

	Pain						
Characteristic	A lot	Some	A little	Not at all	(Missing)	Total	*p*[1]
Location							*0.012*
Neck or back	*108 (17%)*	*94 (15%)*	*175 (28%)*	*246 (39%)*	*5 (0.8%)*	*628 (100%)*	
Limb joint	*92 (15%)*	*83 (13%)*	*155 (25%)*	*293 (47%)*	*5 (0.8%)*	*628 (100%)*	
Muscle soreness	*68 (11%)*	*77 (12%)*	*169 (27%)*	*309 (49%)*	*5 (0.8%)*	*628 (100%)*	

Note: [1]Pearson's Chi-squared test

Pain was very common with fewer than one quarter of respondents reporting being pain free, and over a quarter reporting a lot of pain in at least one body area (Table 7).

Table 7. Overall Pain Level (frequency)

Pain	N = 628[1]
A lot	*161 (26%)*
Some or a little	*334 (53%)*
Not at all	*133 (21%)*

Lifetime doctor diagnosed musculoskeletal condition. About 20% of men and women reported a lifetime doctor diagnosed specific MSD diagnosis (see Table 8).

Table 8. Lifetime Doctor Diagnosed Musculoskeletal Condition

Characteristic	Female, N = 359[1]	Male, N = 264[1]
MSD - Carpal tunnel syndrome	*9 (2.5%)*	*8 (3.0%)*
MSD - Tendonitis	*9 (2.5%)*	*6 (2.3%)*
MSD - Muscle and/or tendon and/or ligament strain	*11 (3.1%)*	*8 (3.0%)*
MSD - Rheumatoid arthritis (RA) or autoimmune	*10 (2.8%)*	*10 (3.8%)*
MSD - Meniscal tear	*6 (1.7%)*	*9 (3.4%)*
MSD - Rotator cuff problem or frozen shoulder	*9 (2.5%)*	*7 (2.7%)*
MSD - Tennis or golfers' elbow	*5 (1.4%)*	*4 (1.5%)*
MSD - Osteoarthritis	*23 (6.4%)*	*8 (3.0%)*
MSD - Repetitive strain injury	*6 (1.7%)*	*4 (1.5%)*
MSD - Chronic back pain or sciatica	*20 (5.6%)*	*16 (6.1%)*
MSD - Degenerative disc disease	*10 (2.8%)*	*6 (2.3%)*
MSD - Ruptured and/or herniated disc	*7 (1.9%)*	*8 (3.0%)*
MSD – None of these	*284 (80%)*	*205 (78%)*

Note. More than one response could be indicated by each respondent

MSD Diagnoses and Level of Pain. The association of self-reported level of pain with MSD diagnosis is shown in Table 9. There is a significant association between MSD and pain. One in five people have a doctor diagnosed MSD (132/628, 21%). Most of these are experiencing some kind of pain (125/132, 95%).

Table 9. MSDs in Each Pain Category (frequency)

	MSD			
Characteristic	Named diagnosis	None or 'Other'	Total	*p*[1]
Pain				*<0.001*
A lot	*64 (40%)*	*97 (60%)*	*161 (100%)*	
Some or a little	*61 (18%)*	*273 (82%)*	*334 (100%)*	
Not at all	*7 (5.3%)*	*126 (95%)*	*133 (100%)*	
Total	*132 (21%)*	*496 (79%)*	*628 (100%)*	

Note: [1]Pearson's Chi-squared test

Conversely most 60% (97/161) of those who report their pain is high have none or "other" of the common MSD diagnoses. In other words, there is more pain evident than could be surmised by reference to the frequency of common MSDs.

MSD diagnoses and Medications, vitamins or supplements. The use of regular pharmacotherapies and other treatments by those with an MSD is shown in Table 10. Medications for MSD were categorised into four types and participants could report medication in more than one category:

- "second-line analgesics" "Codeine", "Oxycodone", "Tramadal", "Fentanyl", "Pregabalin", "Morphine"
- "simple analgesics" "Aspirin", "Nurofen", "Mobic" (and no second-line analgesics)
- "psychotropic" as ANY match with "Endep", "Antidepressant", "Valium", "Sleeping pills Rx" (and no second-line or simple analgesics)
- "Complimentary and alternative medicine (CAM) only" as any match with "Glucosamine", "Pain placebo", "Sleeping pills (over counter)", "Other" (and no analgesics or psychotropics).

Table 10. Recent Pharmacological Treatment in Those with Lifetime MSDs

	Pharmacotherapy					
Characteristic	Second-line analgesics	Simple analgesics	Psycho-tropics	CAM	None	Total
Pain						
A lot	*10 (16%)*	*21 (33%)*	*8 (12%)*	*17 (27%)*	*22 (34%)*	*78/64*
Some or a little	*1 (1.6%)*	*16 (26%)*	*3 (4.9%)*	*10 (16%)*	*35 (57%)*	*65/61*
Not at all	*1 (14%)*	*1 (14%)*	*2 (29%)*	*0 (0%)*	*5 (71%)*	*9/7*
Total	*12 (9.1%)*	*38 (28.8%)*	*13 (9.8%)*	*27 (20.4%)*	*62 (47%)*	*152/132*

More than half of people with a named MSD diagnosis are taking some form of pharmacotherapy (70/132, 53%) (62/132 are not taking mediation see "none" column). Likewise, of those in "a lot" of pain, 22/64 people are not taking any medication and two thirds (42/64, 66%) are taking at least one, and usually two or more medications.

MSD caused change in work or sickness absence in the past 12 months. Almost one in four people with a named MSD diagnosis (30/132, 23%) changed or missed work due to the MSD. One third (22/64) of people in "a lot" of pain missed or changed work, compared to 13% of people in "Some or a little" pain (Table 11). None of people with a pain free lifetime MSD missed or changed work.

Table 11. Frequency of Change to Work or Take Sickness Absence by Pain

	Change work or take absence			
Characteristic	Yes	No	Total	*p*[1]
Pain				*0.006*
A lot	*22 (34%)*	*42 (66%)*	*64 (100%)*	
Some or a little	*8 (13%)*	*53 (87%)*	*61 (100%)*	
Not at all	*0 (0%)*	*7 (100%)*	*7 (100%)*	
Total	*30 (23%)*	*102 (77%)*	*132 (100%)*	

Note: [1]Fisher's exact test

Musculoskeletal Injuries and treatment in the past 12 months. In total, 11% (70/628) people reported a significant injury in the last 12-months with 22 work-related injuries reported, and 52 non-work injuries reported. Among people who indicated a work- or non-work-related injury (Table 12), less than half received regular physical therapy recently (27/70, 39%). Physical therapy included Physiotherapy, Hydrotherapy, Osteopathy, Chiropractic, Remedial massage, and other physical, with more than one "session" in the last four weeks). Most people receiving regular therapy are in "a lot" of pain (18/27, 67%).

Table 12. Regular Physical Therapy (> 1 session per month) by Pain Severity

	Physical therapy			
Characteristic	More than once	Once or none	Total	*p*[1]
Pain				*0.3*
A lot	*18 (47%)*	*20 (53%)*	*38 (100%)*	
Some or a little	*8 (30%)*	*19 (70%)*	*27 (100%)*	
Not at all	*1 (20%)*	*4 (80%)*	*5 (100%)*	
Total	*27 (39%)*	*43 (61%)*	*70 (100%)*	

Note: [1]Fisher's exact test

Prevalence of Musculoskeletal Disorders and Related Problems in NSW Workers in Different Industries

For each of the different aspects of MSDs (pain, MSDs and 12-month workplace injury) we present the observed, estimated, and adjusted prevalence in each industry in NSW:

- The observed prevalence is that obtained from the survey with 95% CI
- The adjusted prevalence is the prevalence in the sample adjusted for age, gender and industry
- The estimated prevalence is the prevalence in NSW workers based on the distribution of each age and sex category per industry in NSW workers (using NSW population data from the ABS 2016 Census).

Pain. The NSW industries with the highest estimated prevalence of employees reporting a lot of pain were Retail Trade, Electricity Gas and Waste Services (both around 35%), and Financial/Insurance, and Professional Scientific/Technical Services (both > 25%). Fewer than 15% of employees in Mining, Construction, Education, Public Administration, and IT reported high pain levels (see Figure 2 and Appendix, Table3A).

Doctor Diagnosed MSD. The industry variability in prevalence of specific Doctor Diagnosed MSDs was lower, and with no statistically significant differences with a range of 10-23% (see Figure 3 and Appendix, Table4A).

12-month work-related injury. With a very low prevalence 4% (22/628) of 12 month work related injury there were, not surprisingly, no significant differences between industries. However, the prevalence was 10% or higher in Electricity Gas Water and Waste Services, Transport, Postal and Warehousing, and Wholesale Trades industries, and less than 1% in Finance (see Figure 4 and Appendix, Table5A).

Figure 2. Prevalence of Workers in "A lot" of Pain in each Industry in NSW Workers

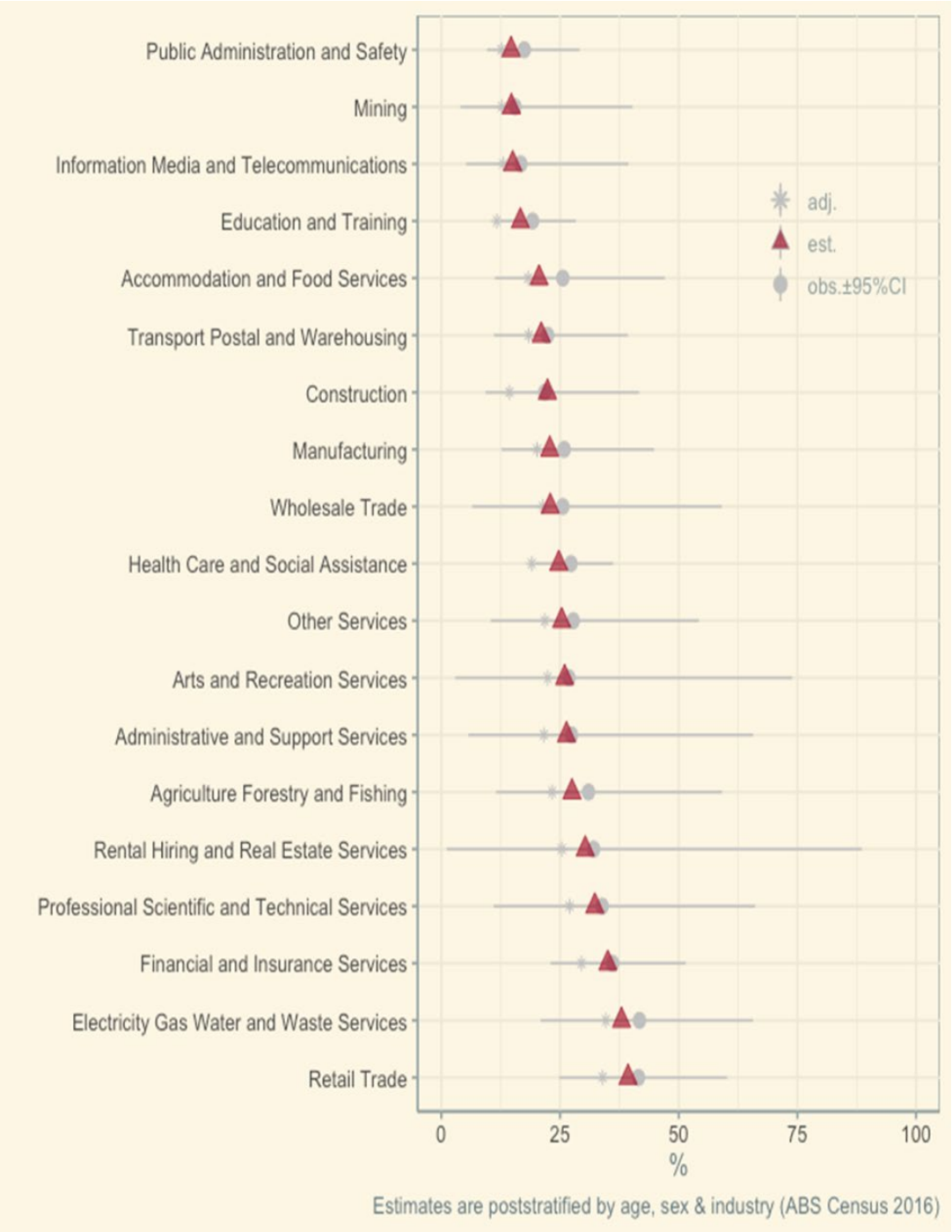


Figure 3. Prevalence of Lifetime Doctor Diagnosed MSDs by Industry in NSW Workers

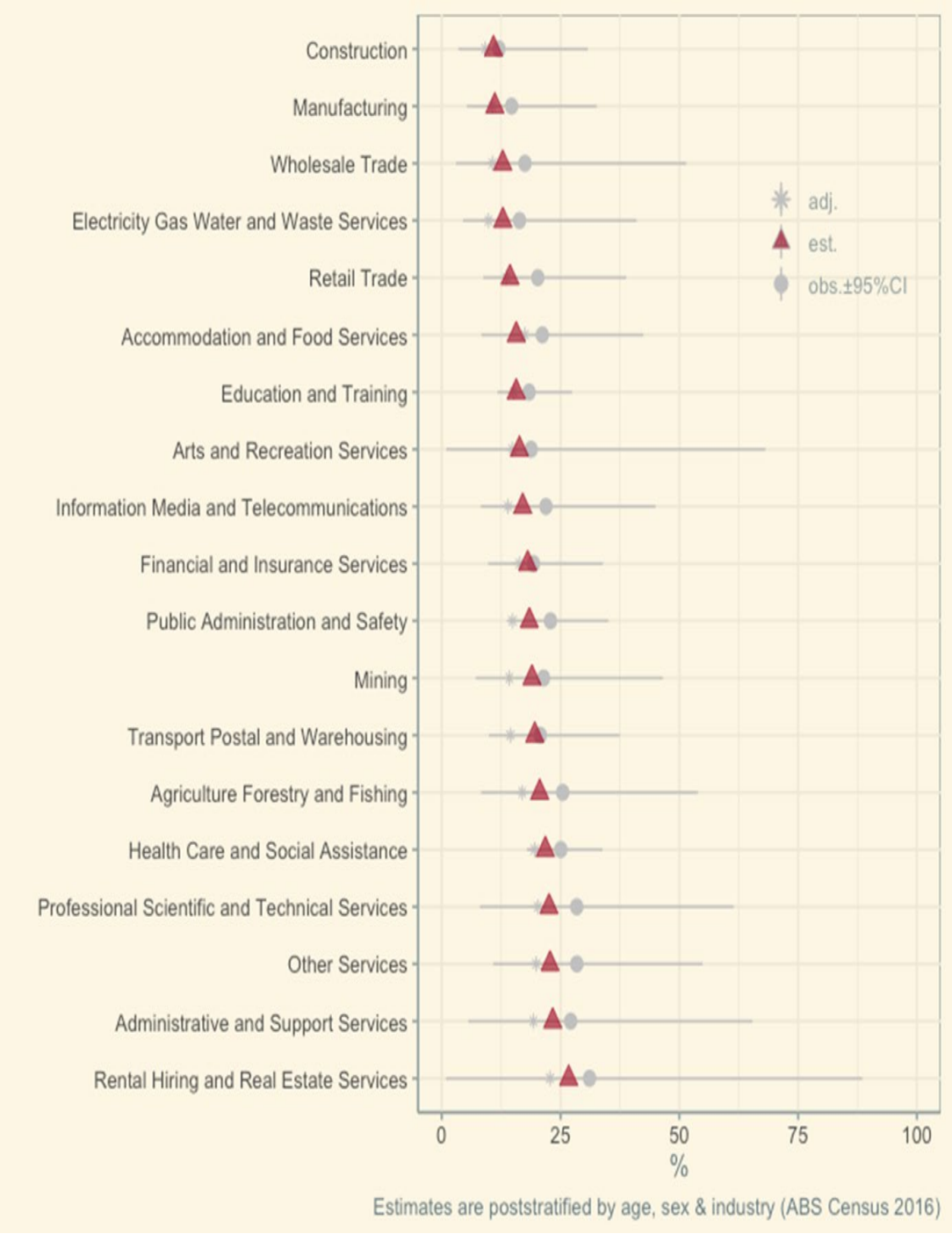


Figure 4. Prevalence of 12 Month Work Related Injury by Industry in NSW Workers

Study Two: Cross-sectional relations between psychosocial and physical factors with MSD's in NSW workers

Association of Risk Factor with MSD Outcomes

The individual associations of each risk factor with each MSD outcome are shown in the appendix.

Pain. People who reported being in a lot of pain reported greater distress (depression, r = .24, p < .01 and burnout, r = .21, p < .01) and higher levels of several work-related risks – physical (r = .18, p < .05) and psychological (r = .19, p < .05) demands, lower psychosocial safety climate (r = -.17, p < .05), and more bullying (r = .13, p < .05) and harassment (r = .19, p < .05) but no differences in autonomy or support (See Appendix, Table 6A and 7A).

Doctor Diagnosed MSD. The only factor associated with a doctor diagnosed MSD was increasing age, r = .18, p <.01 and there was no association with any physical or psychosocial workplace risk (See Appendix, Table 8A).

12-month work-related injury. Work related injury was associated with greater distress (depression, r = .11, p < .01 and burnout, r = .15, p < .01) and only one type of work risk factor - higher levels of physical demands, r = .15, p < .01, and risk factors, r = .19, p < .01 (See Appendix, Table 9A).

Evaluating the Psychosocial Safety Climate as a Distal Risk Factor for MSDs

A priori we aimed to evaluate Psychosocial Safety Climate as a distal risk factor for each MSD outcome and whether any effect was mediated by psychosocial risk factors (work pressure, job control, social support, bullying), psychological distress (burnout, depressive symptoms), and physical workplace risk factors (see Table 8 for summary of risk factors).

Table 13. Risk Factors for MSDs

Psychosocial Safety Climate	Workplace Psychosocial factors	Psychological Distress	Workplace Physical factors	Demographics
PSC	*Psychological demands*	*Depressive Symptoms*	*Physical demands*	*Female*
	Skill discretion	*Burnout*	*Physical risk*	*Age*
	Decision authority			*Education*
	Supervisor support			*Income*
	Co-worker support			
	Bullying			
	Harassment			

The effect of each path in evaluating the Psychosocial Safety Climate model (see Figure 1) was compared to evaluate their relative predictive capacity for each MSD outcome. We finally evaluated a full model of all risk factors, with (model V) and without (model IV) psychological distress (which may be an outcome of MSD rather than a risk in cross-sectional analyses).

Summary of Findings of Modelling PSC as a Distal Risk Factor for MSDs

Pain. The association of PSC with pain is accounted for in a model where this is path is mediated by psychological risk factors (demands and harassment) and psychological distress (effects are presented below). Physical risk factors are associated with pain, independently of PSC and psychological risk factors.

Doctor Diagnosed MSDs. Only age and skill discretion were associated with this outcome

12 month work related injury. Only burnout was associated with 12 month work related injury. There were no effects with PSC, psychosocial factors or demographic characteristics

Figure 5. Study 2 Significant Multivariate Paths (Cross-sectional)

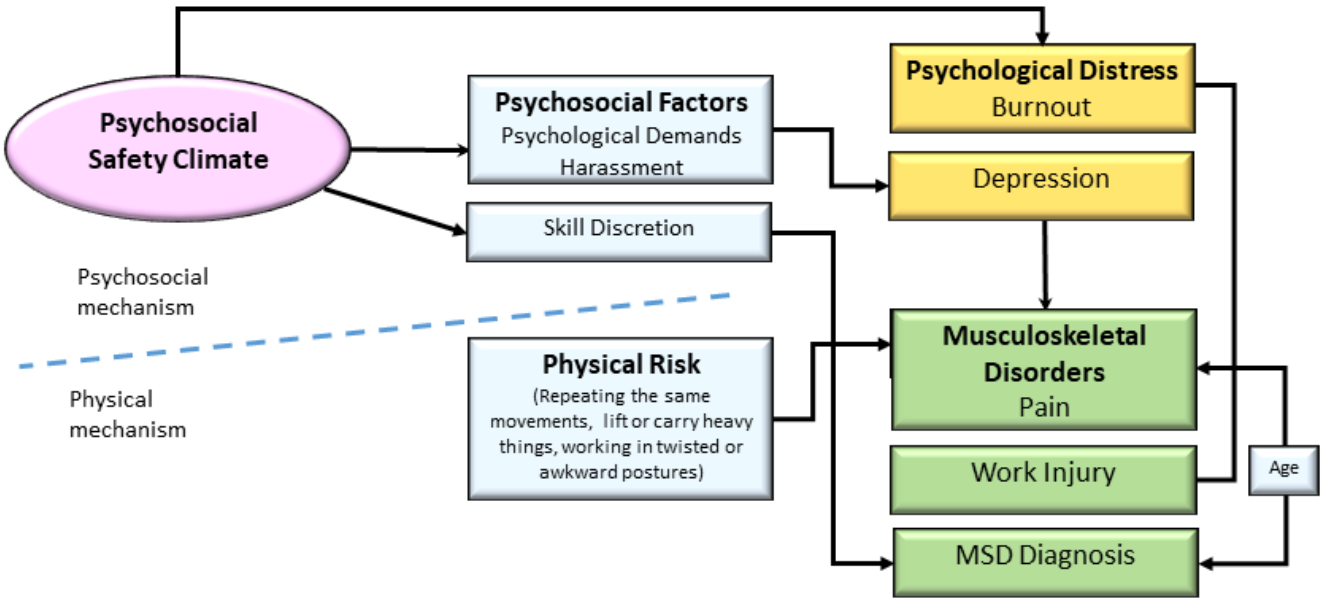


Table 14. PSC and Risk factors for Pain – Multivariate Model

Model	Term	Odds ratio	2.5%	97.5%	p value	p	R2
0	PSC	0.72	0.61	0.84	0.00	<.001	0.014
	Female	1.13	0.83	1.55	0.43		
I	PSC	0.80	0.67	0.94	0.01	<.001	0.056
	Physical demands	0.88	0.70	1.10	0.26		
	Physical risk	1.98	1.57	2.50	0.00		
	Female	1.15	0.84	1.57	0.40		
II	PSC	0.82	0.68	1.00	0.05	<.001	0.040
	Psychological demands	1.37	1.16	1.62	0.00		
	Skill discretion	0.87	0.71	1.07	0.20		
	Decision authority	1.03	0.85	1.26	0.76		
	Supervisor support	0.96	0.78	1.19	0.71		
	Co-worker support	1.16	0.96	1.40	0.14		
	Bullying	1.19	0.64	2.23	0.58		
	Harassment	1.28	1.08	1.53	0.01		
	Female	1.02	0.74	1.41	0.90		
III	PSC	0.82	0.67	1.00	0.05	<.001	0.053
	Psychological demands	1.26	1.05	1.52	0.02		
	Skill discretion	0.88	0.72	1.09	0.24		
	Decision authority	1.05	0.86	1.28	0.66		
	Supervisor support	0.98	0.79	1.21	0.82		
	Co-worker support	1.17	0.96	1.42	0.11		
	Bullying	1.09	0.58	2.06	0.80		
	Harassment	1.20	1.01	1.44	0.04		
	Depressive symptoms	1.41	1.15	1.73	0.00		
	Burnout	1.04	0.83	1.30	0.75		
	Female	1.00	0.73	1.38	1.00		
IV	PSC score	0.86	0.70	1.06	0.15	<.001	0.075

Model	Term	Odds ratio	2.5%	97.5%	p value	p	R2
	Physical demands	0.82	0.65	1.03	0.09		
	Physical risk	1.88	1.48	2.40	0.00		
	Psychological demands	1.29	1.08	1.55	0.01		
	Skill discretion	1.00	0.80	1.25	0.97		
	Decision authority	1.00	0.82	1.23	0.98		
	Supervisor support	0.94	0.76	1.17	0.58		
	Co-worker support	1.16	0.95	1.41	0.15		
	Bullying	1.01	0.53	1.93	0.97		
	Harassment	1.21	1.01	1.45	0.04		
	Female	1.01	0.72	1.43	0.94		
	Age	1.23	1.04	1.44	0.02		
	Education	0.84	0.61	1.17	0.31		
	Income	0.98	0.89	1.08	0.65		
V	PSC score	0.86	0.70	1.06	0.15	0.001	0.086
	Physical demands	0.83	0.65	1.04	0.11		
	Physical risk	1.82	1.43	2.33	0.00		
	Psychological demands	1.20	0.99	1.47	0.06		
	Skill discretion	0.99	0.79	1.24	0.95		
	Decision authority	1.02	0.83	1.24	0.89		
	Supervisor support	0.96	0.78	1.19	0.71		
	Co-worker support	1.17	0.96	1.42	0.12		
	Bullying	0.94	0.49	1.80	0.84		
	Harassment	1.15	0.96	1.38	0.13		
	Depressive symptoms	1.40	1.14	1.73	0.00		
	Burnout	1.01	0.80	1.28	0.92		
	Female	1.01	0.71	1.43	0.97		
	Age	1.29	1.10	1.53	0.00		

Model	Term	Odds ratio	2.5%	97.5%	p value	p	R2
	Education	0.87	0.62	1.20	0.39		
	Income	0.99	0.90	1.10	0.89		

In terms of the Psychosocial Safety Climate Process Paths (Figure 1), PSC had a reliable effect on pain levels even after introducing the physical demands (Model I) (final effects below), but not after introducing the psychosocial risks and distress (i.e., closing Paths 2 or 3 (see Table 14, Model II and III). This implies the effect of the PSC on pain levels occurs via psychosocial factors and psychological distress and is independent of the effect of physical risks.

Comparisons of the pseudo R-squared suggest Paths 2 and 3 together explain as much variation in pain as physical factors (Path 1). Age, physical risk factors and depressive symptoms are the most proximal effects on pain.

In Model V, with depression entered, psychological demands and harassment were no longer significant. However since these are both related to depression (r = .26, p < .01 and r = .28, p < .01), respectively this implies a mediation process. Psychosocial factors → depression → pain. Moreover as shown in Model II as the psychosocial factors are entered, PSC is removed from the model. Since PSC is significantly related to psychological demands (r = -.17, p < .05) and harassment (r = -.30, p < .01), this implies a pathway such as PSC→ psychological demands + harassment → pain. Taken together the process is likely represented as PSC → psychological demands + harassment → depression → pain.

MSD Diagnosis

- Skill discretion and age were related to the odds of a lifetime MSD diagnosis (see Table 15). Skill discretion was negatively related (OR=.72, 95% CI: .54 to .96, p < .05) and age was positively related (OR=1.65, 95% CI: 1.33 to 2.07) to MSD diagnosis (Model V).

Table 15. PSC and Risk Factors for Doctor Diagnosed MSD – Multivariable Model

Model	Term	Odds ratio	2.5%	97.5%	p		LRT.p	r^2
0	PSC	0.96	0.79	1.18	0.69		<.001	0.035
	Age	1.61	1.31	2.00	0.00	***		
I	PSC	0.98	0.80	1.20	0.82		0.801	0.036
	Physical demands	1.01	0.76	1.34	0.97			
	Physical risk	1.07	0.80	1.41	0.66			
	Age	1.62	1.31	2.01	0.00	***		
II	PSC	1.00	0.78	1.29	1.00		0.078	0.056
	Psychological	1.19	0.97	1.48	0.10	.		
	Skill discretion	0.73	0.55	0.97	0.03	*		
	Decision authority	1.28	0.99	1.68	0.07	.		
	Supervisor support	0.96	0.76	1.23	0.73			
	Co-worker support	1.26	0.97	1.66	0.09	.		
	Bullying	1.03	0.46	2.21	0.95			
	Harassment	1.18	0.95	1.46	0.13			
	Age	1.65	1.34	2.06	0.00	***		
III	PSC	1.00	0.78	1.29	1.00		0.923	0.056
	Psychological	1.19	0.94	1.51	0.15			
	Skill discretion	0.73	0.55	0.97	0.03	*		
	Decision authority	1.28	0.98	1.68	0.07	.		
	Supervisor support	0.96	0.76	1.24	0.74			
	Co-worker support	1.26	0.97	1.66	0.09	.		
	Bullying	1.03	0.45	2.22	0.95			
	Harassment	1.19	0.96	1.47	0.12			
	Depressive	0.95	0.73	1.22	0.69			
	Burnout	1.03	0.77	1.39	0.82			
	Age	1.65	1.33	2.06	0.00	***		
IV	PSC	0.99	0.77	1.28	0.94		0.80	0.059
	Physical demands	1.00	0.74	1.34	0.99			
	Physical risk	1.00	0.74	1.34	1.00			
	Psychological	1.19	0.94	1.50	0.15			
	Skill discretion	0.72	0.54	0.96	0.03	*		
	Decision authority	1.25	0.96	1.64	0.11			
	Supervisor support	0.97	0.76	1.25	0.82			
	Co-worker support	1.27	0.98	1.68	0.08	.		
	Bullying	1.00	0.44	2.16	1.00			
	Harassment	1.18	0.95	1.46	0.13			
	Female	0.95	0.61	1.49	0.82			
	Age	1.65	1.33	2.07	0.00	***		
	Education	0.89	0.59	1.34	0.57			
	Income	1.09	0.96	1.24	0.21			
V	PSC	0.99	0.77	1.28	0.94		0.983	0.059
	Physical demands	1.00	0.74	1.34	0.99			
	Physical risk	1.00	0.74	1.35	0.99			
	Psychological	1.18	0.92	1.53	0.19			
	Skill discretion	0.72	0.54	0.96	0.03	*		
	Decision authority	1.25	0.96	1.64	0.11			
	Supervisor support	0.97	0.76	1.26	0.82			
	Co-worker support	1.28	0.98	1.68	0.08	.		
	Bullying	1.00	0.44	2.17	1.00			
	Harassment	1.18	0.95	1.47	0.13			
	Depressive	0.98	0.74	1.27	0.86			
	Burnout	1.02	0.75	1.38	0.90			
	Female	0.95	0.61	1.49	0.82			
	Age	1.65	1.33	2.07	0.00	***		
	Education	0.88	0.58	1.34	0.56			
	Income	1.09	0.95	1.24	0.22			

12-month Work-related Injury

Table 16. PSC and Risk Factors for 12-month Work-related Injury - Multivariate Results

Model	Term	Odds ratio	2.5%	97.5%	p		LRT.p	R^2
0	*PSC*	*0.69*	*0.47*	*1.05*	*0.07*	.	*0.08*	*0.017*
I	*PSC*	*0.85*	*0.57*	*1.28*	*0.43*		*<.001*	*0.101*
	Physical demands	*1.26*	*0.68*	*2.39*	*0.47*			
	Physical risk	*1.72*	*0.98*	*2.99*	*0.06*	.		
II	*PSC*	*0.81*	*0.48*	*1.35*	*0.41*		*0.473*	*0.055*
	Psychological demands	*1.18*	*0.76*	*1.86*	*0.46*			
	Skill discretion	*0.94*	*0.56*	*1.59*	*0.80*			
	Decision authority	*0.77*	*0.47*	*1.30*	*0.32*			
	Supervisor support	*0.89*	*0.57*	*1.57*	*0.67*			
	Co-worker support	*1.45*	*0.85*	*2.71*	*0.21*			
	Bullying	*0.57*	*0.09*	*2.53*	*0.49*			
	Harassment	*1.39*	*0.93*	*2.01*	*0.09*	.		
III	*PSC*	*0.82*	*0.49*	*1.38*	*0.46*		*0.008*	*0.109*
	Psychological demands	*0.81*	*0.48*	*1.38*	*0.44*			
	Skill discretion	*0.97*	*0.58*	*1.63*	*0.90*			
	Decision authority	*0.82*	*0.49*	*1.39*	*0.45*			
	Supervisor support	*0.99*	*0.60*	*1.83*	*0.97*			
	Co-worker support	*1.52*	*0.88*	*2.81*	*0.16*			
	Bullying	*0.54*	*0.09*	*2.34*	*0.45*			
	Harassment	*1.33*	*0.86*	*1.97*	*0.17*			
	Depressive symptoms	*1.05*	*0.64*	*1.67*	*0.84*			
	Burnout	*2.22*	*1.17*	*4.37*	*0.02*	*		
IV	*PSC*	*0.87*	*0.51*	*1.46*	*0.59*		*0.035*	*0.131*
	Physical demands	*1.12*	*0.57*	*2.24*	*0.74*			
	Physical risk	*1.73*	*0.96*	*3.17*	*0.07*	.		
	Psychological demands	*1.01*	*0.60*	*1.70*	*0.98*			
	Skill discretion	*1.20*	*0.70*	*2.09*	*0.51*			
	Decision authority	*0.76*	*0.46*	*1.31*	*0.32*			
	Supervisor support	*0.85*	*0.53*	*1.48*	*0.53*			
	Co-worker support	*1.52*	*0.88*	*2.79*	*0.16*			
	Bullying	*0.59*	*0.10*	*2.57*	*0.52*			
	Harassment	*1.28*	*0.81*	*1.91*	*0.26*			
	Female	*0.78*	*0.29*	*2.11*	*0.62*			
	Age	*0.99*	*0.63*	*1.55*	*0.97*			
	Education	*0.76*	*0.28*	*2.03*	*0.58*			
	Income	*0.91*	*0.69*	*1.20*	*0.50*			
V	*PSC*	*0.88*	*0.51*	*1.51*	*0.65*		*0.033*	*0.170*
	Physical demands	*1.17*	*0.59*	*2.35*	*0.65*			
	Physical risk	*1.45*	*0.80*	*2.67*	*0.23*			
	Psychological demands	*0.78*	*0.45*	*1.38*	*0.40*			
	Skill discretion	*1.22*	*0.71*	*2.11*	*0.48*			
	Decision authority	*0.82*	*0.48*	*1.43*	*0.47*			
	Supervisor support	*0.94*	*0.57*	*1.73*	*0.83*			
	Co-worker support	*1.59*	*0.92*	*2.93*	*0.11*			
	Bullying	*0.58*	*0.10*	*2.48*	*0.49*			
	Harassment	*1.26*	*0.78*	*1.92*	*0.30*			
	Depressive symptoms	*0.97*	*0.56*	*1.60*	*0.89*			
	Burnout	*2.15*	*1.08*	*4.42*	*0.03*	*		
	Female	*0.64*	*0.23*	*1.76*	*0.38*			
	Age	*1.07*	*0.67*	*1.71*	*0.77*			
	Education	*0.69*	*0.25*	*1.93*	*0.48*			
	Income	*0.88*	*0.66*	*1.16*	*0.36*			

The relationship between PSC and workplace injury was close to significant, (OR=.69, 95% CI: .47 to 1.05, p = .07). Burnout was the only factor proximally associated with injury (OR=2.18, 95% CI: 1.08 to 4.42, p < .05) (Table 16, Model 5). Since PSC is positively related to burnout (r = -.26, p < .01), and burnout is related to injury, this implies that a modified Path 3 is plausible, PSC→burnout→workplace injury, and is significant, Sobel, t= --2.16, SE= .02, p<.05.

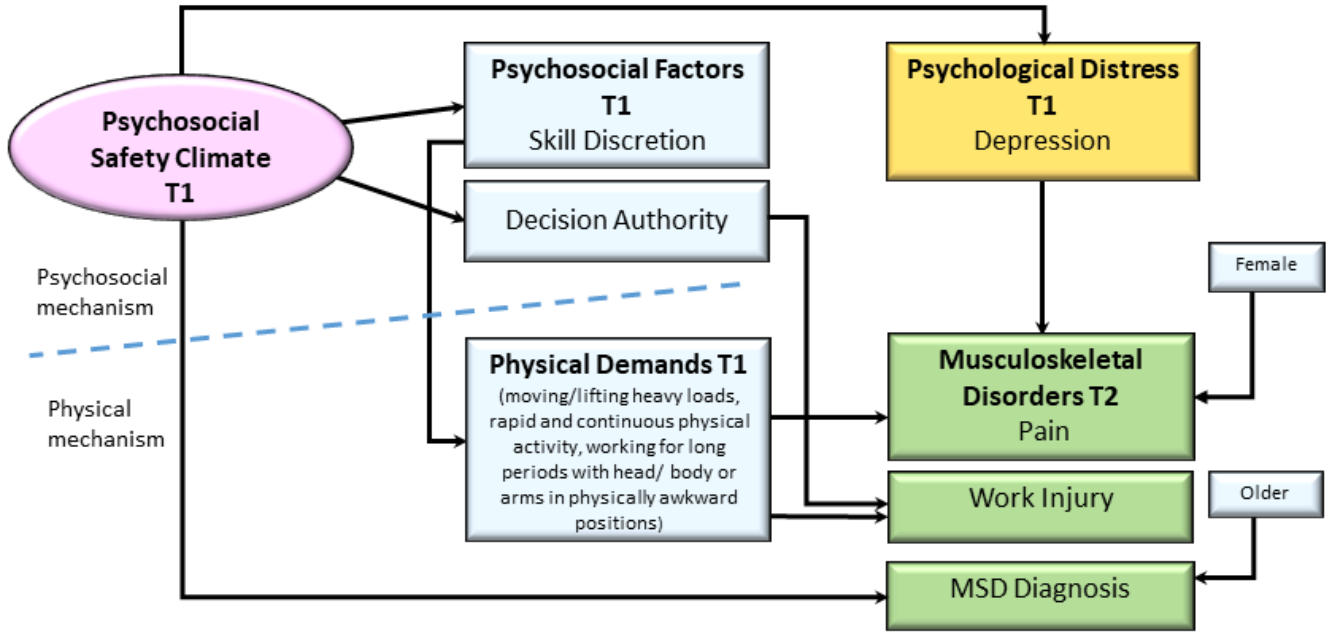
Study Three: Workplace Physical and Psychosocial Risk Factors associated with MSDs in NSW workers (Longitudinal)

Longitudinal Path Analysis

Sample

Matched data (n = 432) were collected across 6 years from employed workers over the age of 18 (Mean = 54 years), randomly selected from a wide range of occupations and industries from New South Wales, Victoria, and Western Australia. The sample was approximately 45 per cent males (n = 193) and 55 per cent females (n = 239), with 65 per cent (n = 280) working full-time with an average income over $80k. Most of the participants had higher education (bachelor's degree or higher, 51.6 per cent, n = 223; Certificate/Diploma, 27.8 per cent, n = 120). Time 1 is 2014/15, Time 2 is 2021. Figure 6 provides a summary of all the significant paths emerging from the longitudinal models below (See Appendix, Table 10A for correlations and 10B for demographics).

Figure 6. Study 3 Model Summarising Longitudinal and Time 1 Cross-Sectional Paths (432 NSW Workers)



Predicting MSD Pain

With MSD Pain as the outcome, in a lagged model (later we control for baseline MSD pain) when PSC was entered (Model 0) it did not add significant variance to the intercept-only model but was close, B = -.02, SE = .001, p = .06 (see Table 17). Physical demands added significantly to the model with PSC, B = .13, SE = .05, p = .01 (Model I). High levels of physical demands were associated with high MSD pain in the future.

In the psychosocial model (Model III), skill discretion added significantly to the model, B = -.07, SE = .02, p <.01 high skill discretion was associated with lower MSD pain in the future. Decision authority was related positively, high levels associated with more MSD pain (note this was not significant in later models).

Psychological distress added significantly to the psychosocial model (Model III). Specifically, depressive symptoms were significantly positively associated, indicating that high levels of depressive symptoms were associated with high levels of MSD pain in the future.

Physical demands were significantly related to pain B = .11, SE = .06, p < .05 and females reported more future MSD pain than men. In this model physical demands appeared to replace skill discretion (Model IV). In the final model, skill physical demands, depressive symptoms and being female remained as significant predictors.

Next we tested possible mediation paths. For Path 1 there was no significant association from PSC to physical demands; only physical demands to MSD pain were significant in that Path.

There were no effects for Path 2.

Path 3 was supported as a short Path (without Path 2/3). As shown in the correlation matrix (appendix), PSC is significantly related to depressive symptoms, B = -.14, SE = .08, p < .001. This implies a Path, PSC T1→ depressive symptoms T1→ MSD pain T2, and a Sobel test showed the mediation effect was significant, Z = -3.40, SE= .004, p = .0007.

To strengthen our findings, we also ran the analyses controlling for baseline levels of MSD pain. We found support for a model (Model VI) whereby MSD pain increase was predicted by physical demands T1, depression T1 and being female. We observed that a significant relationship between skill discretion and MSD pain (evident in Model II) which again appeared mediated by physical demands.

Table 17. Predicting MSDs Pain at Time 2 from Time 1 Measures

Model	Time 1	Estimate	SE	WALD	p	2.5%	97.5%	Chi-sq (*df*)	*p*	R^2
0	*#PSC*	*-0.02*	*0.01*	*3.51*	*0.06*	*-0.04*	*0.00*	*3.43 (1)*	*0.06*	*.008*
I	*#PSC*	*-0.02*	*0.01*	*3.15*	*0.08*	*-0.04*	*0.00*	*9.80*	*0.007*	*0.02*
	Physical Demands	*0.13*	*0.05*	*6.46*	*0.01*	*0.03*	*0.23*	*(2)*		
II	*#PSC*	*-0.02*	*0.01*	*1.61*	*0.21*	*-0.04*	*0.01*	*16.91*	*0.031*	*0.038*
	Psych Demands	*0.01*	*0.02*	*0.22*	*0.64*	*-0.03*	*0.05*	*(8)*		
	Skill discretion	*-0.07*	*0.02*	*10.59*	*0.00*	*-0.11*	*-0.03*			
	Decision authority	*0.04*	*0.02*	*4.37*	*0.04*	*0.00*	*0.08*			
	Supervisor support	*0.04*	*0.08*	*0.22*	*0.64*	*-0.11*	*0.18*			
	Co-worker support	*0.00*	*0.08*	*0.00*	*1.00*	*-0.16*	*0.16*			
	Bullying	*0.08*	*0.38*	*0.04*	*0.84*	*-0.67*	*0.82*			
	Harassment	*0.04*	*0.04*	*0.91*	*0.34*	*-0.04*	*0.11*			
III	*PSC*	*-0.01*	*0.01*	*0.43*	*0.51*	*-0.03*	*0.02*	*40.67*	*0.000*	*0.09*
	Psych Demands	*0.01*	*0.02*	*0.10*	*0.75*	*-0.04*	*0.05*	*(10)*		
	Skill discretion	*-0.07*	*0.02*	*10.52*	*0.00*	*-0.11*	*-0.03*			
	Decision authority	*0.04*	*0.02*	*5.60*	*0.02*	*0.01*	*0.08*			
	Supervisor support	*0.06*	*0.08*	*0.70*	*0.40*	*-0.09*	*0.22*			
	Co-worker support	*0.02*	*0.08*	*0.04*	*0.84*	*-0.14*	*0.17*			
	Bullying	*0.01*	*0.39*	*0.00*	*0.99*	*-0.75*	*0.77*			
	Harassment	*0.00*	*0.04*	*0.01*	*0.91*	*-0.07*	*0.08*			
	Depressive symptoms	*0.13*	*0.03*	*17.73*	*0.00*	*0.07*	*0.19*			
	Burnout	*0.00*	*0.02*	*0.00*	*0.99*	*-0.03*	*0.03*			
IV	*PSC*	*-0.02*	*0.01*	*2.90*	*0.09*	*-0.05*	*0.00*	*27.60*	*0.010*	*0.07*
	Physical Demands	*0.11*	*0.06*	*3.97*	*0.05*	*0.00*	*0.22*	*(13)*		
	Psych Demands	*0.01*	*0.02*	*0.16*	*0.69*	*-0.03*	*0.05*			
	Skill discretion	*-0.04*	*0.02*	*2.31*	*0.13*	*-0.08*	*0.01*			
	Decision authority	*0.03*	*0.02*	*2.44*	*0.12*	*-0.01*	*0.07*			
	Supervisor support	*0.04*	*0.08*	*0.29*	*0.59*	*-0.11*	*0.20*			
	Co-worker support	*-0.01*	*0.08*	*0.02*	*0.89*	*-0.17*	*0.15*			
	Bullying	*0.02*	*0.40*	*0.00*	*0.95*	*-0.76*	*0.81*			
	Harassment	*0.01*	*0.04*	*0.09*	*0.77*	*-0.07*	*0.09*			
	Female	*0.56*	*0.22*	*6.34*	*0.01*	*0.12*	*0.99*			
	Age (Yr of Birth)	*0.00*	*0.01*	*0.02*	*0.90*	*-0.02*	*0.02*			
	Education	*-0.10*	*0.07*	*1.93*	*0.16*	*-0.24*	*0.04*			
	Income	*-0.02*	*0.05*	*0.19*	*0.67*	*-0.12*	*0.07*			
V	*PSC*	*-0.01*	*0.01*	*1.18*	*0.28*	*-0.04*	*0.01*	*50.22*	*0.000*	*0.12*
	Physical Demands	*0.14*	*0.06*	*5.97*	*0.01*	*0.03*	*0.25*	*(15)*		

Model	Time 1	Estimate	SE	WALD	p	2.5%	97.5%	Chi-sq (*df*)	*p*	R^2
	Psych Demands	*0.00*	*0.02*	*0.03*	*0.87*	*-0.05*	*0.04*			
	Skill discretion	*-0.04*	*0.02*	*3.05*	*0.08*	*-0.09*	*0.01*			
	Decision authority	*0.03*	*0.02*	*2.98*	*0.08*	*0.00*	*0.07*			
	Supervisor support	*0.08*	*0.08*	*0.99*	*0.32*	*-0.08*	*0.24*			
	Co-worker support	*0.01*	*0.08*	*0.02*	*0.88*	*-0.15*	*0.18*			
	Bullying	*-0.01*	*0.41*	*0.00*	*0.97*	*-0.81*	*0.78*			
	Harassment	*-0.03*	*0.04*	*0.45*	*0.50*	*-0.11*	*0.05*			
	Depressive symptoms	*0.12*	*0.03*	*15.17*	*0.00*	*0.06*	*0.19*			
	Burnout	*0.01*	*0.02*	*0.24*	*0.63*	*-0.03*	*0.04*			
	Female	*0.60*	*0.22*	*7.18*	*0.01*	*0.16*	*1.04*			
	Age (Yr of Birth)	*-0.01*	*0.01*	*0.30*	*0.59*	*-0.03*	*0.01*			
	Education	*-0.09*	*0.07*	*1.43*	*0.23*	*-0.23*	*0.06*			
	Income	*0.02*	*0.05*	*0.10*	*0.76*	*-0.08*	*0.11*			
VI	*MSD Pain*	*0.96*	*0.17*	*31.61*	*0.00*	*0.62*	*1.29*	*83.14*	*0.000*	*0.18*
	PSC	*-0.01*	*0.01*	*0.51*	*0.47*	*-0.04*	*0.02*	*(16)*		
	Physical Demands	*0.14*	*0.06*	*6.21*	*0.01*	*0.03*	*0.26*			
	Psych Demands	*-0.01*	*0.02*	*0.33*	*0.57*	*-0.06*	*0.03*			
	Skill discretion	*-0.04*	*0.02*	*2.45*	*0.12*	*-0.09*	*0.01*			
	Decision authority	*0.03*	*0.02*	*2.54*	*0.11*	*-0.01*	*0.07*			
	Supervisor support	*0.09*	*0.08*	*1.16*	*0.28*	*-0.07*	*0.25*			
	Co-worker support	*-0.02*	*0.09*	*0.08*	*0.77*	*-0.19*	*0.14*			
	Bullying	*0.02*	*0.42*	*0.00*	*0.96*	*-0.79*	*0.83*			
	Harassment	*-0.02*	*0.04*	*0.24*	*0.62*	*-0.10*	*0.06*			
	Depressive symptoms	*0.12*	*0.03*	*13.11*	*0.00*	*0.05*	*0.18*			
	Burnout	*0.00*	*0.02*	*0.00*	*0.96*	*-0.04*	*0.03*			
	Female	*0.53*	*0.23*	*5.37*	*0.02*	*0.08*	*0.97*			
	Age (Yr of Birth)	*0.00*	*0.01*	*0.01*	*0.94*	*-0.02*	*0.02*			
	Education	*-0.06*	*0.07*	*0.72*	*0.40*	*-0.21*	*0.08*			
	Income	*0.01*	*0.05*	*0.09*	*0.77*	*-0.09*	*0.12*			

Note: R^2 = Cox and Snell pseudo r-sq, *df* = degree of freedom

Predicting Diagnosed MSDs

In the analyses predicting future MSD diagnosis, PSC was significantly negatively related to future MSD diagnosis, B = -.02, SE = .01, p < .05, higher levels of PSC related to low likelihood of MSD diagnosis in the future. Age was the only other significant variable, older workers reporting more MSDs diagnosed, B = -.03, SE = .01, $p < .02$.

Table 18. Predicting Diagnosed MSDs at Time 2 from Time 1 Measures

Model	Time 1	B	SE	WALD	p	Exp (B)	2.5%	97.5%	Chi-sq (df)	p	R^2
0	*#PSC*	*-0.02*	*0.01*	*3.90*	*0.05*	*0.98*	*0.96*	*1.00*	*3.94 (1)*	*0.045*	
I	*#PSC*	*-0.02*	*0.01*	*3.67*	*0.06*	*0.98*	*0.96*	*1.00*	*4.56*		*0.008*
	Physical Demands	*0.05*	*0.06*	*0.66*	*0.42*	*1.05*	*0.94*	*1.18*	*(2)*	*0.10*	
II	*#PSC*	*-0.01*	*0.02*	*0.44*	*0.51*	*0.99*	*0.96*	*1.02*	*14.20*	*0.07*	*0.011*
	Psych Demands	*0.04*	*0.02*	*2.60*	*0.11*	*1.04*	*0.99*	*1.09*	*(8)*		
	Skill discretion	*-0.02*	*0.03*	*0.50*	*0.48*	*0.98*	*0.94*	*1.03*			
	Decision authority	*0.02*	*0.02*	*1.12*	*0.29*	*1.02*	*0.98*	*1.07*			
	Supervisor support	*-0.03*	*0.09*	*0.11*	*0.74*	*0.97*	*0.82*	*1.15*			
	Coworker support	*0.12*	*0.09*	*1.68*	*0.20*	*1.13*	*0.94*	*1.35*			
	Bullying	*0.45*	*0.42*	*1.18*	*0.28*	*1.57*	*0.69*	*3.57*			
	Harassment	*0.05*	*0.04*	*1.42*	*0.23*	*1.05*	*0.97*	*1.14*			
III	*PSC*	*-0.01*	*0.02*	*0.42*	*0.52*	*0.99*	*0.96*	*1.02*	*14.72*	*0.15*	*0.033*
	Psych Demands	*0.04*	*0.03*	*2.03*	*0.16*	*1.04*	*0.99*	*1.09*	*(10)*		
	Skill discretion	*-0.02*	*0.03*	*0.55*	*0.46*	*0.98*	*0.94*	*1.03*			
	Decision authority	*0.02*	*0.02*	*1.23*	*0.27*	*1.02*	*0.98*	*1.07*			
	Supervisor support	*-0.03*	*0.09*	*0.08*	*0.77*	*0.98*	*0.82*	*1.16*			
	Coworker support	*0.12*	*0.09*	*1.62*	*0.20*	*1.13*	*0.94*	*1.35*			
	Bullying	*0.47*	*0.42*	*1.26*	*0.26*	*1.60*	*0.70*	*3.64*			
	Harassment	*0.05*	*0.04*	*1.14*	*0.29*	*1.05*	*0.96*	*1.14*			
	Depressive symptoms	*-0.01*	*0.03*	*0.08*	*0.78*	*0.99*	*0.93*	*1.06*			
	Burnout	*0.01*	*0.02*	*0.27*	*0.60*	*1.01*	*0.97*	*1.05*			
IV	*PSC*	*-0.01*	*0.02*	*0.49*	*0.48*	*0.99*	*0.96*	*1.02*	*18.78*	*0.13*	*0.045*
	Physical Demands	*0.04*	*0.07*	*0.28*	*0.60*	*1.04*	*0.91*	*1.18*	*(13)*		
	Psych Demands	*0.02*	*0.03*	*0.74*	*0.39*	*1.02*	*0.97*	*1.07*			
	Skill discretion	*-0.03*	*0.03*	*1.17*	*0.28*	*0.97*	*0.92*	*1.03*			
	Decision authority	*0.01*	*0.02*	*0.16*	*0.69*	*1.01*	*0.97*	*1.05*			
	Supervisor support	*0.00*	*0.09*	*0.00*	*0.96*	*1.00*	*0.84*	*1.20*			
	Coworker support	*0.13*	*0.10*	*1.80*	*0.18*	*1.14*	*0.94*	*1.38*			
	Bullying	*0.51*	*0.44*	*1.36*	*0.24*	*1.67*	*0.70*	*3.96*			
	Harassment	*0.04*	*0.05*	*0.72*	*0.40*	*1.04*	*0.95*	*1.14*			
	Female	*0.15*	*0.26*	*0.32*	*0.57*	*1.16*	*0.69*	*1.95*			
	Age	*0.03*	*0.01*	*5.34*	*0.02*	*0.97*	*0.95*	*1.00*			
	Education	*0.05*	*0.09*	*0.31*	*0.58*	*1.05*	*0.88*	*1.25*			
	Income	*0.07*	*0.06*	*1.32*	*0.25*	*1.07*	*0.95*	*1.21*			
V	*PSC*	*-0.01*	*0.02*	*0.35*	*0.55*	*0.99*	*0.96*	*1.02*	*19.57*	*0.189*	*0.047*
	Physical Demands	*0.04*	*0.07*	*0.37*	*0.54*	*1.04*	*0.91*	*1.19*	*(15)*		
	Psych Demands	*0.02*	*0.03*	*0.37*	*0.54*	*1.02*	*0.96*	*1.07*			
	Skill discretion	*-0.03*	*0.03*	*1.29*	*0.26*	*0.97*	*0.91*	*1.02*			
	Decision authority	*0.01*	*0.02*	*0.22*	*0.64*	*1.01*	*0.97*	*1.06*			
	Supervisor support	*0.02*	*0.09*	*0.05*	*0.83*	*1.02*	*0.85*	*1.22*			
	Coworker support	*0.13*	*0.10*	*1.80*	*0.18*	*1.14*	*0.94*	*1.38*			
	Bullying	*0.53*	*0.44*	*1.40*	*0.24*	*1.69*	*0.71*	*4.03*			
	Harassment	*0.03*	*0.05*	*0.38*	*0.54*	*1.03*	*0.94*	*1.13*			
	Depressive symptoms	*0.01*	*0.04*	*0.06*	*0.81*	*1.01*	*0.94*	*1.08*			
	Burnout	*0.01*	*0.02*	*0.43*	*0.51*	*1.01*	*0.97*	*1.06*			

Model	Time 1	B	SE	WALD	p	Exp (B)	2.5%	97.5%	Chi-sq (df)	p	R^2
	Female	*0.16*	*0.26*	*0.37*	*0.54*	*1.17*	*0.70*	*1.97*			
	Age	*0.03*	*0.01*	*5.91*	*0.02*	*0.97*	*0.95*	*0.99*			
	Education	*0.06*	*0.09*	*0.40*	*0.53*	*1.06*	*0.89*	*1.26*			
	Income	*0.07*	*0.06*	*1.40*	*0.24*	*1.08*	*0.95*	*1.21*			

Note: R^2 =pseudo r-sq, *df* = degree of freedom, R2 is Cox & Snell

Predicting Future Physical Injuries at Work

Table 19. Predicting Work Related Injury at Time 2 Last 12 months from Time 1 Measures

Model	Time 1	B	SE	WALD	*p*	Exp (B)	2.5%	97.5%	Chi-sq (df)	*p*	R^2
0	*#PSC*	*-0.02*	*0.02*	*0.88*	*0.35*	*0.98*	*0.94*	*1.02*	*(1)*		*0.008*
I	*#PSC*	*-0.01*	*0.02*	*0.42*	*0.52*	*0.99*	*0.95*	*1.03*	*(2)*		*0.008*
	Physical Demands	*0.31*	*0.11*	*8.33*	*0.00*	*1.37*	*1.11*	*1.69*			
II	*#PSC*	*-0.01*	*0.03*	*0.12*	*0.73*	*0.99*	*0.94*	*1.05*	*(8)*		*0.011*
	Psych Demands	*0.05*	*0.05*	*1.10*	*0.30*	*1.05*	*0.96*	*1.16*			
	Skill discretion	*-0.03*	*0.05*	*0.33*	*0.57*	*0.98*	*0.89*	*1.06*			
	Decision authority	*-0.11*	*0.04*	*7.11*	*0.01*	*0.90*	*0.83*	*0.97*			
	Supervisor support	*0.30*	*0.17*	*3.18*	*0.08*	*1.35*	*0.97*	*1.88*			
	Coworker support	*0.06*	*0.19*	*0.11*	*0.75*	*1.06*	*0.74*	*1.54*			
	Bullying	*-0.15*	*0.85*	*0.03*	*0.86*	*0.87*	*0.17*	*4.54*			
	Harassment	*0.05*	*0.08*	*0.32*	*0.57*	*1.05*	*0.89*	*1.23*			
III	*PSC*	*-0.01*	*0.03*	*0.11*	*0.74*	*0.99*	*0.94*	*1.05*	*14.92*	*0.03*	*0.033*
	Psych Demands	*0.05*	*0.05*	*0.87*	*0.35*	*1.05*	*0.95*	*1.16*	*(10)*		
	Skill discretion	*-0.03*	*0.05*	*0.35*	*0.55*	*0.97*	*0.89*	*1.06*			
	Decision authority	*-0.10*	*0.04*	*6.95*	*0.01*	*0.90*	*0.83*	*0.97*			
	Supervisor support	*0.31*	*0.17*	*3.24*	*0.07*	*1.36*	*0.97*	*1.89*			
	Coworker support	*0.06*	*0.19*	*0.11*	*0.75*	*1.06*	*0.74*	*1.54*			
	Bullying	*-0.13*	*0.85*	*0.02*	*0.88*	*0.88*	*0.17*	*4.64*			
	Harassment	*0.04*	*0.08*	*0.26*	*0.61*	*1.04*	*0.89*	*1.23*			
	Depressive symptoms	*0.00*	*0.07*	*0.00*	*0.97*	*1.00*	*0.87*	*1.14*			
	Burnout	*0.01*	*0.04*	*0.05*	*0.83*	*1.01*	*0.94*	*1.09*			
IV	*PSC*	*-0.01*	*0.03*	*0.18*	*0.67*	*0.99*	*0.93*	*1.04*	*25.29*	*0.021*	*0.06*
	Physical Demands	*0.23*	*0.13*	*3.43*	*0.06*	*1.26*	*0.99*	*1.61*	*(13)*		
	Psych Demands	*0.05*	*0.05*	*0.98*	*0.32*	*1.05*	*0.95*	*1.17*			
	Skill discretion	*0.01*	*0.05*	*0.06*	*0.81*	*1.01*	*0.92*	*1.12*			
	Decision authority	*-0.10*	*0.04*	*6.30*	*0.01*	*0.90*	*0.83*	*0.98*			
	Supervisor support	*0.24*	*0.17*	*1.99*	*0.16*	*1.27*	*0.91*	*1.77*			
	Coworker support	*0.09*	*0.19*	*0.25*	*0.62*	*1.10*	*0.76*	*1.59*			
	Bullying	*-0.14*	*0.87*	*0.03*	*0.87*	*0.87*	*0.16*	*4.73*			
	Harassment	*0.01*	*0.09*	*0.01*	*0.93*	*1.01*	*0.85*	*1.19*			
	Female	*-1.01*	*0.54*	*3.58*	*0.06*	*0.36*	*0.13*	*1.04*			
	Age	*0.04*	*0.02*	*3.02*	*0.08*	*0.96*	*0.92*	*1.01*			
	Education	*-0.01*	*0.17*	*0.00*	*0.97*	*0.99*	*0.72*	*1.38*			
	Income	*-0.19*	*0.12*	*2.80*	*0.09*	*0.82*	*0.66*	*1.03*			
V	*PSC*	*-0.01*	*0.03*	*0.17*	*0.68*	*0.99*	*0.93*	*1.05*	*25.84*	*0.04*	*0.06*
	Physical Demands	*0.24*	*0.13*	*3.75*	*0.05*	*1.28*	*1.00*	*1.64*	*(15)*		
	Psych Demands	*0.04*	*0.06*	*0.51*	*0.48*	*1.04*	*0.93*	*1.16*			
	Skill discretion	*0.01*	*0.05*	*0.03*	*0.86*	*1.01*	*0.91*	*1.12*			
	Decision authority	*-0.10*	*0.04*	*6.05*	*0.01*	*0.90*	*0.84*	*0.98*			

Model	Time 1	B	SE	WALD	*p*	Exp (B)	2.5%	97.5%	Chi-sq (df)	*p*	R^2
	Supervisor support	*0.27*	*0.17*	*2.32*	*0.13*	*1.30*	*0.93*	*1.83*			
	Co-worker support	*0.09*	*0.19*	*0.24*	*0.62*	*1.10*	*0.76*	*1.58*			
	Bullying	*-0.07*	*0.87*	*0.01*	*0.93*	*0.93*	*0.17*	*5.08*			
	Harassment	*-0.01*	*0.09*	*0.01*	*0.92*	*0.99*	*0.83*	*1.18*			
	Depressive symptoms	*-0.02*	*0.07*	*0.05*	*0.82*	*0.98*	*0.85*	*1.13*			
	Burnout	*0.03*	*0.04*	*0.54*	*0.46*	*1.03*	*0.95*	*1.12*			
	Female	*-1.01*	*0.54*	*3.51*	*0.06*	*0.37*	*0.13*	*1.05*			
	Age	*0.04*	*0.02*	*3.39*	*0.07*	*0.96*	*0.91*	*1.00*			
	Education	*0.00*	*0.17*	*0.00*	*0.99*	*1.00*	*0.72*	*1.39*			
	Income	*-0.20*	*0.12*	*2.91*	*0.09*	*0.82*	*0.65*	*1.03*			

Note: R^2 = pseudo r-sq, *df* = degree of freedom

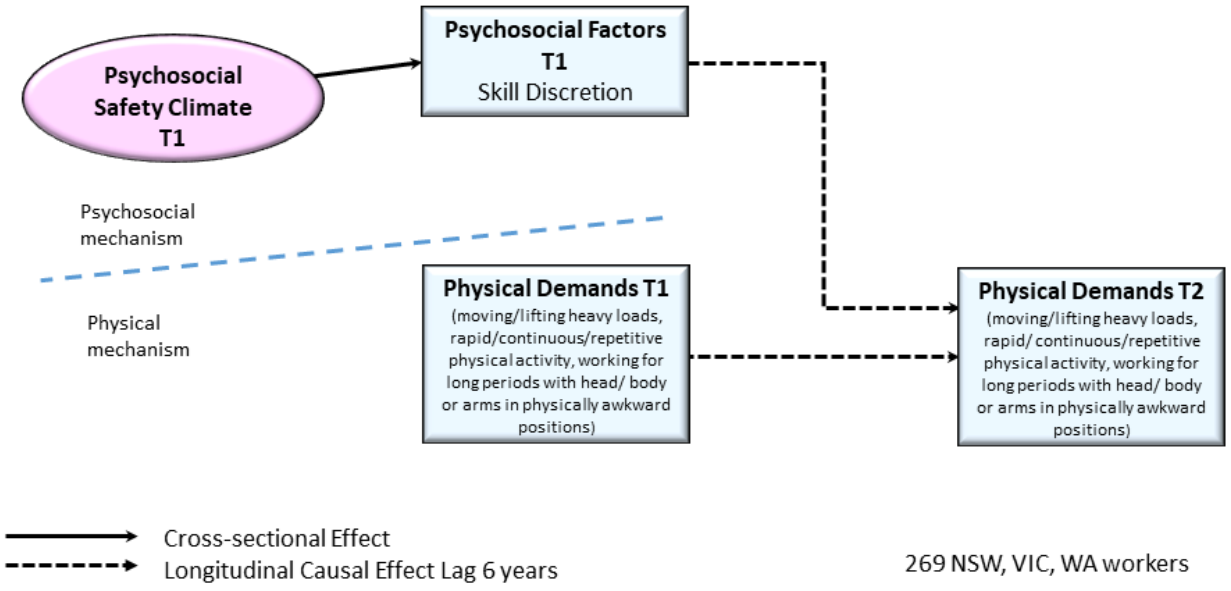
Physical demands T1 were related to future physical injuries at work T2, B = .31, SE = .11, $p < .001$ (Model I). As noted above PSC T1 was not related to physical demands T1 in this sample, so Path 1 from PSC was not supported. Decision authority T1 was negatively related to physical injuries T2, B = -.11, SE = .04, p < .01, higher decision authority associated with fewer physical injuries (Model II). With all variables in the model (Model V) physical demands and decision authority remained in the model, and demographics were not significantly related to physical injuries.

To test Path 2, the mediation effect of PSC on decision authority on physical injuries at work, we regressed PSC T1 on decision authority T1, B = .22, SE = .02, $p < .001$. Using the regression effects of physical injuries T2 on decision authority T1, B = -.10, SE = .04, $p < .05$ in the table above and using the Sobel test we determined that PSC T1 was significantly related to physical injuries via decision authority, Sobel t = -2.43, SE = .01, $p < .05$, supporting Path 2 (PSC T1→decision authority T1→physical injuries T2). Path 3 was not supported since depressive symptoms/burnout were not related to injuries at work.

Predicting Physical Demands

Given the important role of physical demands we tested longitudinal models predicting future physical demands, controlling for baseline levels of physical demands (assessed at Time 1). Since we are predicting working conditions we removed any worker who moved organisations from Time 1 to Time 2 (final sample 269). A summary of findings is shown in Figure 7.

Figure 7. Predicting Future Physical Risks



Results show that physical demands T1 predicted future physical demand and risks T2. Model 0 showed that PSC was not associated with physical demands. Physical demands T1 were significantly positively related to future demands (Model I). Skill discretion T1 was negatively related, harassment positively related T1, and income negatively related to future physical demands at work T2 (Model II). Poor psychological health was not related to future exposure to physical risks (Model III). When controlling for baseline physical demands, harassment was no longer significant (Model IV). Demographics were not significant.

Although PSC was not significantly directly related to future physical demands, since it is a distal predictor, and since it is related to skill discretion (B = 22, $p < .01$) a plausible argument is that PSC influences skill discretion, and this in turn relates to future physical demands.

Table 20. Predicting Physical Demands at Time 2 from Time 1 Measures in Same Organisation

Model	Time 1	B	SE	Beta	t	p	2.5%	97.5%	df F	p	R^2
0	*#PSC*	*-0.01*	*0.01*	*-0.06*	*-0.90*	*0.37*	*-0.04*	*0.01*	*1, 267 .81*	*0.39*	*0.003*
I	*#PSC*	*-0.01*	*0.01*	*-0.05*	*-1.21*	*0.23*	*-0.03*	*0.01*	*2, 265*	*0.000*	*0.49*
	Physical Demands	*0.76*	*0.05*	*0.70*	*16.05*	*0.00*	*0.67*	*0.86*	*129.56*		
II	*#PSC*	*0.02*	*0.02*	*0.07*	*0.93*	*0.35*	*-0.02*	*0.05*	*8, 259*	*0.000*	*0.12*
	Psych Demands	*0.02*	*0.03*	*0.04*	*0.62*	*0.54*	*-0.04*	*0.07*	*4.48*		
	Skill discretion	*-0.11*	*0.03*	*-0.26*	*-3.91*	*0.00*	*-0.16*	*-0.05*			
	Decision authority	*0.00*	*0.02*	*0.00*	*-0.02*	*0.99*	*-0.05*	*0.05*			
	Supervisor support	*0.04*	*0.10*	*0.03*	*0.38*	*0.71*	*-0.16*	*0.24*			
	Coworker support	*-0.06*	*0.11*	*-0.04*	*-0.56*	*0.58*	*-0.27*	*0.15*			
	Bullying	*-0.10*	*0.58*	*-0.01*	*-0.18*	*0.86*	*-1.25*	*1.04*			
	Harassment	*0.16*	*0.05*	*0.21*	*3.09*	*0.00*	*0.06*	*0.26*			
III	*PSC*	*0.01*	*0.02*	*0.07*	*0.90*	*0.37*	*-0.02*	*0.05*	*10, 258*	*0.000*	*0.12*
	Psych Demands	*0.02*	*0.03*	*0.05*	*0.66*	*0.51*	*-0.04*	*0.08*	*3.58*		
	Skill discretion	*-0.11*	*0.03*	*-0.26*	*-3.87*	*0.00*	*-0.16*	*-0.05*			
	Decision authority	*0.00*	*0.02*	*0.00*	*-0.04*	*0.97*	*-0.05*	*0.05*			
	Supervisor support	*0.03*	*0.10*	*0.03*	*0.33*	*0.74*	*-0.17*	*0.23*			
	Coworker support	*-0.06*	*0.11*	*-0.04*	*-0.53*	*0.60*	*-0.27*	*0.15*			
	Bullying	*-0.10*	*0.59*	*-0.01*	*-0.17*	*0.87*	*-1.25*	*1.06*			
	Harassment	*0.16*	*0.05*	*0.22*	*3.09*	*0.00*	*0.06*	*0.27*			
	Depressive symptoms	*-0.01*	*0.04*	*-0.02*	*-0.24*	*0.81*	*-0.09*	*0.07*			
	Burnout	*0.00*	*0.02*	*-0.01*	*-0.18*	*0.86*	*-0.05*	*0.04*			
IV	*PSC*	*-0.01*	*0.01*	*-0.03*	*-0.62*	*0.54*	*-0.03*	*0.01*	*13, 243*	*0.000*	*0.53*
	Physical Demands	*0.69*	*0.05*	*0.64*	*13.44*	*0.00*	*0.58*	*0.79*	*21.31*		
	Psych Demands	*0.01*	*0.02*	*0.03*	*0.52*	*0.61*	*-0.03*	*0.05*			
	Skill discretion	*-0.06*	*0.02*	*-0.15*	*-2.68*	*0.01*	*-0.11*	*-0.02*			
	Decision authority	*0.02*	*0.02*	*0.05*	*0.98*	*0.33*	*-0.02*	*0.05*			
	Supervisor support	*0.03*	*0.07*	*0.03*	*0.46*	*0.65*	*-0.11*	*0.18*			
	Coworker support	*0.05*	*0.08*	*0.03*	*0.59*	*0.56*	*-0.11*	*0.20*			
	Bullying	*-0.15*	*0.45*	*-0.02*	*-0.33*	*0.74*	*-1.03*	*0.74*			
	Harassment	*0.04*	*0.04*	*0.06*	*1.10*	*0.27*	*-0.03*	*0.12*			
	Female	*-0.32*	*0.21*	*-0.08*	*-1.57*	*0.18*	*-0.73*	*0.08*			
	Age	*0.01*	*0.01*	*-0.02*	*-0.46*	*0.64*	*-0.02*	*0.01*			

Model	Time 1	B	SE	Beta	t	p	2.5%	97.5%	df F	p	R^2
	Education	*-0.09*	*0.07*	*-0.06*	*-1.31*	*0.19*	*-0.22*	*0.04*			
	Income	*-0.06*	*0.05*	*-0.07*	*-1.33*	*0.18*	*-0.16*	*0.03*			
V	*PSC*	*-0.01*	*0.01*	*-0.03*	*-0.58*	*0.56*	*-0.03*	*0.02*	*15,241*		
	Physical demands	*0.70*	*0.05*	*0.65*	*13.44*	*0.00*	*0.59*	*0.80*	*18.50*	*0.000*	*0.54*
	Psych demands	*0.01*	*0.02*	*0.01*	*0.10*	*0.92*	*-0.04*	*0.05*			
	Skill discretion	*-0.06*	*0.02*	*-0.16*	*-2.80*	*0.01*	*-0.11*	*-0.02*			
	Decision authority	*0.02*	*0.02*	*0.06*	*1.10*	*0.27*	*-0.01*	*0.05*			
	Supervisor support	*0.04*	*0.07*	*0.04*	*0.60*	*0.55*	*-0.10*	*0.19*			
	Coworker support	*0.04*	*0.08*	*0.03*	*0.52*	*0.60*	*-0.12*	*0.20*			
	Bullying	*-0.12*	*0.45*	*-0.01*	*-0.26*	*0.79*	*-1.01*	*0.77*			
	Harassment	*0.03*	*0.04*	*0.04*	*0.83*	*0.41*	*-0.05*	*0.11*			
	Depressive symptoms	*-0.01*	*0.03*	*-0.01*	*-0.10*	*0.92*	*-0.07*	*0.06*			
	Burnout	*0.02*	*0.02*	*0.06*	*1.06*	*0.29*	*-0.02*	*0.05*			
	Female	*-0.32*	*0.21*	*-0.08*	*-1.55*	*0.12*	*-0.73*	*0.09*			
	Age	*0.01*	*0.01*	*-0.03*	*-0.67*	*0.500*	*-0.03*	*0.01*			
	Education	*-0.01*	*0.07*	*-0.06*	*-1.14*	*0.25*	*-0.21*	*0.06*			
	Income	*-0.06*	*0.05*	*-0.07*	*-1.25*	*0.21*	*-0.16*	*0.03*			

Note: B =Unstandardised B, Beta= Standardised B, R^2 =pseudo r-sq, for the Model, *df* = degree of freedom.

Discussion

The aim of the research was to (i) provide an up to date prevalence estimate of MSDs among NSW employees in 2020-2021, (ii) estimate the associations of physical, psychosocial, and demographic factors with MSDs among NSW employees, specifically evaluating the Psychosocial Safety Climate (PSC) as a distal cause of MSD outcomes, and (iii) evaluate prospective physical and psychosocial process paths to MSDs over 6 years.

For each aim we assessed three different MSD definitions (1) pain severity, (2) lifetime doctor diagnosed MSD, and (iii) a 12-month work-related injury.

Prevalence

In relation to pain, the NSW industries with the highest estimated prevalence of employees reporting a lot of pain were Retail Trade, Electricity Gas and Waste Services (both around 35%), and Financial/Insurance, and Professional Scientific/Technical Services, Rental Hiring and Real Estate Services, and Agriculture and Fishing, Administrative and Support Services (all > 25%). Fewer than 15% of employees in Mining, Construction, Education, Public Administration, and IT reported high pain levels.

For doctor diagnosed MSDs, the industry variability in prevalence was lower, with no statistically significant differences between them and a range of 10-23%.

For 12-month work-related injury, there was a very low prevalence 4% (22/628). Therefore, unsurprisingly there were no significant differences between industries, although the prevalence was 10% or higher in Electricity Gas Water and Waste Services, Transport, Postal and Warehousing, and Wholesale Trades industries, and less than 1% in Finance.

The NSW industries with the highest estimated MSD prevalence as indicated by pain were Retail Trade, Electricity Gas and Waste Services, and Financial and Insurance Services. Overall the wide confidence intervals and limited precision of the estimates preclude strong inference but there seem to be a few trends.

MSDs are possibly less common in “physical” industries, likely reflecting a healthy worker effect.

Study Model

In relation to MSD pain, considering the study model, cross-sectionally and longitudinally there was support for the physical mechanism whereby physical demands were associated with MSD

pain. There was also support for a psychosocial mechanism whereby the association of a low level of PSC with pain was mediated through pathways of greater workplace psychosocial risk factors specifically psychological demands (work and time pressure) and harassment (cross-sectionally), skill discretion (longitudinally) via physical demands, and higher levels of depression (cross-sectionally and longitudinally). Pain was greatest in older workers.

In terms of doctor diagnosed MSDs, there was no association with any physical risk but there negative association with skill discretion, higher skill discretion associated with lower likelihood of diagnosis. Increasing age was also positively associated with doctor diagnosed MSDs. Longitudinally higher levels of PSC were associated with a lower likelihood of future exposure. In both cross-sectional and longitudinal tests there was support for a psychosocial mechanism rather than a physical mechanism.

Work related injury was associated with greater distress (burnout) and marginally with PSC and higher levels of physical demands. Only the cross-sectional association between 12-month workplace injury and burnout remained in more complex analyses. Longitudinally physical demands, and decision authority, were the best predictors of work injury. Marginal effects were noted with being male, older and on a low income.

Taken together the results vary according to MSD outcome under consideration, but in general the results support the study model, which suggests that both work-related psychosocial and physical mechanisms are important in accounting for MSD outcomes. MSDs can be explained in part by considering the corporate climate for worker psychological health (PSC). Knowing about PSC, at low levels, the evidence suggests that psychosocial risk factors such as low job control (skill discretion, decision authority) and high job demands (psychological demands, harassment) can be predicted. These in turn are either directly or indirectly related to MSDs through the experience of psychological distress. Independent of this there is clear evidence of a physical mechanism, whereby physical demands (moving/lifting heavy loads, rapid and continuous physical activity, repetitive work, working for long periods with head/ body or arms in physically awkward positions) are related to MSDs.

These effects were generally over and above other demographic effects noted. MSD diagnosis was more common among older workers, MSD pain more common among women workers, and physical injury more common among male and low- income workers. Being on a low income and being male were specific risk factors for workplace physical injury, and being female was associated with future MSD pain. Being on a low income likely means that one has fewer personal resources to seek and receive early treatment.

To strengthen our findings we also ran a series of analyses controlling for baseline levels of MSD pain. We found support for a model whereby MSD pain increase was predicted by physical demands, depression and skill discretion (also consistent with as per below), whereby the relationship between skill discretion and MSD pain seems mediated by physical demands.

Given the important role of physical demands we tested longitudinal models predicting future physical work demands and risks. In this analysis since we were predicting future work conditions, we included only workers who were in the same organization across both time points. As expected results show that physical demands predicted future physical demands and risks. Over and above this effect low skill discretion, and high harassment, were related to future physical demands and risks at work (the effects of harassment appeared mediated by physical demands). Psychological distress (burnout, depressive symptoms) were not related to future exposure to physical demands. This is an important point since it gives more weight to a working conditions, rather than individual worker, explanation for future exposures.

In sum, MSDs are predictable outcomes of PSC, physical demands, skill discretion, decision authority and psychological health status many years earlier. Occupations where workers are exposed to low skill discretion and decision authority may imply that local actions cannot be taken by employees to reduce or manage physical demands (less agency) resulting in increased risk for MSDs.

Theoretical Implications

Our findings support an understanding of MSDs as an outcome of combined physical and psychosocial mechanisms. This accords with previous literature that suggests a dual process. Zadow, Dollard, McLinton, Lawrence, and Tuckey (2017) highlighted the dual role of physical and psychosocial safety climate in predicting future registered injury rates. The important role of psychosocial risks are also highlighted in a recent literature review by James et al. (2021) who found that psychosocial factors of workplace support, job control and job demands are related to MSDs. Our research suggests both job demands (physical and psychosocial) along with job resources (such as skill discretion and decision authority) are important precursors to MSDs.

An innovation in this research was to test the role of PSC as a leading indicator of MSDs (a 'cause of the causes' of other risk factors). The results align with this notion but as noted below we could not establish a longitudinal relationship between PSC and risk factors, possibly due to the long time lag and limited sample size. Many other studies have found support for the longitudinal association between PSC and risk factors when assessed at shorter intervals (for a review see Loh, Zadow, & Dollard, 2020).

Practical Implications

In sum, MSDs are a predictable outcome of physical demands, low PSC, skill discretion, and decision authority, and poor psychological health status many years earlier. In occupations where workers are exposed to low skill discretion this may imply that employees have little agency and local actions cannot be taken by employees to reduce or manage physical demands. Low income likely implies fewer personal resources to seek and receive early treatment. Given the predictability of workplace factors on MSD and health and that some risks identified are preventable or modifiable, action should be taken to target these (improve PSC, improve skill discretion, reduce harassment, reduce work pressure) to eliminate risk or reduce risks. Although we have identified some factors that are associated with MSDs and psychological health the predictive effects are small and targeting each will have only a small effect. However across employees over a whole NSW state this could have some reasonable population effects.

The finding that psychosocial factors play a strong role in MSDs supports emerging research and requires a fresh preventive approach. A novel intervention not yet tried to improve MSD status among employees would be to focus on improving PSC. Since PSC is antecedent to many risk factors, focusing on improving PSC would be an efficient focus, and is achievable in a short period as illustrated in recent intervention research (Dollard & Bailey, 2021), and would have the added benefit of increasing workplace mental health. Increasing PSC would entail improving communication systems, participation, and increasing management will reduce psychosocial risks.

In the MSDs strategy 2017-22 (published by Safework NSW), 6 sectors are prioritised including Health care and social assistance, Manufacturing, Construction, Agriculture, Transport and Government. Our research suggests that interventions focused on the following industry sectors reporting the most MSD pain in this study might be beneficial: Retail Trade, Electricity Gas and Waste Services, Financial/Insurance, Professional Scientific/Technical Services, Rental Hiring and Real Estate Services, Agriculture and Fishing, and Administrative and Support Services.

The results suggest a much greater focus in any MSD strategy on interventions to reduce psychosocial risk factors since they either directly predicted MSD outcomes, or predicted physical demands, the assumed major cause of MSDs. The study also supports data driven approaches to intervention and evaluation to ensure the right risk factors are targeted. Finally, PSC canvasses participation and consultation in relation to the identification and control of risk factors, involving stakeholders and all levels of the organisation. These features are currently in the MSD strategy and should be reinforced.

Limitations and Future Directions

An issue for the research was securing responses to requests for a telephone interview. The timing of the research was during COVID. The final number of responses was smaller than desired especially for drawing conclusions about industry differences. Nevertheless the sample size was ample to detect small effects if they existed cross-sectionally. We could not find longitudinal associations between PSC, risk factors and outcomes with the exception that PSC predicted future MSD diagnosis. It might be that the length of time between measures (6 years) rendered this relationship too small to detect. Assessing risk levels of PSC in relation to other factors may prove beneficial for assessing relations across time (e.g., predicting new major depression, Zadow, Dollard, Dormann, & Landsbergis, 2021). Future research could focus on designing and evaluating interventions that specifically focus on leading indicators of MSDs.

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Appendix

Study 1

Sample and Prevalence

Table 1A. New Participants Sampling Data

	No. of	%
A. INITIAL SAMPLE	18276	100
UNUSED NUMBERS: A-(NA+ENG+SA+HA+B+D+E)	2152	11.775
No Answer [NA]	1365	7.46881
Message left on A/Machine [06]	1729	9.46049
Engaged (ENG) [07]	22	0.12038
Soft Appointments [SA]	179	0.97943
Hard Appointments [HA]	0	0
B. OUT OF SCOPE	6709	36.7093
B1. Not Connected [04]	2598	
B2. Business numbers [08]	215	
B3. Fax/modem [90]	49	
B4. Incapacitated - too ill, deaf etc [40]	14	
B5. Incorrect contact details - Respondent not known [45]	0	
B6. Respondent known but no new number [46]	0	
B7. Currently unemployed [86]	1117	
B8. Mobile never on at the end of project [42]	0	
B10. Language Difficulty [05]	66	
B11. Retired - Not working [88]	2255	
B12. No 18+ in paid in employment [78]	2	
B13. Away for survey period [60]	9	
B14. Self-employed [82]	176	
B15. Not at same employer for 4 months or longer [85]	121	
B16. NEW RESPONDENT - Not living in NSW - call at later date [87]	87	
C. ELIGIBLE SAMPLE (A - B)	11567	63.2907
D. NO ANSWER AFTER 6 ATTEMPTS	5305	29.0271
E. ELIGIBLE CONTACTS	815	4.4594
E1. Refusals	347	
E2. Terminated	0	
E3. Consent refused (11/17)	0	
E5. COMPLETED INTERVIEWS	468	
F. RESPONSE RATE: E5/(E+D)	0.076471	7.6471
G. CONTACTED RESPONSE RATE:E5/E	0.574233	57.4233
Percentage Total	16547	100

Sample Industry and Occupation Prevalence

The industry and occupation categories of the overall sample (defined using ASCO 1993, ANZSIC 1994) are shown in Table 2A.

Table 2A. Employment characteristics

Characteristic	N = 628[1]
Occupation (ASCO 1993)	
Managers or administrator	173 (28%)
Professional work	221 (35%)
Technician or associate professional	44 (7.1%)
Tradesperson or related work	29 (4.6%)
Advanced clerical, sales or service work	28 (4.5%)
Intermediate clerical, sales or service work	27 (4.3%)
Intermediate plant operator/transport	8 (1.3%)
Elementary clerical, sales or service work	11 (1.8%)
Labourer or related work	22 (3.5%)
Other – please enter job type (specify)	60 (9.6%)
Refused	1 (0.2%)
(Missing)	4
Industry (ANZSIC 1994)	
Accommodation, cafes and restaurants	15 (2.4%)
Agriculture, forestry and fishing	12 (1.9%)
Communications services	21 (3.3%)
Construction	23 (3.7%)
Cultural and recreational services	7 (1.1%)
Education	100 (16%)
Electricity, gas and water supply	15 (2.4%)
Finance and insurance	44 (7.0%)
Government administration and defence	57 (9.1%)
Health and community services	124 (20%)
Manufacturing	31 (4.9%)
Mining	15 (2.4%)
Personal and other services	16 (2.5%)
Property and business services	10 (1.6%)
Retail trade	36 (5.7%)
Transport and storage	27 (4.3%)
Wholesale trade	8 (1.3%)
Other (specify)	67 (11%)
Refused	0 (0%)
Employment status	
Full-time	410 (65%)
Part-time	110 (18%)
Casual	76 (12%)
Fixed term	19 (3.0%)
Other	13 (2.1%)
Refused	0 (0%)
Employer business	
A commonwealth or federal government department or agency	44 (7.0%)
A state or local government agency	157 (25%)
A not-for-profit, religious, or community organisation	66 (11%)
A private sector business	353 (56%)
Something else (specify)	8 (1.3%)
Refused	0 (0%)

Note: [1]n (%)

Conversion of industry categories in the sample to 2006 categories

Estimates are required by industry (ANZSIC 2006 categories), however industry categories were surveyed as ASIC 1994 categories (e.g., Table 2A Employment characteristics above), which are no longer reported by ABS or NSW. A *post hoc* conversion between ASIC and ANZSIC categories was performed using the joint distribution between each from HILDA data for NSW, 2006.

NSW Population Prevalence Estimates

Below we present the estimated prevalence of MSD in NSW by industry. Estimates were provided by a regression model of MSD by industry, age and sex fitted on the survey data, and then applied to the 2016 census of NSW industries, stratified by age and sex (multilevel regression poststratification) with the three MSD outcomes.

Pain prevalence

Table 3A. MSD NSW population prevalence by industry (multilevel regression poststratification)

Industry	est. MSD (n)[1]	NSW (N)[2]	% (.est)
Retail Trade	112,566	286,172	39.3
Electricity Gas Water and Waste Services	11,985	31,580	38.0
Financial and Insurance Services	58,275	166,168	35.1
Professional Scientific and Technical	87,592	270,982	32.3
Rental Hiring and Real Estate Services	17,639	58,193	30.3
Agriculture Forestry and Fishing	19,412	70,543	27.5
Administrative and Support Services	30,385	115,258	26.4
Arts and Recreation Services	12,174	46,875	26.0
Other Services	30,091	118,711	25.3
Health Care and Social Assistance	102,795	415,473	24.7
Wholesale Trade	23,356	101,848	22.9
Manufacturing	43,712	191,383	22.8
Construction	60,307	269,663	22.4
Transport Postal and Warehousing	32,975	156,744	21.0
Accommodation and Food Services	38,331	186,212	20.6
Education and Training	45,893	275,708	16.6
Information Media and	10,717	71,273	15.0
Mining	4,648	31,491	14.8
Public Administration and Safety	29,685	202,079	14.7

Note: [1]Estimated number employed in NSW with MSD; [2]Census of employed in NSW 2016

MSD diagnosis prevalence

The MSD diagnosis were collapsed into a binary variable indicating the presence of any of the twelve named diagnosis or not.

Table 4A. NSW population prevalence by industry (multilevel regression poststratification)

Industry	est. MSD (n)[1]	NSW (N)[2]	% (.est)
Rental Hiring and Real Estate Services	15,549	58,193	26.7
Administrative and Support Services	26,916	115,258	23.4
Other Services	27,055	118,711	22.8
Professional Scientific and Technical Services	61,200	270,982	22.6
Health Care and Social Assistance	90,588	415,473	21.8
Agriculture Forestry and Fishing	14,547	70,543	20.6
Transport Postal and Warehousing	30,687	156,744	19.6
Mining	5,981	31,491	19.0
Public Administration and Safety	37,258	202,079	18.4
Financial and Insurance Services	30,060	166,168	18.1
Information Media and Telecommunications	12,144	71,273	17.0
Arts and Recreation Services	7,666	46,875	16.4
Education and Training	43,212	275,708	15.7
Accommodation and Food Services	29,183	186,212	15.7
Retail Trade	41,111	286,172	14.4
Electricity Gas Water and Waste Services	4,062	31,580	12.9
Wholesale Trade	13,074	101,848	12.8
Manufacturing	21,377	191,383	11.2
Construction	29,350	269,663	10.9

Note: [1]Estimated number employed in NSW with MSD; [2]Census of employed in NSW 2016

Work-related injury (12-mo) prevalence

Table 5A. NSW population prevalence by industry (multilevel regression poststratification)

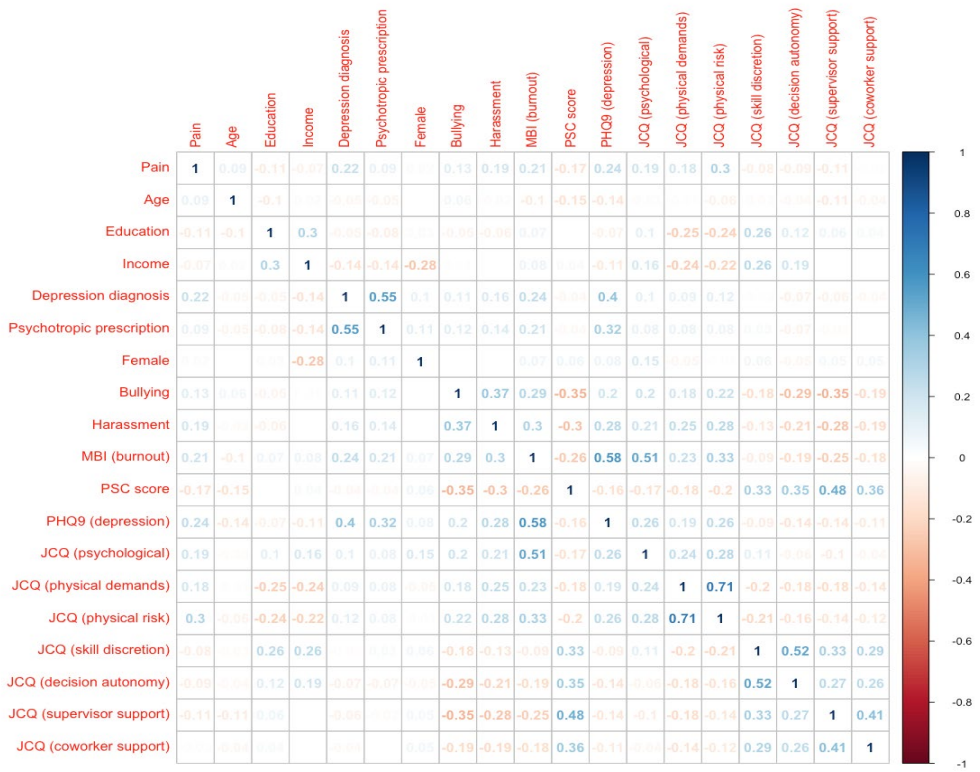
Industry	est. MSD (n)[1]	NSW (N)[2]	% (.est)
Electricity Gas Water and Waste Services	4,347	31,580	13.8
Transport Postal and Warehousing	17,687	156,744	11.3
Wholesale Trade	10,032	101,848	9.9
Administrative and Support Services	7,617	115,258	6.6
Construction	16,005	269,663	5.9
Other Services	7,017	118,711	5.9
Retail Trade	13,184	286,172	4.6
Health Care and Social Assistance	18,307	415,473	4.4
Public Administration and Safety	8,175	202,079	4.0
Manufacturing	6,478	191,383	3.4
Rental Hiring and Real Estate Services	1,578	58,193	2.7
Education and Training	7,321	275,708	2.7
Accommodation and Food Services	3,647	186,212	2.0
Arts and Recreation Services	846	46,875	1.8
Professional Scientific and Technical	4,308	270,982	1.6
Information Media and	1,007	71,273	1.4
Agriculture Forestry and Fishing	556	70,543	0.8
Mining	199	31,491	0.6
Financial and Insurance Services	452	166,168	0.3

Note: [1]Estimated number employed in NSW with MSD; [2]Census of employed in NSW 2016

Study 2

Cross-section associations

Table 6A. Pearson correlations



The highest |r| value was between “JCQ (physical demands)” and “JCQ (physical risk)” at 0.71, and between “Burnout score” and “PHQ9 depressive symptoms” at 0.58

Frequencies of Each Antecedent by MSD Outcome

Pain levels

The frequencies of each antecedent by pain level and their univariate association with pain are shown below.

Table 7A. Frequencies of Each Antecedent by Pain

		Pain (N = 334)[1]		
Characteristic	**Not at all, N = 133[1]**	**Some or a little**	**A lot, N = 161[1]**	**p-value[2]**
PSC score	47 (38, 50)	46 (36, 49)	41 (31, 48)	<0.001
Female	82 (23%)	174 (48%)	103 (29%)	0.022
Age	47 (37, 56)	49 (39, 58)	52 (38, 58)	0.13
(Missing)	0	0	1	
Education				0.057
Did not finish Year 12	2 (14%)	7 (50%)	5 (36%)	
High school	56 (19%)	154 (51%)	91 (30%)	
University	75 (25%)	166 (54%)	64 (21%)	
(Missing)	0	7	1	
Income				0.5
Less than $40,001	16 (20%)	42 (51%)	24 (29%)	
$40,001 - $50,000	12 (22%)	24 (44%)	18 (33%)	
$50,001 - $60,000	11 (17%)	32 (51%)	20 (32%)	
$60,001 - $80,000	26 (24%)	51 (48%)	30 (28%)	
$80,001 - $100,000	20 (23%)	48 (55%)	20 (23%)	
$100,001 - $150,000	34 (24%)	79 (56%)	28 (20%)	
More than $150,000	9 (14%)	40 (63%)	14 (22%)	
(Missing)	5	18	7	
Depressive symptoms	11.0 (9.0, 13.0)	12.0 (10.0, 15.0)	14.0 (12.0, 18.0)	<0.001
(Missing)	1	8	1	
Burnout	14 (9, 20)	15 (10, 21)	20 (13, 27)	<0.001
Physical demands	6.00 (4.00, 6.00)	6.00 (4.00, 7.00)	6.00 (4.00, 8.00)	<0.001
Physical risk	6.00 (5.00, 8.00)	7.00 (5.00, 9.00)	8.00 (7.00, 12.00)	<0.001
Psychological demands	13.00 (11.00, 14.00)	13.00 (12.00, 15.00)	14.00 (13.00,	<0.001
Skill discretion	18.00 (17.00, 19.00)	17.00 (16.00, 19.00)	18.00 (15.00,	0.2
Decision authority	9.00 (8.00, 10.00)	9.00 (8.00, 10.00)	9.00 (7.00, 10.00)	0.2
Supervisor support	9.00 (9.00, 11.00)	9.00 (9.00, 11.00)	9.00 (8.00, 11.00)	0.2
Co-worker support	9.00 (9.00, 12.00)	9.00 (9.00, 11.00)	9.00 (9.00, 12.00)	>0.9
Bullying	6 (11%)	25 (44%)	26 (46%)	<0.001
Harassment	4.00 (4.00, 5.00)	4.22 (4.00, 5.18)	4.67 (4.00, 6.00)	<0.001
(Missing)	0	1	1	

Note: [1]Median (IQR); n (%),[2]Kruskal-Wallis rank sum test; Pearson's Chi-squared test; Fisher's Exact Test for Count Data with simulated p-value (based on 2000 replicates)

MSD diagnosis

The frequencies of each antecedent by doctor diagnosed MSDs and their univariate effects with doctor diagnosed MSDs is shown in Table 8A.

Table 8A. Frequencies of Each Antecedent by MSD Doctor Diagnosis (DX)

Characteristic	Dx No, N = 496[1]	Dx Yes, N = 132[1]	p-value[2]
PSC score	45 (36, 49)	44 (35, 49)	0.2
Female	286 (80%)	73 (20%)	0.6
Age	48 (37, 56)	53 (46, 60)	<0.001
(Missing)	1	0	
Education			0.4
Did not finish Year 12	9 (64%)	5 (36%)	
High school	237 (79%)	64 (21%)	
University	242 (79%)	63 (21%)	
(Missing)	8	0	
Income			0.8
Less than $40,001	69 (84%)	13 (16%)	
$40,001 - $50,000	42 (78%)	12 (22%)	
$50,001 - $60,000	50 (79%)	13 (21%)	
$60,001 - $80,000	83 (78%)	24 (22%)	
$80,001 - $100,000	71 (81%)	17 (19%)	
$100,001 - $150,000	107 (76%)	34 (24%)	
More than $150,000	48 (76%)	15 (24%)	
(Missing)	26	4	
Depressive symptoms	12.0 (10.0, 16.0)	12.0 (10.0, 15.0)	0.8
(Missing)	9	1	
Burnout	16 (10, 23)	17 (11, 22)	0.4
Physical demands	6.00 (4.00, 7.00)	6.00 (4.00, 7.00)	0.5
Physical risk	7.00 (5.00, 9.00)	7.00 (5.00, 10.00)	0.5
Psychological demands	13.00 (12.00, 15.00)	13.00 (12.00, 15.25)	0.12
Skill discretion	18.00 (16.00, 19.25)	17.00 (15.00, 20.00)	0.3
Decision authority	9.00 (8.00, 10.00)	9.00 (8.00, 10.00)	0.2
Supervisor support	9.00 (9.00, 11.00)	9.00 (9.00, 11.00)	0.8
Co-worker support	9.00 (9.00, 12.00)	10.00 (9.00, 12.00)	0.3
Bullying	42 (74%)	15 (26%)	0.3
Harassment	4.00 (4.00, 5.22)	4.45 (4.00, 5.32)	0.11
(Missing)	1	1	

Note: [1]Median (IQR); n (%) [2]Wilcoxon rank sum test; Pearson's Chi-squared test; Fisher's Exact Test for Count Data with simulated p-value (based on 2000 replicates); Fisher's exact test

Work-related injury

The frequencies of each antecedent variable by work-related injury (the presence or absence in the last 12-mo) are shown below, along with their univariate association with injury.

Table 9A. Frequencies of Each Antecedent by Work-related Injury

Characteristic	No, N = 535[1]	Yes, N = 22[1]	p-value[2]
PSC score	45 (36, 49)	41 (26, 48)	0.2
Female	312 (97%)	11 (3.4%)	0.4
Age	49 (38, 57)	50 (38, 57)	0.9
(Missing)	1	0	
Education			0.2
Did not finish Year 12	12 (92%)	1 (7.7%)	
High school	253 (95%)	13 (4.9%)	
University	266 (97%)	8 (2.9%)	
(Missing)	4	0	
Income			0.2
Less than $40,001	65 (93%)	5 (7.1%)	
$40,001 - $50,000	43 (96%)	2 (4.4%)	
$50,001 - $60,000	57 (95%)	3 (5.0%)	
$60,001 - $80,000	94 (99%)	1 (1.1%)	
$80,001 - $100,000	75 (93%)	6 (7.4%)	
$100,001 - $150,000	125 (98%)	3 (2.3%)	
More than $150,000	52 (98%)	1 (1.9%)	
(Missing)	24	1	
Depressive symptoms	12.0 (10.0, 15.0)	17.0 (11.0, 20.0)	0.009
(Missing)	3	1	
Burnout	16 (10, 22)	24 (18, 28)	<0.001
Physical demands	6.00 (4.00, 7.00)	7.50 (5.25, 10.75)	0.003
Physical risk	7.00 (5.00, 9.00)	10.00 (8.00, 12.75)	<0.001
Psychological demands	13.00 (12.00, 15.00)	14.00 (13.00, 15.75)	0.088
Skill discretion	18.00 (16.00, 20.00)	17.00 (15.00, 19.75)	0.3
Decision authority	9.00 (8.00, 10.00)	8.00 (6.00, 10.00)	0.11
Supervisor support	9.00 (9.00, 11.00)	9.00 (7.00, 11.00)	0.2
Co-worker support	9.00 (9.00, 12.00)	9.00 (9.00, 12.00)	0.8
Bullying	46 (94%)	3 (6.1%)	0.4
Harassment	4.00 (4.00, 5.22)	4.56 (4.00, 6.00)	0.3
(Missing)	2	0	

Note: [1]Median (IQR); n (%) [2]Wilcoxon rank sum test; Pearson's Chi-squared test; Fisher's Exact Test for Count Data with simulated p-value (based on 2000 replicates); Fisher's exact test

Study 3

Longitudinal associations

Table 10A. Means, Standard Deviations and Correlations

		M	SD	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.	Age (T1)	54	10.56	432	-																
2.	Gender (T1)	1.55	.50	432	-.10*	-															
3.	Income (T1)	6.77	2.39	409	-.12*	-.36**	-														
4.	Education (T2)	5.97	1.50	432	.14**	.04	.16**	-													
5.	PSC (T1)	40.44	9.70	432	.01	.01	.01	-.09	-												
6.	Physical Demands (T1)	5.93	1.9	432	.02	-.01	-.19**	-.16**	-.06	-											
7.	Psychological Demands (T1)	31.29	5.13	432	-.07	.07	.15**	.15**	-.36**	.11*	-										
8.	Skill Discretion (T1)	35.27	5.19	432	-.05	-.01	.29**	.29**	.22**	-.23**	.03	-									
9.	Decision Authority (T1)	35.56	6.15	432	-.13**	.01	.15**	.05	.35**	-.17**	-.10*	.45**	-								
10.	Supervisors Support (T1)	9.36	1.69	432	.07	-.01	-.01	.03	.53**	-.09*	-.28**	.25**	.38**	-							
11.	Co-workers Support (T1)	9.79	1.39	432	.02	.02	.03	.08	.31**	-.12*	-.12*	.30**	.24**	.47**	-						
12.	Workplace Bullying (T1)	0.09	.28	432	.05	.00	-.01	-.05	-.29**	.08	.19**	-.08	-.17**	-.37**	-.22**	-					
13.	Workplace Harassment (T1)	10.09	2.89	432	-.05	.07	-.01	-.01	-.36**	.22**	.30**	-.09	-.15**	-.32**	-.18**	.40**	-				
14.	Depressive symptoms (T1)	3.59	4.09	432	.08	.04	-.16**	-.05	-.32**	.02	.19**	-.14**	-.18**	-.30**	-.19**	.25**	.31**	-			
15.	Emotional Exhaustion (T1)	15.15	7.42	432	.14**	.00	.03	.02	-.36**	.03	.39**	-.05	-.23**	-.33**	-.15**	.21**	.38**	.54**	-		
16.	Pain (T2)	2.07	.64	432	-.04	.15**	-.11*	-.11*	-.09	.12*	.05	-.15**	.01	-.04	-.05	.04	.08	.24**	.12**	-	
17.	MSDs (T2)	0.25	.43	432	-.13**	.02	.06	.01	-.10*	.05	.13**	-.01	.01	-.07	.01	.11*	.13**	.05	.09	.24**	-
18.	Work-related Injuries (T2)	0.05	.22	432	-.03	-.07	-.07	-.04	-.05	.15**	.05	-.08	-.15**	.04	.03	0	.04	.02	.04	.14**	.16**

Note: * Correlation is significant at the .05 level (2-tailed). ** Correlation is significant at the .01 level (2-tailed). T1 = Time 1 (2014-15) and T2 = Time 2 (2021). Gender (M=1, F=2), PSC = Psychosocial Safety Climate, MSDs = Musculoskeletal Disorders Doctor Diagnosed.

Table 10B. Demographics Longitudinal Matched Sample

Characteristic	N (%)
Gender	
Female	130 (54%)
Male	110 (26%)
Work status	
Permanent Fulltime	280 (66.4%)
Permanent Parttime	85 (20.1%)
Casual/temporary	43 (10.2%)
Fixed term contract	12 (2.8%)
Other	2 (.5%)
Education	
High school	68 (15.7%)
Trade/	15 (3.5%)
Certificate/Diploma	120 (27.8%)
University	223 (51.6%)
(Missing)	6 (1.4%)
Income	
Less than $40,001	59 (13.7%)
$40,001 - $50,000	26 (6%)
$50,001 - $60,000	43(10%)
$60,001 - $80,000	79(24%)
$80,001 - $100,000	69 (23%)
$100,001 - $150,000	102(24%)
More than $150,000	54 (12.5%)
	Mean (range)
Age	43.9 (18,75)

Note: N = 432