

The management of safety risks associated with nightshift in the New Zealand electrical distribution industry.

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Abstract

Night shift work and the effects of fatigue, caused by being awake during normal hours of sleep, has safety implications. Existing research on fatigue focuses on decision-making and the impacts on safety in numerous professions (oil & gas, health care, air traffic control). There has been no research on this specific topic in the New Zealand electrical distribution sector.

The aim of this research was to discover the extent to which the human cost (safety risk) of societies 24/7 reliance on electricity dependent infrastructure is being managed. The findings can support improvement, education, and guidance for this sector and fill in a gap in the current body of knowledge.

A qualitative research design was used, comprising of focus groups with Network Control Operators and Faults Responders and document analysis. Reflexive thematic analysis was undertaken on the narratives using an inductive approach which created themes from the data without any preconceptions. The Deming PDCA model provided a conceptual framework to support evaluation of the themes against the research question.

Fourteen Themes were identified, which supported the conclusion that the safety risks associated with nightshift work in the New Zealand electrical distribution industry were not being fully managed.

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Introduction

At 7:00pm on Friday the 19th of June 2020 a car crashed into a power pole. Emergency services attempts to gain access to the four occupants inside the vehicle were impeded by live streetlight conductors lying across the car. The attending Faults Responder requested a line isolation from the on-duty Network Controller. Network Control in attempts to de-energised the site remotely isolated the wrong feeder three times – this meant the power was left on to the lines across the car. Network Control then instructed the attending Fault Responder to isolate a local transformer to secure the accident scene - this instruction was also wrong. The Fault Responder then traced the supply by sight and de-energised the scene. The mistakes were all potentially lethal and only averted by the Fault Responders' vigilance. The timing of the event may have been a contributory factor to the mistakes made. The Network Controller and Fault Responder both work in the New Zealand electrical distribution industry, where faults and events are responded to through the day and the night to keep the electricity (the power) on. Nightshift is widely understood to lead to fatigue (Parkes K. R., 2012), and fatigue is widely understood to impact decision making (Chan, 2011). Fatigue could have been a contributory factor in this event.

Electricity is a lifeline utility which modern society has a twenty-four-seven reliance on. The electrical industry in New Zealand is comprised of four key parts: generation; transmission; distribution and retail. Generation is where electricity is made (generated) using hydropower, geothermal activity, wind energy and fossil fuels, coal, and gas. The five main generators of electricity in New Zealand are also the five main retailers of electricity (MBIE, 2020). Transmission, also known as the national grid, is the use of nearly 11,000km of high voltage lines and submarine cables with one hundred and seventy-eight substations to connect generation to demand centers like cities or industrial power users (Transpower New Zealand limited, 2020). Distribution is the conveyance or distribution of electricity from grid exit points to businesses, homes and other consumers via overhead lines or underground cables. There are currently twenty-seven electrical distribution businesses (EDB's), and all are members of the Electricity Network Association (ENA) who distribute electricity across New Zealand. Retail is the sale

of electricity to users via metered supply. As well as the various organisations operating across the four sector areas, there are numerous contracting business's which service the needs of the electricity sector.

The twenty-seven EDB's across New Zealand differ greatly in their business models. Some are solely asset owners and operators who use external contractors to conduct 'in the field' activity, while others have an internal contracting arm which supports the company's asset management activities - there are also hybrids of the two models.

The quality of supply and the cost of electricity to consumers is regulated by the New Zealand Commerce Commission (ComCom) under the Electricity Act 1992. ComCom also sets standards and limits for outages - and measures network performance using two indexes; the first is the System Average Interruption Duration Index (SAIDI), which is the duration of all customer interruptions divided by the total number of customers served which means, it measures on average the time a customer experiences no supply in a period (typically one year); the second is the System Average Interruption Frequency Index (SAIFI), which is the total number of customer interruptions divided by the total number of customers served, which means it measures on average the number of events that disrupt supply in a period (again typically one year). EDBs are liable for fines where SAIDI and SAIFI limits are breached (Commerce Commission, 2019) (Commerce Commission, 2020). The expectations set by ComCom place pressure on EDBs to keep the power on, and to limit outages (Government, 2022). Therefore, when power is disrupted, EDBs are under pressure to restore power quickly regardless of the time of day or night – this creates the need for nightshift working. There are two specific roles within the electrical distribution industry which work nightshift. Faults Responders, which consists of line mechanics, technicians, cable jointers and electricians who undertake an on-call nightshift, and Network Controllers who undertake various forms of a rotating nightshift or call back within the twenty-seven EDB's across New Zealand.

This enforcement of the Electricity Act 1992 by ComCom (and specifically the amendments in the Electricity (Continuance of Supply) Bill to maintain a constant and secure supply), is in tension with the expectations set by the Health and

Safety at Work Act 2015 (HASWA) regulated by Worksafe New Zealand. Under HASWA work must be undertaken without risk to the health and safety of any person- so far as is reasonably practicable (New Zealand Government, 2022). The expectation to keep the power on exposes people to the cognitive and physiological impacts of nightshift – and the subsequent safety risks this may pose. However, the potential magnitude of fines for not meeting SADI and SAFI is more than for not meeting the requirements under HASWA. This may be a factor which influences the way that work is undertaken as businesses balance the often-conflicting demands between ensuring worker safety and security of supply (Electircity Authority - Security and Reliability Council, 2017).

Ensuring a sustainable and secure supply of electricity requires complex and variable work activities, reducing the ability for this work to be automated. Electrical distribution assets in New Zealand were built over an eighty plus year time span. While there have been small scale innovations in this industry which include SCADA (remote operation), auto-reclosures, smart meters and data loggers, assets are not designed to a consistent standard or configuration, or in a way which enables large scale remote or mechanical (Artificial Intelligence) intervention. People working on the network assets may be exposed to safety risks associated with suspended loads, heights, mechanical plant energy, live electricity, and driving. All hazards with potentially life changing or taking energy. This complex and variable work relies on the cognitive and adaptive ability of people (Chui, Manyika, & Miremedi, 2016). People that must work nightshift to maintain a constant and secure supply of electricity across New Zealand.

Evidence from many industries has determined that nightshift work has a negative impact on decision making (Chan, 2011) because anytime sleep is compromised this can lead to fatigue (Lerman, et al., 2012). Sleep can be affected by early morning or nightshifts that not only disrupt the circadian rhythm but also affect social and family life (Folkard & Tucker, Shift work, safety and productivity, 2003). Night shift work, defined as working at least 3 hours between midnight and 5:00am (Stevens, et al., 2011) is known to cause fatigue (Lerman, et al., 2012; Harme, Vahtera, Kivimaka, Karhula, & Ropponen, 2018). The requirement to work night shift has the potential to compromise the cognitive and adaptive ability of

people, and for safe work to exist, workers need to be physically and mentally alert (WorkSafe New Zealand, 2017).

Fatigue is the physical and/or mental exhaustion that can be triggered by stress, medication, overwork or mental and physical illness or disease (Ford-Martin, 2011). Working in a fatigued state “decreases the ability to process and react to new information and respond to hazards” (Techera, Hallowell, Stambaugh, & Littlejohn, 2016, p. 961). Fatigue is associated with slower reaction times, poor judgement, increased error rates, and ultimately has a negative impact on worker safety and the safety of others as well (Wagstaff & Lie, 2011). Fatigue therefore has a direct relationship with the achievement of safe outcomes, fatigue affects task control, planning and preparation ability (Lorist, Boksem, & Ridderinkof, 2000).

Each day, greater than twenty percent of the employed population of the United States experiences occupational fatigue. The associated health costs and loss of productivity in the United States alone equate to nearly \$140 billion each year (Techera, Hallowell, Stambaugh, & Littlejohn, 2016). In New Zealand, Waka Kotahi (NZ Transport Agency) stated the social cost for fatigue related crashes was \$283 million in 2019 (Waka Kotahi, 2022). Fatigue has been reported as a causative factor in major disasters such as: Three Mile Island Nuclear Plant (Mittler, et al., 1988), BP Texas City where the United States Chemical Safety and Hazard Investigation Board’s final report examined the relationship between human fatigue, performance and industrial safety (Murray & Matthew, 2016) and the Challenger space shuttle disaster, where the investigation report noted time pressure increased sleep loss and fatigue levels which led to judgement errors (Rogers Commission Report, 1986)

Good sleep is the foundation for good health and wellbeing (Walker, 2017) and yet while organisations are increasing the resources they focus on improving worker wellbeing (Southern Cross Health Insurance, Business NZ, 2021) work still exists where there is the need to undertake nightshift. Humans are not immune to the physiological and cognitive impacts of a disrupted circadian rhythm - despite many people being required to undertake work during normal hours of sleep (James,

Honn, Gaddameedhi, & Van Dongen, 2017). The requirement in the electrical distribution industry for nightshift working poses a safety risk to those undertaking the work – and those who may be impacted by that work.

The New Zealand electricity distribution industry has developed safety guidance material, but there has been no industry-based research into the impacts of nightshift work on safety – or which indicates to what extent the safety risks associated with nightshift work are being managed. This is not unusual, in sectors where fatigue has been recognized as a hazard this recognition has not necessarily led to improved management of the associated safety risks which fatigued people present to themselves, to others or to the business. While recognition exists that shift work can lead to fatigue (Quental, Rocha, Silva, Menezes, & Santos, 2021) it is only in certain sectors that utilize shift work within their activities, such as health care, aviation, freight, and oil & gas does any research exist.

Literature Search

Utilizing the Victoria University Library search database, with the following search words and filters, the following applicable literature was identified:

Table 1. Literature search

Search Words	Filters	Results
night shift	-	1,386,617
night shift AND night work		1,069,010
night shift AND night work AND fatigue	-	56,946
night shift AND night work AND fatigue AND safety	-	24,243
night shift AND night work AND fatigue AND safety AND error	-	8,971
night shift AND night work AND fatigue AND safety AND error AND electric*	-	1,635
night shift AND night work AND fatigue AND safety AND error AND electric*	Narrowing search from <u>everything</u> to <u>articles</u> only	847
night shift AND night work AND fatigue AND safety AND error AND electric*	<u>Peer reviewed Journals only</u> (Publication date from 1972 – 2022)	631
night shift AND night work AND fatigue AND safety AND error AND electric*	Narrowed selection to <u>papers published in the last 20 years.</u> (Publication date from 2000-2022)	594
night shift AND night work AND fatigue AND safety AND error AND electric*	Filtered for relevance of study to <u>Humans and Life Sciences & Biomedicine</u>	304
Night shift AND night work AND fatigue AND safety AND error AND electric*	Filtered subject to <u>shift work</u>	41
night shift AND night work AND fatigue AND safety AND error AND electric*	Checked against <u>target industry relevance.</u> (Vincent, Kinchin, Ferguson, & Jay, 2018)	1**

***This reference related to on call workers but not electrical distribution*

Literature Review

Fatigue is the physical and/or mental exhaustion that can be triggered by stress, medication, overwork or mental and physical illness or disease (Ford-Martin, 2011). Nightshift work, defined as working at least 3 hours between midnight and 5:00am (Stevens, et al., 2011) is known to cause fatigue (Lerman, et al., 2012; Harne, Vahtera, Kivimaka, Karhula, & Ropponen, 2018), and fatigue is known to be a safety risk – and to increase the potential for work related harm to people. Research on the management of safety risk associated with nightshift related fatigue is limited. The national and international research that does exist relates predominantly to the medical profession. Nursing (nine out of the first ten, and thirty-four out of the top fifty search results), Doctors (six), systematic reviews (two), literature reviews (two), oil & gas (one), transport (one) and others (four). The literature search did not identify any research relating to the impact of night shift related fatigue on safety risk in electrical distribution.

Anytime sleep is affected, either the duration of sleep, or the timing of sleep (for example sleeping during the day), can lead to fatigue (Lerman, et al., 2012). Potera 2018 found that “long shifts, shift rotations, double shifts, and evening and nightshifts posed short and long-term safety risks for nurses, as well as danger to their patients” (Potera, 2018, p. 15). This study recognised that the impact on safety goes beyond the person undertaking the work – to those who are impacted by that work. This is supported by the findings of a two-part study in the oil & gas sector which involved a survey of three hundred and twenty stakeholders, and interviews of fifteen individuals involved in fatigue related incidents. The stakeholders universally rated fatigue as the most critical risk identified in incidents (Chan, 2011). This study also considered fatigue as a multidimensional phenomenon, a “trigger risk and the lynchpin to accident mitigation” (Chan, 2011, p. 346).

The National Institute for Occupational Safety and Health (NIOSH) and the Center for Work and Fatigue Research argue that the safety risks associated with workplace fatigue must be a priority for focus, and those working in utilities should be a target audience for interventions because of the percentage of total nightshift

workers in this sector. (National Institute for Occupational Safety and Health, 2021). Similarly, grey literature including 'The Prospect', a London based Trade Union blog, identifies fatigue as "a problem haunting the electricity industry". It references a survey where nearly a third of respondents recall feeling too fatigued to work safely at some point in their working lives (Ferns, 2021). Workers in the electricity industry internationally have been identified as experiencing fatigue because of the necessity for shift work; given similar working arrangements it is reasonable to assume that workers in the New Zealand electrical distribution industry would be no different.

Wagstaff and Lie 2011 undertook a systematic review of shift work and safety implications, evaluating seven thousand articles from five international databases. They concluded that shift work, where nights were included, carried an increased risk of accidents. This is because fatigue is associated with slower reaction times, poor judgement, and increased error rates (Wagstaff & Lie, 2011). Fatigue reduces alertness and inhibits performance, leading to human error. Additional impacts of fatigue include mood changes, cognitive and physical degradation, and human error. Cognitive functions like the ability to plan, make decisions under uncertainty, attention vigilance and response to stimuli are essential for the effective completion of work (Techera, Hallowell, Stambaugh, & Littlejohn, 2016) To ensure safe work, workers need to be physically and mentally alert (WorkSafe New Zealand, 2017).

"Human error is a fact of life, it occurs in all aspects of life and in every occupation with varying consequences" (Bogner, 1994, p. 1). Work and work conditions which rely on human decision making and action has the inherent potential for error and subsequent negative safety outcomes – this is exacerbated when there is time pressure on decision making. "Risks to human health and safety are increased when the human is fatigued from inadequate or interrupted sleep" (Kling, McLeod, & Koehoorn, 2010, p. 611), Where the inherent potential for error is combined with the inherent potential for death or irreversible harm, the requirement to manage the risk becomes critical.

Military operations require human decision making in a multiple hazard environment – while the work is different, this high-hazard complex context has similarities to the electricity distribution industry. A military analyst discussing fatality rates during the initial stages of “Operation Iraqi Freedom” was quoted as saying “The biggest killer is fatigue...” (Szalma & Hancock, 2008, p. 232). Task completion in the electrical distribution Industry work environment is no different – and combined with the impaired decision making abilities associated with fatigue (Bongo & Seva, 2022) from sleep deprivation (Chee & Chuah, 2007), an interrupted circadian rhythm (James, Honn, Gaddameedhi, & Van Dongen, 2017) and the inability to self-assess the presence of fatigue (Cochran, Letvak, McCoy, Bacon, & Karper, 2021), human error can be fatal.

Work in the electrical distribution industry exposes people to multiple safety hazards including suspended loads, heights, confined spaces, machinery, live electricity, and moving vehicles. There have been forty-nine electricity related deaths in the last twenty-eight years (1993-2020), an average of 1.8 per year. There have also been two hundred and eight accidents impacting three hundred and six members of the public which required notification to the regulator New Zealand (WorkSafe , 2021). Similarly, Australian figures of a thirty-year study included sixty-six accidental fatalities in the period 1973-2002 (Wick, Gilbert, Simpson, & Byard, 2006) an average of 2.2 per year. The human and financial cost on those impacted, their families and communities is significant.

Network Controllers and Faults Responders

Within the electrical distribution industry, the performance of, and work on, the electrical distribution network is overseen by ‘Network Controllers’. They work in a control room predominantly in a changing eight or twelve-hour rotating shift pattern across a twenty-four-hour period. In some instances, often only in smaller networks, they work in an on-call environment during the nightshift. Network Controllers are responsible for issuing instructions to electrically isolate parts of the network when repairs or other work activities are required, these are termed switching instructions. Failure to correctly ‘switch’ or isolate the network could result in exposure to live electricity for ‘Fault Responders’.

Fault Responders are line mechanics, cable jointers, technicians, and electricians who physically undertake the repair work on the network. Fault Responders are required to work in unpredictable conditions and emergency situations. They work 'on-call' and 'on demand' in a shift often called 'stand-by'. Both Network Controllers and Fault Responders can be employed by the network owner/EDB or a contractor (to the EDB) and need to perform complicated tasks during normal hours of sleep. Their decisions and activities involve assets that conduct electricity which can impact their own safety, that of each other, and that of others (Lipley, 2013). It is therefore critical that both Network Controllers and Fault Responders are alert and able to perform cognitively and physically. Performing an on-call shift over-night or a nightshift can result in a significant reduction of sleep quality (Ferguson, Paterson, Hall, Jay, & Aisbett, 2016). The sleep wake cycle (the circadian rhythm) follows the environmental cues of light/dark alternation (Galiniere, et al., 2021). Even when not working, research suggests that being on stand-by negatively impacts sleep duration and quality (Wuyts, et al., 2012). Therefore, the work patterns of both Network Controllers and Fault Responders may lead to fatigue – and subsequently impact the ability of both roles to perform optimally in a high-risk environment. The work is not error tolerant and safety critical decisions can lead to death or a life changing harm.

Managing safety risk

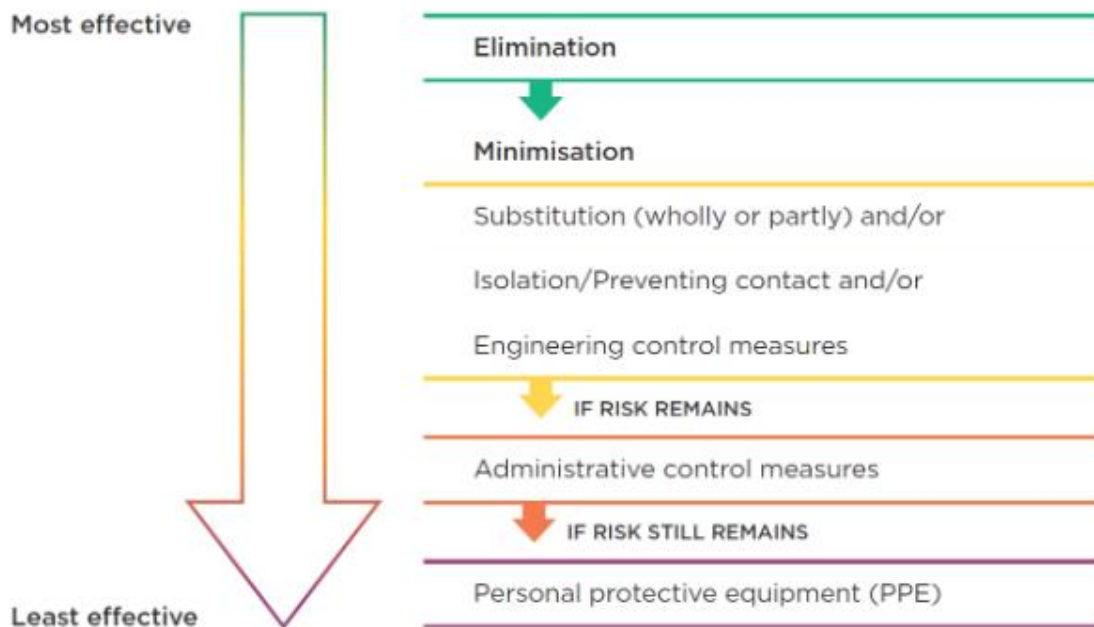
The Health and Safety at Work Act 2015 (HASWA) and associated regulations (New Zealand Government, 2020) places obligations on organisations in New Zealand to manage health and safety risks to workers, and others, including the public so far as is reasonably practicable. The legislation is 'performance' or 'principles' based, meaning it does not prescribe how this must be achieved. It is therefore the responsibility of organisations to determine what is reasonably practicable.

To manage safety risks, the hazards, or sources of potential harm, need to first be identified, before the possibility of the hazard causing harm is assessed to determine the risk. Once the risk assessment has been completed, the hazards and risks need to be controlled by following the hierarchy of control as required by

the legislation (Diagram 1.). The hierarchy requires hazards and risks to be eliminated where possible, or otherwise managed. Management is therefore about all the activities involved in reducing the likelihood and/or consequence of the risk being realized.

To understand to what extent the safety risks associated with nightshift and fatigue are managed in the electrical distribution industry there is a need to understand if the industry has identified and assessed the hazards and risks, defined, and implemented controls, and what type of controls they are according to the hierarchy of controls, which gives an indication of control efficacy.

Diagram 1. Risk Management Hierarchy of Controls



(WorkSafe , 2022)

Where risk is being managed well, a variety of tools and activities will be used to help understand the presence, speed and nature of the hazards and risks within the work as well as the effectiveness of the controls. The causative factors of fatigue and the relationship between cause and effects is complex. Diagram 2. is a system representation which considers a meta-analysis of existing research and demonstrates this complexity. The model illustrates the “empirical literature on the

relationships among causes and effects of fatigue. Dashed lines represent the interrelationships among the causes and consequences of fatigue and solid lines represent the immediate relationships between causes, fatigue, and consequences. Line thickness corresponds directly to the number of studies devoted to each relationship” (Techera, Hallowell, Stambaugh, & Littlejohn, 2016, p. 968).

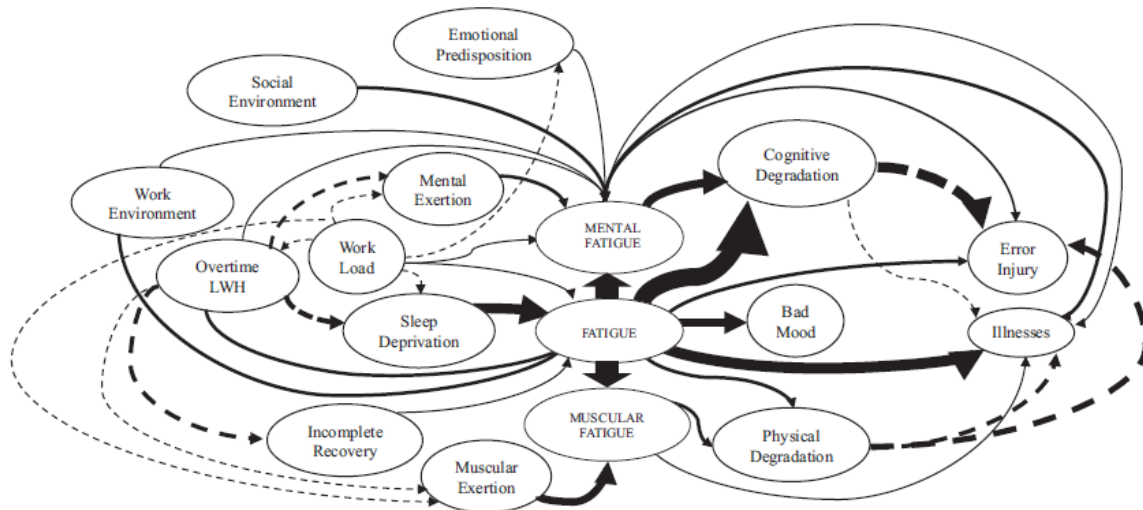


Diagram 2: Systems Model.

After fatigue risk factors have been identified and assessed, a useful framework for considering their management is the Plan-Do-Check-Act (PDCA) cycle. This is a basic method of total quality management based on the scientific method developed from the work of Francis Bacon and used for the control and continual improvement of a process. (Bacon, 1620) (Tague, 2005). The PDCA cycle has four stages.

- Plan. The planning phase, establishing objectives/requirements to deliver results.
- Do. The implementation phase, carrying out the objectives from previous step,
- Check. The inspection phase after gathering data and information to be evaluated, and,
- Act. The processing phase, after issues have been identified with the process.

Although traditionally PDCA was used for quality management, it can readily be used as a framework to enable an evaluation of safety risk management, as demonstrated in research where it was used to improve working conditions in a clinical nursing environment (Pan, Luo, & Duan, 2022) . It is appropriate in this setting to provide a conceptual framework to support an assessment of the extent to which the safety risks associated with nightshift are being 'managed' in this research.

Fatigue, when identified, can be managed through multiple mechanisms including work design (split work, rostering, and rest patterns) workplace naps and the use of biomathematical models to predict fatigue or sleepiness (Roach, et al., 2017), as well as time restricted eating/fasting (Manoogain, et al., 2022). In addition, prescriptive rules around driving hours and resource management practices have been implemented in the transport sector where being fatigued has been shown to impair neurobehavioral performance comparable to a 0.1 percent blood alcohol level (Dawson & Reid, 1997). Up until recently (June 2021) the Health and Safety Executive in the United Kingdom had a fatigue risk index for shift workers. Some organisations tried to use it to justify unsafe work and so the index was removed from circulation. (Health and Safety Executive, 2022) .

Table 2 outlines a summary of the various fatigue management techniques for each step in the PDCA cycle. The consequences of fatigue are more easily identifiable than the causative factors (Techera, Hallowell, Stambaugh, & Littlejohn, 2016) which means controls for hazards and risks associated with fatigue are more focused on the management of outcomes (reactive) than they are on the prevention of fatigue in the first place (proactive). Methods of management and control may be applicable for more than one fatigue risk factor.

Table 2. Fatigue Management Technique Summary in the PDCA Cycle

Element	Management technique	What does this manage	Reference
Plan	Health promotion focusing on healthy eating habits.	Supports attention span, energy levels, concentration, alertness.	(Kolasa & Firnharber, 2011)
	Education and Counselling	Understanding the risks. Building support for the worker through risk understanding. Strong social support/networks at work and at home significantly improve adaptation and tolerance to shift work	(Monk & Folkard, 1992) (Kogi, 1996) (Costa, 2010) (Pisarski, Bohle, & Callan, 1988)
	Shift schedule design – Limit night work, avoid many consecutive nights, prefer swiftly rotating shifts systems (1-3 days), prefer forward rotating shifts, set shift lengths according to psycho-physical demands, avoid morning shifts, get adequate rest days between shifts, keep shift system regular as possible	Circadian rhythm disruption and adaption	(Akerstedt & Landstrom, 1998) (Roach, Sargent, Darwent, & Dawson, 2012) (Hancock, Desmond, & Matthews, 2012)

	Design of work environment	Alertness, error mitigation, physical and mental fatigue, safety, task induced fatigue and stress	(Hancock, Desmond, & Matthews, 2012)
	Progressive decrease of night work with increasing age	Sudden medical incapacitation Sleep degradation as it relates to increased accident risk. The presence of sleepiness during work hours, and concentration	(Gander & Signal, Who Is Too Old for Shift Work? Developing better Criteria, 2009) (Knauth & Hornberger, 2003) (Van Dongen, 2006)
	Allow flexibility to workers needs and preferences	Work life balance	(Costa, 2010) (Barton, 1994)
Do	Additional rest breaks for meals and naps	Sleep as a countermeasure	(Knauth, 1996).
	Sleep inertia managed by caffeine intake	Attention and wakefulness	(Van Dongen, et al., 2001)
	Periodical transfer to day work	Fatigue, recovery, sleep quality	(Costa, Sartori, & Akerstedt, 2006)
	Sleep Monitoring and feedback	Sleep hygiene	(Maclean, Davies, & Thiele, 2003)

	Promotion of recovery during non-work time	Rest Optimization	(Daniel & Sonnentag, 2014)
	Fitness for duty monitoring: Psychomotor vigilance tests, eye/pupil movement monitors, specialised software or memory and decision-making tests	Sleep related performance deficits, sleepiness on the job	(Dawson, Searle, & Paterson, 2014)
	Identification of fatigue symptoms while at work. Either self-identification of symptoms (this must be accompanied with the pre-requisite training to self-identify) understanding the physical, mental, and emotional signs or objective identification with co-pilot type systems measuring fatigue through physiological or performance indicator recognition.	Identification of fatigue and subsequent use of countermeasures	(Sigari, Pourshahabi, Soryani, & Fathy, 2014) (Lerman, et al., 2012)
Check	Carrying out regular medical surveillance (OPEC, 2000) (Smolensky, Di Milia, Ohayon, & Philip, 2011) as sleep disorders and health conditions can affect the length and quality of sleep.	Sleep disorder detection. Fatigue recovery, Incident prevention	(Phillips & Sagberg, 2010)

	<p>Effective asset maintenance program, including asset inspection and testing, replacement programs, vegetation management and the adoption of current and developing technologies ensuring a balance between maximizing asset value while minimizing faults and outages.</p> <p>Addressing discrepancies between planned and actual hours worked, reacting to changes</p>	<p>Workload reduction, reduction in faults call out and reduction in required storm response.</p> <p>Potential for fatigue</p>	<p>(Gaha, et al., 2021).</p> <p>(Phillips, Naevestad, & Bjornskau, 2015)</p>
Act	<p>Act in the sense of this research is about learning and responding. Organisational learning is literally, how does the organisation learn? How does it acquire knowledge, internally by way of audit or observations, does it experiment, learn from the past and from external sources?</p> <p>Learning is critical and is “a process that leads to change, which occurs as a result of experience and increases the potential for improved performance and future learning”</p>	<p>Continuous improvement, Incident risk</p>	<p>(Alerasoul, Afeltra, Hakala, Minelli, & Strozzi, 2022)</p> <p>(Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010)</p>

Optimal staffing levels

Workload management, fatigue

(Lerman, et al., 2012)

Recruitment and selection – medical screens and psychometric testing to ensure workers are free from sleep related disorders and are suited to shift work

Workforce resilience, fatigue

(Trutschel, et al., 2009, March 26-29)

Research Gap

There is no research on the impact of night shift related fatigue in the electrical distribution industry in New Zealand, and therefore no way of currently identifying in the body of knowledge if the associated safety risks are realized or managed appropriately.

Research Question

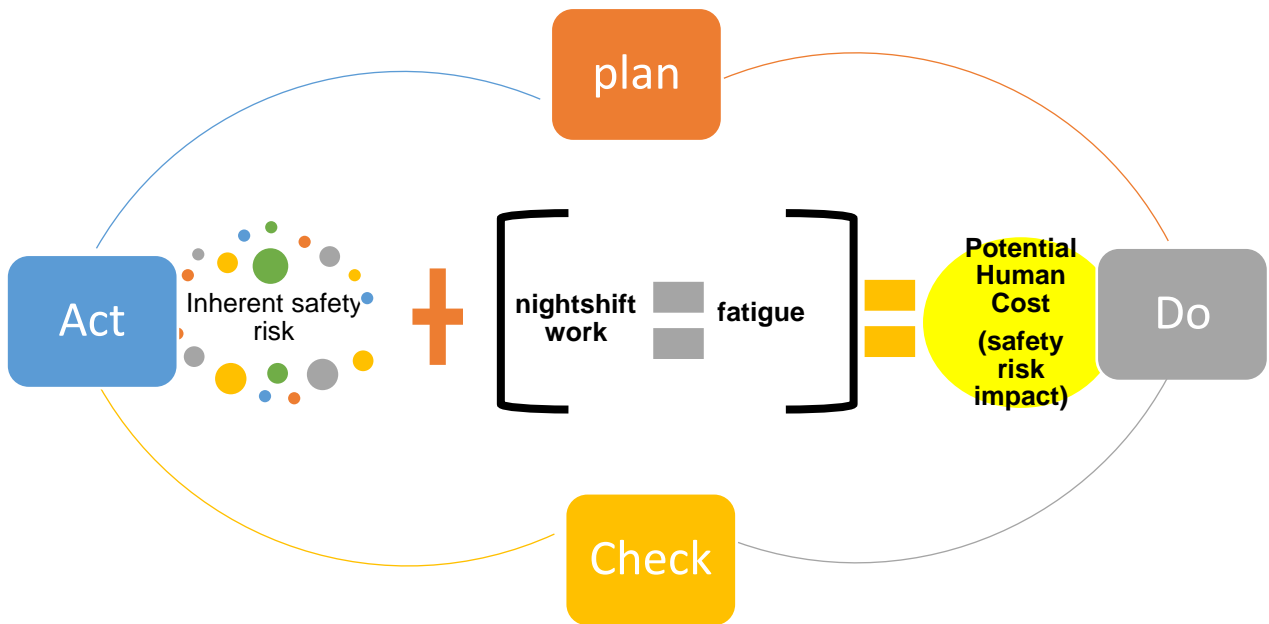
To what extent are the safety risks associated with nightshift work managed in New Zealand electrical distribution industry?

Theoretical / conceptual framing

Fatigue has been examined for over a hundred years, yet there is no convincing theory or theoretical framework for research into fatigue as a risk factor for safety risk management. (Hockey G. , 2011).

A conceptual framework for this research has been developed based on the literature that is available (Diagram 3). This framework demonstrates how the relationship between the consequences of exposure to the inherent safety risks in the electrical distribution (human cost) can be impacted because of the relationship between nightshift work and fatigue. The management of this relationship can then be moderated through proactive and reactive controls at each stage of the Plan-Do-Check-Act cycle (Bacon, 1620) made popular by Deming.

Diagram 3: Conceptual Framing



Overall Research Design/Methodology

The extent to which fatigue is managed within the electrical distribution industry has not been explored internationally or within New Zealand. A qualitative research design was chosen to explore this topic because the experiences of those working within the industry provide the richest and most reliable source of information and data. Purposive sampling and focus groups comprising participants from within the industry, enabled knowledge to be built through industry individual's views (Creswell & Poth, 2016). The information obtained was coded and verified against the original source data from which themes were determined.

The research aim was to understand to what extent the human cost (safety risk) of societies twenty-four/seven reliance on electricity dependent infrastructure was being managed. The learnings could support industry improvement initiatives.

The research is grounded in a pragmatic world view. Pragmatist research is undertaken using methods and approaches that suit the actual or specific conditions that really exist – the best approach for the question - rather than using fixed theories, rules, or ideas. Primarily this is an attempt to interpret with consistency the world of knowledge and its progress through the effect of time (King, 1905). The pragmatist view is ideal for participatory approaches because it can yield solution-focused and real-world knowledge, providing insights into the lived experience of the participants while allowing the flexibility to answer the research question. Inductive qualitative research is the most practical application of this research view and approach.

Sample/Participants/Data Source

The electrical distribution industry consists of twenty-seven electrical distribution businesses (EDBs) and contracting companies who maintain the electrical distribution networks across the country. The industry holds safety forums, and participants at those forums were asked to express interest 'in principle' in participating in the research. This resulted in ten companies stepping forward providing geographic and business model representation of industry. Therefore, it

was not necessary for all twenty-seven lines companies (or the entire collection of contractors working on the assets) to participate in the research.

Actual Design

Setting

The research focused on the New Zealand electrical distribution industry. It was undertaken during the global N-Cov-SAR-19 (COVID-19) pandemic and therefore the focus groups were necessarily conducted using the Microsoft Windows Teams platform, and participant organisations provided their documents relating to fatigue and/or night shift by e-mail. The involvement of industry workers and organisations has increased the potential for the research findings to be more widely accepted by the industry. All participants requested a copy of the completed research.

Participants

The research participants and sample size were selected through a combination of judgement/purposeful and convenience sampling which resulted in a key informant sample. The participants selected had industry relevant expertise and a required level of experience of over 5 years. The aim of the research was to improve understanding of a complex question which is more important than the ability to generalize the findings, therefore purposive sampling with strict participant selection criteria was appropriate. (Marshall, 1996).

There are twenty-seven lines companies and circa ten contracting companies of significant size that employ the population of interest -Network Controllers and Faults Responders. Collectively the lines companies employ circa one hundred Network Controllers and circa three hundred Faults Responders. Ten companies were formally invited to participate in the research by email and asked to identify and invite two participants in their company from the two roles of interest; Network Controllers and Faults Responders, who had worked in the electrical distribution industry for at least five-years to attend the focus groups and participate in the research.

Participants working in these two role types were allocated into focus groups of their peers. The participants in both the Faults Response focus group, and the Network Controller focus group collectively had two hundred- and sixty-five-years' experience.

A Koha was considered for all participants and the cultural appropriateness of this was determined through consultation with two participants. As a result, a Prezzy card to the value of fifty dollars was offered to all focus group participants.

The study did not need to be stratified because while each network has been built over many decades and contains variable asset designs, the practices in Network Control and Faults Response are similar across the country. This is because this work is directed by all of industry guidance material including the line mechanics handbook which is now in its sixth edition (Electricity Engineers Association, 2013) and forty-five other health and safety publications on the Electrical Engineers Association (EEA) website.

The focus groups were undertaken at a time which coincided with winter storms and the COVID pandemic in New Zealand. This meant the seasonal increase in electricity usage placed more wear and tear on the electricity networks assets and this was combined with the ongoing variation in working capacity with the COVID pandemic and seasonal illness. This created a higher probability of the participants being needed for busier periods of emergency restoration fault work or required to cover those on sick leave and therefore being unable to participate. Therefore, participation was extended to ten businesses instead of the originally intended eight to ensure that even with the potential for sickness or a storm event, minimum participation numbers would be reached. Of the ten Faults Responders asked to participate the expectation was that only a percentage would attend. One hundred percent of invited participants attended for the first focus group. Similarly, ten Network Controllers were asked to attend, and ninety percent attended (with experience across five businesses) on the day with one late withdrawal due to illness. This equates to a sample size of ten percent of Network Controllers and just over three percent of Faults Responders. This is considered a representative

size which provides confidence in the information gathered for the research to answer the research question (Marshall, 1996).

All contributing companies and participants completed written consent forms prior to any focus group discussions, or submission of documents for analysis. In line with ethical requirements all participants had the right to withdraw their participation from the study at any stage. No reason was required for withdrawal however, if the withdrawal was after data had been collected as the information provided was anonymized contributions would not be withdrawn. No participants withdrew during the research process.

Table 3. Population and Sample size

Population	Sample size	Participants per business	Actual focus group size
27 EDBs	5 EDBs	2 participants each	1 meeting 9 participants
10 Contractors	5 Contractors	with 5 + years' experience	1 meeting 10 participants

Given the variable business models ten would cover the contracting businesses significant enough in size to have been awarded a faults contract. Although there would be hundreds of contractors who perform work on the twenty-seven EDB's they would mostly be engaged in primarily planned work, not fault response work which is the substantive portion of night shift work.

The organisational and participant involvement in this study has been anonymized. Participants have been given pseudonyms to protect their identify in line with the ethics requirements. They are shown in the table (Table 4.).

Table 4. Participant Pseudonyms and Experience

FG FR	Pseudonym	Experience (years)	FG NC	Pseudonym	Experience (years)
1.	Fred	15	1.	Chris	7
2.	Ian	6	2.	Arthur	35
3.	Scott	20	3.	Jack	6
4.	Richie	12	4.	Jordie	22
5.	Wayne	18	5.	Graham	7
6.	Jamie	30	6.	Laurie	13
7.	Aaron	15	7.	Bryce	3
8.	Charlie	5	8.	Eric	4
9.	Leon	15	9.	Ivan	7
10.	Clark	25			
Total		161	Total		104

Methods

A qualitative research design comprising semi-structured focus group discussions and document analysis was used. Focus groups and organisational documentation created spoken and written words which were converted into data – this is in-keeping with a basic definition of qualitative research. (Braun & Clarke, 2013).

Focus groups.

The focus group discussions were held across two successive days on the afternoons of the 26th and 27th of July 2022 for one and a half hours each. Each was undertaken using the Microsoft Teams platform for video conferencing due to the pandemic environment. This option also reduced the cost of travel for the participants and the researcher.

Focus group discussions were facilitated using pre-defined questions to extract information from participants that was directly related to the research question. The questions and use of the focus group itself enabled experienced participants to express their experiences and opinions. (Braun & Clarke, 2013). Most (eight out

of ten) of the preliminary questions asked in the focus groups were the same as the tried and tested questions in the Massey University Sleep/Wake Research Centre study of fatigue in the aviation industry (Van Den Berg, Signal, & Gander, 2020). This gives the primary question set in this research more validity because it was used successfully in previous research on the same topic in another industry. The questions acted as “prompts to elicit general discussion” (Braun & Clarke, 2013, p. 117).

The questions used are outlined in Table 5. There were also prompts and/or supplementary questions which were created by the author informed by operational experience in the industry and literature review. The full list of questions is available in appendix A. Focus Group Questions

Table 5. Primary questions which guided the focus group discussion

Question 1.	When you think of fatigue, what comes to mind?
Question 2.	When you are at home what makes you feel fatigued?
Question 3.	When you are at work what makes you feel fatigued?
Question 4.	How does fatigue effect you when you are at home?
Question 5.	How does fatigue effect you when you are at work?
Question 6.	Are there safety related tasks at work that are affected by your level of fatigue?
Question 7.	How do you currently manage your fatigue at home?
Question 8.	How do you manage your fatigue at work?
Question 9.	When you started did you get any advice from work or colleagues on how to cope with the demands of nightshift, and what was it?
Question 10.	If you think that fatigue is a safety concern at work, what do you think could be changed?

The skill of the facilitators (researcher Matthew Sadgrove, and Professor Joanne Crawford) drew out participant contributions. These contributions (experiences and opinions) provided the data to answer the research question. (Seale, 1999). As well as individual contribution, group interaction during the focus groups was actively encouraged giving further depth to the narrative. Through interaction,

participants were able to explain in more detail their opinions and experiences – and through conversation created more data for analysis. (Barbour & Kitzinger, 1988).

Best practice approaches for the design and conduct of the focus group (Kruger, 2002) were applied. The subjectivity of the facilitators added value to the focus group process. With a considered qualitative approach “our humanness, our subjectivity, can be used as a research tool” (Braun & Clarke, 2013, p. 51).

Focus groups are flexible as a method, enabling the facilitator to adjust the pace, questions, and other elements of the methodology to fit the attributes of the research. As a research technique the two focus groups enabled the gathering of comprehensive data sets and offered unique advantages in the ability to transfer findings. (Fern, 2001) (Barbour R. , 2007).

Documents

Documentation relating to fatigue management was requested from the participating companies. No specific type of documentation was prescribed so that the companies had a broad scope and could supply a range of documentation they perceived as relevant.

Fifteen industry documents for the management of shift work and related fatigue were submitted from eight organisations within the electrical distribution industry. The purpose of requesting documentation was to analyze whether fatigue safety risks have been identified and management approaches outlined.

The fatigue documentation submitted for review included a variation of structures.

- four policies
- four standards
- two procedures
- one plan
- one checklist
- one guideline

- one alert
- one manual extract

Analysis methods

The focus group audio recordings were orthographically transcribed (Jefferson, 2004) by the researcher. Every effort was made to capture “all verbal utterances from all speakers” (Braun & Clarke, 2013, p. 178). There were no corrections for slang into standard English and the audio was not cleaned or edited which would alter the perception of the participants and their contributions. Punctuation was used in the transcripts after checking the audio for intonation and language use (Sandelowski, 1994) because in New Zealand, people speaking English lift the pitch of their voice at the end of a sentence as they ask a question which creates emphasis on certain words (Britain, 1992). Once initially transcribed, the transcripts were cross checked against the audio recordings and corrected where needed, then the transcripts were anonymized by removing the names and replacing them with synonyms. Names in text were replaced with (Name) and company names were removed and replaced with (Company) additionally any mention of a geographic location was replaced by (Location). All the above activities during transcription added to the familiarization process. Participants were given copies of the transcripts as per their request on the consent form.

The documents were already in written form and so were able to be analyzed directly.

Reflexive thematic analysis using NVivo software was undertaken on the documentation and the focus group narratives. This followed a period of familiarization which was an active process involving “reading the data as data” (Braun & Clarke, 2013, p. 220). After familiarization of the data these data sources were manually coded then auto coded using NVivo software which led to the establishment of themes, main themes, patterns, and relationships of themes within the data. Thematic analysis itself is a flexible methodology which has

advantages however, being 'phrase based' the intended meaning in the text can lack coherence when developing themes (Holloway & Tordes, 2005).

Understanding the multiple layers in the data captured was incredibly important because, language shapes reality and words create worlds (Heschel & Heschel, 1996). The identification of human qualities or facets that related to the research question were manually identified in the focus group transcriptions and then using sentiment analysis in the NVivo software coded appropriately. Likewise, the instructional language present in the documents provided by industry for the research was also coded. This involved identifying the emphasis used in the written and spoken word and for thoroughness a combination of selective and complete coding was used in this research. With selective coding, nodes were defined based on sleep -further separating the data with consideration to sleep duration, sleep environment, and sleep quality. Complete coding enabled the inductive identification of patterns, groups, and themes from the bottom up by arranging the data into increasingly more abstract pieces of information (Creswell & Creswell, 2020). In doing so, the perspectives of participants and as articulated in the documented data sources and supported an understanding about whether the electrical distribution industry is in fact managing the safety risks associated with night shift and fatigue and to what extent this is being accomplished.

Rigour/validity strategy

Although dispute exists about validity as a concept in real-life studies (Cypress, 2017) it is often seen as a strength in qualitative research (Creswell & Creswell, 2020). Terms like credibility, trustworthiness, and authenticity are representative of validity (Creswell & Miller, 2000). The approach to the research used multiple methods to enable triangulation of information sources and ensure validity and "maintain standards of scientific inquiry" (Bowen, 2005, p. 214). (See diagram 4 below)



Diagram 4: Triangulation to ensure validity and reliability

The study was evaluated and given approval by the Victoria University Human Ethics Committee. Application ID #30379. Table 3 outlines the ethics consideration for this research.

Table 6: Ethical Considerations

Risk of harm	This research involved interviewing people. For this, standard ethics approval was required. The potential harm to participants was minimal but could have included stress or psychological harm if participants had perceived the interviews to be threatening. There was also minimal potential for harm to the research because all focus groups were conducted using technology in workplaces. During the focus groups, the rights, needs and values of the participants was at the forefront and considered (Merriam, 1988).
Consent	All participants were required to provide written permission to proceed with the study. This consent could have been withdrawn at any time without need for a reason. The participants comment during the focus group cannot be attributable to them, as it is anonymized, meaning that while they can withdraw consent at any time, their contribution cannot be withdrawn. Participants were informed of all recording devices. Transcriptions have been made available to the participants
Confidentiality	Participants names are absent from the study; additionally, the participating organisations names as contributors are hidden and this will not affect the acceptance of the findings by the industry. This research did not require commercially sensitive information to be disclosed
Anonymity	The research is about the electricity industry and was conducted by gathering the views of people within the industry. Naming participants adds no value to the research. No participants names or their industry affiliation can be connected to responses and narratives collected.

FINDINGS

“It’s as simple as that, if you need help, please ask.”

The coded data supported the identification of clear themes. These are in numerical order and have been sorted into Demings’ P.D.C.A. management cycle, which is part of the conceptual model underpinning the research. This provided a framework that enabled an evaluation in which themes were used to answer the research question “To what extent are the safety risks associated with night-shift work managed in the New Zealand electrical distribution industry.”

Identified themes (numbered, 1-14) are named, defined and, in some cases broken down into subthemes (alpha numeric a, b, c) that support the main theme.

Plan

These themes are about identifying and understanding the problem and planning the action.

Theme 1. Hit the ground stumbling - *Company information and expectation about fatigue management was not well communicated.*

Subtheme 1a. *No evidence of an induction to working nightshift.*

Jamie, the most experienced worker in his focus group reflected that *“In the early days there wasn’t any real briefs about it you were just like if you were tired be careful when you drive home, um you know it was pretty raw, and if your line of questioning is should there be some better understanding about fatigue and tiredness and the difference between the two then most definitely there should be.”*

To see if this was just an isolated case, the second focus group was asked “what was covered in your induction in relation to your role on night shift if anything?” *“nothing”* was the overwhelming response of the network controllers focus group. The response did not refer to night shift, its effects, how to set up a good sleep environment, or what fatigue was, but to no induction being provided at all.

Safety inductions are highly effective in reducing unsafe conditions (Aksorn & Hadikusumo, 2010) and support hazard identification and the utilization of the hierarchy of control. “Properly managing fatigue in a high-risk environment typically involves multiple levels of control, implemented with strong education and training” (Sawatzky, 2017, p. 45). Education and training start with a structured induction process, as demonstrated in other industries, who work a night shift such as nursing. It is through the provision of information and the setting of expectations that awareness is increased and capability built.

Subtheme 1b. No mentoring into night shift; a cope or fail mentality.

When asked whether work had provided any guidance on how to manage fatigue Wayne said “*Basically, find your own way*” and Laurie confessed when asked if he got any advice from work colleagues on how to cope with the demands and what was it “*I just got told harden up*”.

This “thrown in the deep end”, “sink or swim” or “hit the ground running” attitude is not new for occupations in New Zealand where the work is considered dangerous and difficult. A qualitative study within New Zealand focused on graduate nurses (Cracknell, 2018) found that not only did the education system for nursing not offer adequate preparation for nurses who opt to work in mental health but that the principal issue was graduates working in mental health continue to have negative experiences and feel thrown in the deep end. Not prepared for the work environment or the workload. The feedback from the focus groups would suggest the same is true for Faults Responders and Network Controllers in the electrical distribution industry. A systematic review and meta-analysis study identified fatigue training as having a favourable impact on both patient safety and shift worker safety (Barger, et al., 2018) and therefore training and support may be a valuable control in the electrical distribution industry.

Thrown in the deep end appears to have become the norm for this industry. There has been a normalization of deviance, or otherwise a conformity through socialization (Hollinger & Clark, 1982). Graham another very experienced worker who had transitioned into managing Faults Response said, “*You are either built for it or you aren’t*” which seemed to be a common feeling, amongst the participants of both groups, the sentiments expressed reflected a view that individuals were

different in a special way (supermen) if they could cope. However, being able to perform work during normal hours of sleep does not demonstrate immunity from the health and safety effects of a disrupted circadian rhythm (James, Honn, Gaddameedhi, & Van Dongen, 2017) and may indicate either a constrained awareness of, ability to, or willingness to, self-identify fatigue during the work.

Theme 2. Dazed and Confused - Fatigue documentation contains vague or ambiguous information that is sometimes contradictory.

Some of the documents obtained from industry participants were voluminous (seventeen pages) and contained confusing, inconsistent, and ambiguous instructions and information about various elements – including working and resting hours. The documents used phrases including ‘shall’, ‘should’, ‘may’ and ‘need’, ‘require’ and, ‘responsibility’, with no clear indication of the definition or hierarchy of these terms for the reader. For example:

“This form shall be used to record any approved departure from the Working Hours set down in this policy”.

“Where it can be foreseen that it will not be possible to complete work within the recommended times, either the Line Manager or the Fault Coordinator should be contacted ahead of time to make a decision on the most appropriate course of action”.

“Workers shall inform their supervisor/manager or appropriate personal immediately if they themselves or anyone else within their team are suffering or are perceived to be suffering from the effects of fatigue”.

“In the event an employee reasonably believes they are unfit for work due to fatigue, either from extended work hours or out of work factors, they should report this to their Manager/Supervisor immediately”.

“Emergencies arise from time to time and workers may be required to work extended hours to either.

- Ensure public safety,
- Restore the network, or
- Support the restoration process”.

Richie a network controller with over fifteen years' experience expressed his concerns about procedures not being easy to follow (ambiguous) and therefore interpreted in a particular way, or manipulated, when the need arises *"[...] it is all good and well having all these fancy fatigue management policies but implementing them is another story. When the heat comes on management tend to put the rules on the back burner and use bullying tactics to force staff to into working over their hours"*.

In the document review, of the eight companies across New Zealand that provided fifteen documents, there were six different definitions of fatigue across the eight businesses, and two companies that had no definition for the term at all in the fatigue documents they provided. One document contained several sentences that started with *"fatigue is..."* and had four different descriptions written within the one document. None of the documents provided mentioned specifically that fatigue had safety implications. However, focus group participants identified their mental, physical, and emotional state as *"highly important"* to safe outcomes, also acknowledging *"It doesn't matter who you are or what you are, if you are fatigued and that it has to be as your first and foremost thought especially for the guys in the field"* this however in both instances requires self-recognition. It is well documented by sociologists that people are not equally proficient at observing, understanding, and interpreting their own behaviour and the behaviour of others (Jackson, 1970). In the document review only two documents inferred a reduction in functional capacity from being fatigued. "Fatigue is a series of symptoms (e.g., sleepiness, forgetfulness, lethargy, apathy, irritability) accompanied by a progressive decline in a person's functional capacity" Secondly, "Fatigue is...it can reduce a person's capability to an extent that may impair their strength, speed, reaction time, coordination, decision making or balance".

Theme 3. Words create worlds - Controls in company documents centre around restricting work time and mandating breaks and are worded in a way that allows for multiple interpretations of these controls.

Most of the documents received referenced the Land Transport Act 1998 as a guide for hours fatigued "In any cumulative work period, a driver may not exceed seventy hours of work time" (New Zealand Government, 1998). Not all Fault

Responders and no Network Controllers are required to drive a heavy vehicle for work. There is no evidence that a requirement to abide by a rule meant for long haul freight operations is either useful or appropriate in managing fatigue in the electrical distribution industry and specifically activities not covered by this legislative requirement. Examples of the differing instructions in respect of working hours include:

“Maximum workday 14hrs in 24hr period”

“Maximum workweek should not exceed 65hrs per week over 4-week period”

“No employee should exceed 780 working hours over 12 weeks period”

“Where an Employee has worked (means physically attending work) 72 hours in a 7-day period they must be stood down for a rest day (24 hours)”

“A worker may work up to 6 hours of planned overtime per day (14 hours total), providing that total working hours do not exceed 70 cumulative hours before having a 24-hour break”.

Inside the submitted documentation there were additional allowances for eighty-four-hour weeks and sixteen, or eighteen-hour days if needed for emergency work. With multiple references to fatigue and fatigue tolerance being different for everyone, yet no mention of how to measure fatigue or fatigue tolerance. For example, one document stated, “Individuals have differing capacities to work extended hours due to individual fatigue tolerance” combined with comments like “Managing fatigue does not mean employees must never work extra hours”.

Despite the intention to keep workers safe, most of these restrictions are either explicitly or implicitly able to be manipulated to enable double shifts, which is what happens when there is the need for the essential restoration of power. If these restrictions on hours as outlined in the Land Transport Act were enough to reduce or control fatigue risk, then the trucking and freight companies they were put in place to protect would have stopped looking for further ways to identify and reduce the effects of fatigue. Instead, they have utilized technology with cameras monitoring and detecting yawning, blink rates, eyelid closure - and using vibrating seats and audible alarms to notify the driver often accompanied by a phone call that they need to pull over and rest.

Limits or restrictions on hours can be ineffective in creating the desired outcome – like limits on road speeds are (Kempa, 2019). The seventy-hour working limit could be seen as a target not a limit or could be abused or disregarded dependant on the risk tolerance of the organisation. Limits could also be missed if the requirement is not communicated, or the communication is ambiguous leading to workers thinking it doesn't apply. Irrespective of how it is interpreted within the documentation, the fact that there are multiple ways to do so was irrefutable.

Theme 4. Tell me how you feel - Company intervention is largely reliant on self-management and self-recognition of fatigue

“You are required to keep track of your own working hours and must report to your supervisor if you feel fatigued”

“Workers shall inform their supervisor/manager or appropriate personal immediately if they themselves or anyone else within their team are suffering or are perceived to be suffering from the effects of fatigue”

“We all have a different tolerance for fatigue and as a company, and as individuals, we must manage fatigue”.

A study into whether nurses can self-assess in relation to being fatigued (Cochran, Letvak, McCoy, Bacon, & Karper, 2021) found almost half (forty six percent) were not able to accurately self-assess fatigue. Therefore, making it unrealistic to expect nurses to do so and a poor control. Self-assessment is therefore unreliable as a control in nursing, a discipline where there is a greater awareness of, and training in, anatomy and physiology and the biological signs and symptoms of fatigue. Therefore, self-identification should be considered unreliable in the electrical distribution industry as a management control given the translatability of these findings.

Theme 5. Documents that shout – A large percentage of company documents are written with a majority negative sentiment.

All fifteen documents provided by industry were put through the sentiment analysis functionality of the NVivo 12 software. The below findings show a clear difference between the amount of negative to positive references (examples) found in the text.

- Very negative sentiment in 11 files with 75 references
- Moderately negative sentiment in 16 files had 367 references
- Moderately positive in 15 files with 175 references
- Very positive in 7 files with 20 references

The context of this theme sits inside the functionality of the NVivo software and its sentiment analysis. It is the process of discovering emotion in text and is a technique used to understand the emotional tone.

Examples of negative and positive sentiment found inside the text of the provided documentation are below:

Negative – “This process should be initiated during the planning phase and may include, but should not be limited to [...]”

Positive – “The responsible manager identifies the risk in consultation with workers as appropriate by considering [...]”

The theme title “Documents That Shout” is a reference to the forceful command-and-control type language and prescriptive rules used by companies in their documentation. This reflects the business trying to exercise control and reduce the occurrence of fatigue. This usually takes the shape of restricting the hours and worktimes with absolutes (ceiling limits) to ensure the opportunity of rest and sleep and therefore recovery. The problem with this is outlined in theme two “Dazed and Confused”. If the language is inconsistent or ambiguous in an attempt to have rules, but enable flexibility where needed, it is not easily understood. Furthermore, if the intended audience feels it is being shouted at or controlled in an inconsistent way, it can limit the absorption of, and confidence in, the message. If rules can be broken then they are not rules, they are only guidelines.

“Documents That Shout” also reflects industry maturity in that the control of fatigue within the business may not have evolved into an opportunity for worker participation. When worker participation is done correctly it is a great way to overcome potentially undiscovered overt or passive resistance within the work force, and to ensure that the intended messages are clear, consistently interpreted

and understood. (Walters & Nicholas, 2006) (Walters, Quinlan, Johnstone, & Wadsworth, 2016).

As well as differing interpretations of the rules by workers, participants noted individual managers interpretation of the rules was variable and based on their backgrounds and experience. Leon shared *“I do feel there is some management that do not have a background of being a fault man or doing shift work. They don’t always understand where we are coming from, they have their targets [...]”*.

Participants shared that they preferred supervisors/managers who could read through the confusion created by the documented language and interpret the rules in a way that enabled the best thing for the people they managed, demonstrating care rather than resorting to blame. Ivan noted how his business tried to understand storm events *“[...] after a storm though we have a meeting and pull it to bits and say how many mistakes did you make”*. Highlighting how the command-and-control type language in the documentation seems to shape negative low trust conversations.

Theme 6. A hard day’s night - balancing expectations at work and at home

Leon shared that the demands and timing of the job don’t necessarily fit in with the needs of the family or his own needs of sleep and recovery *“[...] last night we did a fifteen-hour shift and got home an hour before my boy was supposed to get ready for school so, you just need to do it and live on four hours”*. Although the safety connection of this theme may not be obvious on the surface, it is a direct reflection of the workers reality and follows the conceptual model. Night shift is a work environment that creates fatigue, the inherent safety risk in the work plus fatigue equals potential human cost through safety impact. Health & Safety are related, “Healthier employees result in fewer health claims, better safety records, and greater productivity. Well-rested, alert employees are critical to safe and productive operations” (Lerman, et al., 2012, p. 231). If you are not healthy, you can’t be safe, if you aren’t safe, you can’t be healthy.

Jordie shared his perspective as a caring father about trying to balance the needs of the family around shift work *“If you have done eighteen hours you just want to*

sleep, but the kids haven't seen you for eighteen hours they want to play with dad". This theme/phenomenon was evident in a study conducted on German police in the nineteen eighties that found sixty to eighty percent of those working shift stated they did not have enough time to take part in family life and other social activities (Knauth, Eichorn, Lowenthal, Gartner, & Rutenfranz, 1983).

Laurie a network controller with thirteen years in the role expressed the expectation at home he placed on himself to contribute to the home environment *"And then there is the general household stuff you need to do [...] if you don't get done then takes a mental toll [...] it needs to get done so then you sacrifice sleep for that [...] the family and day to day tasks take a toll while you are at home"*. This contribution highlights a juggled duality in the balance between being a provider and the expectation to contribute to the home environment including social time against the biological need for sleep. Relationships, especially those with a shift workers children have been shown to suffer through a reduction in common time together (Nachreiner, Baer, Diekman, & Ernst, 1984) (Pietch & Oginska, 1981).

Laurie seems aware of his plight further sharing his motivational drivers together as *"I stay active when I get home because I want to achieve things, but then I guess that circles back to not getting enough rest for work"*. Although the reach of a business outside its gate to influence health and safety behaviours is minimal, a happy social and domestic life is a significant foundation for good mental health and therefore a critical piece in the puzzle of safe outcomes. As such relationship demands can lead to a shift worker to organise their daily routine with an unhealthy tilt, putting their own health needs second to his family's needs as the contributions above have shown. With little to no structure in place to encourage/influence/manage workers to do otherwise, the industry is not managing the state of its people and how external factors effect internal performance.

A large proportion of the current research highlights the physiological effects of shift work however shift work also includes substantial social desynchronisation, involving working on days and at times that can make it tough to preserve a balanced home and social life in an effort to achieve a work life balance (Mott, Mann, McLoughlin, Warwick, & Abor, 1965). Being present, having clarity of

thought and being mindful of the task in front of you is a significant contributor to achieving a safe outcome (Kao, Thomas, Spitzmueller, & Huang, 2021). Working in a fatigued state inhibits your ability to be present or have the clarity required which can result in a safety incident. Hence, there is an obligation to protect people “outside the gate” although it is a shared duty. The June 2022 prosecution in Australia, *Martinca vs Coalroc* highlighted what was expected when the Judge confirmed the company Coalroc Mining Services had a duty outside the gate (Fowler, 2022) and awarded one point one three million dollars after a single vehicle accident even though the plaintive had some responsibility. The Judge stated “The common law test is to ask whether work induced fatigue caused or materially contributed to the accident” which looks to set a precedent for shift work related fatigue and the requirement for companies to take responsibility outside of working hours and may be the start of a broader responsibility for Person Conducting a Business or Undertaking. Jamie a thirty-year veteran with twenty years faults experience and now in faults response management reinforces the idea the people inside of work have obligations outside worktime which influence work behaviour “[...] *other guys with young families and pressures at home and that’s a dramatic strain on fatigue wise. They have got more than one thing they are thinking about, absolutely*”.

Do

These themes are about implementing the action.

Theme 7. Shaped by Osmosis – *Experience and awareness of fatigue is shaped through time in the role.*

Subtheme 7a. Discovery of fatigue through experience

Clark a Faults Responder with over twenty-five years’ experience divulged his experience “*When you’ve done a lot of hours and you’re starting to think things are taking longer than they should for you to come up with answers then it’s time to go home. Whether you’ve done your hours or not it’s time to go home cause that’s when you’ll make a bad choice*”. Clark also stated when asked if he had ever felt irritable, chronically tired, or sleepy at work “*I would pretty much guarantee everyone here has felt chronically tired at work [...] I would say relatively regularly [...]*”.

Sleep (duration and quality) directly affects how we think and feel (Suni, 2022) and, sleep deprivation impairs short term memory (Chee & Chuah, 2007). Eric a Faults Responder who also has shift work experience in other industries attests to the onset of forgetfulness, he added *“Yeah, double-checking things cause short term memory has gone you’ve done it, then you drive away and think, fuck did I do that. You stop turn around, go back, yeah, I did do that, but you have no recollection of having done it. So it is that double checking yourself or putting things down not remembering where you have left them. Yeah, short term memory is my one when I start to get fatigued”*. Worsening memory is a known symptom of sleep deprivation. Eric while on shift, works a full day and is then also available for after hour call outs on demand as needed. This requires long days and/or interrupted nights meaning he has lengthy duty periods which have been shown in utilities to be associated with performance declines (Rosa & Bonnet, 1993).

Shift work disorder or shift work sleep disorder is a condition that largely affects those that work night, early morning, or rotating shifts. It can cause excessive sleepiness while at work and result in microsleeps. Microsleeps are short periods of sleep which are measured in seconds, normally fifteen second or less (Summer, 2022). Micro sleeps most frequently occur after sleep deprivation. Because of this people working shift patterns often experience micro sleeps. When the focus groups were asked if they had ever noticed themselves having microsleeps at work the responses was unanimously yes. Aaron a seasoned professional of fifteen years said *“All the time, all the time. You are fine at the job and then driving home and even just one or two jobs say through the week at two or three am definitely by the time I’ve got home I won’t recall the drive home. It is quite common”*. Eric recanted his experience and the effects a reduced capacity had on him in the field on faults *“I think the worst part of that is you feel you might have missed something although you didn’t, but you were so doing it as a normal routine you don’t even notice what you are doing [...]”*. Fred shared an experience which shows self-recognition and compensatory measures undertaken by individuals in a fatigued state to get the job done when asked about noticing micro sleeps at work.

“Yeah, I will say if I am switching at the end of the night, and I’ve had a massive night and it’s a complicated switching. I’ll look at my switching, I’ll look at the switch, then look at the switching, then look at the switch. Yes, I’ve done it, but I mean it is either do that or blow something up”.

Micro sleeps and the reduction in functional capacity has safety implications. This is evidenced in many other industries, “air or ship traffic control and long-distance driving, as well as patient status monitoring in intensive care units, are examples where failure to detect, register, and process visual information as a result of sleep deprivation may have disastrous outcomes” (Chee & Chuah, 2007, p. 9487). Network controllers and Faults Responders could be added to this list of professions in which failure to detect, register or process information could be catastrophic.

Subtheme 7b. No education on sleep hygiene - duration, environment, or quality

Participants described sleep quality as “*diminished*” “*deprived*” “*rat shit*” and “*poor*”, while sleep environment was described by Aaron as “*terrible*”. For context Richie added “*I’ve got to be off for at least three days before my pattern comes right*”. “*No*” was the only answer that came back when asked if the participants had been given any guidance or advice on staying alert during work and “*no*” was also the majority response when asked if they had had any advice guidance on sleep quality. Participants shared self-researched examples of their methods to improve sleep hygiene, duration, environment, and quality, which included black out curtains, ear plugs and a hot shower before bed to unwind. These were learnt through individual experience and trial.

Theme 8. Not all roads lead to Rome - No agreed standard practice for shift patterns/hours/manning in Network Control or Faults Response

Private forums exist on the EEA Knowledge Network called the Collective Network Operators Group (CNOG) and the North Island Network Operators (NINO) for the sharing of shift patterns and what works best, along with incidents. Any incidents or information relating directly to fatigue in Network Controllers could be shared on these private forums. Arthur a very experienced Network Controller shared his

perspective. *“The problem I have got is taking in the whole concept New Zealand wide and even with NCOG and the regional controls, why we are not working the same shift patterns to co-ordinate with one another, everybody should be talking in this distribution outfit of the effects of the different shift patterns”.*

Data collected in the focus groups highlighted two neighbouring networks had tried backward rotating shift patterns (two nights then two days) independently with negative results, only to revert to what they had done previously (two days then two nights) after a short period. One business tried this shift on the back of a recommendation from a staff member who said it was better even though research existed to the contrary stating a backward rotation schedule as being associated with an increased need for recovery and poor overall health as compared with a forward rotation schedule (van Amelsvoort, Jansen, Swaen, van den Brandt, & Kant, 2004). Arthur recalled *“[...] within about four weeks the guys were that bitchy between one another. They were starting to fight between one another, and we said that was the end of it. We just through it out the door and went back to the two days two nights and been there ever since”.* The company he worked for hadn't shared its experience or findings with any other network. WorkSafe within their guidance recommends roster shifts to be forward-rotating where reasonably practicable (WorkSafe NZ, 2021).

During the focus groups there were many conversations about staffing (manning) approaches - single person faults response, double crewing, single network controllers on duty and multiple person configurations, tasks undertaken like switch writing only during certain times of the night and stand down shifts of daytime work only for varying set periods. There were various models and practices within the participating businesses with no agreed view on best practice.

Theme 9. Living in the moment - Recognition of a different working environment in relation to time itself in Network control compared to other working roles

Chris shared his experience about the reactive nature of the work as a Network Controller in a fault situation where the nightshift is filled with time pressure and surprise. Chris stated *“I don't think people appreciate it but, control rooms work in real time. Real time situations, real time decisions, now, we don't have weeks to think about things or mull things over or anything. You have to respond*

competently in moments you have things unfold in front of you there and then and you have to respond there and then". There is a reduced ability to plan because of the variability of the assets, the situations and the people involved, no set playbook of things that might happen, and even where there is knowledge of potential events on the network, this does not help to prepare for either their location or scale (storm escalation). This means the work is undertaken in a chaotic context. Chaotic in this sense requiring the Network Controller to take totalitarian control, acting, sensing, and responding (Snowden & Boone, 2007) in the most appropriate fashion, with a view to restoration of the power. Planning is a key aspect of risk management, and, in this setting, it is reactive at best.

Check

These themes are about measuring performance against the plan – verifying and validating control effectiveness.

Theme 10. In my day... - *Network Controllers and Faults Responders perceive work conditions have improved over time*

Subtheme 10a. *Personal accounts of improvement in work conditions*

When asked if changes had been noticed in relation to the care expressed by the employer through better work conditions Laurie contributed, "[...] *it has definitely got better [...] ten years ago there was no capping on hours there was no monitoring of hours there was no nothing, just work till the job was finished*".

Wayne, with just under twenty years' experience in his role recalled "*back ten years ago I can remember doing twenty-four-hour shifts. Just seven in the morning to seven the next morning because that is what was expected, but things are definitely not like that now*".

Aaron, a line mechanic with a young family considered the change within his employer over the time while he has been on *faults* "*Like a few years ago we would work an eighty-five or ninety-hour week and you would come in on Monday and you would be told because you hadn't breached the (Company) policy at that stage you had to carry on working. If you wanted a day off you have to keep working or take sick leave, obviously, things have changed a lot now we have ten-*

hour breaks, twenty-four-hour breaks. So, fatigue honestly, I get more fatigued at home with my three kids than I do with faults”.

Aaron a line mechanic with a young family stated, *“Our cultures changed, like it used to be you weren’t entitled to a nine-hour break were as now there has definitely been a shift in acknowledging it rather than just telling you to harden up”.*

Subtheme 10b. *New legislation helped create positive change.*

When speaking about the driver for change Chris stated, *“I would say it really changed in the upper management in the companies when they became liable if anything could happen to the workers”.*

Aaron reinforced the opinion of Chris *“Yep a hundred percent that is when it changed for us when CEOs were held liable that is when rules and policies come in for sure”.*

This is internal recognition of external stimulus for change. An adjustment made through legislative pressure and the need for compliance, not a direct act of internal management. Research into legislative impact on health and safety injury rates however, specifically fatality rates, show no evidence of legislative impact (Lilley, et al., 2022).

Theme 11. The exception to the rule - The juxtaposition of self-perceived invulnerability and personal recognition of forgetfulness because of fatigue.

There is a case to be made that a good positive mindset to shift work is an advantage in coping with unusual working hours. In this case that could be referred to as hardiness (Wedderburn, 1995). Arthur a network controller who has worked shift work for most of his working life suggested you could develop a tolerance by indicating *“I can get away with three hours sleep in a twenty-four-hour period”* the science although developing to further understand sleep as a function better, would suggest otherwise. In fact, a report out of the National Sleep Foundation which looked to answer the question *“How much sleep do we need?”* (Hirshkowitz, et al., 2015) made recommendations across nine age groups, for young adult and adults the recommendation was seven to nine hours, for older

adults seven to eight hours. When asked how many hours sleep on average would you get? The average for all participants who choose to answer the question (seventeen out of nineteen) was six hours. Specifically, five point nine hours for Faults Responders and six point one hours for Network Controllers.

On noticing the effects of fatigue or potential consequences Aaron shared *“I have seen a lineman fall asleep while driving. Driving the bucket truck back from the (location) after a big day, and the weather was atrocious and yeah, we were driving along a big straight and he fell asleep. So, I had to grab the steering wheel and switch jobs [...]”*.

Participants shared experiences of seeing the effects of fatigue and exhaustion in others, yet statements built around their own ability to cope with fatigue and exhaustion on the job didn't reflect a perception of their own vulnerability to fatigue.

Fred expressed his opinion when he said, *“it is only a certain few that actually can handle it and carry on for the many years”*.

Graham disclosed when asked what his sleep quality was like *“Yeah, you can sleep when you die, that is what I tell the boys”*. A response again on the surface which could be taken as bravado, but in this context was more about the sacrifice made by Faults Responders putting other's needs, the requirement for electricity supply, above their own needs as individuals for good quality sleep.

The expression of outward confidence may stem from experience with large amounts of exposure to dangerous situations (working with energy that could change or take life), combined with the assumption that past success equals future success. This has been evidenced in combat experienced veteran soldiers who have higher risk-taking propensity influenced by successful missions and a desensitization from experience in life threatening situations. This has been suggested to be a major factor that could lead to increased risk-taking behaviour in individuals. (Ben-Zur & Zeidner, 2009). This can lead to workers not reaching out or asking for help because they are under the false impression everything is going to be just fine. The documentation analysed highlighted that communication is an expected action along with self-recognition, and therefore the efficacy of

these two controls is weak. Equally, the outward expression of confidence could reflect the vast experience within the group (two-hundred and sixty-five years combined) and the history of the role. Chris recalled. *“Back in the day, you had to wait for someone to die or leave to get onto faults”*. Historically being on faults was seen as a badge of honour and meant you would have the ability to substantially increase income being on faults was a sort after position. With such sought-after positions, it is unlikely workers would have jeopardised them by asking for help or changed working conditions.

Through the focus groups, there was a conversational undertone that demonstrated a devaluing of sleep, an over estimation of tolerance to exhaustion and an acute awareness of the need for the power/electricity to stay on. There was a perception that the needs of the customer and the business outweigh the needs of the worker. *“That is what I sometimes find it is unrealistic expectations by the public these days that electricity is non interruptible. You tell kids they can’t have internet it is the end of the world”*. This is also a feature of the documentation reviewed “You may be required to work extended hours from time-to-time” which is quite subtle compared to “Managers will [...] stand down any employees showing signs of fatigue from critical safety work and amend the work plan. The grammar in this sentence starts out prescriptive “will” but finishes with “stand down from critical safety work” so, this is still interpretable for managers to utilise workers who are fatigued for other work.

Theme 12. It’s tough but someone has to do it - The workload is physically and mentally draining, with long hours and variable management/worker relationships.

Subtheme 12a. A potential disconnect between management and frontline.

“I do feel there is some management that do not have the background of being a faults man or doing shift work, they don’t always understand where we are coming from... we just feel disconnected from them sometimes if we have raised issues”. Fred shared his opinion about the pressure currently to keep the power on “[...] part of that is the systems the government put in place. If the network has too much power off, they get in the crap, so stuff gets pushed down to the worker.

Whereas in the old days it would be like they are staying off for another day, you got to try your best to get everything back on”.

Subtheme 12b. Feeling of exhaustion

When asked how often they feel tired or fatigued veteran network controller Arthur responded “[...] *when I first went on shift was and sleeping during the day, you might get three hours sleep and then you have to do a twelve hour shift you know it is the environment around you at the time*”. Graham suggested “*well it is the pressure*” Chris said, “*Just knowing what you are facing every day*” and Ivan mentioned “*The monotony of writing operating orders and checking it*”.

Ivan added when asked Do you think the work is taxing or demanding either mentally or physically? “[...] *the amount of alertness that we should show even if we have been called out and you’ve only slept an hour or two. You should show an immense amount of alertness to handle these high-pressure situations, you never know what you are going into and that is really taxing mentally*”.

When asked How important would you say your physical and mental or emotional state is to safe outcomes Jamie said, “*highly important*” and when talking about the working environment as the conversation progressed in the network controllers focus group about how busy they are during the night shift Arthur verified “*We are busy the whole twelve hours because we are writing the switching, taking the phone calls, everything*”. Richie clarified in the conversation age was a factor in recovery “*One small contributing factor to, is age. I found from thirty to forty your recovery time is a lot slower*”. When asked if they had ever fallen asleep at work, three answered yes in the network controller focus group.

The nature of the work has led the workers in both focus groups to add naps into their routine when they can to cope “*When I’ve been coming back from a job I’ve stopped and had a sleep* “. Clark added in when asked about sleeping at work. Aaron confirmed he had also used a nap deliberately at work to help recover “*I’ve only ever fallen asleep intentionally, when I’ve been waiting for a sucker truck to dig out a hole*”. Research results are mixed on the efficacy of napping on fatigue, but napping is recognised as a fatigue countermeasure that may reduce, and under certain conditions reverse, the effects of sleep loss in aviation and other

industries (Roach, Darwent, Sletten, & Dawson, 2011) (Bonnet, 1990) (Dinges & Broughton, 1989) (Driskell & Mullen, 2005) (Faraut, Andrillon, Vecchierini, & Leger, 2016).

Some but not all Network Controllers stated that mentally taxing tasks like writing and checking switching logs should stop part way through the shift and that they should go into monitor mode which allowed for rest, but this process was not formalised. Chris stated *“What we decided on our control room Matt is that we would not write switching after two am in the morning, would not write or check. Cause it seemed, no matter how warm the room was your actual body temperature drops. So, once that happened, and that happened for most of us around two-three o’clock. So, we would stop writing and checking and we would just go into a monitoring mode in which you could put your chair back and just, you don’t sleep its not to sleep, just dose”*.

Only one business supplied resources to enable naps, but there was no formal guidance or instruction on use. Network Controller Bryce said, *“so in (Company) [...] you are offered, there is a mattress in there, but we are sort of the same thing, after two o’clock we do have that option, they (management) are not against it, but it is more of a lie down and not a sleep just causes of alarm and that and just being aware of anything”*.

This act of napping was not endorsed by management as a coping mechanism as seen at the end of Fred’s admission to sleeping at work to cope with fatigue *“I have had a snooze in my Ute while I’ve been waiting for traffic control and everyone to turn up because you know they are going to take ages and you can’t do anything. You got to stay onsite so why not have a sleep. Like a big car v pole site on a state highway once you start going you are not going to get another rest, but you don’t really sleep. You get about half an hour maybe, you keep waking up because you think oh, they are going to catch me asleep”*.

Act

These themes are about adjusting and improving based on the information gathered in the check phase.

Theme 13. Less is less - *There is a skills/people shortage.*

When the group was asked about the physical demands of the work the conversation turned to a shortage of manpower, Laurie confirmed the comments of another fault's responder with *"[...] the shortage is putting a lot of pressure on a lot of people to do over and above what they should really be doing to be honest. They shouldn't be doing sixteen hours, no one should have to be doing sixteen hours."* The shortage of Faults Responders is not a surprise as New Zealand immigration have identified electric line mechanics as an occupation on their long-term skill shortage list since 2014 (Immigration New Zealand, 2022). Network Controllers stated a combination of better maintenance of the network (which included tree clearing around lines) and increasing staffing capacity would be good solutions to the skills shortage. They stated these actions would both lower the occurrence of outages and therefore workload, the help to sharing the workload that remained.

Chris shared *"I tell you what the one thing that really helped us out was when (Company) increased its arborist teams and really got stuck into the trees around the feeders"*.

Arthur's input was *"the easiest answer and the hardest answer is staffing levels"*.

The most common answer for Faults Responders was more people to either double crew faults response or to have specific day time and night-time only shifts. Scott suggests *"it is a no brainer, day-time workers and night-time workers is the only way you could do it"*.

Night work should be "reduced as much as possible" (Knauth, 1996, p. 39). Older studies such as (Wilkinson, 1992) suggest permanent night shift is better for safety outcomes given the adaptability of people and the potential to adjust however, (Folkard, 1992) in the same journal makes light of the sleep deficit risk to attention on the last shift of permanent nights and additionally the social disconnection. A need for more research is often parked inside the conclusion of fatigue studies (Knauth, 1996) (Techera, Hallowell, Stambaugh, & Littlejohn, 2016) (James, Honn, Gaddameedhi, & Van Dongen, 2017).

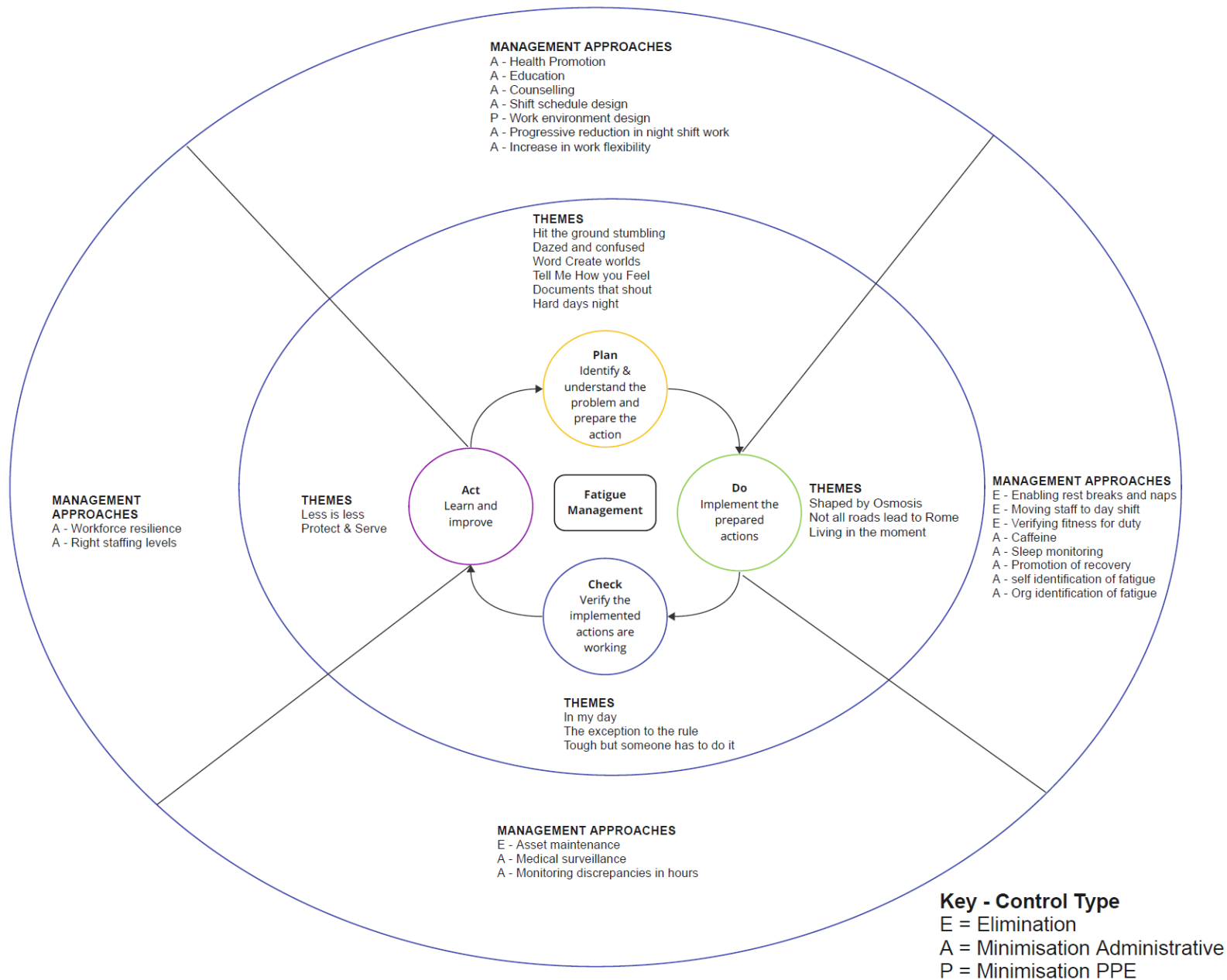
Theme 14. Protect and serve – we look after our own.

Chris recalled *“I know that I had one staff member who had been working on shift for quite a number of years. Things started to go a little bit pear shaped at home, um to the extent that he came in and said [...] I don’t want to be alone by myself can I just do day shift? We had to do that for several months and things came right at home for him, and again it is just that fatigue and constant expectation of the job just doesn’t stop, it is always in front of you”*. This protective nature expressed in the focus group as the network controllers being conscientious in the absence of leadership is worker lead not management led control. This is a real-world example of filling a management void and closing the gap between work as imagined and work as done. The same sentiment of care exists within the fault’s response as Scott noted about whether he felt supported in raising issues about fatigue to management *“[...] if senior management said, ‘no you can’t do that’, it would bother me. I’d make the call and stay by the team”*. This brotherhood created through a shared experience of high-risk work and joint sense of purpose in *“keeping the power on”* for both Faults Responders and Network Controllers was evident in the focus group conversations

Summary of findings.

Diagram 4 outlines the 14 themes identified in the research, and the associated management / control techniques identified in the literature review. This highlights how the themes align with the PDCA cycle, and how best practice controls are reflected in the identified themes.

Diagram 5. Themes and management approaches as they relate to the sections of the PDCA cycle



Discussion

“It’s absolutely fatiguing because you are working against you own body clock”.

The objective of this research was to discover to what extent the safety risks associated with nightshift work (fatigue) are managed in the New Zealand electrical distribution industry.

Summary

A Faults Responder in the electrical distribution industry is exposed to multiple energy sources that can change or take life, every day. Working experiencing the effects of fatigue created by nightshift exacerbates the potential for harm. A Network Controller is directing Faults Responders in their activity during nightshift so their actions can negatively affect the safety of others, and a Faults Responder is working physically with energy sources, interpreting the directions of the Network Controller, and making in the moment decisions which could impact their lives and those near them.

Management of safety risk associated with nightshift.

This research has identified that the controls for fatigue in the New Zealand electrical distribution industry are predominantly administrative. While this is in line with the guidance and direction provided by representative bodies and available regulatory information on fatigue, it does not mean that fatigue risk is well controlled. Administrative control is at the bottom of the hierarchy of control and therefore has low efficacy. The causative factors of fatigue, and the impact of nightshift in the work of Network Controllers and Faults Responders specifically is not well understood by the industry, and therefore this has compromised the ability of the industry to define, implement and monitor effective controls.

This is not a surprise as fatigue is an issue which despite being studied formally for well over a hundred years, there is still no mature scientific theory of its origins and functions (Hockey G. , 2011). Differences in how fatigue is described and thought of is evident in the subtle difference between Diagram 5. and Diagram 6. The former depicts an impending overflow, in that it becomes too much input to

manage, whereas the later created nearly twenty-five years after depicts having nothing left to give and an emptiness or shortage of personal resource to cope.

Diagram 6. The Combined Effect of Fatigue

Theoretical diagram of the combined effect of fatigue and the recuperation necessary to offset them (Grandejan, 1979, p. 180)

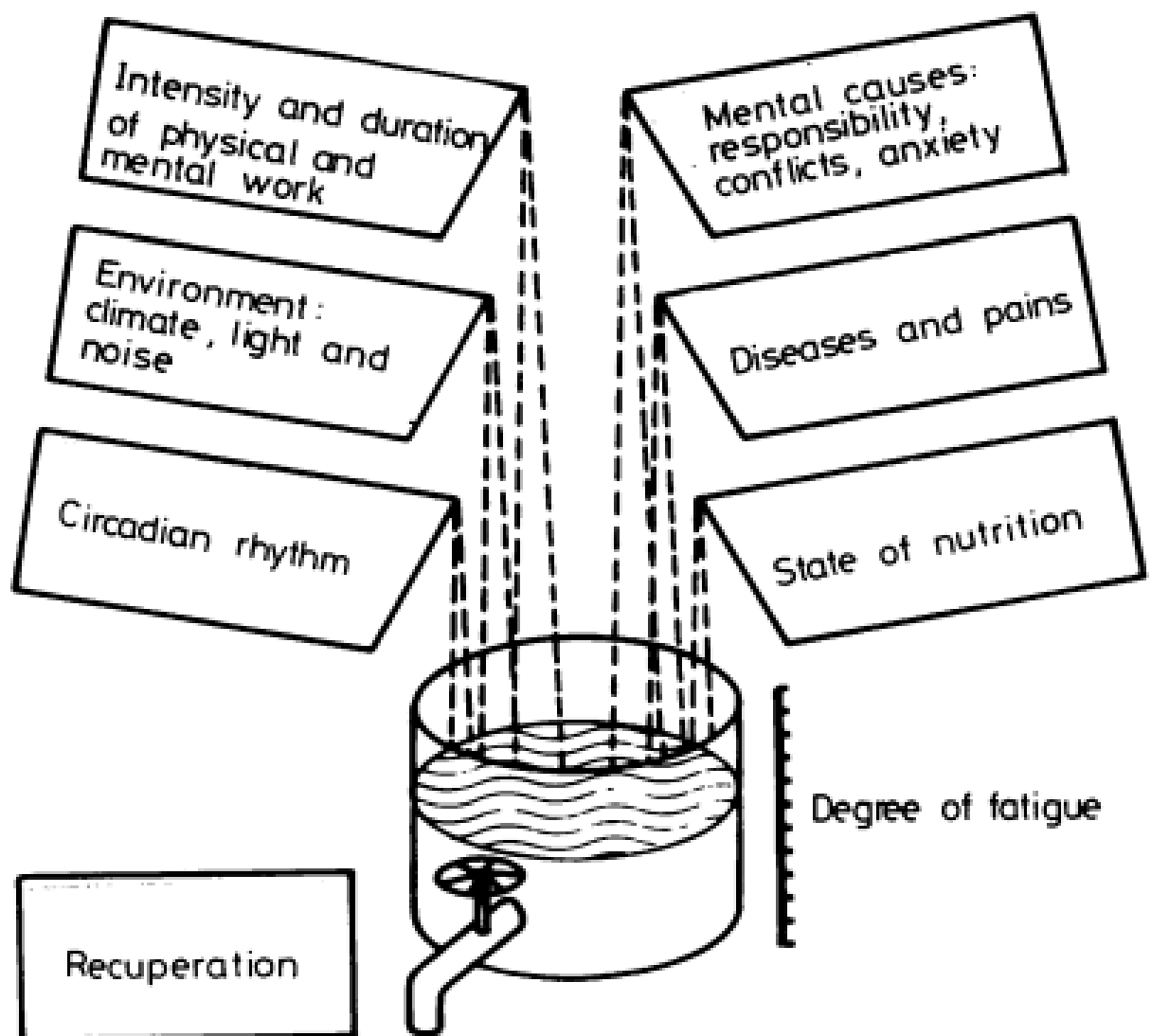
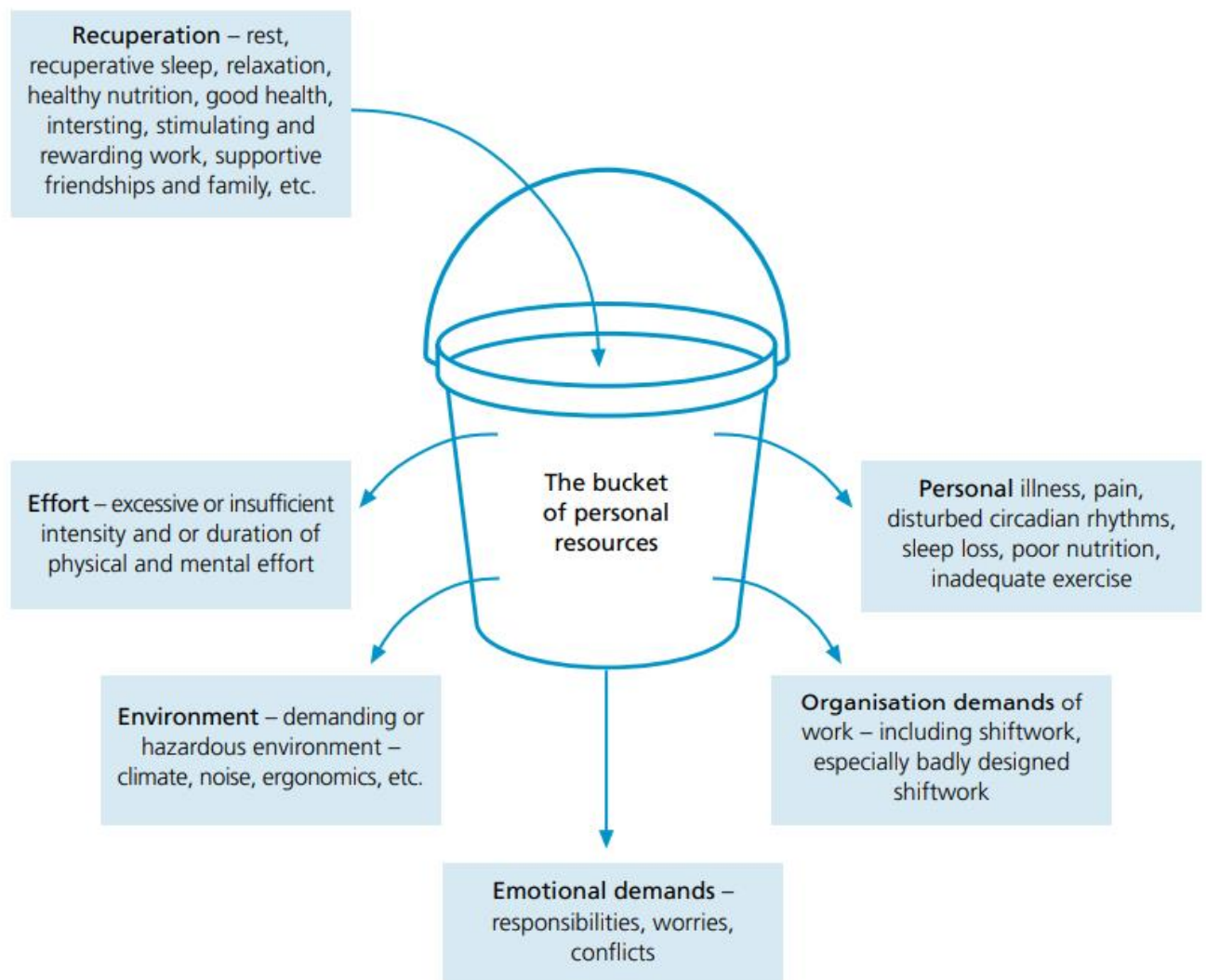


Diagram 7. The Bucket Model of Fatigue

The simpler 'bucket' model suggests that stress and fatigue may occur when a person's reservoir (bucket) of personal resilience is drained faster than it can be replenished (Department of Labour, 2003, p. 10).



Absent Management Controls Identified

The research determined the absence of the following management approaches.

Plan.

There were no formal structured or unstructured inductions to nightshift

Inductions provide educational content on fatigue, sleep hygiene, or diet and fatigues effects on decision making and cognitive performance and therefore safety. Safety inductions are extremely successful in reducing unsafe conditions (Aksorn & Hadikusumo, 2010) and support understanding of hazard identification and the application of the hierarchy of control. Studies have also shown fatigue training is beneficial in mitigating fatigue related risk (Barger, et al., 2018). A crucial element of fatigue management is sleep hygiene education (Lerman, et al., 2012) and fatigue awareness training is a requirement in commercial aviation (FAA, 2012), rail and freight (Meuleners, Fraser, Govorko, & Stevenson, 2015).

There is a heavy emphasis on self-identification of fatigue as a control. This has been shown in the literature (Cochran, Letvak, McCoy, Bacon, & Karper, 2021) and the focus groups to be unreliable, late or after the fact which makes it ineffective. Two instances of positive self-identification in the Faults Responder focus group where when one participant had extensive fatigue training in another profession, *“I did lots a fatigue management stuff in (Organisation), so I see stuff coming and I’ll see within myself, and I will say [...]”* and when one supervisor spoke about the close nit environment he had created inside his team that allowed open and frank communication, *“If they touch base with me and we justify it, we get it written down and documented, we stand them down, we take them off standby, we will leave the truck on site to if it is safe to do so and we will get someone else to pick them up, there is no issues”*. The key point in the previous quote is *“If”* and, that these two were the minority with most other accounts including having to grab a steering wheel as a co-worker who was driving feel asleep behind the wheel, to others acknowledging micro sleeps during shift and not being able to remember the immediate past.

Communication was not always received nor understood. There is Legislation which explains in broad brush strokes the duty to control risk (which includes

safety risk associated with night shift) to a level as low as reasonably practicable (ALARP). There are no regulations, no approved codes of practice, no industry guidance, only company-based policy, process, and guidance, - none of which explains “how” to manage fatigue and has various interpretations of “what” fatigue is. The EEA do cover fatigue in the worker capability section of their Safety Manual for the Electricity Industry (SM-EI) specifically: rule 1.409 Workers shall be monitored for fatigue and; rule 1.504 Where a worker considers that fatigue or stress is interfering with their ability to work safely (including the perceived fatigue or stress of other workers), they shall advise the supervisor immediately and take direction from them (Electrical Engineers Association, 2022) Both EEA rules require either self-identification or identification by something or someone else. The rules are both instructive (shall) but also non-specific, vague, yet required, and again with no idea or direction on how.

Technology to detect fatigue was not identified or used. The adoption of technology for fatigue detection has been used in other industries.

Do.

There was no formal verification of fitness for duty. While most documentation in some way referenced the need to be fit for work, there was no defined approach to determining fit versus unfit with any reliability. One company provided a check list to identify fatigue, however three of the five questions required self-identification which is unreliable (Cochran, Letvak, McCoy, Bacon, & Karper, 2021). There are a multitude of available fatigue measures which include but are not limited to the Swedish Occupational Fatigue Index, Multidimensional Fatigue Symptom Inventory, and the Fatigue Severity Scale (Phillips, 2014). No evidence of any recognized scale or pre shift measurement was found in the research data. The most common approach was discovery post shift, after the fact, with a simple question from the incoming shift replacement or direct supervisor as Laurie explains “*we get a hand over at the end of our shift, which is are you fit to drive get home*”. Or, fatigue is potentially observed in a hand over type conversation as Jamie a seasoned Fault Responder and now Faults Response Supervisor confirms in his experience, “*some guys can’t handle two nights, some guys can handle two nights and to me as a supervisor it becomes obvious when you talk to*

them the following day [...]” this observation or detection of fatigue is retrospective and after it has potentially had an effect on work outcomes already. Tools on assessment of information processing and cognitive function in the context of being fatigued are listed by (Ackerman, 2011). They with variable levels of proficiency and selectivity test for variation in or the presence of “alertness, perceptual skills, emotional processing and control, verbal fluency, reaction times, psychomotor coordination, response omissions, response inhibition, innovative and flexible thinking, judgements, decision making and risk assessment, social cognition and moral judgement, general cognitive slowing, memory deficits and effects on balance” (Phillips, 2014, p. 52).

Check.

Monitoring is reactive and related to hours worked. There was no identified way of actively measuring fatigue. Fatigue may be present before the hours’ worked marker is reached and workers ‘stood down’. Specific medical surveillance testing for the effects of shift work on the body (health surveillance) which could include regular visits with a psychologist or counsellor to monitor for psychosocial harm including the effects of social desynchronization caused by night shift could be undertaken. In New Zealand the absence of a focus on occupational health and specifically fatigue is not surprising given business activity which includes the electrical distribution industry is heavily focused on safety and occupational injury issues (Parkes H. , 2013) and not yet the larger picture of health or particularly health effects on safety. Fifty-one safety alerts in 2021 (bulletins used to raise awareness of an adverse event relating to health or safety within the electricity industry) were submitted to the electrical engineer’s association (EEA) for sharing across their knowledge network platform, zero were about health. If the industry that submits information to its representative body has not yet built capacity to look at health, it is not able to manage a symptom like fatigue and, in turn its relationship with safety outcomes for its people.

Act.

The industry does not learn from others. While there is research in other high risk professions around fatigued decision making as it relates to safety like oil &

gas (Parkes K. R., 2012), air traffic control (Luna, 1997) and nursing (Ramadan & Al-Saleh, 2014), there has been little transferable learnings adopted by the electricity supply industry in New Zealand. This impacts the ability to educate workers about the issue of fatigue and more specifically how to manage it, because it is not well understood.

Learnings and issues are not shared or approached by the whole industry collaboratively. Industry wide communication about shift schedule design and preferred shift patterns was identified as deficient. Theme 8. Not all roads lead to Rome identified the absence of communication between businesses. The structures created across organizations for learning and sharing may not be mature enough yet to reap the benefits intended by interorganizational relationships. Such as technological innovation, or process design. The strength of these relationships themselves is important in terms of value creation (Das, 2012).

Information for families / whanau was not provided. The provision of education material for families, friends, and colleagues of night shift workers to build external and internal support structures. If the issue of managing exposure to the safety risks associated with fatigue is reliant on an extension of care past the boundaries of work. Then engaging the support system (family) outside the company could be a way forward. The support of the family was identified in emergency services, specifically firefighting as vital (Regehr, Dimitropolous, Bright, George, & Henderson, 2005) in reducing the impact of highly stressful work which included the impact of shift work on the family.

Partial Management Approaches Identified.

The research findings demonstrated partial evidence of the following.

Plan.

Rest and recuperation practices were identified in some businesses.

Movement of Network Controllers to a period of day shift only. Three separate companies used the movement of Network Controllers to day shift only as part of their fatigue management. All three companies did this differently with varying periods of day shift worked into shift schedule design.

Napping was introduced as a counter measure to fatigue. There was evidence of nap taking from both Network Controllers and Faults Responders focus groups however, Graham's comment "*I wouldn't say it was encouraged at work*" summed up the general tone of responses from the focus group data. No company documentation mentioned napping, although one company provided a mattress for napping to take place during night shift as a Network Controller. Faults Responders perform on call work which has "the potential to disrupt sleep, but it may also allow for napping between calls. However, apprehension about receiving (or missing) a call may reduce the recuperative potential of nap sleep" (Honn, Garde, Fischer, & Van Dongen, 2016, p. 583). Despite this relevant literature concludes napping is a credible countermeasure to fatigue (Ferguson, Paterson, Hall, Jay, & Aisbett, 2016) (Dinges & Broughton, 1989) (Driskell & Mullen, 2005)

Do.

Supervisor welfare checks of staff on faults and storm response were sometimes undertaken. Even though these are a subjective tool and have been criticized as inadequately sensitive, studies have shown subjective assessment has its place in detection and consequently management as performance decreases could be related to subjectively felt increases in fatigue (Dawson & McCulloch, 2005) making it still important to measure fatigue subjectively.

Check.

Asset maintenance and protection significantly reduced faults work. An increase in asset protection activity, specifically a lift in tree trimming and tree removal around strategically important feeder lines and sub transmission lines - to reduce the impact of storms and therefore the number of faults during severe weather events.

In summary, there are more gaps than there are controls in the management of safety risks associated with nightshift in the electrical distribution industry.

Workers are expected to flex to meet the ever increasing societal and regulatory expectations to keep the power on, but the electrical distribution industry does not appear to be mature in its ability to manage the associated risk of harm to those workers.

Conclusion

“Fatigue is a complex and dynamic phenomenon” (Phillips, 2014)

This research has shown that the safety risks associated with nightshift in the New Zealand electrical distribution industry are not well managed. Management of risk starts with identification, assessment and defining controls (plan), followed by the implementation of those controls (do) which must be continuously verified as being effective (check) and, finally, learning from current practices to improve the risk management process and ultimately outcomes (act).

The research determined that the controls for risks associated with night shift in this sector are predominantly administrative, indicating deficiencies in the ‘plan’ stage in respect of risk assessment and preparation, and subsequently being of low efficacy in the ‘do’ stage. Monitoring was inconsistent and of limited value in prevention of harm and there have been little transferable learnings adopted from other industries. This has led to the sector not improving to the same extent as other industries like aviation, oil & gas, nursing, and freight transport.

The work environment for both Network Controllers and Faults Responders in this industry carries a burden of risk involving energy that could change or take life. So, the potential for fatigue and its effects in that environment must be managed, and currently they are not.

Significance of the research

This research is significant as there was no existing literature which indicated how the New Zealand electrical distribution industry managed the safety risks associated with nightshift (fatigue). Faults response is an on-demand or on call shift where responders can suffer from the same sleep disruption as the physicians (Lecca, et al., 2021). Comparatively network control is like air traffic control in the nature of the work, it requires competency of decision making in an urgent or thoughtful manner (Bongo & Seva, 2022). This research has contributed to the body of knowledge about fatigue risk management generally, and to the management of fatigue risk caused by nightshift work in a high-risk sector. This research has identified opportunities for the sector to improve, which in turn could prevent loss of life and the economic and social cost of that. It has also identified the pressures placed on workers in the electrical distribution industry by the law makers and standard setters; pressures which create tension and ambiguity for businesses in the industry and which the standard setters and law makers have a level of influence over.

Future research

Future research opportunities could include testing the research questions and findings with a managerial focus group. Future research could also build on the understanding of possible controls / management approaches for fatigue risk in this industry to determine which specific controls have a mediation effect on nightshift related fatigue risk in the specific context of Network Controllers and Faults Responders – and to what extent.

Internal working groups sponsored by the industry with facilitation by the EEA could be used for the development of sharing and learning from other industries who face the same complex issue of fatigue management.

Limitations of the research

A limitation of qualitative research design and methodology used in this research is the limited ability to generalize the findings. This limitation is compounded by the small sample size in comparison to the total population. The findings are not generalizable across the total population (Morris, 1999) and only apply to the participating organisations. This is despite the research project gathering data from over fifty percent of the industry by a representation of geographical land mass coverage.

Time constraints on the research precluded a third focus group of managers/supervisors from being organised. The two focus groups of nine and ten participants created a large volume of data which took a considerable amount of time to transcribe and analyze. It is noted that two participants from the Fault Responders focus group and one from the Network Controllers group had vast experience which included a current supervisory position which enabled some management commentary although limited.

Due to my working experience inside the industry, there was a potential for researcher bias. This was corrected for by using an impartial moderator for the focus groups which also ensured the experience of the facilitator/moderator mitigated any power inequity among the participants. Multiple insider and outsider positions (Gallais, 2008) were recognised during the focus group sessions. For example, as the researcher insider positions such as male and works within the industry. Outsider positions included but were not limited to, never having performed night shift, and never having worked as a Network Controller or Faults Responder.

My industry experience was beneficial in understanding industry specific terminology within the provided documents, and which enhanced the ability to translate the intent, giving a clearer view on their contribution towards answering the research question (Creswell & Creswell, 2020).

The focus groups were hard to organise as it was during winter (a busy faults season) and the COVID pandemic so, there was a real risk of absenteeism given sickness and organisational pressure that could have created a lower turnout than expected. The original study was to be two groups of eight and to allow for the possibility of sickness and work pressure I asked for two groups of ten. I had nineteen participants across the two groups therefore achieving above the original intended participation. Originally it was thought that heterogeneity would be best with a fifty/fifty split between network controllers and faults response but, after further consideration homogeneity was arranged creating the familiar or easy social environment which produced a shared basis for discussion and a level of comfort which allowed for free conversation (Laimputtong, 2011).

References

- Ackerman, P. L. (2011). 100 years without resting. In P. L. Ackerman, *Cognitive fatigue: Multidisciplinary perspectives on current status and future for research and application* (pp. 11-14). Washington DC: American Psychological Association.
- Akerstedt, T., & Landstrom, U. (1998). Work place countermeasures of night shift fatigue. *International Journal of Industrial Ergonomics*, 167-178.
- Aksorn, T., & Hadikusumo, B. H. (2010). Measuring effectiveness of safety programmes in the Thai construction industry. *Construction Management and Economics*, 409-421.
- Alerasoul, S. A., Afeltra, G., Hakala, H., Minelli, E., & Strozzi, F. (2022). Organizational learning, learning organisation, and learning orientation: An integrative review and framework. *Human Resource Management Review*, 1-26.
- Alonso, I. J., & Broadribb, M. (2018). Human error: A myth eclipsing real causes. *Process safety progress*, 145-149.
- Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). *How Learning works: Seven research-based principles for smart teaching*. San Francisco: John Wiley & Sons, Incorporated.
- Bacon, F. (1620). *Novum Organum*. London: Francis Bacon.
- Barbour, R. (2007). *Doing focus groups*. London: SAGE publications.
- Barbour, R. S., & Kitzinger, J. (1988). *Developing Focus Group Research: Politics, Theory and Practice*. London: SAGE Publications.
- Barger, L. K., Runyon, M. S., Renn, M. L., Moore, C. G., Weiss, P. M., Conde, J. P., . . . Patterson, D. (2018). Effect of Fatigue Training on Safety, Fatigue, and Sleep in Emergency Medical Services Personnel and Other Shift Workers: A Systematic Review and Meta-Analysis. *Prehospital Emergency Care*, 58-68.
- Barton, J. (1994). Choosing to work at night: a moderating influence on individual tolerance to shift work. *Psychology*, 449-454.
- Ben-Zur, H., & Zeidner, M. (2009). Threat to life and risk-taking behaviors a review of explanatory models. *Pers Soc Psychol Rev*, 109-128.

- Bloor, M. (1997). Techniques of validation in qualitative research: a critical commentary. In G. M. Dingwall, *Context and method in qualitative research* (pp. 37-50). London: Sage.
- Bogner, M. S. (1994). *Human Error in Medicine*. Hillside, New Jersey: Lawrence Erlbaum Associates, Inc., Publishers.
- Bongo, M., & Seva, R. (2022). Effect of fatigue in air traffic controllers workload, situation awareness, and control strategy. *The International Journal of Aerospace Psychology*, 1-23.
- Bonnet, M. H. (1990). Dealing with shift work: Physical fitness, temperature, and napping. *Work and Stress*, 261-274.
- Bowen, G. (2005). Preparing a qualitative research based dissertation: Lessons learned. *The Qualitative Report*, 208-222.
- Braun, V., & Clarke, V. (2013). *Successful Qualitative Research: a practical guide for beginners*. London: SAGE Publications Ltd.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 77-101.
- Bridge, G., Ozkaynak, B., & Ethemcan, T. (2018). Energy Infrastructure and the fate of the nation. *Energy Research & Social Science*, 1-11.
- Britain, D. (1992). Linguistic change in intonation: The use of high rising terminals in New Zealand English. *Language Variation and Change*, 77-104.
- Brown-Haysom, J. (2022, May). Shifts Happen. *Safeguard: Shift work: The Overlooked Serious Health Exposure*, pp. 10-14.
- Chan, M. (2011). Fatigue: the most critical accident risk in oil and gas construction. *Construction Management and Economics*, 341-353.
- Chee, M., & Chuah, Y. (2007). Functional neuroimaging and behavioural correlates of capacity decline in visual short-term memory after sleep deprivation. *PNAS Proceedings of the National Academy of Sciences of the United States of America*, 9487-9492.
- Chui, M., Manyika, J., & Miremadi, M. (2016, July). Where machines could replace humans - and where they can't (yet). *McKinsey Quarterly*, pp. 1-12.
- Cochran, K., Letvak, S., McCoy, T., Bacon, C., & Karper, W. (2021). Can Nurses Self-Assess Fatigue?: Implications for Nurse Leaders. *Journal of Nursing Administration*, 507-512.

- Commerce Commision. (2019, March 22). *Vector penalised \$3.5 million for excessive level of power outages*. Retrieved from Commerce Commision New Zealand: [https://comcom.govt.nz/news-and-media/media-releases/2019/vector-penalised-\\$3.5-million-for-excessive-level-of-power-outages](https://comcom.govt.nz/news-and-media/media-releases/2019/vector-penalised-$3.5-million-for-excessive-level-of-power-outages)
- Commerce Commision. (2020, March 24). *Aurora Energy penalised almost \$5 million for excessive level of power outages*. Retrieved from Commerce Commision New Zealand: [https://comcom.govt.nz/news-and-media/media-releases/2020/aurora-energy-penalised-almost-\\$5-million-for-excessive-level-of-power-outages](https://comcom.govt.nz/news-and-media/media-releases/2020/aurora-energy-penalised-almost-$5-million-for-excessive-level-of-power-outages)
- Costa, G. (2010). Shift Work and Health: Current Problems and Preventative Actions. *Safety and Health at Work*, 112-123.
- Costa, G., Sartori, S., & Akerstedt, T. (2006). Influence of flexibility and variability of working hours on health and well-being. *Chronobiology International*, 1125-1137.
- Cracknell, D. J. (2018, December). 'Thrown in the Deep End': A qualitative study with New Zealand New Graduate Nurses Working in Mental Health. *Dissertation submitted for the degree of Master of Health Sciences*. Dunedin, Otago, New Zealand.
- Creswell, J. W., & Creswell, J. D. (2020). *Research Design: qualitative, quantitative and mixed methods approaches- Fifth edition*. Thousand Oaks, California: Sage Publications Inc.
- Creswell, J. W., & Miller, D. (2000). Determining validity in qualitative inquiry. *Theory Into Practise*, 124-130.
- Creswell, J., & Poth, C. (2016). *Qualitative inquiry and research design: Choosing among five approaches*. Thousand Oaks California: Sage publications.
- Cypress, B. S. (2017). Rigor or Reliability and Validity in Qualitative Research. *Dimensions of Critical Care Nursing*, 253-263.
- Daniel, S., & Sonnentag, S. (2014). Work to non-work enrichment: the mediating roles of positive affect and positive work reflection. *Work & Stress*, 49-66.
- Darby, F. W. (1998). *Stress and fatigue: their impact on health and safety in the workplace: Information for occupational health professional, human resource practitioners and other*. Wellington: Occupational SAFety & Health Service, Dept. of Labour.

- Das, T. K. (2012). *Management Dynamics in Strategic Alliances*. Information Age Publishing.
- Dawson, D., & McCulloch, K. (2005). Managing fatigue: it's about sleep. *Sleep medicine reviews*, 365-380.
- Dawson, D., & Reid, K. (1997). Fatigue, alcohol and performance impairment. *Nature*, 235.
- Dawson, D., Searle, A. K., & Paterson, J. (2014). Look before you (s)leep: Evaluating the use of fatigue detection technologies within a fatigue risk management system for the roadtransport industry. *Sleep medicine Reviews*, 141-152.
- Dekker, S., Cilliers, P., & Hofmeyr, J. (2011). The Complexity of failure: Implications of complexity theory for safety investigations. *Safety Science*, 1-7.
- Department of Labour. (2003). *Healthy Work: Managing stress and fatigue in the workplace*. Wellington: occupational Safety and Health Service.
- Dinges, D. F., & Broughton, R. J. (1989). The significance of napping: A synthesis. In D. F. Dinges, & R. J. Broughton, *Sleep and alertness* (pp. 299-308). New York: Raven Press.
- Driskell, J. E., & Mullen, B. (2005). The efficacy of naps as a countermeasure: a meta-analytic integration. *Human Factors*, 360-377.
- Electricity Authority - Security and Reliability Council. (2017, July 28). *Reliability implications of reduced use of high voltage live line techniques - Why health and safety decisions may reduce use of HV live line work and what this means for reliability of electricity supply*. Retrieved from Electricity Authority: <https://www.ea.govt.nz/assets/dms-assets/22/22381SRC08-Reliability-implications-of-reduced-live-line-work.pdf>
- Electrical Engineers Association. (2022). *SM-EI Safety Manual Electricity Industry*. Retrieved from EEA Knowledge Network: <https://publications.eea.co.nz/manual/SMEI/document/process/>
- Electricity Engineers Association. (2013). *EEA Line Mechanics and Cable Joints Handbook (6th Edition)*. Retrieved from EEA: <https://www.eea.co.nz/tools/products/details.aspx?SECT=publications&ITEM=2525>
- FAA. (2012, January 4). Flightcrew member duty and rest requirements. *CFR Part 117, 119 and 121*. Washington, DC: FAA.

- Faraut, B., Andrillon, T., Vecchierini, M., & Leger, D. (2016). Napping: A public health issue. From epidemiological to laboratory studies. *Sleep Medicine Reviews*, 85-100.
- Ferguson, S. A., Paterson, J. L., Hall, S. J., Jay, S. M., & Aisbett, B. (2016). On-call work: To sleep or not to sleep? It depends. *Chronobiology International*, 678-684.
- Fern, E. F. (2001). *Advanced Focus Group Research*. Thousand Oaks California: Sage Publications Inc.
- Ferns, S. (2021, June 21). *Problem of fatigue haunts electricity industry*. Retrieved from Prospect: <https://prospect.org.uk/news/problem-of-fatigue-haunts-electricity-industry/>
- Fielding, N. G., & Lee, R. M. (1991). *Using computers in qualitative research*. London: Sage.
- Folkard, S. (1992). Is there a best compromise shift system? *Ergonomics*, 1453-1464.
- Folkard, S., & Tucker, P. (2003). Shift work, safety and productivity. *Occupational Medicine*, 95-101.
- Ford-Martin, P. A. (2011). Fatigue. *The Gale Encyclopedia of Medicine*, 1688-1691.
- Fowler, G. (2022, August 13). *Mt Hutton coal miner Troy Matinca wins \$1.13 million in damages after falling asleep at the wheel*. Retrieved from Newcastle Herald: <https://www.newcastleherald.com.au/story/7857368/employer-found-negligent-in-driver-fatigue-case-pays-113-million-in-damages/>
- Gaha, M., Bilal, C., Komljenovic, D., Cote, A., Herbet, C., Blancke, O., . . . Abdul-Nour, G. (2021). Global Methodology for Electrical Utilities Maintenance Assessment Based on Risk-Informed Decision Making. *Sustainability*, 1-23.
- Galinier, J., Becquelin, A. M., Bordin, G., Fontaine, L., Fourmaux, F., Ponce, J. P., . . . Zilli, I. (2021). Anthropology of the night. *Current Anthropology*, 819-847.
- Gallais, T. L. (2008). Wherever I go there I am: reflections on reflexivity and the research stance. *Reflective Practice: International and Multidisciplinary Perspectives*, 145-155.
- Gander, P., & Signal, L. (2009). Who Is Too Old for Shift Work? Developing better Criteria. *Chronobiology International*, 199-213.

- Gander, P. (2001). Fatigue management in air traffic control: the New Zealand approach. *Transportation research*, 49-62.
- Government, T. N. (2022, August 5th). *What are lifeline utilities?* Retrieved from Civil Defence National Emergency Management Agency: <https://www.civildefence.govt.nz/cdem-sector/lifeline-utilities/what-are-lifeline-utilities/>
- Grandejan, E. (1979). Fatigue in industry. *British Journal of Industrial Medicine*, 175-186.
- Hancock, P. A., Desmond, P. A., & Matthews, G. (2012). Conceptualizing and defining fatigue. In G. Matthews, P. Desmond, & C. Neubauer, *The handbook of operator fatigue* (pp. 63-73). Farnham: Ashgate Publishing Ltd.
- Harme, M., Vahtera, J., Kivimaka, M., Karhula, K., & Ropponen, A. (2018). Association of changes in work shifts and shift intensity with change in fatigue and disturbed sleep: a within-subject study. *Scandinavian Journal of Work, Environment & Health*, 394-402.
- Health and Safety Executive. (2022). *RR446 -The development of a fatigue/risk index for shiftworkers*. Retrieved from Health and Safety Executive: <https://www.hse.gov.uk/research/rrhtm/rr446.htm>
- Hennecke, J., Meehan, L., & Pachero, G. (2021). *Workplace Safety and the future of work in NZ*. Auckland: New Zealand Work Research Institute.
- Heschel, A. J., & Heschel, S. (1996). *Moral Grandeur and Spiritual Audacity: Essays*. New York: Farrar, Straus and Giroux.
- Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., DonCarlos, L., . . . Ware, C. (2015). National Sleep Foundation's updated sleep duration recommendations: final report. *Sleep Health*, 233-243.
- Hockey, G. (2011). A motivational control theory of cognitive fatigue. In G. Hockey, & P. Akerman, *Cognitive Fatigue: Multidisciplinary perspectives on current research and future applications* (pp. 167-187). American Psychological Association.
- Hockey, R. (2013). *The Psychology of Fatigue: Work, Effort and Control*. Cambridge: Cambridge University Press.
- Holden, R. J. (2009). People or systems: to blame is human. The fix is to engineer. *Professional Safety*, 34-41.

- Hollinger, R. C., & Clark, J. P. (1982). Formal and Informal Social Controls of Employee Deviance. *The Sociological Quarterly*, 333-343.
- Holloway, I., & Tordes, L. (2005). The status of method: Flexibility, consistency and coherence. In I. Holloway, *Qualitative Research in health Care* (pp. 90-103). Berkshire: Open University Press.
- Honn, K. A., Garde, A. H., Fischer, F. M., & Van Dongen, H. P. (2016). 22nd International Symposium on Shiftwork and Working Time: Challenges and solutions for healthy working hours. *Chronobiology International*, 581-588.
- Hutch, D. (2018, January). *Bowtie Analysis and Barrier Based Risk Management*. Retrieved from ISPE: <https://ispe.org/pharmaceutical-engineering/january-february-2018/bowtie-analysis-and-barrier-based-risk-management>
- Immigration New Zealand. (2022). *Scarce List - Long Term Skill Shortage List*. Retrieved from New Zealand Immigration: <https://www.immigration.govt.nz/new-zealand-visas/already-have-a-visa/one-off-residence-visa/2021-resident-visa-scarce-lists/long-term-skill-shortage-list>
- Jackson, J. A. (1970). *Professions and professionalisation*. Cambridge: Cambridge University Press.
- James, S. M., Honn, K. A., Gaddameedhi, S., & Van Dongen, H. P. (2017). Shift Work: Disrupted Circadian Rhythms and sleep -Implications for health and well being. *Current Sleep Medicine Report*, 104-112.
- Jefferson, G. (2004). Glossary of transcript symbols with an introduction. In G. H. Lerner, *Conversation analysis: Studies from the first generations* (pp. 13-31). Philadelphia: John Benjamins.
- Kao, K. Y., Thomas, C. L., Spitzmueller, C., & Huang, Y. (2021). Being present in enhancing safety: Examining the Effects of Workplace Mindfulness, Safety Behaviors, and Safety Climate on Safety Outcomes. *Journal of Business and Psychology*, 1-15.
- Karasek, R., & Theorell, T. (1990). *Healthy Work: Stress, Productivity, and the reconstruction of Working Life*. New York: Basic Books.
- Kempa, J. (2019). Respecting a speed limit and its effectiveness in a traffic calming zone. *IOP conference series. Materials Science and Engineering*, 1-8.
- King, E. (1905). The Pragmatic Interpretation of the Christian Dogma: A suggestion as to the nature of reality. *The Monist*, 248-261.

- Kling, R. N., McLeod, C. B., & Koehoorn, M. (2010). Sleep problems and workplace injuries in Canada. *Sleep*, 611-618.
- Knauth, P. (1996). Designing better shift systems. *Applied Ergonomics*, 39-44.
- Knauth, P., & Hornberger, S. (2003). Preventative and compensatory measures for shift workers. *Occupational Medicine*, 109-116.
- Knauth, P., Eichorn, B., Lowenthal, I., Gartner, K. H., & Rutenfranz, J. (1983). Reduction of nightwork by redesigning of shift-rotas. *International archives of occupational and environmental health*, 371-379.
- Kogi, K. (1996). Improving shift workers health and tolerance to shiftwork: recent advances. *Applied Ergonomics*, 5-8.
- Kolasa, K. M., & Firnharber, G. C. (2011). 13 tips on surviving the 12 hour shift. *Nursing*, 55-60.
- Kruger, R. A. (2002, October). *Designing and Conducting Focus group Interviews*. Retrieved from Eastern Illinois University - Illinois Higher Education Center: <https://www.eiu.edu/ihec/Krueger-FocusGroupInterviews.pdf>
- Laimputtong, P. (2011). *Focus group methodology: Principles and practise*. London: Sage.
- Lecca, R., Bonanni, E., Battaglia, E., Maestri, M., Figorilli, M., Congiu, P., . . . Puligheddu, M. (2021). Prevalence of sleep disruption and determinants of sleepiness in a cohort of Italian physician: The PRESOMO study. *Journal of Sleep Research*, 1-9.
- Lerman, S. E., Eskin, E., Flower, D. J., George, E. C., Gerson, B., Hartenbaum, N., . . . Moore-Ede, M. (2012, February). Fatigue Risk Management in the Workplace. *Journal of Occupational and Environmental Medicine*, 231-258.
- Lilley, R., Davie, G., McNoe, B., horsburgh, S., Driscoll, T. R., & Cryer, C. (2022). Impact of legislative reform on worker fatalities in New Zealand: a 30-year retrospective population-level analysis. *Occupational & Environmental Medicine*, 602-609.
- Lipley, N. (2013). Night shift staff more likely to make mistakes at work. *Nursing standard*, 8.
- Lorist, M. M., Boksem, M., & Ridderinkof, K. R. (2000). Mental fatigue and task control: planning and preparation. *Psychophysiology*, 614-625.
- Luna, T. D. (1997). Air traffic controller shiftwork: what are the implications for aviation safety? *Aviation, space, and environmental science*, 69-79.

- Macleane, A. W., Davies, D. R., & Thiele, K. (2003). The hazard and prevention of driving while sleepy. *Sleep Medicine Reviews*, 507-521.
- Manoogain, E., Zadourian, A., Lo, H., Golshan, S., Taub, P., & Panda, S. (2022). Feasibility of time-restricted eating and impacts on cardiometabolic health in 24-h shift workers: The Healthy Heroes randomised control trial. *Cell Metabolism*, 1442-1456.
- Marshall, M. N. (1996). Sampling for qualitative research. *Family Practice*, 522-525.
- MBIE. (2020, August 4). *Electricity Industry*. Retrieved from Ministry of Business, Innovation and Employment: <https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-generation-and-markets/electricity-market/electricity-industry>
- McElvenny, D. M., Crawford, J. O., & Cherrie, J. W. (2018). What should we tell shift workers to do to reduce. *Occupational Medicine*, 5-7.
- Merriam, S. B. (1988). *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.
- Meuleners, L., Fraser, M. L., Govorko, M. H., & Stevenson, M. R. (2015). Obstructive sleep apnea, health-related factors, and long distance heavy vehicle crashes in Western Australia; a case study. *Journal of Clinical Sleep Medicine*, 413-418.
- Ministry of Business, Innovation and Employment. (2022, July 25). *Small Business*. Retrieved from Ministry of business, Innovation and Employment: <https://www.mbie.govt.nz/business-and-employment/business/support-for-business/small-business/>
- Mitler, M. M., Carskadon, M. A., Czeisler, C. A., Dement, W. C., Dingers, D. F., & Graeber, R. C. (1988). Catastrophes, sleep, and public policy: a consensus report. *Sleep*, 100-109.
- Monk, T. H., & Folkard, S. (1992). *Making Shiftwork Tolerable*. London: Taylor & Francis.
- Morris, J. M. (1999). Qualitative Generalizability. *Qualitative Health Research*, 5-6.
- Mott, P. E., Mann, F. C., McLoughlin, Q., Warwick, D. P., & Abor, A. (1965). *Shift Work: The Social, Psychological, and Physical Consequences*. Michigan: University of Michigan Press.
- Murray, S., & Matthews, S. (2016). *Human Fatigue Risk Management*. Academic Press.

- Myszewski, J. M. (2012). Management responsibility for human errors. *TQM Journal*, 326-337.
- Nachreiner, F., Baer, K., Diekman, A., & Ernst, G. (1984). Some new approaches in the analysis of the interference of shift work with social life. In A. Wedderburn, & P. Smith, *Psychological approaches to night and shift work*. Edinburgh: Heriot-Watt University.
- National Institute for Occupational Safety and Health. (2021, June 11). *Center for Work and Fatigue Research PPOP*. Retrieved from CDC Centers for disease Control and Prevention The National Institute for Occupational Safety and Health (NIOSH): <https://www.cdc.gov/niosh/programs/ppops/cwfr.html>
- New Zealand Government. (1998). *Land Transport Act 1998*. Retrieved from New Zealand Legislation: <https://www.legislation.govt.nz/act/public/1998/0110/166.0/DLM434625.html>
- New Zealand Government. (2020, December 1). *Health and Safety at Work Act 2015*. Retrieved from New Zealand Legislation: <https://www.legislation.govt.nz/act/public/2015/0070/latest/whole.html#DLM6564700>
- New Zealand Government. (2022, August 10). *Health and Safety at Work Act 2015 subpart 2 - Duties of PCBU's section 36 Primary duty of care*. Retrieved from New Zealand Legislation: <https://www.legislation.govt.nz/act/public/2015/0070/latest/DLM5976895.html>
- New Zealand Institute of Safety Management. (2022). *Annual Report*. Auckland: NZISM.
- OPEC, O. f. (2000). *Shiftwork and Health*. Best. Dublin, Ireland: European Foundation for the Improvement of Living and Working Conditions.
- Pan, N., Luo, Y., & Duan, Q. (2022). The Influence of PDCA Cycle Management Mode on the enthusiasm, Efficiency, and Teamwork Ability of Nurses. *BioMed Research International*, 1-7 Article ID 9352735.
- Pannuchetty, R. (2022, May 2). *Infrastructure thinking must be long term - LGNZ*. Retrieved from Ko Tatou Local Government New Zealand: <https://www.lgnz.co.nz/news-and-media/2022-media-releases/infrastructure-thinking-must-be-long-term-lgnz/>
- Parkes, H. (2013, April). *Occupational Health: Information Paper - Independent Health and Safety Taskforce*. Retrieved from Independent Taskforce on Workplace Health and Safety:

<http://hstaskforce.govt.nz/documents/occupational-health-information-paper.pdf>

- Parkes, K. R. (2012). Shift schedules on the North Sea oil/gas installations: a systematic review of their impact on performance, safety and health. *Safety science*, 1636-1651.
- Peace, C. (2017). The risk matrix: uncertain results? *Policy and Practice in Health and Safety*, 131-144.
- Phillips, R. O. (2014). *What is fatigue and how does it affect the safety performance of human transport operators?* Oslo: Institute of Transport Economics.
- Phillips, R. O., & Sagberg, F. (2010). *Fatigue management in occupational driving. AN assessment by literature review.* Oslo: Institute of Transport Economics.
- Phillips, R. O., Naevestad, T. O., & Bjornskau, T. (2015). *Fatigue in Operators of land and sea based transport forms in Norway.* Oslo: Institute of Transport Economics.
- Pietch, E., & Oginska, H. (1981). Family life organisation in shift workers of a steel combine. In A. Reinberg, N. Vieux, & P. Andlauer, *Night and shift work: biological and social aspects, Collective advances in Biosciences* (p. 30). Oxford: Pergamon.
- Pisarski, A., Bohle, P., & Callan, V. J. (1988). Effects of coping strategies, social support and work-nowork conflict on shift worker's health. *Scandinavian Journal of Work Environment Health*, 141-145.
- Popov, G., Lyon, B. K., & Hollcroft, B. (2021). *Risk Assessment: A Proactical Guide to Assessing Operational Risks.* Missouri: John Wiley & Sons.
- Potera, C. (2018). Fighting Night-Shift Fatigue. *American Journal of Nursing*, 15.
- Quental, N., Rocha, J., Silva, J., Menezes, L., & Santos, J. (2021). The Impact of Cognitive fatigue on Airline Pilots Performance. *Journal of Airline and Airport Management*, 16-33.
- R Wilkinson, & Marmot, M. (2003). *Social determinants of health - the solid facts.* Copenhagen: WHO Regional Office Europe.
- Ramadan, M. Z., & Al-Saleh, K. S. (2014). The association of sleep deprivation on the occurrence of errors by nurses who work the night shift. *Current health sciences journal*, 97.

- Regehr, C., Dimitropolous, G., Bright, E., George, S., & Henderson, J. (2005). Behind the Brotherhood: Rewards and Challenges for Wives of Firefighters. *Family Relations*, 423-435.
- Roach, G. D., Darwent, D., Sletten, T. L., & Dawson, D. (2011). Long Haul pilots use in flight napping as a countermeasure to fatigue. *Applied Ergonomics*, 214-218.
- Roach, G. D., Robert, P., Dawson, D., Ferguson, S., Meuleners, L., Brook, L., & Sargent, C. (2017). Controlling fatigue risk in safety-critical workplaces: A summary of selected papers from the 9th International Conference on Managing Fatigue in Transportation, Resources and Health. *Accident Analysis & Prevention*, 379-382.
- Roach, G. D., Sargent, C., Darwent, D., & Dawson, D. (2012). Duty periods with early start times restrict the amount of sleep obtained by short-haul airline pilots. *Accident Analysis & Prevention*, 22-26.
- Rogers Commission Report. (1986). *Report of the Presidential Commission on the Space Shuttle Challenger Accident*. Washington: U.S. Government.
- Rosa, R. R., & Bonnet, M. H. (1993). Performance and Alertness on 8-Hour and 12-Hour Rotating Shifts at a Natural Gas Utility. *Ergonomics*, 1177-1193.
- Sadgrove, M. D. (2021). *Assignment 1 HLTH521*. Wellington : Victoria University.
- Sandelowski, M. (1994). Notes on transcription. *Research in Nursing & Health*, 311-314.
- Sawatzky, S. (2017). Worker Fatigue: Understanding the risks in the workplace. *Professional Safety*, 45-51.
- Scolobig, A., Prior, T., Schroter, D., Jorin, J., & Patt, A. (2015). Towards people-centred approaches for effective disaster risk management: Balancing rhetoric with reality. *International Journal of Disaster Risk Reduction*, 202-212.
- Seale, C. (1999). Quality in Qualitative Research. *Qualitative Inquiry*, 465-478.
- Shiftwork and Health. (2000, January). *Best: European Studies on Time*. Loughlinstown, Dublin, Ireland: The European Foundation for the Improvement of.
- Sigari, M., Pourshahabi, M., Soryani, M., & Fathy, M. (2014). A review of driver face monitoring systems for fatigue and distraction detection. *International Journal of Advanced Science and technology*, 73-100.

- Singer, E., Frankel, M. R., & Glassman, M. B. (1983). The effect of interviewer characteristics and expectations on response. *PUBLIC Opinion Quarterly*, 68-83.
- Smolensky, M. H., Di Milia, L., Ohayon, M. M., & Philip, P. (2011). Sleep disorders, medical conditions, and road accident risk. *Accident Analysis & Prevention*, 533-548.
- Snowden, D. J., & Boone, M. E. (2007, November). A Leader's Framework for Decision Making. *Harvard Business Review*, pp. 1-8.
- Southern Cross Health Insurance, Business NZ. (2021). *Workplace Wellness Report 2021*. Auckland.
- Stevens, R. G., Hansen, J., Costa, G., Haus, E., Kauppinen, T., Aronson, K. J., . . . Straif, K. (2011). Considerations of circadian impact for defining "shift work" in cancer studies: IARC Working Group Report. *Occupational and Environmental Medicine*, 154-162.
- Summer, J. (2022, April 25). *Microsleep: What is it, What causes it, and is it safe?* Retrieved from Sleep Foundation: <https://www.sleepfoundation.org/how-sleep-works/microsleep>
- Suni, E. (2022, September 22). *Sleep Deprivation*. Retrieved from Sleep Foundation: <https://www.sleepfoundation.org/sleep-deprivation#:~:text=The%20primary%20signs%20and%20symptoms,hallmark%20signs%20of%20sleep%20deprivation.>
- Szalma, J. L., & Hancock, P. (2008). *Performance Under Stress*. Burlington: Ashgate Publishing Company.
- Tague, N. R. (2005). P-Plan-Do-Check-Act cycle. *The Quality Toolbox*, 390-392.
- 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*, 961-973.
- Transpower New Zealand limited. (2020). *Transmission Planning Report*. Wellington: Transpower New Zealand Limited 2020.
- Trutschel, U., Sirois, B., Aguirre, A., Dawson, T., Morre-Ede, M., Sommer, D., & Golz, M. (2009, March 26-29). Shiftwork adaptation testing system. *International Conference on fatigue management in transport operations*. Boston.

- University, C. (2022). *Cambridge Dictionary*. Retrieved from Cambridge Dictionary: <https://dictionary.cambridge.org/dictionary/english/pragmatic>
- van Amelsvoort, L., Jansen, N., Swaen, G., van den Brandt, P., & Kant, I. (2004). Direction of shift rotation among three-shift workers in relation to psychological health and work-family conflict. *Scandinavian Journal Work Environmental Health*, 149-156.
- Van Den Berg, M. J., Signal, T. L., & Gander, P. H. (2020). Fatigue risk management for cabin crew: the importance of company support and sufficient rest for work-life balance - a qualitative study. *Industrial Health*, 2-14.
- Van Dongen, H. (2006). Shift work and inter-individual differences in sleep and sleepiness. *Chronobiology International*, 1139-1147.
- Van Dongen, H., Price, N. J., Mullington, J. M., Szuba, M. P., Kapoor, S. C., & Dinges, D. F. (2001). Caffeine eliminates psychomotor vigilance deficits from sleep inertia. *Sleep*, 813-819.
- Vincent, G. E., Kinchin, I., Ferguson, S. A., & Jay, S. M. (2018). The Cost of Inadequate Sleep among On-Call Workers in Australia: A Workplace Perspective. *International Journal of Environmental Research and Public Health*, 398.
- Wagstaff, A. S., & Lie, J. S. (2011). Shift and night work and long hours - a systematic review of safety implications. *Scandinavian Journal of Work, Environment & Health*, 173-185.
- Waka Kotahi. (2022). *Advice for employers*. Retrieved from Waka Kotahi NZ Transport Agency: <https://www.nzta.govt.nz/safety/what-waka-kotahi-is-doing/education-initiatives/fatigue/advice-for-employers/>
- Walker, P. M. (2017). *Why We Sleep - The New Science of Sleep and Dreams*. Simon & Schuster.
- Walls, C., & Darby, F. (2007). The New Zealand governments approach to stress and fatigue. *Work & Stress - An International Journal of Work, Health & Organisations*, 142-145.
- Walters, D., & Nicholas, T. (2006). Representation and Consultation on health and Safety in Chemicals: An Exploration of limits to the Preferred Model. *Employee Relations*, 230-254.
- Walters, D., Quinlan, M., Johnstone, R., & Wadsworth, E. (2016). Cooperation or resistance? Representing workers' health and safety in a hazardous industry. *Industrial Relations Journal*, 379-395.

- Wedderburn, A. (1995). Men and women who like continuous shiftwork are more "hardy" but what does that mean? *Work and Stress*, 206-210.
- Wick, R., Gilbert, J. D., Simpson, E., & Byard, R. W. (2006). Fatal electricution in Adults - A 30 year study. *Medicine, Science and the Law*, 166-172.
- Wilkinson, R. T. (1992). How fast should night shift rotate? *Ergonomics*, 1425-1446.
- Wood, J. C., & Wood, M. C. (2002). *Henri Fayol Critical evaluations in business and Management*. London: Routledge.
- WorkSafe . (2021, July 13). *Energy Safety Annual report 2020 - Electrical and Gas accidents*. Retrieved from WorkSafe - Mahi Haumaru Aotearoa: <https://www.worksafe.govt.nz/topic-and-industry/energy-safety/electrical-and-gas-accidents/electrical-and-gas-accidents-2020-annual-report/>
- WorkSafe . (2022). *Risk Management*. Retrieved from WorkSafe Mahi Haumaru Aotearoa: <https://www.worksafe.govt.nz/topic-and-industry/hazardous-substances/managing/risk-management/>
- WorkSafe New Zealand. (2017, October 17). *fatigue-quick-guide*. Retrieved from WorkSafe: <https://www.worksafe.govt.nz/topic-and-industry/fatigue/fatigue-quick-guide/>
- WorkSafe NZ. (2021, August). *Managing the risks of shift work*. Retrieved from WorkSafe: Fatiuge: SHift work advice for small businesses: <https://www.worksafe.govt.nz/topic-and-industry/fatigue/shift-work-advice-for-small-businesses/>
- Wuyts, J., De Valck, E., Vanderkerckhove, M., Pattyn, N., Exadaktylos, V., Haex, B., . . . Cluydts, R. (2012). Effects of pre-sleep simulated on-call instructions on subsequent sleep. *Biological Psychology*, 383-388.
- Zaire, P. (2017). Structured onboarding process to promote safety. *AAACN Viewpoint*, 10-11.

Appendices

Appendix A - Focus group Questions

1. When you think of fatigue, what comes to mind?
 - a. Do you know the difference between being fatigued and just being tired?
 - b. What was covered in your induction on night shift?
 - i. Prompt health effects of night work, potential safety impacts
 - c. Establish a common understanding in the group of what fatigue is! Use this from my proposal: Fatigue is the physical and/or mental exhaustion that can be triggered by stress, medication, overwork or mental and physical illness or disease (Ford-Martin, 2011)
2. When you are at home what makes you feel fatigued?
 - a. Do you use any tools to transition from work to home to help you sleep?
 - i. Prompt - After a night shift do you put on dark glasses for the journey home to limit the light going into your eyes.
 - b. How would you describe your sleep environment at home, is it good or bad and why?
 - i. Prompt – a good environment for sleep is dark, quiet, and cool in temperature (<https://www.heartandstroke.ca/articles/your-healthy-sleep-checklist>).
3. When you are at work what makes you feel fatigued?
 - a. Do you consider your work taxing/demanding either mentally, physically, or emotionally in any way?
 - b. Do you use any tools or practises when going from home to work to help you stay awake (during a night shift)?
 - i. Prompt – do you expose yourself to bright light, drink coffee, exercise
4. How does fatigue affect you when you are at home?
 - a. How long have you been exposed to night shift work?
5. How does fatigue affect you when you are at work?

- a. Have you ever felt irritable, chronically tired, or sleepy at work or home and if so, how often?
 - b. Do you feel your state at work is influenced by your condition and how?
 - c. Has there been any times you felt less than 100% present at work for example slowed reflexes, impaired decision making or judgement, poor concentration? Please feel free to tell any stories you have about these times.
6. Are there safety related tasks at work that are affected by your level of fatigue?
 - a. How important would you say your physical, mental, and emotional state is to safe outcomes in your work?
 - b. Have you ever raised concerns about nightshift and or fatigue at work and what where they?
 - c. Did you feel supported by work when you raised issues?
7. How do you currently manage your fatigue at home?
 - a. How did you decide this was an appropriate way manage fatigue? Was it a work suggestion or otherwise?
 - b. What words would you use to describe your sleep quality?
 - c. How many hours a night or day would you say you get each night?
8. How do you manage your fatigue at work?
 - a. Have you ever fallen asleep at work?
 - b. Is sleeping at work encouraged during nightshift, is there anything provided for you or in place in your work environment to help you manage fatigue during a night shift, if so, what is it?
9. When you started did you get any advice from work or colleagues on how to cope with the demands of nightshift and what was it?
 - a. Do you have any specific health related checks at work because you undertake night shift, if so, what are they?
 - b. What if any changes in you physical or mental state since being on a night shift have you noticed?
10. If you think that fatigue is a safety concern at work, what do you think could be changed?

- a. Have you ever suggested ideas before on how to make your work safer or your work environment healthier?
- b. What were those suggestions?