



Mental Awareness, Respect and Safety (MARS) Centre

# Reframing fatigue in mining: a scoping literature review

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## Executive Summary

This report presents a scoping review of international scholarly and grey literature on fatigue in the mining sector. Conducted by the Mental Awareness, Respect and Safety (MARS) Centre, the review examines how fatigue is conceptualised in mining, identifies key contributing factors, and evaluates associated health, safety, and organisational impacts, as well as current management approaches.

Fatigue is defined as a state of physical, mental, and/or emotional impairment that reduces safe and effective work performance. In mining, fatigue is a critical safety risk linked to errors, incidents, injuries, musculoskeletal disorders, poorer mental health, physical illness, and long-term health outcomes. Fatigue has significant impacts on productivity, absenteeism, presenteeism, worker retention and industry costs.

The review synthesised more than 350 sources spanning over 50 years of research. Early studies focused primarily on heat and physical fatigue, while more recent literature increasingly addresses shift work, sleep disruption, cognitive workload, and mental and emotional fatigue. Despite this breadth, most research examines fatigue risk factors in isolation, with limited consideration of how multiple factors interact in mining contexts.

Findings are organised into four interrelated categories: physical environment (e.g. heat, noise, lighting, vibration), work tasks (physical and cognitive workload), work organisation (e.g., shift schedules or rosters), and individual characteristics. The review highlights that fatigue develops through the interaction of these factors, and an integrated fatigue development model is proposed to illustrate these interactions and their contribution to physical, mental, and emotional fatigue.

The review concludes with the broad range of potential fatigue prevention and risk management controls aligned with the hierarchy of controls. Given the complex interactions involved in the development of fatigue, effective management of fatigue in mining requires comprehensive, multi-level Fatigue Risk Management Systems (FRMS) integrated into existing safety management systems and optimal design of work. The gaps identified in the literature that call for further research about fatigue in mining include mental health outcomes, the long-term health effects, the impacts of workforce diversity, fatigue detection technologies, and the impacts of increasing automation.

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# 1.0 Introduction

This report summarises the findings of a scoping literature review of fatigue in the mining sector. The review aimed to explore the extent and nature of fatigue in mining; to identify how fatigue is conceptualised in the industry; explore the evidence of organisational impacts; and prevention and management strategies. This work is part of the wider MARS Centre research program concerned with creating physically and mentally healthy mining work.

SafeWork Australia’s code of practice (2025) states that:

*“Fatigue is a state of physical, mental or emotional impairment. Fatigue can develop over the short or long term, can prevent people from functioning safely and can have health effects. In a work context, fatigue is more than feeling sleepy, tired and drowsy.”*

Fatigue is a physiological state of impairment that reduces the ability to perform tasks (Bofinger et al., 2002; Horberry et al., 2022; ICAO, 2015). The impairment might be physical (e.g., loss of coordination or strength), mental (e.g., reducing attention, affecting decision-making) and/or emotional (e.g., affecting engagement or emotional regulation) (Safe Work Australia, 2025).

Fatigue is a critical safety risk in mining (Bauerle et al., 2022) and can result in:

- errors, incidents and injuries (e.g., Dugdale et al., 2022; Halvani et al., 2009)
- musculoskeletal pain and injury (e.g., Khoshakhlagh et al., 2017; Carlisle & Parker, 2014; Friedman et al., 2019; James et al., 2021; Shkempi et al., 2022; Taggart et al., 2024)
- poorer mental health (e.g., Albrecht & Anglim, 2018; Carlisle & Parker, 2014; Horberry et al., 2022; Matamala Pizarro & Aguayo Fuenzalida, 2021; Xie et al., 2020)
- physical illness (e.g., Taggart et al., 2024)
- long-term health problems (e.g., Asare et al., 2021; Hossain et al., 2004)

While highly likely to be under-reported, Australian mining sector data shows that between 0.5% and 2.5% of all reported notifiable incidents include fatigue as a contributing factor (Horberry et al., 2022). Around 80% of these are vehicle-related and 20% are associated with manual tasks. The impacts of fatigue have serious implications for the mining industry for work productivity, worker retention, absenteeism, presenteeism and associated financial costs. For example, fatigue is associated with musculoskeletal pain and injuries (Carlisle and Parker (2014), and in Australia this accounts for 92% of all serious injury or disease claims in the mining industry (James et al., 2021). Long working hours in mining have been associated with a 32% higher chance of death and 73% more chance of one incident resulting in two or more workers being injured (Friedman et al., 2019).

The industry has made considerable progress in fatigue management (Horberry et al., 2022), particularly in supporting sleep and recovery from fatigue (e.g., shift patterns, accommodation standards), but the evidence suggests that there many more factors that influence the development of fatigue in mining that need to be considered and that provide opportunities for improvement. This paper summarises this evidence and presents a framework to create awareness of the full range of factors that contribute to fatigue in mining and to inform fatigue risk management.

## 2.0 Search Process

This scoping review searched the international peer-reviewed scholarly and grey literature for documents about fatigue in mining. The literature searched for English language publications in two robust databases across all years. The grey literature was searched using four free versions of Generative Artificial Intelligence. Both searches followed a systematic process, including adding relevant articles referenced in the documents found. Overall, some 325 potentially relevant articles were found in the peer-reviewed literature and 27 documents in the grey literature.

## 3.0 Findings

Research addressing fatigue in the mining sector dates back more than 50 years and covers six continents. Heat as a contributing factor for fatigue is the most frequently published research topic and the early work focussed exclusively on this area. In the 1980's, fatigue associated with physical work appears in the literature, and in the mid-1990's, research into shift patterns and fatigue was published and a focus of this area has continued until today, including a growing emphasis on sleep and lifestyle. Mental and emotional fatigue has been considered more often in the last decade as the nature of mining work changes.

Slightly more than a quarter of the scholarly literature (44 articles) about fatigue in mining was Australian based. Approximately one third of this was related to hot working environments and heat stress, particularly in the earlier literature. Sleep and shift work was the focus for about 27% of the Australian based fatigue in mining work. The remaining small number of articles (2-4 in each area) considered mental health, physical fitness, fatigue detection, fatigue risk management, vibration, noise and physical work with. The grey literature was almost exclusively Australian, dominated by the NSW Mine Safety Advisory Council materials, the Resources Regulator documents and research reports commissioned by the Australian Coal Industry's Research Program (ACARP).

The review found that in the current literature there was little holistic consideration given to the range of factors that contribute to fatigue in mining. Indeed, research attention to the interactions between the wide range of potential contributory factors in fatigue is lacking. A framework that illustrates the different contributory factor areas and factor interactions identified in the literature is shown in Figure 1. The following sections of this report provide a summary of review findings as they relate to each contributory factor area.

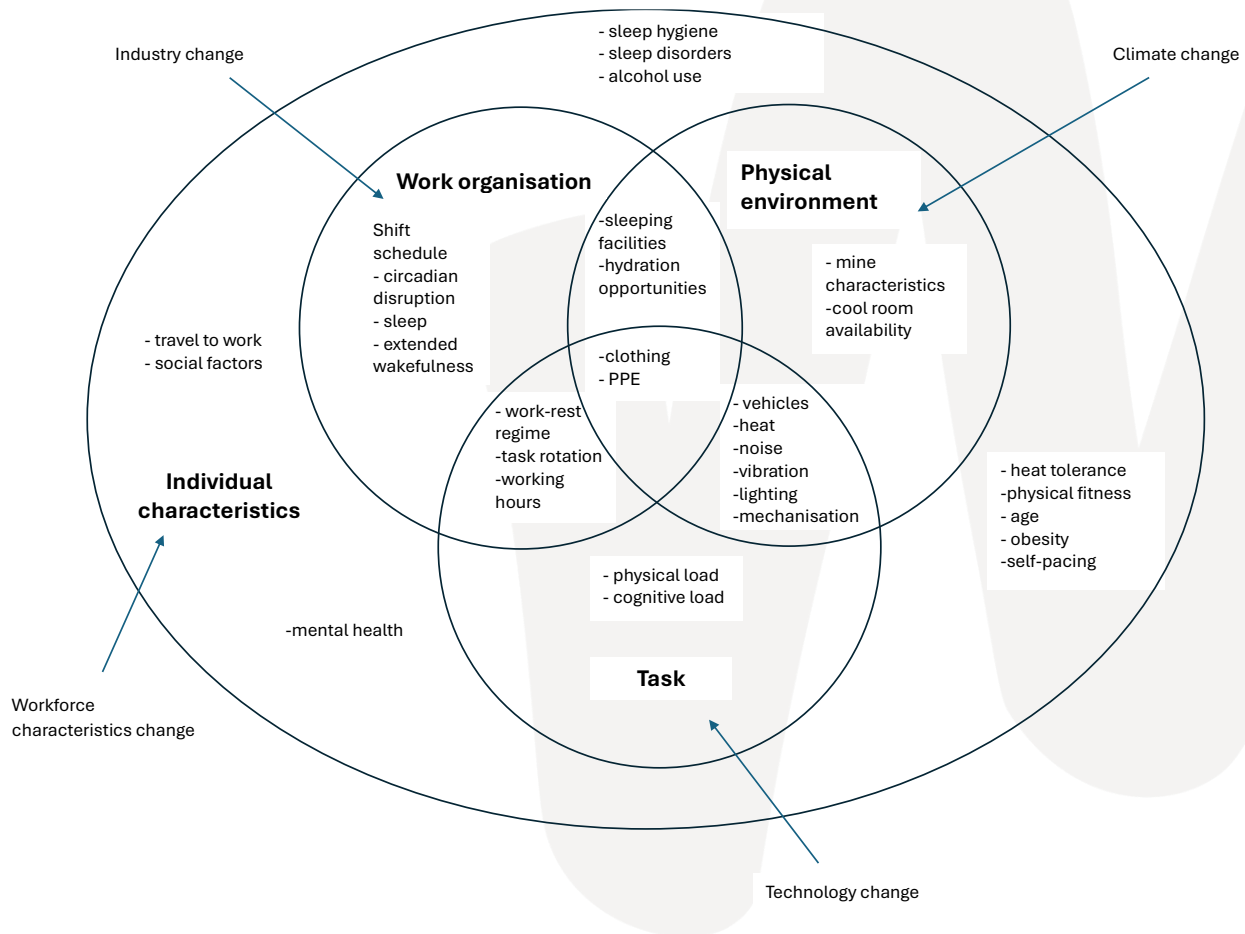


Figure 1 Framework of factors contributing to fatigue in mining

### 3.1 Physical environment

Shown in the right circle of the graphic, characteristics of the mining physical environment contribute to fatigue. This includes the context, e.g., the type of mine, location, available facilities, and heat, noise, lighting and vibration.

#### Heat

Hot working environments:

- Increase the rate of fatigue (Department of Mines and Petroleum Resources Safety, 2013; Industry & Investment NSW, 2009; Queensland Department of Natural Resources and Mines, 2013).
- Increase with mining depths, mechanisation (Ryan & Euler, 2017), type of personal protective equipment and/or clothing (Donoghue & Bates, 2000) and climate change (Hanna et al., 2011; Kim & Lee, 2020; Kjellstrom et al., 2009).
- Lead to heat stress for workers and serious short and long-term illnesses and incidents and injuries related to attention or judgement errors (Deshayes et al., 2024 Bhattacharjee et al., 2007; Kielblock, 2002; Taggart et al., 2024).
- Decrease work productivity (Flouris et al., 2018).

#### Noise

Mining equipment and machinery have been identified as contributing to excessive noise environments for miners and are rated by miners as an important factor influencing their fatigue (Butlewski et al., 2020). Noise can also impact the quality of the sleeping environment when workers are sleeping on-site (Jay et al., 2015). Excess noise in work environments:

- Increase fatigue and affect health and performance by creating difficulties with communication and reduced ability to recognise warning signals (Kovalchik et al., 2008; Shkempi et al., 2022).
- Effect night-shift workers more (Li et al., 2022).
- Can result in noise induced hearing loss (NIHL) and is the most compensated, occupational disease in Australian coal mining (Liebenberg et al., 2023).
- Can impact worker sleep quality in accommodation facilities (Maisey et al., 2022).

## Lighting

The lighting environment in mining is identified as a risk for fatigue where the natural and artificial lighting can be much lower than other workplaces (Bauerle, 2022). Working in dim light:

- Decreases cognitive functions, such as alertness and reaction time (Bauerle, 2022).
- Decreases visual cues and can lead to a greater risk of mistakes and injuries (Bauerle, 2022; Dugdale, 2022).
- Can lead to circadian disruption (Dugdale, 2022).

## Vibration

Vehicles used in mining increase the risk of fatigue due to rough terrain, vehicle dynamics, suspension systems, seating design, operational behaviour and working techniques (Ismail & Matthews, 1999; Plewa et al., 2012; Wolfgang & Burgess-Limerick, 2014b). The vibration experienced in vehicles and from equipment:

- Impacts on fatigue through muscular fatigue (Santos et al., 2008) or from musculoskeletal symptoms (Kumar, 2004).
- Is a risk factor for back pain and other health effects (Santos et al., 2008).
- Is experienced differently in men and women (Govers et al., 2021).

## 3.2 Tasks

Mining tasks are varied and put different demands on workers. These demands depend on the context of the mining (e.g., type, location, job) and are changing as the industry adapts to mechanisation and the introduction of other technology.

### Physical workload

Physical workload is associated with work tasks that put movement or postural demands on workers. This might include lifting or handling loads, repetitive work, or working in awkward body postures. In mining:

- Physically demanding tasks are a risk factor for fatigue and may lead to awkward movement patterns, affect balance, concentration, coordination and musculoskeletal pain or injury (Bauerle et al., 2022; SafeWork Australia, 2025; Khoshakhlagh et al., 2017).
- The impact of the weight of materials and lifting tasks on musculoskeletal disorders and muscular fatigue has been established (Chen et al., 2022; Gallagher et al., 1988).

- More than 80% of an Australian sample reported pain in one or more body areas associated with fatigue (Carlisle & Parker, 2014).
- Musculoskeletal pain and injury increase absenteeism and workers' compensation costs (Carlisle & Parker, 2014).
- The physical workload depends on the specific tasks, the work to rest regimes, the work duration and the thermal work environment (Kenny et al., 2012). You can see these overlapping areas in the lower circle in Figure 1.
- There is increased cardiovascular stress for older workers compared to younger workers (Saha et al., 2008).

### Cognitive workload

Cognitive workload is the mental effort required to perform tasks and includes attention, memory, and problem-solving processes. Prolonged and demanding cognitive activities increase the risk of fatigue at work (Karim et al., 2024; Nurahma et al., 2022). Mental workload can also impact sleep quality, which significantly affects fatigue and recovery (Kusmawan et al., 2024). Mental fatigue affects all stages of cognition, from perception to decision-making, to emotional and motor responses (Djamalus et al., 2021; Drews, 2020). In mining workers:

- Higher prevalence of mental fatigue and mental distress is associated with particular work tasks and areas (Carlisle & Parker, 2014; Djamalus et al., 2021; Nurahma et al., 2022; Sun et al., 2022).
- Workload and emotional demands have been identified as a predictor of emotional fatigue and stress (Albrecht & Anglim, 2018).
- Monotonous work tasks and long work hours contribute to cognitive fatigue (Bauerle et al. 2022; Chen et al., 2024; Leso et al., 2021).
- Self-assessment of cognitive fatigue may not correlate to performance (Chen et al., 2024; Purto et al., 2024).

### 3.3 Work organisation

The circle on the left in Figure 1 shows factors that affect fatigue to do with how the work is organised. Aspects of work organisation that intersect with task and environment factors that have been discussed above can be seen in the lower and right parts of the circle.

## Shift schedules

Much research has been done in the mining sector about shift schedules for workers, the impact on fatigue and the risks associated with it (Di Milia & Bowden, 2007; Duchon et al., 1994; Hossain et al., 2004; Langdon et al., 2016). Various shift work schedules in 24-hour continuous mining operations have been studied including fixed shifts, forward and backward rotating shifts, night shifts, eight-, ten- and twelve-hour shifts, fly-in, fly-out (FIFO) rosters and overtime. In mining, shift characteristics that are risk factors for fatigue include:

- The number of consecutive shifts particularly consecutive nights (Bauerle et al., 2022; Bofinger et al., 2002; Ferguson et al., 2012).
- Excess overtime, unscheduled overtime and overtime extending the length of shifts (Bofinger et al., 2002; Baker et al., 2001, 2003; Eiter et al., 2014).
- Extended shift lengths (Bise & Breysse, 1999; Bauerle et al., 2022; Bofinger et al., 2002; Maisey et al., 2022; Paech et al., 2010).
- The first shifts in the roster (Bofinger et al., 2002; Ganesan et al., 2022; Roach et al., 2022).
- Break patterns within and between shifts (Bauerle et al., 2022; Bofinger et al., 2002; Eiter et al., 2014; Paech et al., 2010).
- Early and/or irregular shift start times (Bauerle et al., 2022; Bofinger et al., 2002; Ferguson et al., 2012; Maisey et al., 2022).
- Changes to rosters (Bofinger et al., 2002; Hossain et al., 2004).
- Backward rotating shifts i.e., moving from nights to evenings to days (Hossain et al., 2004; Maisey et al., 2022; Smith & Eastman, 2012).

These factors contribute to the development of fatigue through circadian rhythm disruption, sleep loss, extended wakefulness, and lack of restorative sleep and recovery (Beranek et al., 2025; Ganesan et al., 2022; Horberry et al., 2022; Hossain et al., 2004; Maisey et al., 2021; Nurahma et al., 2022; Paech et al., 2010).

Shift work is associated with significant increased health risks including cardiovascular disease and gastrointestinal disorders (Asare et al., 2021; Hossain et al., 2004). In mining, fatigue associated with shift schedules:

- Decreases cognitive performance (Ferguson et al., 2012; Leso et al., 2021),
- Decreases alertness (Maisey et al., 2022)
- Contributes to errors and incidents (Baker et al., 2001; Bauerle et al., 2022; Dugdale et al., 2022; Halvani et al., 2009)
- Is a factor in staff turnover (Langdon et al., 2016) and absenteeism (Baker et al., 2001)
- Is increased by commuting to work (Di Milia & Bowden, 2007; Maisey et al., 2022).

### 3.4 Individual characteristics

The outer, surrounding circle of Figure 1 depicts individual characteristics that modify the impact of fatigue associated with the physical environment, work organisation and task factors in mining work. These include physical characteristics such as:

- heat tolerance and self-pacing ability (Hanna et al., 2011; Kenny et al., 2012; Roy et al., 2022)
- physical fitness (Donoghue & Bates, 2000)
- age (Kenny et al., 2012)
- obesity (Donoghue & Bates, 2000; Maisey, 2023)
- sleep disorders (Maisey et al., 2022).

Social characteristics such as family and social situations sleep hygiene (Beranek et al., 2025), alcohol and/or substance use and travel to work requirements also play a part (Maisey et al., 2022; Maisey, 2023). Mental health (Horberry et al., 2023; Matamala Pizarro & Aguayo Fuenzalida, 2021) and general health and well-being factors also influence the experience of fatigue.

The effect that individual attributes have on the development and risk of fatigue in mining is subject to change as the characteristics of the mining workforce changes. For example, there is current limitations in the research about women in mining (Hossain et al., 2004; Jay & Brotherhood, 2016) and the impact of older workers in mining (Tetzlaff, 2024)

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## 4.0 Development of fatigue

This review identified a gap in the literature around paying attention to the combinations of the contributing factors and how these interactions can lead to the development of fatigue. It has been noted that fatigue is rarely reported as contributing to notifiable incidents in Australia (Horberry et al., 2022), which is surprising given the nature of mining operations and the reports of incidents associated with fatigue in the wider literature. Reasons for this may include the lack of awareness or consideration of the multiple factors contributing to fatigue (Horberry et al., 2023), the work culture or the organisational safety culture (Sprajcer et al., 2022; Wong et al., 2019).

Figure 2 presents a model of fatigue development based on the literature review findings that shows how task factors, circadian factors and sleep factors may interact with each other and with personal factors to result in physical, mental, and emotional fatigue.

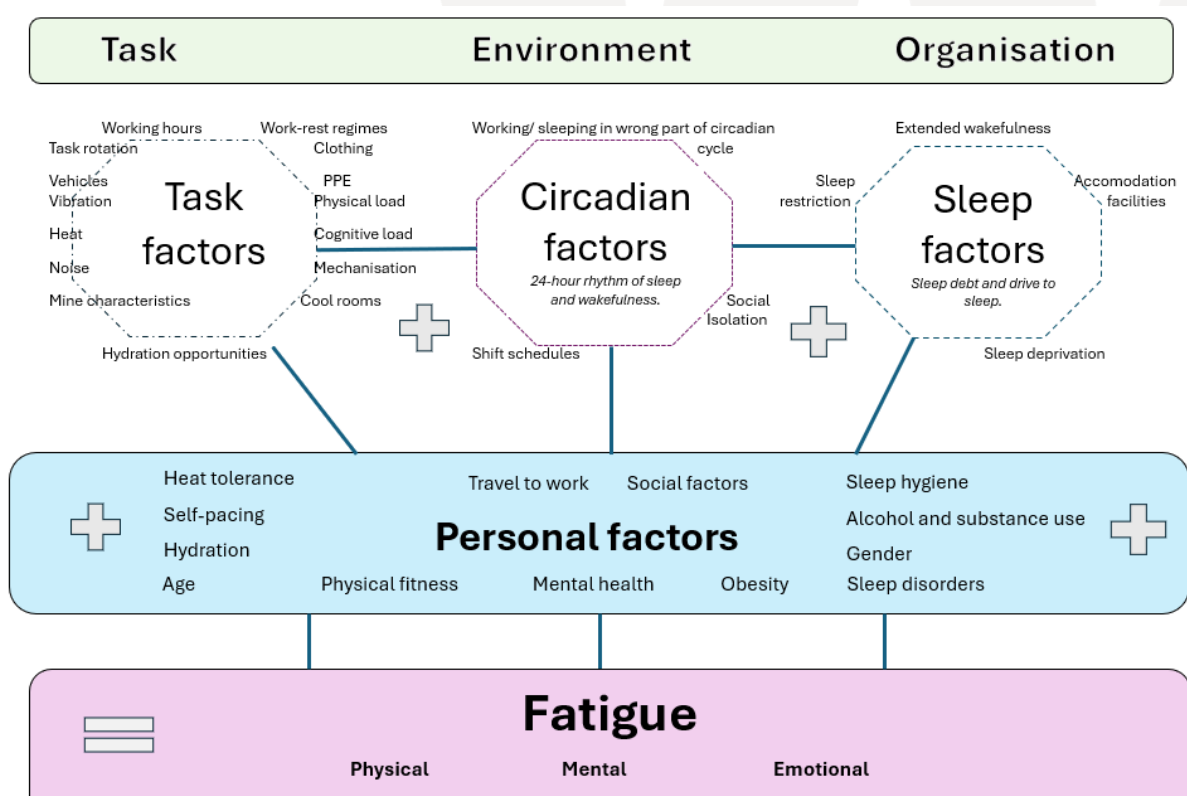


Figure 2. Fatigue development model considering the interaction of task, environmental, organisational and personal factors

## 5.0 Health, Safety and Psychosocial Benefits

The literature review identified a range of fatigue prevention and risk management interventions for mining work linked to the interrelated contributory factors. Examples of these are presented in terms of the risk control hierarchy of engineering, administrative and personal protective equipment in Table 1.

*Table 1 Potential controls for preventing and managing risk of fatigue in mining based on the literature*

Factor contributing to fatigue	Engineering controls	Administrative controls	Personal protective equipment
<b>Heat</b>	<ul style="list-style-type: none"> <li>Cooling systems for plant and environment e.g., cool rooms, shielding heat sources (Ryan &amp; Euler, 2017, WorkSafe Victoria, 2009)</li> <li>Ventilation (Roy et al., 2022)</li> </ul>	<ul style="list-style-type: none"> <li>Hydration opportunities (Brake &amp; Bates, 2003; Taggart et al., 2024)</li> <li>Acclimatisation (Deshayes et al., 2024)</li> <li>Heat and health monitoring (Ijaz et al., 2024; Ryan &amp; Euler, 2017) including wearables (Saidi &amp; Gauvin, 2023).</li> <li>Supervisory surveillance (Bofinger et al., 2002)</li> <li>Work-rest regimes (Brake &amp; Bates, 2002; Kenny et al., 2012)</li> <li>Self-pacing (Horberry et al., 2023)</li> <li>Thermal limits (Brake &amp; Bates, 2002b, Jay &amp; Brotherhood, 2016)</li> <li>Education (Taggart et al., 2024)</li> </ul>	<ul style="list-style-type: none"> <li>Cooling garments (Ioannou et al., 2021; Sarkar &amp; Kothari, 2014; Zhou et al., 2023)</li> </ul>
<b>Noise</b>	<ul style="list-style-type: none"> <li>'Quiet-by-design' noise treatments (Kivade et al., 2011; Kovalchik et al., 2008)</li> <li>Sleeping environment design (Maisey et al., 2022)</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring effectiveness of personal protective equipment</li> <li>Noise surveillance (WorkSafe Victoria, 2009)</li> <li>Acoustic analysis</li> <li>Audiometry examinations (Butlewski et al., 2020)</li> </ul>	<ul style="list-style-type: none"> <li>Hearing protection devices</li> </ul>

Factor contributing to fatigue	Engineering controls	Administrative controls	Personal protective equipment
<b>Vibration</b>	<ul style="list-style-type: none"> <li>Seating design</li> <li>Tool design</li> <li>Vehicle maintenance</li> <li>Road maintenance</li> </ul> <p>(Lynas &amp; Burgess-Limerick, 2020; Burgess-Limerick &amp; Bialkowski, 2023)</p> <ul style="list-style-type: none"> <li>Road design (Horberry et al., 2023)</li> </ul>	<ul style="list-style-type: none"> <li>Measurement</li> <li>Monitoring devices</li> <li>Work technique training (Wolfgang &amp; Burgess-Limerick, 2014a; Burgess-Limerick &amp; Lynas, 2016)</li> <li>Working hours.</li> <li>Workload design.</li> </ul>	
<b>Lighting</b>	<ul style="list-style-type: none"> <li>Optimising ambient and personal lighting for the tasks (Jayawardena et al., 2014)</li> </ul>	<ul style="list-style-type: none"> <li>Bright light as an intervention for circadian disruption (Bauerle, 2022)</li> </ul>	
<b>Physical workload</b>	<ul style="list-style-type: none"> <li>Mechanisation</li> <li>Task and equipment design to reduce load, repetition, force and awkward postures</li> <li>Improving physical work environment (e.g., heat, lighting)</li> </ul> <p>(NSW Mine Safety Advisory Council, 2021; WorkSafe Victoria, 2009).</p>	<ul style="list-style-type: none"> <li>Work-rest schedules (Horberry et al., 2023)</li> <li>Self-pacing (Kenny et al., 2012; Horberry et al., 2023)</li> <li>Hydration opportunities.</li> <li>Task design to reduce load, repetition, force and awkward postures</li> <li>Task rotation (Horberry et al., 2023; James et al., 2021; Jones &amp; James, 2018).</li> <li>Overtime and call-out restrictions</li> </ul>	
<b>Cognitive workload</b>	<ul style="list-style-type: none"> <li>Human-equipment interface design to optimise operation and reduce cognitive load (Horberry et al., 2023)</li> </ul>	<ul style="list-style-type: none"> <li>Work-rest schedules (Horberry et al., 2023)</li> <li>Wearable and other technology to detect fatigue (Chen et al., 2024; Rogers et al., 2023)</li> <li>Task design to reduce cognitive load.</li> <li>Monitoring/rescheduling of cognitively demanding work during low circadian phases (Horberry et al., 2023)</li> <li>Limit duration of monotonous work</li> <li>Optimise communication channels and decision-making processes (Horberry et al., 2023)</li> </ul>	

Factor contributing to fatigue	Engineering controls	Administrative controls	Personal protective equipment
<b>Shift schedules</b>		<ul style="list-style-type: none"> <li>• Roster design including consultation with workers to allow for adequate rest and recovery and holistically consider operational requirements, health and safety outcomes, and family and social life.</li> <li>• Limit shifts to 12 hours or 8 hours at night</li> <li>• Use forward rotation shift schedules (morning-afternoon-evening).</li> <li>• Limit consecutive night shifts.</li> <li>• Allow for at least two full night's sleep after the last night shift.</li> <li>• Avoid permanent night shifts.</li> <li>• Avoid early morning starts.</li> <li>• Limit consecutive workdays to maximum of 7.</li> <li>• Limit overtime.</li> <li>• Rest period between shift should allow for commuting, meals and sleep.</li> <li>• Build regular free weekends into the schedule.</li> <li>• Include journey management plans for commuting.</li> <li>• Pre-employment medicals. (Horberry et al., 2022, 2023)</li> <li>• Resourcing to meet site roster requirements.</li> <li>• Policy and procedures to manage fatigue.</li> <li>• Provision of training and information (Bofinger et al., 2002).</li> <li>• Biomathematical modelling to aid design of shift schedules and rosters</li> <li>• Provision of additional sleep opportunities following periods of consecutive nights (Maisey et al., 2022).</li> </ul>	



Factor contributing to fatigue	Engineering controls	Administrative controls	Personal protective equipment
<b>Sleep loss, extended wakefulness and circadian disruption</b>	<ul style="list-style-type: none"> <li>Accommodation facility design (Beranek et al., 2025; Roach et al., 2022)</li> </ul>	<ul style="list-style-type: none"> <li>Education about sleep, circadian rhythms, sleep hygiene, prioritisation of sleep prior to work shifts (Beranek et al., 2025; Dugdale et al., 2022; Ganesan et al., 2022)</li> <li>Light exposure treatment (Dugdale et al., 2022; Smith &amp; Eastman, 2012)</li> <li>Technological interventions for detecting fatigue (e.g., Aidman et al., 2015; Bongers, 2009; Dawson et al., 2014; Maisey et al., 2021; Rogers et al., 2023; Saidi &amp; Gauvin, 2023).</li> </ul>	<ul style="list-style-type: none"> <li>Use of caffeine (Ganesan et al., 2022)</li> </ul>
<b>Individual and personal factors</b>	<ul style="list-style-type: none"> <li>Accommodation facility design.</li> <li>Recreational planning and design at accommodation facilities.</li> </ul>	<ul style="list-style-type: none"> <li>Onsite health systems.</li> <li>Health promotion e.g., minimising alcohol consumption, maintaining a healthy body weight (Maisey et al., 2022).</li> <li>EAP services</li> <li>Clear policies for drug and alcohol use.</li> <li>Sleep disorder screening and treatment interventions (Horberry et al., 2023; Maisey et al., 2022)</li> </ul>	

## 5.1 Fatigue risk management systems

The complexity of fatigue development and available controls in mining means that the best way to manage the risk is with comprehensive multi-level fatigue risk management systems (FRMS) and optimal design of work (Bofinger et al., 2002; Safe Work Australia, 2025).

FRMS include workplace strategies or interventions to identify, assess, control and review risks associated with worker fatigue specific to the mine context and their specific workers (Bofinger et al., 2002; Horberry et al., 2022, 2023; Maisey et al., 2022). A FRMS typically includes the elements listed in Table 2 and is best integrated into existing safety management systems.

*Table 2 Elements of a Fatigue Risk Management System (based on Maisey et al., 2022; Wong et al., 2019)*

Policies, procedures, implementation plans
Leadership and commitment
Consultation
Shift and roster design
Health and safety data collection and analysis
Fatigue risk management and sleep hygiene training
Healthy lifestyles support
Psychological health and safety at work
Travel and commuting policies and controls
Sleep disorder management
Workplace hazards identification and controls
Sleep environment design
Individual fatigue monitoring
FRMS evaluation and continual improvement

The key enablers of successful implementation of FRMS include organisational and worker commitment, workplace culture, and training (Sprajcer et al., 2022). Effectiveness of fatigue management strategies need to be verified, regularly reviewed and supported by research that evaluates the best way to implement fatigue management interventions and in the mining industry and how effective they are (Dugdale et al., 2022; Horberry et al., 2023). Additional recommendations for management of fatigue in mining include:

- better monitoring of long-term health effects of fatigue
- more consideration of mental health outcomes (Matamala Pizarro & Aguayo Fuenzalida, 2021; Horberry et al., 2023)
- more fatigue-detection technology exploration (Horberry et al., 2023; Purto et al., 2024)
- better understanding of fatigue in a changing workforce, such as women (Hossain et al., 2004; Jay & Brotherhood, 2016) and older workers (Tetzlaff, 2024)
- more consideration of the impacts of increased automation in mining on worker fatigue (Bauerle, 2022).

## 6.0 Conclusion

This scoping review demonstrates that fatigue in the mining sector is complex and multidimensional arising from the interaction of physical, organisational, task-related, and individual factors. While the literature on fatigue in mining is extensive, it has largely examined contributing factors in isolation, limiting understanding of how fatigue develops in real operational contexts. The review highlights that fatigue is not solely a function of shift work or sleep loss, but is shaped by environmental conditions, workload demands, work design, and personal characteristics often compounded by circadian disruption and inadequate recovery.

The findings underscore the need for a more integrated approach to fatigue prevention and management in mining. Comprehensive, multi-level Fatigue Risk Management Systems embedded within existing safety management systems are essential to effectively address fatigue risk. Strengthening leadership commitment, worker consultation, and organisational culture, alongside ongoing monitoring and evaluation, is considered critical. Future research should prioritise mental health outcomes, long-term health effects, workforce diversity, fatigue detection technologies, and the impacts of increasing automation to better inform evidence-based fatigue management in the mining industry.