RESEARCH AND EVALUATION

Risk factors, prevalence, and interventions to address workplace fatigue

LITERATURE REVIEW

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EXECUTIVE SUMMARY

This document summarises the evidence of interventions to address the risk factors and consequences of workplace fatigue.

Evidence from WorkSafe's Workforce Segmentation and Insights Programme (WSIP) suggests that New Zealand workers commonly experience fatigue at work, which is in line with international findings. The WSIP also suggests that fatigue levels are lower among workers aged 50+, although the reasons for this are unknown. The risk factors of fatigue discussed in this review are:

- mental and muscular exertion
- sleep deprivation
- heavy or repetitive workload
- overtime and long work hours
- inadequate recovery time
- environmental exposures such as noise, vibration, heat, low light and red light (or blue light during sleep hours)
- workplace safety culture
- poor psychosocial health.

Not all these risk factors fall within the purview of regulatory activity.

There is a consensus in the literature that workplace fatigue cannot be eliminated but can be effectively mitigated and managed. Mitigation and management requires a systematic approach, involving workers, employers and wider industry players. Expert opinion and some evaluations support the efficacy of six types of interventions to address fatigue. These are:

- shortening work hours
- managing shift and night work
- workplace napping and breaks
- improving the workplace environment
- lowering work demands and increasing worker control
- improving workplace safety culture.

Barriers to the effectiveness of all these interventions have also been identified, as have trade-offs between different types of interventions. For instance, while there is a long history of regulation and legislation to restrict maximum work hours, it is often difficult to enforce if employers pressure workers with excessive work demands, schedule long work hours or expect overtime from employees. Some employees may also prefer longer shifts to maximise days off or income. Improving workplace safety culture and finding ways to encourage employers to prioritise fatigue prevention over other demands such as profitability or a sense of professionalism can help overcome these barriers.

Culture, both in the workplace and in wider society, also affects the efficacy of other interventions. For instance, if napping or taking breaks is not an accepted part of working culture, workers become reluctant to nap or take breaks or feel guilty in doing so. Similarly, if there is no culture of workers having a degree of control over the pace of work or shift scheduling, it is difficult to reduce workplace demands or to properly manage shift and night work to minimise fatigue.

A systematic approach underpins many 'Fatigue Risk Management Systems' (FRMS) and a well-functioning FRMS shares many features of good health and safety management systems, including:

- evidence-based policies informed by objective data, continuous feedback and targeted improvements
- cooperative development between workers and employers
- system-wide implementation and support for tools, policies and procedures
- integration of the FRMS into existing health and safety systems
- financial support and ownership of the FRMS by senior leadership.

The FRMS provides a framework for the implementation of interventions addressing fatigue.

In summary, there is solid evidence available for the prevalence of and risk factors for fatigue. There are several empirically and theoretically supported interventions to address the risk factors for fatigue in the workplace. However, as with many occupational health and safety interventions, the success of these interventions is dependent on wider changes in the safety system to address demands that conflict with good health and safety practice.

1.0 Introduction

This document provides a literature review of organisational interventions aimed at addressing workplace fatigue.

The review found a significant body of literature outlining interventions to address the risk factors and consequences of workplace fatigue, and multiple existing reviews addressing specific types of interventions.

There is strong evidence that fatigued workers are more likely to be injured at work than non-fatigued workers (Lipscomb et al., 2006; Robb et al., 2008; Swaen et al., 2003; Swaen et al., 2004) and that they have poorer long-term health outcomes (Wadsworth et al., 2008). Fatigue has been associated with several catastrophic accidents such as the Three Mile Island and Chernobyl meltdowns and the Exxon Valdez tanker disaster (Akerstedt et al., 2002). This makes fatigue a key risk factor for workplace injury and ill-health.

1.1 Prevalence

The WorkSafe-commissioned Workforce Segmentation and Insights Programme (WSIP) provides indicative data on the prevalence of fatigue in the workplace. This data suggests that approximately 31% of workers often or mostly/always work when fatigued. It also suggests that women are more likely to suffer fatigue than men and that fatigue levels drop significantly among workers over 50 years old.

The WSIP also provides indicative data that physical industries may suffer less fatigue than average, with agricultural, forestry, manufacturing, and electrical/gas workers all significantly less likely to say they often or mostly/always work when fatigued. By contrast, professional, scientific and technical service workers are more likely to report working when fatigued. These findings were not adjusted for age or gender and so should be viewed as indicative only.

1.2 Risk factors

This review divides risk factors into organisational/systems level factors, and individual and task related factors. The factors discussed are:

- organisational and systems level factors:
  - workload characteristics - particularly heavy workload, high strain tasks, monotonous tasks design
  - overtime and long work hours
  - shift and night work – together they cause shift work disorder characterised by insomnia and excessive sleepiness; there is also evidence that accident rates increase during night shifts
  - effort-reward imbalance

  - at work environmental factors including: warm, lowly lit environments, exposure to vibration and noise, and exposure to blue lights during sleep hours.
- individual and task related factors:
  - sleep deprivation
  - mental exertion
  - muscular exertion
  - circadian factors
  - homeostatic factors (a.k.a. sleep debt)
  - task design.

These risk factors are interrelated, and in some cases, they are difficult to isolate from one another. For instance, there is significant overlap between task design and workload characteristics. Furthermore, the organisation of industries likely creates additional risk factors that either directly impact on fatigue levels or influence the likelihood of workers being exposed to other risk factors. For example, expectations of just-in-time deliveries result in pressures on drivers to work long work hours. Tedestedt George et al. (2021) provide an AcciMap analysis of these risk factors in the transportation industry, and similar AcciMaps may be producible for other industries. However, industry-specific risk factors are largely outside of the scope of this review.

1.3 Interventions

While there are some points of contention in the literature, there is generally consensus as to the features of interventions that successfully address workplace fatigue. The literature advocates for a systematic approach to managing fatigue that requires support from workers, management and other organisations in the supply chain (Tedestedt George et al., 2021). As Tedestedt George summarised "[a]ddressing fatigue requires that we address a host of other, higher-up and systemic issues such as pay, payment methods, and the work time rules, among others" (Tedestedt George et al., 2021). Organisational level interventions have been labelled 'Fatigue Risk Management Systems' (FRMS) and share many features with occupational health and safety good practice. The following are required for a successful FRMS:

- evidence-based policies as the foundation of the FRMS
- FRMS decisions made based on objectively analysed data
- cooperation between workers and employers
- system-wide implementation and support for tools, policies and procedures
- the FRMS to be integrated into existing health and safety systems
- continuous feedback and improvement of the FRMS
- financial support for the FRMS
- ownership and commitment to managing fatigue by senior leadership (Lerman et al., 2017).

These features are based on expert opinion and theory. This is unsurprising given the dearth of evaluations of interventions. Despite this lack of evaluation, several interventions have expert and empirical support, and are frequently suggested in the literature. These are:

- shortening work hours
- managing shift and night work
- workplace napping and breaks

- improving the workplace environment
- lowering work demands and increasing worker control
- improving workplace safety culture.

Regulating work hours is the oldest of these interventions with a history stretching back to work hour regulations won by unions in the 19th century. Work hour regulations were partially successful, and much of the literature discussed in this review explores the barriers to their success - primarily industry opposition, and regulation being a ‘blunt instrument’ by nature. This review also explores the laws passed in the late 1990s and early 2000s in France that aimed to reduce the working week to 35 hours, but again only demonstrated partial success before being partially overturned in 2007.

The negative effects of night and shift work can only be comprehensively addressed by eliminating night and shift work. However, several authors have provided evidence-based good practice guidelines for shift and night work. These include the use of slowly forward rotating shift schedules, shorter shifts, predictable and equitable shift schedules, maximising weekend free days for night workers, and ensuring that shift workers have adequate recovery times between shifts. The literature also highlights the importance of individual biological features, such as chronotype and comorbidities that affect workers’ suitability for night and shift work. Blocking out blue light during the sleeping hours of shift workers can also help workers adapt to night shifts.

There is evidence that workplace napping and extended breaks are effective ways to address fatigue, particularly during long or night shifts. However regular sleep should not be disrupted by overly long naps. Additionally, a period of ‘sleep inertia’ that may last for up to half an hour after waking needs to be managed. For workers to nap, they need to be provided with adequate sleep spaces and a workplace culture that supports napping when fatigued.

Ensuring that there is bright light at night, ideally on the blue light spectrum, changes the workplace environment to address fatigue and helps workers’ circadian rhythms adapt to night work. Other environmental interventions include avoiding warm or cold temperatures; and minimising noise and vibration exposure during long shifts.

Improving industry-wide safety culture is the broadest, and most complex of the interventions discussed in this review, but is also the most important (Tedestedt George et al., 2021). There is evidence that a poor safety culture, where other demands such as financial concerns, professionalism or job security are prioritised above safety, lead to poor fatigue management practices. In contrast, a good safety culture is a prerequisite for the success of a FRMS or any other occupational health and safety intervention. This review also suggests that addressing safety culture requires accounting for economic factors, supply chain pressures and other business-related demands on organisations that result in a poor safety culture.

2.0 Method

This is a review of the academic and grey literature on interventions that organisations and employers could implement to reduce the risk or consequences of worker fatigue in the workplace.

As a non-systematic approach was adopted, to be included a text must:

- be either in a peer-reviewed journal or published by an organisation with a similar remit to WorkSafe (such as the Health and Safety Executive (HSE) or Occupational Safety and Health Administration)
- provide or review evaluations of interventions to address workplace fatigue
- provide expert opinion or theoretically supported argument for unevaluated interventions that may address workplace fatigue.

Articles were collected through keyword searches on academic databases, Google Scholar and Semantic Scholar. Additional articles were sourced through a snowballing approach, using citation trees of key articles.

3.0 Defining fatigue

There is no universal definition of fatigue in the literature. Fatigue is often used interchangeably with sleepiness or is used to describe a particular type of 'wearing out' such as compassion fatigue.

With these caveats, there is some commonality in many definitions of fatigue. Lerman et al. (2017) defined fatigue as "the body's response to sleep loss or to prolonged physical or mental exertion" (Lerman et al., 2017, p. 231). This is similar to the Lees et al. (2019) definition that "fatigue is considered a mental state in which an individual's capacity to initiate or continue performing a task is diminished" (p. 20), and the Aaronson et al. (1999) definition of fatigue as "a decreased capacity for physical and/or mental activity due to an imbalance in the availability, utilization, and/or restoration of resources needed to perform [the] activity" (cited in Nejati et al., 2016, p. 70).

Other authors have provided contrasting definitions. Courtney (2013) defines fatigue as "a general tiredness and lack of energy irrespective of whether an individual has had enough sleep or has been working hard, which persists even on rest days and holidays" (p. 22). Miller (2006) would classify Courtney's definition as 'chronic fatigue', as distinct from acute fatigue (tiredness lasting only one day) or cumulative fatigue (an intermediate state that requires a rest day or holidays to recover from).

There are also various subtypes of fatigue, such as mental fatigue (Van Cutsem et al., 2017), physical fatigue or compassion fatigue (Aycock & Boyle, 2009). These types of fatigue fall under the definitions given above in that they are manifested through difficulty in performance, due to prolonged periods of activity but are specific to types of activities. For instance, Van Cutsem et al. (2017) define mental fatigue as a 'psychobiological state' manifested through errors, poor performance, decreased motivation and alertness and a lack of energy. Compassion fatigue manifests through feelings of emotional exhaustion, feelings of inadequacy, recognition of mortality or pessimism brought on by periods of emotionally demanding work (Aycock & Boyle, 2009).

This review will focus on a 'general' definition of fatigue and will only focus on specific types of fatigue when it is emphasised in the literature. The definition of fatigue will be taken from WorkSafe's existing definition of fatigue as "a state of physical and/or mental exhaustion which reduces a person's ability to perform work safely and effectively". This loosely aligns with the definitions provided above by Aaronson et al. (in Nejati et al., 2016), Lerman et al. (2017) and Lee et al. (2019).

4.0 Prevalence of workplace fatigue

Regardless of the definition used, workplace fatigue is a commonly experienced condition (Noy et al., 2011), with between 20% and 40% of the working population reporting significant fatigue at any given time (Bultmann et al., 2002; Bultmann et al., 2001). The Workforce Segmentation and Insights Programme (WSIP) survey found that approximately 31% of workers were fatigued often or most/all the time (95% CI MoE = +-1.40%). Women were significantly more likely to be fatigued at work (35% +-2.4% 95% CI MoE) compared to men (28% +-1.7% 95% CI MoE).

WSIP data also suggests that workers over the age of 50 report declining levels of fatigue. This is shown in figure 1 below:

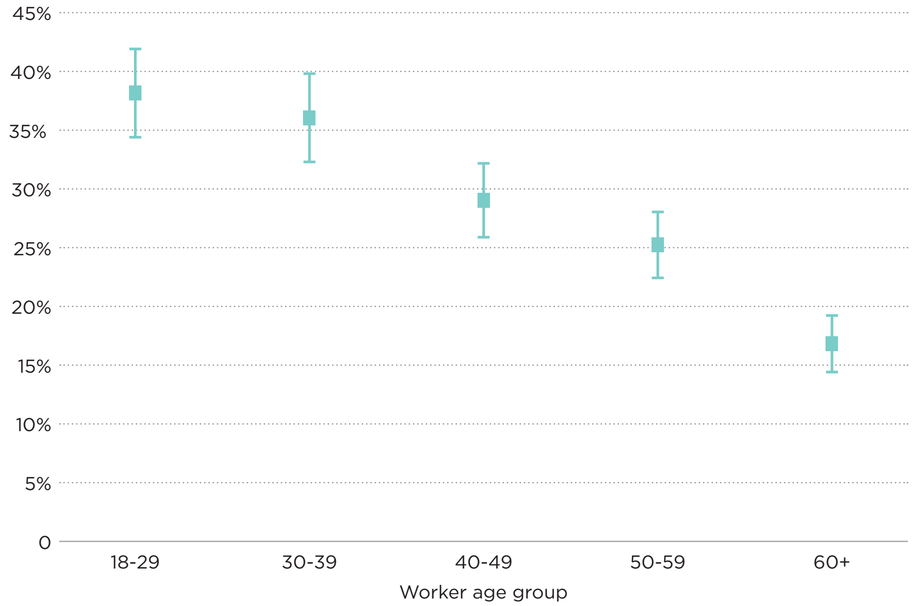

FIGURE 1: Fatigue prevalence by age in New Zealand (WSIP 2019)

The percentage of workers working while fatigued by industry in the WSIP data is provided below:

2019 WSIP prevalence of fatigue in selected industries (n=4196)

INDUSTRY	SAMPLE	FATIGUED (OFTEN, MOST OR ALL OF THE TIME)	MOE (95%CI)
Professional, scientific and technical services	**103**	**43%**	**+/-9.56%**
Commercial fishing	107	38%	+/-9.20%
Financial and insurance services	46	38%	+/-14.03%
Education and training	141	36%	+/-7.92%
Healthcare and social assistance	154	34%	+/-7.48%
Administrative and support services	104	34%	+/-9.10%
Accommodation and food services	231	34%	+/-6.11%
Arts and recreation services	44	33%	+/-13.89%
Other	151	33%	+/-7.50%
Public administration and safety	63	32%	+/-11.52%
Water and waste	43	31%	+/-13.82%
OVERALL	4196	31%	+/-1.40%
Construction	272	28%	+/-5.34%
Transport, postal and warehousing	446	28%	+/-4.17%
Wholesale trade	67	28%	+/-10.75%
Retail trade	169	26%	+/-6.61%
Agriculture	**788**	**25%**	**+/-3.02%**
Manufacturing	**447**	**24%**	**+/-3.96%**
Forestry	**198**	**24%**	**+/-5.95%**
Information media and telecommunications	45	23%	+/-12.30%
Electricity or gas	**540**	**22%**	**+/-3.49%**
Rental, hiring and real estate services	37	21%	+/-13.12%

TABLE 1: Working while fatigued by industry in New Zealand (WSIP 2019)

The large margins of error that have emerged from some small sample sizes mean that the fatigue outcomes by industry should be viewed with caution. Only professional, scientific, and technical services had a fatigue prevalence significantly higher than the average of all workers. Electricity or gas, manufacturing, agriculture, and forestry workers all had fatigue levels lower than the average of all workers.

Academic attention given to fatigue has tended to focus on a few occupations namely, healthcare (Courtney, 2013; Harma et al., 2019), transportation (Boeggild Dohrmann & Leppin, 2016; Hobbs et al., 2011), military (Lees et al., 2019; Miller, 2006), law enforcement (Lees et al., 2019), pilots (van Drongelen et al., 2013) and manufacturing (Yamazaki et al., 2007).

5.0 Risk factors of workplace fatigue

IN THIS SECTION:

Fatigue is a recognised risk factor for occupational injury.

The Maastricht cohort study found that the adjusted relative risk of occupational accidents for the most fatigued workers was 1.69 (95% CI 1.03 – 2.78) compared to the least fatigued workers (Swaen et al., 2003).

In relation to fatigue management, Tedestedt George et al. (2021) provided an AcciMap analysis of the risk factors for fatigue in the New Zealand Transport industry:

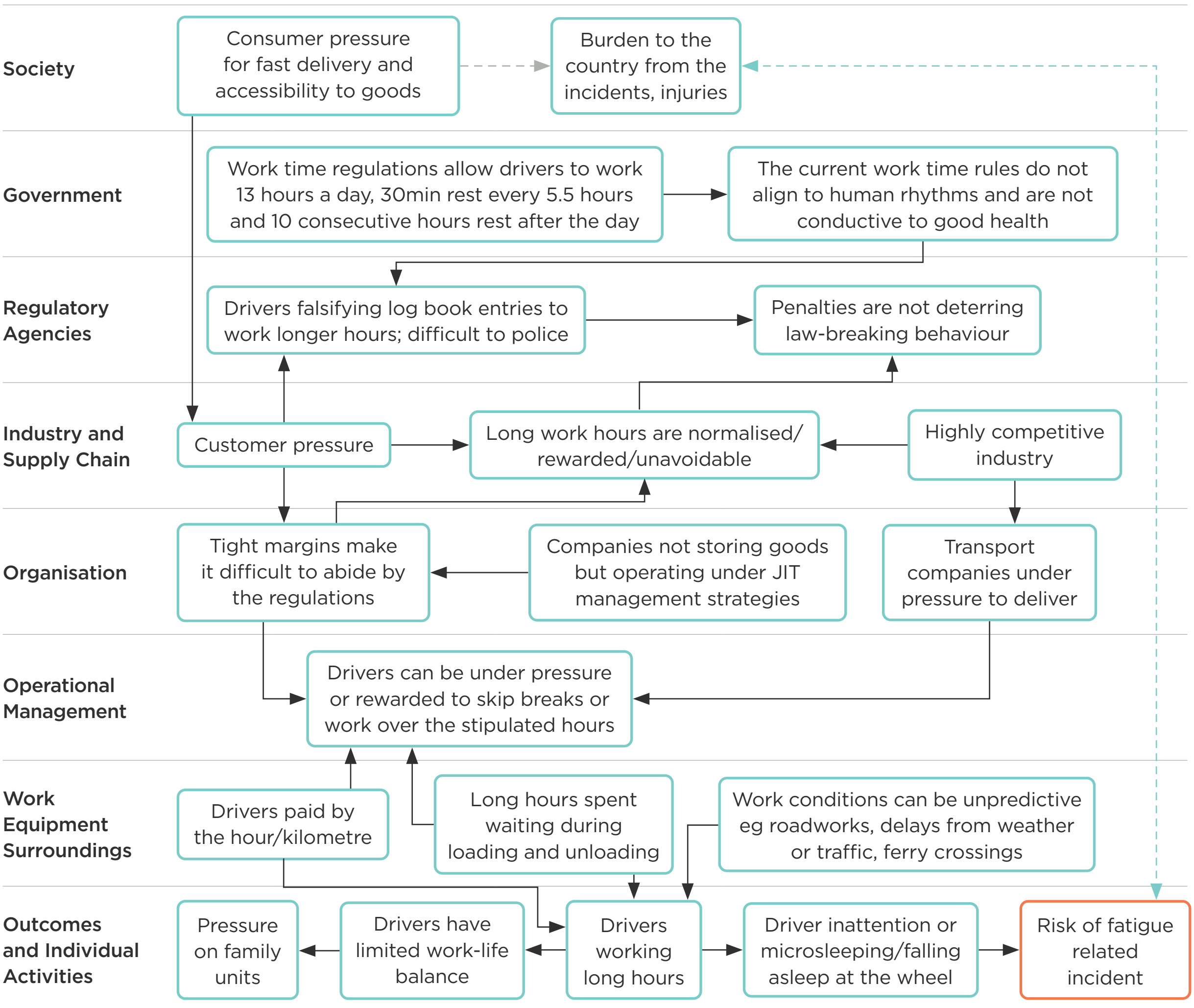

FIGURE 2: AcciMap of risk factors for fatigue in the transport sector (Tedestedt George et al. 2021, p. 126)

Techera, Hallowell, Stambaugh, and Littlejohn (2016) provide a list of risk factors for occupational fatigue across industries:

- sleep deprivation
- mental exertion
- muscular exertion
- workload characteristics

- overtime and long work hours
- incomplete recovery
- at-work environmental factors
- safety culture
- poor psychosocial health.

In addition, epidemiological data provides some individual and task-design risk factors for fatigue (Caldwell et al., 2019; Lerman et al., 2012; Williamson et al., 2011). Williamson et al. (2011) divide the epidemiological risk factors for fatigue into three groups:

- Circadian factors
- Homeostatic factors
- Task-related factors.

This review will provide an overview of these risk factors in addition to organisational or systems level risk factors.

5.1 Organisational and systems level factors

Workload characteristics

Monotonous job design has also been identified as a significant risk factor for workplace fatigue, with performing a monotonous, repetitive task resulting in fatigue after only 10 minutes and progressively having a greater impact (Caldwell et al., 2019). The type of fatigue an activity produces depends on the effort required to perform the activity, with mentally straining activities producing mental fatigue, and physically straining activities producing physical fatigue (Techera et al., 2016).

Boeggild et al.'s (2016) systematic review found that time pressures, constant interruptions and high levels of responsibility were associated with fatigue among seafarers.

Overtime and long work hours

Continuous task performance results in cognitive decline and fatigue, particularly with monotonous or boring tasks. Long shift lengths (greater than eight hours) also increase fatigue, as do long working weeks (40+ work hours) (Boeggild Dohrmann & Leppin, 2016; Techera et al., 2016). Environmental features such as warm environments and low lighting can amplify this impact (Techera et al., 2016). Lilley et al. (2002) found that long hours were a risk factor for fatigue among New Zealand forestry workers.

Shift and night work

According to StatsNZ's December 2018 survey of working life, approximately 37.8% of New Zealand workers worked an evening shift (7 – 11pm) at least once in the last month and 12.8% worked a night shift at least once in the past month (11pm – 5am) (StatsNZ, 2019).

Shift work has long been recognised as a causal factor for fatigue, primarily via the mechanism of lowering workers' sleep by an average of 1.5 – 2 hours (Akerstedt & Wright, 2009). The impact of shift work is strong enough that 'shift work disorder', characterised by insomnia and excessive sleepiness is a recognised condition in the International Classification of Diseases (ICD10) Code G47.26. Although limited, there is evidence that performance decreases during night shift and that accident rates increase (Akerstedt & Wright, 2009).

Different workers adapt differently to night shift, but it appears that the increased risk factor of night work cannot be entirely removed. Miller (2006) describes night work as a ‘crime against nature’ and argues that human circadian rhythms do not allow the perfect adaption of workers to unusual work hours. Night work may have long term impacts. For instance, Harma et al. (2019) found that continuous night shifts are associated with increased sleep problems compared to no night work, six years after night work ceased.

Effort-reward imbalance

The effort-reward imbalance model is based upon the premise that work-related benefits depend upon a reciprocal relationship between efforts and rewards at work. Efforts represent job demands and/or obligations that are imposed on the employee. Occupational rewards distributed by the employer (and by society at large) consist of money, esteem, and job security/career opportunities. More specifically, the effort-rewards imbalance model claims that work characterised by both high efforts and low rewards represents a reciprocity deficit between ‘‘costs’’ and ‘‘gains’’. This imbalance may cause sustained strain reactions (van Vegchel et al., 2005).

At-work environmental factors

The impact of light as a risk factor for fatigue changes depending on when in the individual’s circadian rhythm, they are exposed to the light. Blue light exposure during daytime office shifts has been found to significantly improve alertness, performance, evening fatigue and reduce daytime sleepiness compared to white light (Viola et al., 2008b). Red light exposure has been shown to increase sleepiness and encourage sleep. Thus, exposure to lights outside of the workers’ expected circadian rhythms (blue light during the sleeping hours, red light during waking hours) increases fatigue.

Other environmental exposures can also make fatigue more likely. For example, vibration exposure and noisy environments can contribute to feelings of fatigue (Boeggild Dohrmann & Leppin, 2016; Techera et al., 2016).

5.2 Individual and task related factors

Sleep deprivation and inadequate recovery

Sleep deprivation, while the most obvious risk factor for fatigue, is also likely to be one of the most significant (Lilley et al., 2002; Techera et al., 2016). Experimental evidence has demonstrated that even slight restrictions of sleep (7 hours/night) reduce response speed and increase lapses in concentration (Belenky et al., 2003). Sleep deprivation causes:

- a loss of attention
- declining working memory
- poorer reward processing
- increased risk taking and impulsivity
- emotional hypersensitivity and decreased emotional recognition (Krause et al., 2017).

There is a dose-response relationship between sleep and fatigue, namely that the effect of a loss of sleep becomes more extreme the more restricted the person’s sleep is, and continues after the disturbed sleep (Belenky et al., 2003). In addition to its direct effects on fatigue, sleep deprivation may be a causal factor for a range of fatigue comorbidities including obesity, hypertension and diabetes which have a reciprocal impact in making fatigue more likely (Banks & Dinges, 2007).

Sleep deprivation is a form of inadequate recovery from exertion. However inadequate recovery can also occur within shifts, particularly if excessive exertion is combined with inadequate break times (Lilley et al., 2002). Results from the

Saskatchewan farm injury cohort study found that farmers reporting less than less than or equal to 5 hours a night during non-peak farming season was correlated with an increased risk of work-related injury compared to workers with more than 7 hours sleep per night. Other self-reported variates of poor sleep such as sleep apnoea, snoring or use of mediation for sleep were not significantly associated with an increase in injury after adjustment (Lilley et al., 2012).

Mental exertion

Techera defines mental exertion as "sustained cognitive activity that requires extraordinary mental effort" and is characterised by difficulty in focusing attention, decision making and planning (Techera et al., 2016).

Muscular exertion

Excessive exertion of muscle groups results in localised fatigue. This can become generalised fatigue if sufficient energy is used up across muscle groups (Techera et al., 2016).

Circadian factors

There is general consensus that circadian rhythms play a key role in many accidents, but Williamson et al. (2011) note that it is hard to accurately assess the exact impact of circadian rhythms. The human circadian rhythm is slightly longer than 24 hours, and is characterised by periods of sleepiness at night and during the early afternoon, and wakefulness in the morning and evening (Lerman et al., 2017). Under normal circadian patterns, the peaks of sleepiness occur at about 6am, with another peak at 3pm, however circadian rhythms vary between people (Baehr et al., 2001; Lerman et al., 2017). A particularly important distinction is between 'morningness' (the characteristic of being most active and alert during the morning) and 'eveningness' chronotypes, with people displaying the latter chronotype being able to adapt to night shift work more readily than the former (Courtney, 2013). Furthermore, circadian rhythms may also contribute to a peak of injuries in the afternoon, when many people suffer a period of drowsiness and sleepiness (Stutts et al., 2003). However, Lingard, Cook, and Gharaie (2013) suggest this peak may instead be the result of workers being tired at the end of their shifts (Lingard et al., 2013). This adds further complexity to the relationship between circadian rhythms and health and safety outcomes, as associating accidents with a particular time period does not necessarily indicate a causal relationship between circadian rhythms and occupational health and safety outcomes.

Homeostatic factors

Homeostatic factors (aka sleep debt) emerge from either the amount of time since the previous sleep, a lack of sleep, or both (Williamson et al., 2011). As with circadian factors, there is insufficient data to comprehensively isolate homeostatic factors from confounders. However, Williamson et al. (2011) conclude there is sufficient evidence to suggest that workers who have trouble sleeping, or have insufficient sleep, are significantly more likely to die from work related injuries. They also note that sleep disorders such as sleep apnoea are associated with an increased risk of accidents. Shift work is a key contributor to a lack of sleep, on top of its circadian effects, with night shift workers getting less sleep, and more likely to have disturbed sleep. Unsurprisingly, circadian factors and homeostatic factors are closely related, as it is often difficult to disentangle sleep debt and long waking hours with sleepiness caused by working when the body expects to be asleep.

Task design

Task design is the most complex, and least researched of the three groups of factors for fatigue identified by Williamson et al. (2011). Whilst Williamson et al. conclude that the "evidence for the effects of task-related inputs to fatigue and performance is also quite strong", they note that there is a lack of direct evidence of their impact on health and safety outcomes (Williamson et al., 2011, p. 511). There is evidence of a protective factor from taking breaks, and changing work patterns, but there is also a complex relationship between the amount of time on task and time of day, with contradictory evidence on which is most important (Williamson et al., 2011). While more physically demanding tasks have been associated with fatigue, less demanding occupations, such as long periods of sitting without a break in office work have also been found to increase the risk of fatigue (Thorp et al., 2014).

5.3 A generic AcciMap for fatigue risk factors

The factors discussed by Techera et al. and outlined above are broader than individual and task-related factors. However, they lack both the wider focus of Tedestedt George et al.'s (2021) adaption of Rasmussen's AcciMap approach and a theoretically supported structure. The AcciMap approach has also been adopted by WorkSafe Research and Evaluation as the primary way of modelling risk factors and interventions. Because of this, an AcciMap for risk factors for fatigue across industries was developed and is displayed below:

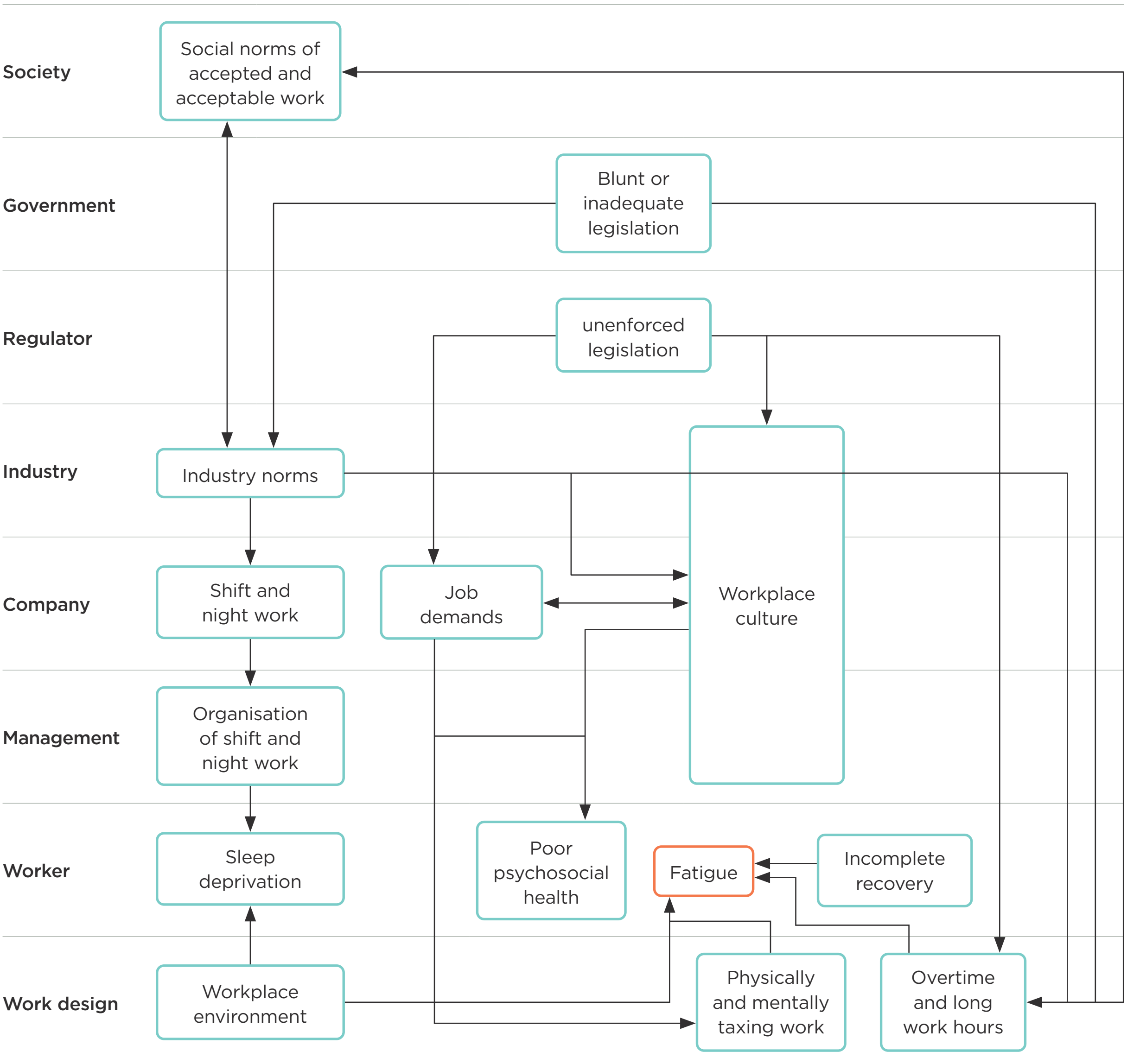

FIGURE 3: An AcciMap of generic risk factors for workplace fatigue

6.0 Interventions to address fatigue

IN THIS SECTION:

Fatigue management requires a systems-level approach.

This changing focus in the past few decades echoes a wider shift in focus of occupational health and safety away from individual or educational approaches toward a systematic understanding of accident causation (Carayon et al., 2015; Dallat et al., 2019; Dekker, 2011; Rasmussen, 1997; Salmon et al., 2012; Svedung & Rasmussen, 2002; Wilson, 2014).

As noted by many authors, a high quality fatigue management system requires investment from both workers and employers (Caldwell et al., 2019; Gander et al., 2011; Lerman et al., 2017; Schutte, 2010). Worker investment involves worker education on, and practicing of, sleep hygiene, fatigue prevention and healthy lifestyles to promote sleep. Controlling the consumption of certain drugs (such as caffeine) and foodstuffs can also help maintain a healthy sleep schedule (Caldwell et al., 2019).

As will be discussed in later sections, workers are also responsible for taking required breaks/naps and supporting a healthy workplace culture. Personal and behavioural causes of fatigue are particularly hard for organisations to address. The rest of this review will focus on organisational and employer interventions, because various worker-focused interventions are ineffective if the workplace environment is not conducive for them to manage fatigue and the risks for fatigue (Gander et al., 2011).

The history of interventions addressing workplace fatigue mirrors occupational health and safety intervention trends. Interventions in the early 20th century focused on prescriptive regulations that outlined employers' legal requirements, most notably various laws restricting the hours of work, generally to eight hours a day, that were implemented in anglophone countries (Gander et al., 2011). These regulations, while displaying some success, were blunt instruments and failed to account for variations in work demands, workers and risks that workers were exposed to (Dawson & McCulloch, 2005). There was a shift toward 'performance based' approaches that were less prescriptive about what employers were required to do, instead of a focus on the standards employers should meet, with the 1972 Roben's report being a key turning point in the shift toward performance based regulation.

In addition to the move away from prescriptive interventions, there has been greater recognition that single interventions are insufficient to adequately manage fatigue and fatigue related risks in the workplace. Instead, multiple system-wide layers of defence are required (Gander et al., 2011; Patterson et al., 2018). This systems-wide approach has been termed a Fatigue Risk Management System (FRMS) (Gander et al., 2011; Lerman et al., 2017), and it shares many similarities with general systems-wide occupational health and safety interventions. The specifics of the intervention(s) will vary depending on the particulars of the work being performed and the workers performing it, but it requires the following features to be successful:

- evidence-based policies
- decisions made based on objectively analysed data

- cooperative development between workers and employers
- system-wide implementation and support for tools, policies and procedures
- the FRMS to be integrated into existing health and safety systems
- continuous feedback and improvement
- financial support, based on a business case
- ownership by senior leadership (Lerman et al., 2017).

Similar features were noted in Gander et al. (2011)[1] and *Guidelines for applying a FRMS (termed Alternative Fatigue Management Scheme) in Transport* which was published by the NZTA in 2010 (NZ Transport Agency, 2010). These guidelines improved on prescriptive working hour restrictions, and provided transport employers the opportunity to submit and receive feedback on their proposed fatigue management system (NZ Transport Agency, 2010). Gander et al. (2011) also highlighted Air New Zealand's FRMS as an example of a good FRMS system in the transport sector.

(NZ Transport Agency, 2010). These guidelines improved on prescriptive working hour restrictions, and provided transport employers the opportunity to submit and receive feedback on their proposed fatigue management system (NZ Transport Agency, 2010)[2]. Gander et al. (2011) also highlighted Air New Zealand's FRMS as an example of a good FRMS system in the transport sector.

Several authors have listed interventions that may be implemented as part of a FRMS. Akerstedt (2000) provides one such example:

- regulation, practice, and policy changes based on scientific evidence
- a system-wide shared responsibility for addressing fatigue and its causes
- promote education on fatigue
- standardise accident reporting criteria to ensure that fatigue is properly reported
- ensure that fatigue related medical conditions are part of licence examinations
- identify barriers to fatigue prevention strategies and identify ways past these barriers
- address perverse incentives, that encourage unsafe work practices such as long hours
- evaluate implemented strategies (Akerstedt, 2000).

Caldwell et al. (2019) provide an alternative and more recent list:

- ensuring adequate staffing levels and a healthy workload balance
- using evidence-based shift work models to minimise fatigue among shift workers
- educating employees about sleep, but also ensuring that management provide motivation and the recourses necessary for workers to be well-rested
- ensuring the workplace environment encourages alertness through adequate lighting, humidity, noise control and good ergonomic design
- controlling the nature and duration of work to avoid long shifts, and repetitive tasks

[1] Gander et al. Gander, P., Hartley, L., Powell, D., Cabon, P., Hitchcock, E., Mills, A., & Popkin, S. (2011). Fatigue risk managment: Organizational factors at the regulatory and industry/company level. Accident Analysis and Prevention, 43(2), 573 - 590. https://doi.org/10.1016/j.aap.2009.11.007 cite Dawson and McCullock's (2005) multi-layered 'defences in depth' approach to fatigue risk management with five levels: Level 1: providing adequate opportunities for sleep, including recognising the importance of the placement of sleep opportunities with respect to the circadian cycle. Level 2: processes for confirming that adequate sleep is obtained. Level 3: processes to detect and prevent behavioural symptoms of fatigue. Level 4: processes for detecting fatigue-related errors. Level 5: processes for investigation of fatigue-related incidents and accidents.

[2] Earlier work along the same lines appears to have been implemented in Australia [Record #472 is using a reference type undefined in this output style.].

- ensuring that rest breaks and naps are available
- ensuring that employees and managers are able to recognise excess fatigue and have the resources to address it, such as by shifting workers to a less sensitive role or changing the environment (Caldwell et al., 2019).

Caldwell et al.'s list is primarily worker lifestyle focused (such as limiting caffeine and tobacco use) when compared to Akerstedt and also a list of elements that a fatigue management system needs to include to be effective. Most articles and evaluations found as part of this review address one or more of the interventions listed by Akerstedt (2000), Lerman et al. (2017) and Caldwell et al. (2019), and consequently this section of the review will be divided into the following groups:

- shortening work hours
- shift and night work management
- lowering work demands and encouraging worker control
- breaks and napping
- workplace environment
- workplace culture and climate.

These groups overlap as the same interventions address multiple risk factors. The overlaps are especially evident in shift and night work management, which could include all the other groups. It is also important to note that none of these interventions aim for zero fatigue, but rather to mitigate the risks and consequences of fatigue as much as is reasonably practicable (Hobbs et al., 2011). There are also trade-offs between different elements of fatigue management. For instance in many industries, such as healthcare, working at night and shift work are unavoidable, and long work hours are preferred by shift workers (Miller, 2006).

6.1 Industry specific interventions

Two industries have received significant attention in the fatigue literature due to the length of hours commonly worked: healthcare and truck driving. Both industries have regulations in place to prevent excessive work hours, however conflicting demands within both industries make these regulations only partially effective.

Nurses and junior doctors frequently work 12 hour shifts, and paramedics may work as long as 24 hours in a shift (Courtney, 2013; Jha et al., 2001; Nejati et al., 2016). Long work weeks are common in New Zealand hospitals, where most junior doctors work 50 or more hours a week, with nearly half reporting that they had made clinical errors due to fatigue in the past six months (Gander et al., 2007). Long work hours are an expected part of the industry and are seen by some industry members as improving doctor-patient relationships and encouraging professionalism (Nejati et al., 2016). They are also sometimes preferred by shift workers such as hospital nurses, many of whom would rather work a 'compressed' (although longer) week of four 12-hour shifts than five 8-hour shifts. Furthermore, reduced work hours can also have adverse consequences for hourly workers, as they may be forced to seek alternative payment to make up for the lost income from fewer hours (Smith-Miller et al., 2014). Shorter work days may also face opposition from workers who prefer the extra off days in exchange for working longer shifts (Chen et al., 2013).

Much like the healthcare industry, the transport industry has extreme work hours and has received significant academic attention (George, 2018) indeed as Tedestedt George et al. noted, there may be a reluctance in transport to continue discussing fatigue, due to the long history of talk about addressing fatigue with no real progress (Tedestedt George et al., 2021).

The industry displays a range of systemic issues that pressure drivers to work long hours and skip breaks. Tedestedt George et al. (2021) provide a summary of potential intervention approaches from a systems level in a second AcciMap:

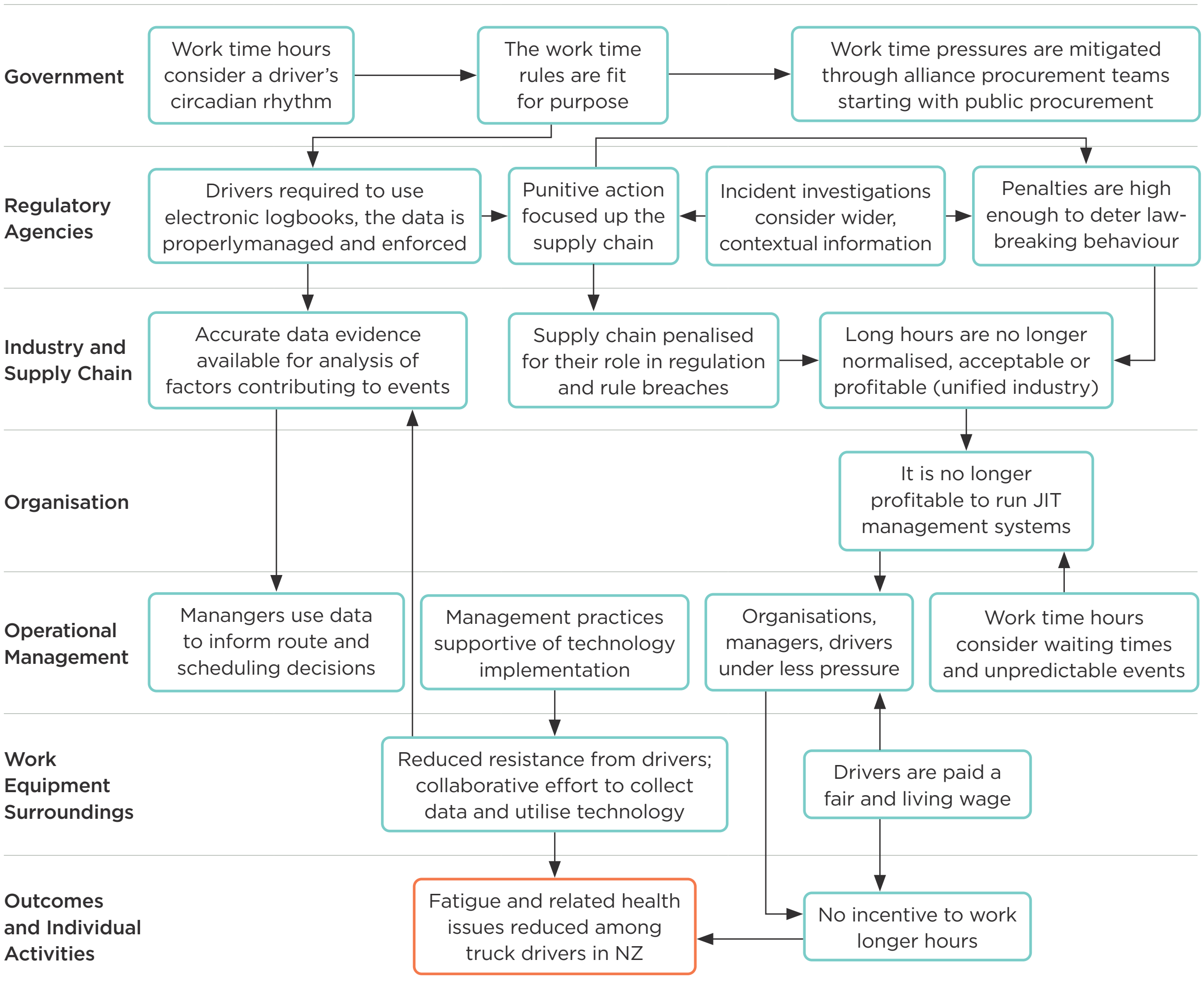

FIGURE 4: AcciMap of interventions to address fatigue the transport sector (Tedestedt George et al., 2021, p. 127)

New Zealand transport sector worker pressures are similar to other nations, namely long work hours, getting inadequate sleep and drivers frequently falsifying logbooks to meet deadlines despite regulations intended to prevent excessive or unhealthy work hours (Baas et al., 2000; Mackie, 2008; Tedestedt George et al., 2021). These demands have become more severe as 'just in time' deliveries and overnight courier deliveries have become more common (also see Charlton & Bass, 2000). George (2018) has found recent evidence that long work hours have continued in New Zealand trucking, with excessive work hours cited as a reason why younger workers are reluctant to work in the industry. One of her interviewees suggested that long work hours were also required for truckers to earn a decent wage, with truck contractors earning an estimated $7 per hour after costs (George, 2018). International studies have found similar pressures on work hours in the Netherlands and Israel (de Croon et al., 2002; Sabbagh-Ehrlich et al., 2005).

Tedestedt George et al. (2021) provide an overview of several interventions to address road transport safety. Of particular relevance to fatigue is the Safe Rates Australia intervention by the Transport Workers Union, which provides an example of a systems-level intervention designed to address harm in the transport sector. The goal of the intervention was to reduce hours by improving regulation and extending the paid work hours for transport workers to include waiting times (Tedestedt George et al., 2021).

Both the healthcare and transport industries highlight that shortening work hours requires industry support and an improved safety culture (Baas et al., 2000), however the association between organisational factors and work hours is under-researched (George, 2018). Unrealistic expectations of the amount of work that can be completed in a healthy 8-hour day pressures workers to work unhealthy hours for fear of losing employment or being punished. While these demands can be financially driven (such as in the trucking industry), the above discussion of the healthcare industry highlights that there are other pressures working against shortening work hours, such as care for patients or a desire for workers to appear more professional. In addition to being difficult to enforce, regulations can often be a blunt instrument, and fail to take into account the time of day worked, the type of work performed and personal confounding factors (Haworth, 1998; Lerman et al., 2017).

6.2 Shortening work hours

New Zealanders work some of the longest hours in the OECD, with nearly one quarter of the workforce reporting working over 50 hours a week. Long work hours are particularly common among lower paid workers (Reilly, 2012). The earliest implemented intervention to address fatigue was the regulation of work hours, limiting both the length of a working day and of the working week (Gander et al., 2011). However, despite nearly a century of these regulations being in effect, long work hours continue to be the most commonly identified cause of workplace fatigue (Akerstedt et al., 2002; Hobbs et al., 2011; Lerman et al., 2017; Nagashima et al., 2007) and there is a lack of evaluations that have demonstrated that shortening work hours reduces fatigue (George, 2018). Long work hours have also become more common (alongside unusual work hours) in recent decades, as a result of the economic liberalisation and globalisation that occurred in the 1980s and 1990s (Azaroff et al., 2004; Campbell, 2007; Johnson & Lipscomb, 2006; Reilly, 2012). Johnson and Lipscomb argue that long work hours are more common among professional workers and male workers (Johnson & Lipscomb, 2006), but other authors suggest that long work hours are common among all professions, including construction workers (Hallowell, 2010), and truck drivers (Charlton & Bass, 2000).

Shortening workdays is an effective way of reducing fatigue and improving sleep. Schiller et al. (2017) conducted a randomised controlled trial involving 821 public sector employees in Sweden. They found that reducing work hours from 8 hours a day to 6 hours improved sleep duration and quality, lowered daytime sleepiness and reduced worker stress. This improvement was significant for both men and women, of all ages, regardless of whether the participant had children at home. Similarly, Chen et al. (2013) found that nurses working three 12 hour shifts a week reported higher fatigue than those working five 8 hour shifts a week. Shorter work hours also have a demonstrable effect on safety outcomes. Weaver et al. (2015) found that shifts of 8 hours or less were associated with lower injury rates among emergency medical service workers. Unsurprisingly, longer work hours were correlated with an increased likelihood of doctors reporting having made a clinical error in the past six months (Gander et al., 2007). Despite the negative impact of longer work hours on safety, health and performance outcomes having been long recognised, many industries continue to have excessive work hours. This is due to various pressures on employees to work long hours that have not been addressed (Akerstedt, 2000).

Pressures to work unhealthy hours include insufficient staffing, long periods of workers being on-call (Smith-Miller et al., 2014) and long hours of overtime (Campbell, 2007; Macky & Boxall, 2008; Yamazaki et al., 2007). Australian data suggests that overtime, particularly unpaid overtime for full-time employees, has become increasingly common since the 1980s (Campbell, 2007). In many industries such as healthcare, overtime is perceived to be a requirement for the continued functioning of the industry (Campbell, 2007). Campbell (2007) identifies weakened regulation with loopholes for employers as facilitating the growth of overtime. They also reject arguments that it is employee ‘choice’, noting that most employees who work overtime do so because it is required to 'get the work done', or because employers treated overtime as 'voluntary but expected', particularly for lower skilled and lower income workers (Campbell, 2007). Campbell also emphasises the importance of management policies and practices in encouraging overtime – either through persistent understaffing, overly heavy workloads, or through performance indicators being linked to overtime (Campbell, 2007); a finding corroborated by other studies (Macky & Boxall, 2008). Limiting voluntary and involuntary overtime, as well as restricting the use of 'on call' workers, may facilitate rest and reduce fatigue with less of an impact on workers' incomes (Campbell, 2007; Smith-Miller et al., 2014).

Many employees are paid by the hour, so unless compensation is provided, shortening work hours results in a loss of income for the worker. Townsend et al. (2008) trialled the implementation of a shortened five day week in the Australian construction industry and encountered worker reluctance and resistance on the basis of lost wages. However, workers preferred the shorter work hours once they were implemented (Townsend et al., 2008), a finding that has been supported on a national scale in Europe (Lepinteur, 2016). Given the loss of income, shorter work hours can result in moonlighting or workers seeking other employment, while adding to the pressure on the remaining workers (Lees et al., 2019; Scott et al., 2010). Reilly has suggested that a basic income would help to remove pressures to work longer hours in New Zealand, as well as addressing issues of insecure work that have emerged in recent decades (Reilly, 2012).

Costs to businesses due to lost productivity are another argument against shortening work hours. However, analyses of the French 35-hour working week laws suggest that there was no evidence for this argument at a national level, although this may have been the result of increased flexibility of working hours (Hayden, 2006). Townsend et al. also found that employee output did not significantly drop when hours were shortened in several case-study organisations, as workers are able to work faster and with less recovery time in shorter shifts (Townsend et al., 2008); a finding echoed by other studies of compressed working weeks (for example Berman, 2009). Baltes et al.'s (1999) early meta-analysis suggests that the absence of a productivity drop is due to limits to the time that employees are productive each day, meaning longer work hours merely extend unproductive hours.

The productivity improvement outlined above is unlikely to apply to all industries, however. For instance, in factories operating with traditional Taylorist production lines; workers' output is consistently dictated by the speed of the production line, thus there are fewer opportunities for downtimes. In hospitality and retail, workers' productivity is similarly dictated by external demands (customer presence), and so shorter work hours will likely result in lower worker output. Workers in manufacturing, hospitality and retail are frequently paid by the hour of work, meaning that shorter work hours will lead to lost income for workers, or if workers' hourly wages are increased, lost profits for employers.

The 35-hour week laws implemented in France[3] demonstrated the issues associated with blanket reduction of working hours (Hayden, 2006). The two laws were generally received positively by what were initially hostile employers and employees and resulted in modest reductions in weekly work hours with no loss of wages (Askenazy, 2013; Fagnani & Letablier, 2004; Hayden, 2006). However, there were some issues with the implementation of the law, particularly with non-compliance by employers. Many employees with young children reported that their employer did not respect the commitments required by law, or that their conditions had not changed, or that employers had responded to the reduced hours by intensifying work demands (Fagnani & Letablier, 2004; Hayden, 2006). Hayden also found that many employers bypassed the laws by reclassifying breaks and work hours, and also used them as an opportunity to freeze wages (Hayden, 2006). Many workers were also adversely affected by the increased flexibility

[3] The 'Aubry Laws' of 1998 and 2000

that the laws gave employers to assign their work hours (Askenazy, 2013). Overall, Fagnani and Letblier concluded that “taking into account the extreme heterogeneity of workplaces, it is not sufficient to mechanically reduce working time for there to be an improvement in the daily lives of working parents living with young children” (Fagnani & Letablier, 2004, p. 568). The conservative Sarkozy government later reversed many elements of the 35 hour working week from 2007 to 2012 by allowing greater freedom for employers to encourage overtime, meaning that the long-term effects of the initial laws will never be adequately assessed (Askenazy, 2013).

The literature reviewed here supports shorter work hours as an effective intervention to reduce workplace fatigue, providing that there is sufficient compliance by employers. Employer non-compliance in contrast means that legislation changes alone are inadequate to restrict work hours. The French 35-hour working week case study demonstrates that legislative changes can easily be reversed or undermined by subsequent governments before their long-term impacts can be properly assessed. The need to get employers on-board with changes by presenting business cases on the benefits of a change are a common feature of Fatigue Risk Management Systems (see above). However, these will need to be established on an industry by industry basis and may not apply to all industries. Reducing or more strongly legislating against overtime is a promising avenue of exploration, particularly if the practices discussed above that Campbell identified in Australia also apply to New Zealand.

6.3 Shift and night work management

Unusual work hours, either through irregular shift schedules or through regular night and evening work, have been identified as increasing fatigue and the risk of injury among workers. Shift and night work have also become more common in recent decades, both globally and in New Zealand. StatsNZ’s (2019) Survey of Working life found that 67% of New Zealand workers at least occasionally worked outside the ‘non-standard hours’ of 7am – 7pm Monday to Friday, and 23.3% of workers had worked night shifts (11 pm – 5 am). In some industries shift work has become standard, with over 80% of workers employed in mining, accommodation and food services, agriculture, forestry and fishing working non-standard hours in 2018 (StatsNZ, 2019).

Driving the international increase in shift and night work has been a move toward a ‘24 hour economy’ and legislation passed to allow more flexible and longer business hours (Akerstedt, 2000; Askenazy, 2013; Courtney, 2013; Lerman et al., 2017; Purnell et al., 2002). Specific industries have seen knock-on effects from these changes, for instance demands for ‘just in time deliveries’ have resulted in tight, around the clock shifts for truck drivers (de Croon et al., 2002). However, the effect is also more general. As early as 2000, less than a quarter of European workers reported working ‘traditional’ 9 – 5 hours (Costa, 2003), and only one third of New Zealand workers worked traditional hours in 2019 (StatsNZ, 2019). Johnson and Lipscomb found that, while professional men worked longer paid hours on average, women and working class workers worked more irregular hours and had less control over their work hours (Johnson & Lipscomb, 2006).

Irregular shift work is associated with increased fatigue, even among workers who reported satisfaction with the shifts they worked (Smith-Miller et al., 2014). It can result in ‘shift-lag’ which is “characterized by feelings of fatigue, sleepiness, insomnia, disorientation, digestive troubles, irritability, poorer mental agility and reduced performance efficiency” (Costa, 2003, p. 84). Shift lag can also cause other sleep disorders (Colligan & Higgins, 2005; Richter et al., 2016). Rapid rotating day-night shift work is particularly problematic, as workers’ circadian rhythms do not have sufficient time to adapt, particularly when workers’ day-time demands remain even when they work night shifts (Costa, 2003; Smith-Miller et al., 2014). Although the literature is unanimous in identifying a need to intervene to promote good shift work, specific intervention advice can be difficult to provide because shift and night work vary dramatically between organisations (Harrington, 2001).

Tolerances of shift work vary between people, and some authors advocate for more robust assessments of potential employees' abilities to handle shift work during the recruitment process (Costa, 2003). Younger workers, those who pursue hobbies that can be done alone, those whose body clock more easily synchronises to new sleep cycles and who have a proneness to evening wakefulness, are generally more tolerant of shift work (Costa, 2003; Harrington, 2001). In contrast, people who display a 'morningness chronotype' (being more active and alert in the morning), have family commitments, are more neurotic, or have a history of mental health issues or sleep disorders generally find adapting to night shifts harder (Courtney, 2013; Pallesen et al., 2010; Richter et al., 2016). While these personal factors seem to be generally accepted in the literature, Courtney (2013) concludes that further complex and longitudinal studies are required to fully untangle their impact on workers' suitability for shift work.

Regardless of individual employees' relative ability to adapt to night or shift work, the negative effects cannot be entirely eliminated. However, certain practices will mitigate the risk and consequences of fatigue among shift workers as much as is possible (Costa, 2003; Miller, 2006; Pallesen et al., 2010). Miller (2006) provides nine principles of good shift work:

1. allow circadian stability when possible
2. ensure short shift lengths of 8 hours or fewer
3. minimise the number of consecutive night shifts, and ideally there should be no consecutive night shifts in a shift plan
4. allow sufficient recovery after each night shift by following a night shift with 24 hours off to allow the recovery of sleep debt
5. maximise free days on the weekend
6. ensure that shift workers get at least 104 days off per year
7. ensure equity between workers in work and free day allocation
8. ensure that shift work and off days are predictable primarily by following a regular schedule
9. ensure that shift workers have what they perceive to be quality time off (Miller, 2006).

All these principles are based on their review of the literature, and so are shared with many other authors. However, Miller (2006) also notes that it is impossible for employers to maximise all nine principles, and so trade-offs need to occur.

One trade-off is between circadian stability and minimising the number of consecutive night shifts. Rotating shift work creates a constant 'shift lag' for workers (Miller, 2006; Pallesen et al., 2010); however, relatively few workers fully adapt to night shifts with only 3% fully adapting and 25% partially adapting to the unusual schedules (Courtney, 2013). Jha et al. (2001) suggest that this adaption may be a result of workers' daytime commitments. Given this, Jha et al. (2001) and Akerstedt et al. (2002) recommend a slowly forward rotating shift schedule, with shift changes over two to three days (one shift on morning, one shift in the evening and one night shift), to allow workers to adapt, and to minimise shift lag. Miller (2006) suggests employers adopt either a slowly forward rotating shift schedule in order to minimise shift lag for workers, or consistent work schedules.

In general, a forward rotating shift schedule seems to be the shift organisation that is most beneficial in reducing fatigue (Miller, 2006; Pallesen et al., 2010). Workers can adapt more easily to a forward rotating schedule because the human circadian rhythm is slightly longer than 24 hours (Courtney, 2013; Miller, 2006). However, the speed of rotation is less certain, with some studies suggesting that a fast rotation can help workers maintain their circadian rhythm, but most studies finding the opposite (Pallesen et al., 2010). In contrast, Smith-Miller et al. (2014) recommended that rotating shift work should be abandoned whenever possible, and that workers should always get at least a 48 hour break between a night shift and day shift.

Regardless of the shift schedule adopted, there is a need for shift workers to have adequate time off between shifts. Miller's suggestion of a minimum of 104 full days off per year puts shift workers on par with Monday to Friday workers (Miller, 2006). Miller emphasises that due to daytime demands on workers, this would ideally be a complete day off work, not just a period of 24 hours between shifts. Pallersen et al. (2010) suggest a more conservative period of a minimum of 12 hours between shifts, but also note that a compressed working week of four days on and three days off gives shift workers a better work-life balance and reduces reported fatigue. Miller (2006) also suggests a more radical change in shift scheduling: moving toward a 14-day shift schedule with eight days on and six days off, or ten days on and four days off. They argue that this would help address shift workers' desires for continuous periods of time off, and help managers plan schedules in advance. Many of these changes require balancing against longer working days or weeks, i.e., a compressed working week of eight days on and six off may result in more days off, but it will also result in longer shifts.

Employee involvement is another tool to minimise fatigue from shift work (Miller, 2006; Pallesen et al., 2010). Worker control will be discussed in more detail later, but two points are worth commenting on here. As noted above, there is a trade-off between employee desires for more days off, and the need to restrict shift lengths, particularly in safety sensitive jobs. Additionally, good shift work organisation requires predictable schedules and informing employees about their shifts well in advance. This will require adequate managerial resources to be allocated to shift scheduling and negotiation with workers (Miller, 2006).

Informing workers of the shift schedule in advance and ensuring that workers feel a sense of equity in free day allocation can help in employee retention by reducing stress and anxiety and helping workers to plan their sleep schedules to ensure they arrive at work rested (Miller, 2006). Hobbs et al. (2011) suggest that schedules should be fixed, and provided to workers at least one month in advance. Pallesen et al. (2010) suggests that allowing employees to choose their shifts lessens the negative effects of shift work. High quality and dedicated management is needed to balance these conflicting demands and to ensure that there is adequate staffing, while at the same time meeting workers' preferred shifts.

Educating shift workers on good sleep hygiene is a commonly identified intervention to address shift and night work fatigue. Despite being the least effective intervention in changing behaviour or outcomes (Haworth, 1998), education is already common practice for new shift workers in many industries (Akerstedt, 2000; Scott et al., 2010; van Drongelen et al., 2013). As Lowden and Moreno (2014) note, work organisation is a more significant risk factor for fatigue than worker lifestyles, and so health promotion needs to focus on factors beyond the immediate worker's behaviour. Pallesen et al. (2010) suggest informing night workers of the importance of using dark curtains to block out light when sleeping during the day and encouraging moderate exercise to support adaption to night work.

6.4 Workplace napping and breaks

Several authors have suggested that napping is a promising intervention to address workplace fatigue (Pallesen et al., 2010; Richter et al., 2016). The literature identifies a short 20-30-minute nap as an effective way of reducing fatigue, particularly for night workers and those working long hours. However, there are barriers, namely the need to provide adequate resources for napping, accounting for sleep inertia post-nap, and encouraging workers to nap (Pallesen et al., 2010).

Purnell et al.'s (2002) study of New Zealand airline maintenance engineers found that a 20 minute nap during a night shift lowered fatigue during the shift and improve alertness when driving home. Miller has also suggested that shift workers should be encouraged to nap before driving home to reduce traffic accidents (Miller, 2006). However while napping can prevent fatigue, it also results in sleep inertia – a period of up to 30 minutes after the nap where people are confused, disorientated and have reduced mental capacity (Jha et al., 2001; Miller, 2006; Pallesen et al., 2010; Purnell et al., 2002).

Improving breaks and napping was a key element of the Fatigue Countermeasures Programme for Nurses (FCMPN) trialled in Michigan hospitals (Scott et al., 2010). Scott et al. (2010) measured the reported drowsiness, fatigue, mistakes, and sleep quality of 47 nurses, mostly on 12-hour day-night shifts, pre- and post- the intervention. The intervention entailed a mixture of educating the nurses on sleep, fatigue and the impact of shift work on fatigue; and working with hospital administrators to ensure that there was a conducive environment for nurses to take breaks and nap. The administrative changes entailed:

- ensuring there was adequate staffing for nurses to take their breaks
- ensuring that nurses were completely relieved of duties during their breaks
- providing facilities for nurses to take strategic naps during break and meal periods (Scott et al., 2010).

Scott et al. (2010) found significant improvements on all measures of fatigue after the intervention. Fatigue was not eliminated, however, with nearly half of the nurses still reporting severe drowsiness and fatigue post-intervention, and nearly all nurses continuing to report poor sleep quality. Furthermore, while nurses did attempt to nap during work, they reported emotional stress and guilt from taking naps during work hours, and consequently the uses of 'strategic napping' rapidly decreased after the intervention period. Scott et al. (2010) note that in multiple studies nurses have been reluctant to adopt such measures, particularly if their workplace culture was not conducive to taking breaks. Finding places to nap can also be an issue in some industries such as long-haul transport, leading to drivers skipping naps, even when they recognise they are fatigued (Sabbagh-Ehrlich et al., 2005).

There are further considerations for napping, particularly around the provision of spaces for breaks and naps. Miller (2006) notes that managers need to provide adequate sleeping quarters for workers if they intend to encourage workers to nap. Pallesen et al. (2010) also note that there is a need to ensure that normal sleep is not disturbed, both by limiting the length of naps and ensuring that workers' sleep spaces are sufficiently dark. Nejati et al. (2016) recommended that napping and break policies be accompanied by design changes for staff break areas to ensure access to daylight and fresh air.

This review has found evidence that naps, if properly implemented, can reduce worker fatigue in the workplace. However, there are several barriers that need to be overcome to implement napping. There is also likely resistance from employers and potentially negative public perception of workers napping in some industries. Finally, there are potential negative impacts on safety if sleep inertia is not properly managed.

6.5 Improving the workplace environment

Certain environmental features can either mitigate or amplify feelings of fatigue among workers and several environmental interventions have been trialled and evaluated in the literature. The most common intervention involves addressing lighting conditions in the workplace by using bright and blue lighting to keep workers alert during their shift. Other interventions include ensuring that workplace temperature is not too warm or cold and improving air quality in the workplace.

Bright and blue lights can help keep workers alert and also facilitate the changes to the circadian rhythm and melatonin suppression that are needed if shift and night workers are to reduce shift lag (Caldwell et al., 2019; Jha et al., 2001; Pallesen et al., 2010; Viola et al., 2008a). Viola et al.'s (2008a) study of 94 office workers found that blue light exposure during the day improved a range of fatigue related factors such as sleep quality, alertness, concentration levels and reduced daytime sleepiness when compared to white light of the same intensity (Viola et al., 2008a).

While blue light improves wakefulness for exposed workers, it can also negatively affect sleep quality if exposure occurs too closely to scheduled sleeping times (Caldwell et al., 2019). To mitigate the impact of blue light on sleep, the American Academy of Sleep Medicine recommends that workers use blue-light blocking glasses or sunglasses upon leaving a night shift (Richter et al., 2016). When coupled with minimising light exposure in the morning, blue-light blocking glasses can facilitate circadian adaptation. However, their use also creates a risk of sleepiness if workers drive home after their shift.

Pallesen et al. (2010) note additional negative effects of lighting choices in the workplace beyond impacts on sleep, including eye strain, headaches, 'feeling wired' and irritability. There is however no evidence of long-term ill effects from exposure to bright lights for individuals with healthy eyes. They also suggest that oestrogen levels (which effects both sleeping and fatigue) may increase, as bright lights suppress the production of melatonin which in turn suppresses oestrogen production.

High temperatures may reduce alertness and decrease performance and should be avoided in the workplace where possible (Pallesen et al., 2010; Seppanen et al., 2003). Improving air quality may also help to reduce fatigue symptoms (Wyon, 2004). Vibration exposure is also a risk factor for muscle fatigue, and so reducing vibration exposure can help reduce worker fatigue (Adamo et al., 2002).

Controlling the workplace environment is an effective way to address workplace fatigue. Ensuring that the workplace environment is brightly lit, ideally with blue lights, is of a comfortable temperature and is well ventilated can all help reduce worker fatigue. This is particularly relevant for shift and night workers as it helps them adapt to unusual working hours. However, blue lights should be avoided near the end of shifts, and steps should be taken to limit sunlight exposure when workers are driving home.

6.6 Lowering work demands and increasing worker control

High demands on workers and a lack of job control are both common causes of fatigue in many industries. Smith-Miller et al. stated that:

> The prevalence of work-related fatigue among nurses is attributed to the ongoing demands of caregiving and other job-related stressors such as rapid admission and discharge cycles and high patient acuity levels that require increasingly complex occupational skill levels. (Smith-Miller et al., 2014).

A study of New Zealand workers found that there was clear correlation between increased worker control and lower fatigue and stress (Macky & Boxall, 2008). Their finding echoes Smith et al.'s (2005) study of Japanese manufacturing workers, which found perceived lack of job control as the most significant causal factor for sleeplessness and fatigue among the workers. Samaha, Lal, Samaha, and Wyndham (2007) also found evidence that a lack of job control was associated with increased fatigue among nurses.

Workload was a strong causal factor for fatigue in Smith et al.'s (2005) study, and also resulted in fewer naps and breaks taken by night-shift workers. Baulk et al.'s (2007) study of Australian metalworkers added that the impact of workload on fatigue was higher when initial fatigue was already high, particularly during night shifts. Baulk et al. (2007) however have argued that workload's impact on fatigue was likely to be less significant than that of shift length or the structure of shift organisation.

Strahan, Watson, and Lennon. (2008) found that occupational stress increased fatigue among Australian truck drivers and proposed, but did not test, several ways to reduce fatigue by addressing stress:

> at the organisational level clarification of roles through position evaluation and review, and careful position design have the potential to reduce occupational stress by reducing role ambiguity. Further, at the individual level counselling services, employee assistance programs and stress management training may also reduce occupational stress and in turn affect the safety behaviours of work-related drivers. (Strahan et al., 2008, p. 16).

There is a common-sense assumption that work-related stress leads to increased fatigue however, the literature exploring or even establishing the connection is surprisingly lacking (de Lange et al., 2009). However, De Lange et al. (2009) conducted a longitudinal study of work-demands, stress and fatigue, and established that high work demands, and stress do result in fatigue. However, the authors were unable to untangle work demands from long working hours in their analysis. One crucial requirement in reducing work demands is to ensure adequate staffing (Caldwell et al., 2019). Ensuring that workers can maintain a work-life balance by limiting work-related contact with staff outside of their prescribed work hours can also help reduce stress and the demands that workers feel from their job (Caldwell et al., 2019).

High physical work demands are also closely associated with increased fatigue, particularly among workers with impaired cardiovascular fitness (Aisbett & Nichols, 2007). Dawson and McCulloch (2005) argue that management of physical fatigue is relatively straightforward by limiting work hours and maximising break periods. Despite this purported simplicity, the difficulties in limiting work hours have already been discussed earlier in this document.

Monotonous task design is closely linked to fatigue (Caldwell et al., 2019). This may be by monotonous tasks 'unmasking' existing sleepiness as opposed to causing increased fatigue (Williamson et al., 2011). Williamson et al. (2011) found evidence that providing stimulating secondary tasks, that did not require reaction types or working memory, stimulated alertness and reduced fatigue during monotonous 'vigilance tasks'. In contrast, Hobbs et al. (2011) note that the self-pacing of tasks and modification of task order can help address the risks associated with fatigue.

Work pace is a key determinant of stress and fatigue in the workplace. Job control is also key in determining the level of stress workers feel every day. Frustration may be a confounding factor – for instance, Head (2009) found that frustration was the highest correlation with job stress among 246 merchant seamen. It is also an issue with shortening the working week, if employers decide not to decrease the working load on employees (Fagnani & Letablier, 2004; Lepinteur, 2016). As discussed in the shift and night work section above, workers having control over their schedule can help to reduce stress and feelings of fatigue, as well as helping to give a feeling of equity among workers.

6.7 Improving workplace safety culture

Since the 1986 Chernobyl disaster, there has been a recognition that safety culture, and the related safety climate are key requirements in any systematic approach to address occupational health and safety (Cooper, 2000; Cox & Flin, 1998; Pidgeon, 2010; Reason, 2008), including fatigue management (Gander et al., 2011; Tedestedt George et al., 2021)[4].

There are several connections between safety culture and fatigue. As outlines of the FRMS at the start of the review demonstrate, there is a need for a supportive managerial and worker culture for any fatigue intervention to be successfully implemented (Baas et al., 2000). Bentley et al. (2012) note that workplace bullying results in increased fatigue for the target. The limitations of work hour regulations discussed above also demonstrate how a poor safety culture, coupled with other pressures such as speed of work or financial concerns, can lead to regulations being ignored or bypassed by employers.

Han, Trinkoff, and Geiger-Brown. (2014) found that a supportive work environment was correlated with lower fatigue and faster recovery for nurses working 12-hour shifts. Poor safety culture has been inversely correlated with fatigue among truck drivers (Strahan et al., 2008). Improving workplace safety culture more generally is also the basis of the American Nurses Credential Centre ‘MAGNET’ hospitals, which Chen et al. (2013) found resulted in lower levels of fatigue than those in non-MAGNET hospitals.

As well as facilitating the implementation of an improved FRMS, a good safety culture can also be evident through the demands placed on and behaviours expected of, workers. Encouraging workers to take breaks, acceptability of refusing overtime, workers not feeling pressured into taking unhealthy shift schedules, supportive management and staff who are alert to signs of fatigue are all examples of how a good safety culture can assist in the implementation of a FRMS. It can also have a more direct impact on fatigue, as an encouraging work environment can increase satisfaction and decrease stress, and thus decrease the impact of fatigue (Smith-Miller et al., 2014).

Due to the impacts of industry practice on organisations, a positive safety culture at the industry level, and even pan-industry level, can help reduce fatigue (Tedestedt George et al., 2021). This is not a new finding. Baas et al. (2000) argued that changes to truck driver safety culture need to occur at both the management level and also the supply chain level to ensure that drivers can prioritise healthy work hours without falling behind. Greater recognition of the problem is also required in some cases. Arnold et al. (1997) found that Australian truck drivers and company managers who thought fatigue was a problem in the industry were also unlikely to see it as a problem for themselves or their company. A New Zealand study found a similar result, with drivers typically viewing fatigue as a problem for other drivers (Charlton & Bass, 2000).

Poor safety culture can also emerge from a desire to perform a job to the highest level possible. As discussed above, Jha et al. (2001) found concerns among senior doctors that reducing the shift length of junior doctors would lead to decreased training levels and less professionalism among doctors. There was also a feeling that long work hours facilitated more of a connection with patients. Similarly, nurses’ reluctance to take naps (Scott et al., 2010; Smith-Miller et al., 2014) highlights how the culture of care in the healthcare sector may conflict with good fatigue management practices. Employers have also claimed that long-work hours are often justified through a ‘love’ for the work or workplace culture to mask the financial demands underpinning them (Peticca-Harris et al., 2015). Recent media reports suggest that ‘crunch periods’, often more than 100

[4] There are multiple, often conflicting definitions of safety culture, and even more when the related but distinct concept of safety climate is incorporated into it, though such a discussion is outside the scope of this review.

hours a week, are common practice in creative industries such as in video game design. Employers justify crunch periods by referring to the demands of artistry or the need for workers to 'love' the creative process in their work (Gilbert, 2019, May 9; Schreier, 2019, February 4; Wright, 2018, October 19).

A comprehensive discussion of safety culture is beyond the scope of this review. Instead, a brief outline of some of the evidence directly pertinent to fatigue management has been provided to demonstrate the importance of a conducive safety culture in implementing a FRMS, or any other systems-wide approach to safety management. The literature is near unanimous in identifying that a systems-wide approach, supported by management, workers and external organisations is needed to address the risk factors for, and consequences of, workplace fatigue. Interventions with evaluations that have clearly demonstrated impacts to workplace safety culture are rare. This may be due to the complex and poorly defined nature of safety culture as a concept. What seems to be clear however is that improvements to safety culture need to be tailored to specific workplaces or industries. This tailoring needs to account for the demands on and practices common within the specific workplace or industry being intervened on.

7.0 Conclusion

This document has provided an overview of the prevalence, risk factors and main interventions to address workplace fatigue.

Many of the risk factors for fatigue such as sleep deprivation are self-evident, and difficult if not impossible for a regulator to address. Others, particularly risk factors impacting at a systems or organisational level are possible to address. The risk factors identified in the literature were:

- Organisational and systems level factors:
  - workload characteristics - particularly heavy workload, high strain tasks, monotonous tasks design
  - overtime and long work hours
  - shift and night work – together they cause shift work disorder characterised by insomnia and excessive sleepiness; there is also evidence that accident rates increase during night shifts
  - effort-reward imbalance
  - at work environmental factors: including warm, lowly lit environments, exposure to vibration and noise, and exposure to blue lights during sleep hours.
- Individual and task related factors:
  - sleep deprivation
  - mental exertion
  - muscular exertion
  - circadian factors
  - homeostatic factors (a.k.a. sleep debt)
  - task design.

As noted in the section on risk factors, many of these risk factors are closely related or impact on one another. This was demonstrated in the AcciMap of generic risk factors for occupational fatigue that was outlined earlier in this document (figure 4).

This review has addressed six groups of interventions that have expert and theoretical support:

- shortening work hours
- shift and night work management
- lowering work demands and encouraging worker control
- breaks and napping
- workplace environment
- workplace culture and climate.

In most cases these interventions involve eliminating or managing specific risks – for instance interventions to address long work hours are, essentially, shortening work hours. Because of this, this review has echoed much of the literature in attempting to highlight the barriers to addressing each risk factor in addition to the interventions that have been trialled or proposed.

In most cases an improved safety culture and addressing demands that conflict with a focus on minimising worker fatigue are key underlying requirements. The concept of a systems oriented FRMS emphasises the centrality of these requirements in addressing the risk factors and consequences of fatigue. The features of the FRMS align well with a general systematic approach to improved occupational health and safety outcomes.

Appendix

IN THIS SECTION:

Adamo, D., Martin, B., & Johnson, J. (2002). Vibration-induced muscle fatigue, a possible contribution to musculoskeletal injury. *European Jounral of Applied Physiology, 88,* 134 - 140.

Aisbett, B., & Nichols, D. (2007). Fighting fatigue whilst fighting bushfire: an overview of factors contributing to firefighter fatigue during bushfire suppression. *The Australian journal of emergency management*, 22(3), 31 - 39. https://doi.org/10.3316/INFORMIT.943666236119043

Akerstedt, T. (2000). Consensus Statement: Fatigue and accidents in transport operations. *Journal of Sleep Research, 9*(4), 395. https://doi.org/10/1046/j.1365-2869.2000.00228.x

Akerstedt, T., Fredlund, P., Gillberg, M., & Jansson, B. (2002). A prospective study of fatal occupatinal accidents - relationship to sleeping difficulties and occupational factors. *Journal of Sleep Research, 11*(1), 69 - 71. https://doi.org/10.1046/j.1365-2869.2002.00287.x.

Akerstedt, T., & Wright, K. (2009). Sleep Loss and Fatigue in Shift Work and Shift Work Disorder. *Sleep Medicine Clinics, 4*(2), 257 - 271. https://doi.org/10.1016/j.jsmc.2009.03.001

Arnold, P., Hartley, L., Corry, A., Hochstadt, D., Penna, F., & Feyer, A. (1997). Hours of work, and perceptions of fatigue among truck drivers. *Accident Analysis and Prevention, 29*(4), 471 - 477. https://doi.org/10.1016/s0001-4575(97)00026-2

Askenazy, P. (2013). Working time regulation in France from 1996 to 2012. *Cambridge Journal of Economics, 37*(2), 323 - 347. https://doi.org/10.1093/cje/bes084

Aycock, N., & Boyle, D. (2009). Interventions to Manage Compassion Fatigue in Oncology Nursing. *Clinical Journal of Oncology Nursing, 13*(2), 183 - 191. https://doi.org/10.1188/09.CJON.183-191

Azaroff, L., Lax, M., Levenstein, C., & Wegman, D. (2004). Wounding the messenger: the new economy makes occupational health indicators too good to be true. *International Journal of Health Services, 34*(2), 271 - 303. https://doi.org/10.2190/4H

Baas, P., Charlton, S., & Bastin, G. (2000). Survey of New Zealand truck driver fatigue and fitness for duty. *Transportation Research Part F: Traffic Psychology and Behaviour, 3*(4), 185 - 193. https://doi.org/10.1016/S1369-8478(01)00003-1

Baehr, E., Revelle, W., & Eastman, C. (2001). Individual differences in the phase and amplitude of the human circadian temperature rhythm: with an emphasis on morningness-eveningness. *Journal of Sleep Research, 9*(2), 117 - 127. https://doi.org/10.1046/j.1365-2869.2000.00196.x.

Baltes, B., Briggs, T., Huff, J., Wright, J., & Neuman, G. (1999). Flexible and Compressed Workweek Schedules: A Meta-Analysis of Their Effects on Work-Related Criteria. *Journal of Applied Psychology, 84*(4), 496 - 513. https://doi.org/10.1037/0021-9010.84.4.496

Banks, S., & Dinges, D. (2007). Behavioral and physiological consequences of sleep restriction. *Journal of Clinical Sleep Medicine, 3*(5), 519 - 528. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1978335

Baulk, S., Kandelaars, K., Lamond, N., Roach, G., Dawson, D., & Fletcher, A. (2007). Does variation in workload affect fatigue in a regular 12-hour shift system? *Sleep and Biological Rhythms, 5*(1), 74 - 77. https://doi org/10.1111/j.1479-8425.2006.00249.x

Belenky, G., Wesensten, N., Thorne, D., Thomas, M., Sing, H., Redmond, D., Russo, M., & Balkin, T. (2003). Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: a sleep dose-response study. *Journal of Sleep Research, 12*(1), 1 - 12. https://doi.org/10.1046/j.1365-2869.2003.00337.x.

Bentley, T., Catley, B., Cooper-Thomas, H., Gardner, D., O'Driscoll, M., Dale, A., & Trenberth, L. (2012). Perceptions of workplace bullying in the New Zealand travel industry: Prevalence and management strategies. *Tourism Management, 33*(2), 351 - 360. https://doi.org/10.1016/j.tourman.2011.04.004

Berman, D. (2009). *Cost-Benefit Analysis of a Four 10-Hour Day Work Week In Construction* University of Florida]. Florida. https://ufdc.ufl.edu/UFE0024436/00001

Boeggild Dohrmann, S., & Leppin, A. (2016). Determinants of seafarers' fatigue: a systematic review and quality assessment. *International Archives Occupational Environmental Health, 90*(1), 13- 37. https://doi.org/10.1007/s00420-016-1174-y

Bultmann, U., Kant, I., Kasl, S., Beurskens, A., & van den Brandt, P. (2002). Fatigue and psychological distrss in the working population: Psychometrics, prevalence, and correlates. *Journal of Psychosomatic Research, 52*(6), 445 - 452. https://doi.org/10.1016/s0022-3999(01)00228-8

Bultmann, U., Kant, Y., van Amelsvoort, L., van den Brandt, P., & Kasl, S. (2001). Differences in fatigue and psychological distress across occupations: results in the Maastricht Cohort study of fatigue at work. *Journal of Occupational and Environmental Medicine, 43*(11), 976 - 983. https://doi.org/10.1097/00043764-200111000-00008

Caldwell, J. A., Caldwell, J. L., Thompson, L., & Lieberman, H. (2019). Fatigue and its management in the workplace. *Neuroscience and Biobehavioural Reviews, 96*, 272 - 289. https://doi.org/10.1016/j.neubiorev.2018.10.024

Campbell, I. (2007). Long Working Hours in Australia: Working-Time Regulation and Employer Pressures. *The Economic and Labour Relations Review, 17*(2), 37 - 68. https://doi.org/10.1177/103530460701700203

Carayon, P., Hancock, P., Leveson, N., Noy, I., Sznelwar, L., & van Hootegem, G. (2015). Advancing a sociotechnical systems approach to workplace safety - developing the conceptual framework. *Ergonomics, 58*(4), 548 - 564. https://doi.org/10.1080/00140139.2015.1015623

[Record #445 is using a reference type undefined in this output style.]

Chen, J., Davis, K., Daraiseh, N., Pan, W., & Davis, L. (2013). Fatigue and recovery in 12-hour dayshift hospital nurses. *Journal of Nursing Management, 22*(5), 593-603. https://doi.org/10.1111/jonm.12062

Colligan, T., & Higgins, E. (2005). Workplace stress: Etiology and consequences. *Journal of Workplace Behavioral Health, 21*(2), 89 – 97.

Colmar Brunton. (2019). *Segmentation and insights programme: Employers and Workers*.

Cooper, M. (2000). Towards a model of safety culture. *Safety Science, 36*(2), 111 - 136. https://doi.org/10.1016/S0925-7535(00)00035-7

Costa, G. (2003). Shift work and occupational medicine: an overview. *Occupational Medicine, 53*(2), 83 - 88. https://doi.org/10.1093/occmed/kqg045

Courtney, J. (2013). *Fatigue and Mental Health in Ambulance Paramedic Shiftworkers* La Trobe University]. Australia. http://hdl.handle.net/1959.9/525454

Cox, S., & Flin, R. (1998). Safety culture: Philosopher's stone or man of straw? *Work and Stress, 12*(3), 189 - 201. https://doi.org/10.1080.0267837808256861

Dallat, C., Salmon, P., & Goode, A. (2019). Risky system versus Risky people: To what extent do risk assessment methods consider the systems approach to accident causation? A review of the literature. *Safety Science, 119*, 266 - 279. https://doi.org/10.1016/j.ssci.2017.03.012

Dawson, D., & McCulloch, K. (2005). Managing fatigue: It's about sleep. *Sleep Medicine Reviews, 9*(5), 365 - 380. https://doi.org/10.1016/j.smrv.2005.03.002

de Croon, E., Blonk, B., de Zwart, B., Frings-Dresen, M., & Broersen, J. (2002). Job stress, fatigue, and job dissatisfaction in Dutch lorry drivers: towards an occupation specific model of job demands and control. *Occupational and Environmental Medicine, 59*(6), 356 - 361. https://doi.org/10.1136/oem.59.6.356

de Lange, A., Kompier, M., Taris, T., Geurts, S., Beckers, D., Houtman, I., & Bongers, P. (2009). A hard day's night: a longitudinal study on the relationships among job demands and job control, sleep quality and fatigue. *Journal of Sleep Research, 18*(3), 374 - 383. https://doi.org/10.1111/j.1365-2869.2009.00735.x

Dekker, S. (2011). *Drift into Failure: From Hunting Broken Components to Understanding Complex Systems*. CRC Press.

Fagnani, J., & Letablier, M. (2004). Work and family life balance: the impact of the 35-hour laws in france. *Work, employement and society, 18*(3), 551 - 572. https://doi.org/10.1177/0950017004045550

Gander, P., Hartley, L., Powell, D., Cabon, P., Hitchcock, E., Mills, A., & Popkin, S. (2011). Fatigue risk managment: Organizational factors at the regulatory and industry/company level. *Accident Analysis and Prevention, 43*(2), 573 - 590. https://doi.org/10.1016/j.aap.2009.11.007

Gander, P., Purnell, H., Garden, A., & Woodward, A. (2007). Work patterns and fatigue-related risk among junior doctors. *Occupational and Environmental Medicine, 64*(11), 733 - 738. https://doi.org/10.1136.oem.2006.030916

George, C. (2018). *An Inquiry into Contextual Factors Impacting the Occupational Health, Safety, and Well-Being of New Zealand Truck Drivers: An Ecological Systems Approach* Auckland University of Technology]. Auckland. http://handle.net/10292/12005

Gilbert, B. (2019, May 9, May 9, 2019). *Gruelling, 100-hour work weeks and 'crunch culture' are pushing the video game industry to a breaking point. Here's what's going on*. Business Insider Australia. https://www.businessinsider.com.au/video-game-development-problems-crunch-culture-ea-rockstar-epic-explained-2019-5?r=US&IR=T

Hallowell, M. (2010). Worker Fatigue: Managing concerns in rapid renewal highway construction. *Professional Safety, 55*(12), 18 - 26. https://www.elcosh.org/record/document/2087/d001102.pdf

Han, K., Trinkoff, A., & Geiger-Brown, J. (2014). Factors associated with work-related fatigue and recovery in hospital nurses working 12-hour shifts. *Workplace Health and Safety, 62*(10), 409 – 414. https://doi.org/10.3928/21650799-20140826-01

Harma, M., Karhula, K., Puttonen, S., Ropponen, A., Koskinen, A., Ojajarvi, A., & Kivimaki, M. (2019). Shift work with and without night work as a risk factor for fatigue and changes in sleep length: A cohort study with linkage to records on daily work hours. *Journal of Sleep Research, 28*. https://doi.org/10.1111/jsr.12658

Harrington, J. (2001). Health Effects of Shift Work and Extended Hours of Work. *Occupational and Environmental Medicine, 58*(1), 68 - 72. https://doi.org/10.1136/oem.58.1.68

Haworth, N. (1998). *Fatigue and fatigue research: The Australian experience* 7th Biennial Australasian Traffic Education Conference, Speed, Alcohol, Fatigue, Effects, Brisbane. https://www.monash.edu/muarc/archive/our-publications/papers/fatigue

Hayden, A. (2006). Frances's 35-Hour Week: Attack on Business? Win-Win Reform? Or Betrayal of Disadvantages Workers? *Politics and Society, 34*(4), 503 - 542. https://doi.org/10.1177/0032329206293645

Head, B. (2009). Human-System Dis-Integration: Management of Stress, Strain and Fatigue in the Workplace. *Ergonomics SA, 21*(2).

[Record #430 is using a reference type undefined in this output style.]

Jha, A., Duncan, B., & Bates, D. (2001). Fatigue, Sleepiness, and Medical Errors. In A. Markowitz, R. Wachter, & K. McDonald (Eds.), *Making Health Care Safer: A Critical Analysis of Patient Safety Practices* (Vol. 43, pp. 519 - 532). AHRQ Publication. https://archive.ahrq.gov/clinic/ptsafety/chap46a.htm

Johnson, J., & Lipscomb, J. (2006). Long working hours, occupational health and the changing nature of work organization. *American Journal of Industrial Medicine, 49*(11), 921 - 929. https://doi.org/10.1002/ajim.20383

Krause, A., Ben Simon, E., Mander, B., Greer, S., Saletin, J., Goldstein-Piekarski, A., & Walker, M. (2017). The sleep-deprived human brain. *Natural Review of Neuroscience, 18*(7), 404 - 418. https://doi.org/10.1038/nrn.2017.55

Lees, T., Elliott, J., Gunning, S., Newton, P., Rai, T., & Lal, S. (2019). A Systematic Review of the Current Evidence regarding Interventions for Anxiety, PTSD, Sleepiness and Fatigue in the Law Enforcement Workplace. *Industrial Health, 57*(6), 655 - 667. https://doi.org/10.2486/indhealth.2018-0088

[Record #454 is using a reference type undefined in this output style.]

Lerman, S., Eskin, F., Flower, D., George, E., Gerson, B., Hartenbaum, N., Hursh, S., & Moore-Ede, M. (2012). Fatigue risk management in the workplace. *Journal of Occupational and Environmental Medicine, 54*(2), 231 - 258. https://doi.org/JOM.0b013e318247a3b0

Lerman, S., Flower, D., Gerson, B., & Hursh, S. (2017). Fatigue Risk Management in the Workplace. *Journal of Occupational and Environmental Medicine, 54*(2), 231 - 258.

Lilley, R., Day, L., Koehncke, N., Dosman, J., Hagel, L., Pickett, W., & Study, S. F. I. C. (2012). The relationship between fatigue-related factors and work-related injuries in the Sasketchewan farm injury cohort study. *American Journal of Industrial Medicine, 55*, 367 - 375. https://pubmed.ncbi.nlm.nih.gov/22213463/

Lilley, R., Feyer, A., Kirk, P., & Gander, P. (2002). A survey of forest workers in New Zealand: Do hours of work, rest, and recovery play a role in accidents and injury? *Journal of Safety Research, 33*, 53 - 71. https://linkinghub.elsevier.com/retrieve/pii/S0022437502000038

Lingard, H., Cooke, T., & Gharaie, E. (2013). The how and why of plant-related fatalities in the Australian construction industry. *Engineering, Construction and Architectural Management, 20*(4), 365-380. https://doi.org/10.1108/ECAM-09-2011-0085

Lipscomb, H., Dement, J., Nolan, J., & Patterson, D. (2006). Nail gun injuries in apprentice carpenters: Risk factors and control measures. *American Journal of Industrial Medicine, 49*(7), 505- 513. https://doi.org/10.1002/ajim.20325

Lowden, A., & Moreno, C. (2014). Workplace interventions: a challenge for promoting long-term health among shift workers. S*candinavian Journal Work Environment Health, 40*(6), 539 - 541.

Mackie, H. (2008). *The health and fitness of log truck drivers: An evaluation of the industry and recommendations for action.* http://www.ternz.co.nz/Publications/The%20Health%20and%20Fitness%20of%20Log%20Truck%20Drivers.pdf

Macky, K., & Boxall, P. (2008). High-involvement work processes, work intensification and employee well-being: A study of New Zealand worker experiences. *Asia Pacific Journal of Human Resources, 46*(1), 38 - 55. https://doi.org/10.1177/1038411107086542

[Record #472 is using a reference type undefined in this output style.]

[Record #427 is using a reference type undefined in this output style.]

Nagashima, S., Suwazono, Y., Okubo, Y., Uetani, M., Kobayashi, E., Kido, T., & Nogawa, K. (2007). Working hours and mental and physical fatigue in Japanese workers. *Occupational Medicine, 57*(6), 449 - 452. https://doi.org/10.1093/occmed/kqm047

Nejati, A., Shepley, M., & Rodiek, S. (2016). A review of design and policy interventions to promote nurses' restorative breaks in health care workplaces. *Workplace Health and Safety, 64*(2), 70 - 77. https://doi.org/10.1177/2165079915612079

Noy, Y., Horrey, W., Popkin, S., Folkard, S., Howarth, H., & Courtney, T. (2011). Future directions in fatigue and safety research. Accident *Analysis and Prevention, 43*(2), 495 - 497. https://doi.org/10.1016/j.aap.2009.12.017

[Record #441 is using a reference type undefined in this output style.]

Pallesen, S., Bjorvatn, B., Mageroy, N., Saksvik, I., Waage, S., & Moen, B. (2010). Measures to counteract the negative effects of night work. *Scandinavian Journal of Work and Environment Health, 36*(2), 109 - 120.

Patterson, D., Higgins, S., van Dongen, H., Buysse, D., Thackery, R., Kupas, D., Becker, D., Dean, B., Lindbeck, G., Guyette, F., Penner, J., Violanti, J., Lang, E., & Martin-Gill, C. (2018). Evidence-Based guidelines for fatigue risk management in emergency medical services. *Prehospital Emergency Care, 22*(sup1), 89 - 101. https://doi.org/10.1080/10903127.2017.1376137

Peticca-Harris, A., Weststar, J., & McKenna, S. (2015). The perils of project-based work: Attempting reistance to extreme work practices in video game development. *Organization, 22*(4), 570 - 587. https://doi.org/10.1177/1350508415572509

Pidgeon, N. (2010). Systems thinking, culture of reliability and safety. *Civil Engineering and Environmental Systems, 27*(3), 211 - 217. https://doi.org/10.1080/10286608.2010.482660

Purnell, M., Feyer, A., & Herbison, G. (2002). The impact of a nap opportunity during the night shift on the performance and alertness of 12-hour shift workers. *Journal of Sleep Research, 11*(3), 219 -227. https://doi.org/10.1046/j.1365-2869.2002.00309.x

Rasmussen, J. (1997). Risk Management in a Dynamic Society: A Modelling Problem. *Safety Science, 27*(2/3), 183 - 213. https://doi.org/10,1016/50925-7535(97)00052-0

Reason, J. (2008). *The Human Contribution: Unsafe Acts, Accidents and Heroic Recoveries.* Ashgate Publishing.

Reilly, A. (2012). Time, work, and law: a *New Zealand perspective. New Zealand Journal of Employment Relations, 37*(1), 152 - 160. https://openaccess.wgtn.ac.nz/articles/journal_contribution/Time_Work_and_Law_A_New_Zealand_Perspective/12431096/1

Richter, K., Acker, J., Adam, S., & Niklewski, G. (2016). Prevention of fatigue and insomnia in shift workers - a review of non-pharmacological measures. *The EPMA Journal, 7*(1), 16 - 26. https://doi.org/10.1186/s13167-016-0064-4

Robb, G., Sultana, S., Ameratunga, S., & Jackson, R. (2008). A systematic review of epidemiological studies investigating risk factors for work-related road traffic crashes and injuries. *Injury Prevention, 14*, 51 - 58. https://doi.org/10.1136/ip.2007.016766

Sabbagh-Ehrlich, S., Friedman, L., & Richter, E. (2005). Working conditions and fatigue in professional truck drivers at Israeli ports. *Injury Prevention, 11*(2), 110 – 114. https://doi.org/10.1136/ip.2004.007682

Salmon, P., Cornelissen, M., & Trotter, M. (2012). Systems-based accident analysis methods: A comparison of Accimap, HFACS and STAMP. *Safety Science, 50*(4), 1158-1170. https://doi.org/10.1016/j.ssci.2011.11.009

Samaha, E., Lal, S., Smaha, N., & Wyndham, J. (2007). Psychological, lifestyle and coping contributors to chronic fatigue in shift-worker nurses. *Journal of Advanced Nursing, 59*(3), 221 - 232. https://doi.org/10.1111/j.1365-2648.2007.04338.x

Schiller, H., Lekander, M., Rajaleid, K., Hellgren, C., Akerstedt, T., Barck-Holst, P., & Kecklund, G. (2017). The impact of reduced worktime on sleep and perceived stress - a group randomized intervention study using diary data. *Scandinavian Journal Work Environment Health, 43*(2), 109 - 116.

Schreier, J. (2019, February 4). *How BioWare's Anthem Went Wrong*. Kotaku. https://www.kotaku.com.au/2019/04/how-biowares-anthem-went-wrong/

Schutte, P. (2010). Fatigue risk management: charting a path to a safer workplace. *The Journal of the South African Institute of Mining and Metallurgy, 110*(1), 53 - 55. http://ww.scielo.org.za/pdf/jsaimm/v110n1/11.pdf

Scott, L., Hofmeister, N., Rogness, N., & Rogers, A. (2010). An interventional approach for patient and nurse safety. *Nursing Research, 5*9(4), 250 - 258. https://doi.org/10.1097/NNR.0b013e3181de9116

Seppanen, O., Fisk, W., & Faulkner, D. (2003). *Cost benefit analysis of the night-time ventilative cooling in office building*. https://escholarship.org/uc/item/3j82f642

Smith-Miller, C., Kokot, S., Curro, B., & Jones, C. (2014). Fatigue Among Nurses in Acute Care Settings: An Integrated Review. *The Journal of Nursing Administration, 44*(9), 487 - 494. https://doi.org/10.1097/NNA.0000000000000104

Smith, L., Tanigawa, T., Takahashi, M., Mutou, K., Tachibana, N., Kage, Y., & Iso, H. (2005). Shift locus of control, situational and behavioural effects on sleepiness and fatigue in shiftworkers. *Industrial Health, 43*(1), 151 - 170. https://doi.org/10.2486/indhealth.43.151

StatsNZ. (2019). *Survey of working life: 2018*. https://www.stats.govt.nz/reports/survey-of-working-life-2018

Strahan, C., Watson, B., & Lennon, A. (2008). Can organisational safety climate and occupational stress predict work-related driver fatigue. *Transportation Research Part F: Traffic Psychology and Behaviour, 11*(6), 418 - 426. https://doi.org/10.1016/j.trf.2008.04.002

Stutts, J., Wilkins, J., Osberg, J., & Vaughn, B. (2003). Driver risk factors for sleep-related crashes. *Accident Analysis and Prevention, 35*(3), 321 - 331. https://doi.org/10.1016/S0001-4575(02)00007-6

Svedung, I., & Rasmussen, J. (2002). Graphic representation of accident scenarios: mapping system structure and the causation of accidents. *Safety Science, 40*(5), 397 - 417. https://doi.org/10.1016/50925-77535(00)00036-9

Swaen, G., van Amelsvoort, L., Bultmann, U., & Kant, I. (2003). Fatigue as a risk factor for being injured in an occupational accident: results from the Maastricht Cohort Study. *Occupational and Environmental Medicine, 60*(S1), i88 - i92. https://doi.org/10.1136/oem.60.suppl_1.i88

Swaen, G., van Amelsvoort, L., Bultmann, U., Slangen, J., & Kant, I. (2004). Psychosocial work characteristics as risk factors for being injured in an occupational accident. *Journal of Occupational and Environmental Medicine, 46*(6), 521 - 527. https://doi.org/10.1097/01.jom.0000128150.942272.12

Techera, U., Hallowell, M., Stambaugh, N., & Littlejohn, R. (2016). Causes and consequences of occupational fatigue: meta-analysis and systems model. *Journal of Occupational and Environmental Medicine, 58*(10), 961 - 973. https://doi.org/10.1097/JOM.0000000000000837

Tedestedt George, C., Mackie, H., Ashby, L., Hirsch, L., Tappin, D., Lamm, F., & Crawford, J. (2021). *Managing vehicle-related risks from supply chain pressures. M. Research*.

Thorp, A., Kingwell, B., Owen, N., & Dunstan, D. (2014). Breaking up workplace sitting time with intermittent standing bouts improves fatigue and musculoskeletal discomfort in overweight/obese office workers. *Occupational and Environmental Medicine, 71*(11), 765 - 771. https://doi.org/10.1136/oemed-2014-102348

Townsend, K., Brown, K., Bradley, L., & Lingard, H. (2008). *When working five days a week seems radical: compressed working weeks in the Australian construction industry* 22nd Conference of the Association of Industrial Reslations Academics of Australia and New Zealand - Workers, Corporations and Community: Facing Choices for a Sustainable Fututre, Melbourne. https://researchportal.scu.edu.au/esploro/outputs/conferencePaper/When-working-five-days-a-week-seems-radical-compressed-working-weeks-in-the-Australian-construction-industry/991012820410002368

Van Cutsem, J., Marcora, S., De Pauw, K., Bailey, S., Meeusen, R., & Roelands, B. (2017). The Effects of Mental Fatigue on Physical Performance: A Systematic Review. *Sports medicine*, 1 – 20.

van Drongelen, A., van der Beek, A., Hlobil, H., Smid, T., & Boot, C. (2013). Development and evaluation of an intervention aiming to reduce fatigue in airline pilots: design of a randomised controlled trial. *BMC Public Health, 13*, 776 – 784. https://doi.org/10.1186/1471-2458-13-776

van Vegchel, N., de Jonge, J., Bosma, H., & Schaufeli, W. (2005). Reviewing the effort-reward imbalance model: drawing up the balance of 45 empirical studies. *Social Science and Medicine, 60*(5), 1117 - 1131. https://doi.org/10.1016/j.socscimed.2004.06.043

Viola, A., James, L., Schlangen, L., & Dijk, D. (2008a). Blue-enriched white light in the workplace improves self-reported alertness, performance and sleep quality. *Scandinavian Journal Work Environment Health, 34*(4), 297 - 306.

Viola, A., James, L., Schlangen, L., & Dijk, D. (2008b). Blue-enriched white light in the workplace improves self-reported alertness, performance and sleep quality. *Scandinavian Journal of Work, Environment and Health, 34*(4), 297 - 306. https://doi.org/10.5271/sjweh.1268

Wadsworth, E., Allen, P., McNamara, R., & Smith, A. (2008). Fatigue and health in a seafaring population. *Occupational Medicine, 58*(3), 198 - 204. https://doi.org/10.1093/occmed/kqn008

Weaver, M., Patterson, D., Fabio, A., Moore, C., Freiberg, M., & Songer, T. (2015). An observational study of shfit length, crew familiarity, and occupational injury and illness in emergency medical services workers. *Occupational and Environmental Medicine, 72*(11), 798 - 804. https://doi.org/10.1136/oemed-2015-102966

Williamson, A., Lombardi, D., Folkard, S., Stutts, J., Courtney, T., & Connor, J. (2011). The link between fatigue and safety. *Accident Analysis and Prevention, 43*(2), 498 - 515. https://doi.org/10.1016/j.aap.2009.11.011

Wilson, J. (2014). Fundamentals of systems ergonomics/human factors. *Applied Ergonomics, 45*(1), 5 - 13. https://doi.org/10.1016/j.apergo.2013.03.021

Wright, S. (2018, October 19). Despite Resistance, *Crunch Continues to Define the Video Game Industry*. Variety. https://variety.com/2018/gaming/features/video-game-union-crunch-industry-practice-1202985642/

Wyon, D. (2004). The effects of indoor and air quality (IAQ) on performance, behaviour and productivity. *Indoor Air, 14*(Sup. 7), 92-101. https://doi.org/10.1111/j.1600-0668.2004.00278.x

Yamazaki, S., Fukuhara, S., Suzukamo, Y., Morita, S., Okamura, T., Tanaka, T., & Ueshima, H. (2007). Lifestyle and work predictors of fatigue in Japanese manufacturing workers. *Occupational Medicine, 57*(4), 262 - 269. https://doi.org/10.1093/occmed/kqm006

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