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The Self-Management of Fatigue in Train Drivers

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Supervisor: Dr. Maria Chiara Leva

Student Reaffirmation of Academic Integrity under Approved Changes to Delivery and Assessment of TU Dublin Programmes

Arising from the unforeseen emergency measures required for the containment of the COVID-19 virus outbreak, the University enacted contingency Quality Assurance procedures (Approved by Academic Council on March 23, 2020). Under the referred enactment, physical face-to-face examinations, invigilated in the traditional manner, will not take place in May. Programmes have moved, where possible, towards alternative assessment arrangements.

This is a reaffirmation that each student is responsible for knowing and abiding by TU Dublin Academic Regulations and Policies. Any student violating these regulations/policies will be subject to action in accordance with the University's procedures for breaches of assessment regulations. Some guidelines towards compliance with Academic Integrity are outlined overleaf.

By signing this form, I understand and will abide by the University Regulations and Policies, including those covering Academic Integrity. Therefore, I declare that any individual work being submitted for assessment is entirely the product of my own effort. For all group assessments, I accept that each member of the group is responsible for the academic integrity of the entire submission. I will retain a copy of this agreement for future reference.

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1. No student shall complete, in part or in total, any assessment for another person.
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3. No student shall plagiarise or copy the work of another and submit it as his or her own work.
4. No student shall employ devices excluded by the lecturer in undertaking assessments.
5. No student shall knowingly procure, provide, or accept any materials that contain questions or answers to any assessment to be given at a subsequent time.
6. No student shall procure or accept assessments from any other student from current or prior classes of their programme.
7. No student shall provide their assessments, in part or in total, to any other student in current or future classes of this programme, unless authorised to do so.
8. No student shall submit substantially the same material in more than one module without prior authorisation and acknowledgment of the previous submission.
9. No student shall alter a marked assessment and then resubmit it for remarking unless specifically requested to do so by the lecturer.
10. All programming code and documentation submitted for assessment must be the students original work or material specifically authorised by the lecturer.
11. Collaborating with other students to develop, complete or correct assessments is limited to activities explicitly authorised by the lecturer.
12. For all group assessments, each member of the group is responsible for the academic integrity of the entire submission.

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Abbreviations

CBT	Cognitive Behavioural therapy
FRMS	Fatigue Risk Management System
HIV	Human Immunodeficiency Virus
KSS	The Karolinska Sleepiness Scale
NASA-PVT	National Aeronautics and Space Administration - Psychomotor Vigilance Task
OTC	Over the counter
REM	Rapid Eye Movement
SPAD	Signal passed at danger
TUD	Technological University Dublin

1. Abstract

Although the consequences of fatigue in transport are well documented, deficiencies in rail-specific fatigue research compared to road and aviation, as well as the absence of a validated questionnaire for assessing train driver fatigue within the rail industry, highlights the requirement for additional research to shed light on rail fatigue and its management.

This study expands on current knowledge concerning train driver fatigue and fatigue self-management strategies, by developing and validating a pilot questionnaire designed to assess fatigue and its self-management in train drivers. This was achieved by determining fatigue levels and causes, methods used to manage fatigue at work and manage sleep, their effectiveness and the willingness of train drivers to use particular types of fatigue management strategies to manage their fatigue.

An extensive literature review that reviews peer reviewed sources and industry operational documents was compiled to inform the content of the pilot questionnaire, which was then validated by an industry expert and an external expert.

Face validation, content validation and reliability analysis confirmed that the questionnaire was a valid tool which adequately assessed fatigue, identified countermeasures used, their effectiveness and the willingness of train drivers to use particular countermeasures to help combat fatigue. Importantly, the findings of the pilot questionnaire, are in line with literature indicating the impact and effectiveness of various fatigue management strategies. Altogether, the findings of this study may inform fatigue risk management systems in rail, consequently reducing fatigue-related risks to the health and safety of drivers and passengers.

2. Introduction

Fatigue is regarded as a hallmark of modern life. Extending workday duration is a method commonly employed by organisations to augment occupational productivity and flexibility of work hours. The consequences of which are a decrease in resting time intervals between workdays and an increase in the variability in shift start and finish times (Dawson et al., 2011; Wang and Chuang, 2014). Fatigue is a pertinent and complex issue within the workplace that is shaped by work-related and non-worked-related risk factors (Gander et al., 2011). It is a major contributor to human-related accidents, many of which have prompted improvements in rail safety management systems, specifically, fatigue risk management systems (FRMS) (Fan and Smith, 2018). Indeed, such catastrophic accidents are associated with significant economic costs. A study conducted by Gertler et al. (2012) which evaluated the economic cost of human-factor accidents reported an 11-65% increase in the probability of fatigue-related-human factors accidents and economic costs of approximately 1.5 million, when an employee is fatigued, relative to $400k in the absence of fatigue as a risk factor (Gertler et al., 2012).

Various definitions of fatigue have been proposed in the literature. Nonetheless, the majority of the definitions share the common concept that it is a state caused by exertion (Philips, 2015). For instance, Lee and Kim (2018) described fatigue as a mental and physical decline that may be coupled with rest defects (Lee and Kim, 2018). Moreover, the British Office of Rail Regulations (2012) defined railway fatigue as a state of "perceived weariness that can result from prolonged working, heavy workload, insufficient rest, and inadequate sleep" (British Office of Rail Regulations, 2012).

Fatigue can be classified as two different types depending on its stage, namely acute fatigue and chronic fatigue. Acute fatigue is fatigue that occurs in healthy persons and is believed to be a protective physiological role of the body. Its onset is rapid, but it lasts for a short duration. Acute occupational fatigue may occur during or after work. Its effects can be ameliorated through rest, physical activity and stress management. Thus, acute fatigue has a minor impact on daily activities and quality of life. However, persistent acute fatigue may develop into chronic fatigue, which is the accumulative effect of acute fatigue. It is not alleviated by the aforementioned restorative methods. Consequently, it has significant repercussions on an individuals' daily activities and quality of life (Shen et al., 2006; Fan and Smith 2018).

Certainly, train driver fatigue, is an international issue due to the fact that it is a safety-critical job that requires the physical operation of the train. Analogous to other forms of passenger transportation, rail safety depends in part on the actions and attentiveness of the driver, in order to transport passengers safely. However, it is important to note that passenger safety does not rely solely on the driver. It is also highly impacted by the cooperation and the activity of the sociotechnical system that the driver operates within. For instance, driver vigilance and attentiveness are dictated to some extent by work shift duration, which is a decision made in part by management. In contrast to other road transport modes, train manoeuvrability is limited. The nature of railway transport such as the train's weight, forward momentum and its stopping distances i.e. "train dynamics" requires drivers to take certain measures prior to a desired response. For example, train drivers must brake prior to advancing towards a sign, when undergoing speed changes (Naweed et al., 2013, 2015).

Failure to manage train driver fatigue may result in a high risk to the health and safety of train drivers and passengers. Leading sleep scientists have described fatigue as being the "largest identifiable and preventable cause" of 15-20% of all transport operation accidents (Akerstedt, 2000). In addition, a study conducted by Williamson et al. (2011) reported a relationship between fatigue and safety outcomes within high risk industries (Williamson et al., 2011). Furthermore, driver fatigue has been described to be a contributing cause of truck crashes (Young and Hashemi, 1996).

In general, fatigue is associated with deficiencies in mentally demanding tasks. Fatigued individuals commonly experience deficiencies in cognitive performance and functioning (Cercarelli and Ryan, 1996; Beurskens et al., 2000). Similarly, fatigue is associated with deficiencies in physically demanding tasks, a by-product of impairments in physiological processes, which occur as a result of decreases in cell, tissue, or organ responses following excessive stress or activity (Hirshkowitz, 2013). Fatigued individuals think and move at a slower pace, are more prone to making mistakes and experience more difficulties remembering things, relative to unfatigued individuals (Caldwell et al., 2009).

Fatigue can be caused by a variety of risk factors which can be classified into work-related and non-work-related risk factors. Work-related risk factors include, workload, shift duration and job control. On the contrary, insufficient sleep and time of day are examples of non-work-related risk factors (Fan and Smith, 2018).

Due to the fact that fatigue impairs employee attention and performance, it is of paramount importance to address this issue as it poses a grave threat to safety critical workers. This study aims to examine fatigue causes, consequences and countermeasures via a literature review that reviews peer reviewed sources and industry operational documents. Emphasis is placed on fatigue risk management strategies, namely, fatigue self-management strategies. Potential fatigue measurement and mitigation strategies that can be employed by train drivers to manage their levels of fatigue at work and at home are also discussed. Importantly, this study aims to develop and validate a pilot questionnaire designed to assess fatigue and its self-management in train drivers by determining fatigue levels and causes, methods used to manage fatigue at work and manage sleep, their effectiveness and the willingness of train drivers to use particular types of fatigue management strategies to manage their fatigue.

Although the consequences of fatigue in transport are well documented, the deficiency in rail-specific fatigue research relative to road and aviation, highlights the importance of additional research to shed light on this matter (Philips, 2014; Anund et al., 2015). This study will expand our knowledge of the train driver fatigue self-management strategies and as a consequence facilitate the integration of these strategies into FRMS in rail. Thus, reducing fatigue-related risks to the health and safety of drivers and passengers.

3. Literature Review

3.1. Causes of fatigue

In general, the causes of fatigue can be classified into work-related and non-work-related risk factors. Shift work and the nature of the job are examples of work-related causes of fatigue. Conversely, inadequate sleep, lighting, sleep disorders, medication and sleep hygiene are examples of non-work-related risk factors. The impact of work-related factors will only be discussed briefly as this study is more concerned with identifying risk factors that can be self-managed by train drivers.

3.1.1. Shift work

It has been established that shift workers suffer from sleep deprivation and circadian rhythm disruptions (Harma et al., 1998; Drake et al., 2005). Chronic sleep deprivation and circadian rhythm disruption have been associated with various sleep disorders. Importantly, declines in alertness, vigilance and performance are the outcome of insufficient sleep and circadian rhythm disruptions (Van Dongen and Dinges, 2005). Shift duration has been found to be a significant inducer of fatigue through its performance degrading-effects and its adverse impact on rest intervals (Gawron, 2016; Reis et al., 2016; Lee and Kim, 2018; Williamson et al., 2011). Goode (2003) reported a significant association between shift duration and accident frequency (Goode, 2003). Furthermore, shifts that start at unusually early or late times result in sleep deprivation which significantly contributes to fatigue onset. (Roach et al., 2012).

3.1.2. Lighting

Light exerts it effects by synchronising circadian rhythms to the external environment. This is achieved through the regulation of autonomic and neuroendocrine systems, particularly melatonin (Fisk et al., 2019). A study conducted by Boubekri et al. (2014) reported that office workers in environments lacking windows slept relatively less than those working in environments with windows, due to reduced daytime light exposure. In particular, daytime blue light exposure positively impacts night time sleep (Boubekri et al., 2014). Furthermore, Viola et al. (2008) demonstrated that blue office light increased employee performance by decreasing sleepiness and improving sleep quality (Viola et al., 2008).

On the contrary, Chang et al. (2015) revealed that reading e-books in the evening, which are known to emit blue-enrich light, was associated with reduced sleep quality and problems with alertness the next morning (Chang et al., 2015). In addition, other studies have indicated that individuals that use electronic media in the evening such as TV, phone, computers and electronic games, have later bedtimes and reduced sleep quantity. Again, this can be attributed to the fact that these devices emit high levels of blue light that may increase arousal and impair sleep onset latency (Cain and Gradiser, 2010; Fossum et al., 2014).

3.1.3. The nature of the job

The train driving task involves the exertion of high levels of mental effort, as well as sustained concentration over extended periods of time during each shift (Philips and Sagberg, 2010). Conversely, it also involves long, extremely repetitious sections of track, that require very little input from the driver. As a result, the train driver task demands sustained vigilance that does not facilitate recovery, thereby lowering alertness and reducing the ability to react (Dunn and Williamson, 2012; Larue et al., 2011). Overall, the nature of the train driving task serves as a mediator of fatigue.

3.1.4. Sleep disorders

Sleep disorders are major contributors to sleep deprivation and performance deterioration. Sleep apnoea, insomnia and periodic limb movement syndrome are the most prevalent sleep disorders, with incidences of 6-13%, 10-48% and 0.1-13%, respectively (Institute of Medicine, 2006; Peppard et al., 2013; Chung et al., 2015; Scofield et al., 2008). When left untreated, sleep disorders can negatively impact an individual’s health and well-being by effecting sleep quantity and quality, therefore resulting in daytime sleepiness. Sleep disorders may also have adverse effects on work productivity by reducing employee productivity and increasing work absences (Yazdi et al., 2014).

3.1.5. Medication

Medications used to treat medical disorders may contribute to inadequate sleep by inducing daytime sleepiness or alternatively, by causing poor sleep quality at night.
Medications that disrupt sleep may contribute to daytime sleepiness. Examples of commonly used medications that have sleep-disrupting effects include, antidepressants, antipsychotics, antiepileptics, antihistamines and pain medications. In addition, their sedative effects induce daytime sedation and reduces daytime alertness. Conversely, corticosteroids, pseudoephedrine, phenylpropanolamine and theophylline are examples of medications that disrupt sleep as a result of their stimulating effects (Drake et al., 2013).

3.1.6. Poor sleep hygiene

Sleep hygiene plays a key role in sleep initiation and maintenance. Poor sleep hygiene habits and practises such as poor sleep environments, inconsistent sleep/wake schedule, association between the bedroom and non-sleep behaviours and taking part in arousal-producing activities prior to bedtime, may interfere with the process of sleep onset latency and sleep maintenance. If left unaddressed, these insomnia-like symptoms may have negative impacts on health, well-being and occupational performance (Stepanski and Wyatt, 2003).

3.1.7. Education

Knowledge of fatigue among staff at all levels in the organisation has been identified as an organisational factor that impacts fatigue in transportation (Arnold and Hartley 2001). Fatigue education serves as an important fatigue management strategy as it provides a common knowledge base that serves as a platform for developing an effective FRMS (Gander et al., 2011). Importantly, it is the only logical way of addressing the effects of non-work-related activities that contribute to fatigue onset, through an appeal to enlightened self-interest (Gander et al., 1998). Educating employees about fatigue self-management strategies, especially methods that help manage sleep, may improve employee productivity, health, safety and well-being (Gander et al., 2011). Thus, these studies suggest that inadequate fatigue education may be a contributor to train driver fatigue.

3.2. Consequences of fatigue

Despite the multifaceted nature of fatigue, its consequences are relatively consistent amongst individuals. The consequences discussed are classified into operational consequences, impairment of critical skills and functions and effects to health and well-being.

3.2.1. Operational consequences

3.2.1.1. Incidents, accidents and injuries

The operational consequences associated with fatigue are relatively consistent across the various transport industries. Fatigue has been established by various rail investigation reports as a contributor to railway incidents and accidents. Gibson et al. (2012) revealed that 21% of recent British high-risk railway incidents were a product of fatigue (Gibson et al., 2012). Moreover, studies have established that shift work, as well as long working hours can lead to 50-100% increase in accident rates (Wagstaff and Sigstad Lie, 2011). Studies have reported a relationship between human error in railway accidents and fatigue-related symptoms, namely drowsiness and motivation, as well as fatigue-related risk factors, such as time of day (Kogi and Ohta, 1975; Ugajin, 1999). In addition, a study by Buck and Lamonde's (1993) indicated an association between crew fatigue and critical train accidents (Buck and Lamonde's, 1993).

In an attempt to explain the relationship between fatigue and railway accidents, Morgan et al. (2016) attributed the occurrence of these accidents to the difficulties fatigued workers experienced in making rapid decisions and managing risks. Fatigue made workers more more prone to making mistakes, increasing the likelihood of accidents and incidents and the probability of near-miss occurrences (Morgan et al., 2016). Finally, Calabrese et al. (2017) indicated that fatigue induced by time of day elevated the probability of non-fatal and fatal injuries in train crew during night shifts (Calabrese et al., 2017) (Calabrese et al., 2017).

3.2.1.2. Signal passed at danger

Signal passed at danger (SPAD), also known as running a red light in the U.S and Canada, is a critical rail safety violation that occurs when a train passes a stop signal without the authority to do so (Filtness and Naweed, 2016). Naweed et al. (2015) reported a constant rise in SPAD occurrences over the past decade (Naweed et al., 2015). Despite the lack of research on the impact of fatigue on rail safety critical events such as SPADs, evidence suggests that they are the outcome of fatigue-related symptoms, namely increased sleepiness, increased distraction and compromised decision-making that leads to an overall slower response by the train driver. Altogether, the aforementioned symptoms increase the likelihood of a SPAD (Anderson and Horne, 2006; Harrison and Horne, 2000). Thus, this highlights the complex nature of the train driving task, emphasising the need for fatigue countermeasures that help manage fatigue at work.

3.2.1.3. Economic burden

Recent fatigue-related rail research has focused its efforts on train handling impairments. It revealed that fatigued train drivers experience a diminished ability to handle the train effectively, which presents a major safety risk. Dorrian et al. (2007) reported recurrent speed violations and heavy brake use by train drivers with a high probability of experiencing fatigue (Dorrian et al., 2007). Importantly, due to the fact that both acceleration and brake use significantly impact fuel consumption, fatigued drivers can be viewed as an economic burden to the railway industry as they have higher rates of fuel consumption (Dorrian et al., 2006; 2007)

3.2.1.4. Reactive organisational culture

A study that interviewed train drivers about fatigue, revealed that fatigue was a taboo topic that induced a reactive culture within their workplace. Due to the fact that an extremely reactive organisational culture of fear had evolved around the issue, fatigued drivers were apprehensive of reporting fatigue to management, despite being conscious of the hazards associated with driving while fatigued. Drivers reported being afraid of reporting fatigue because it would lead to a medical assessment. Consequently, fatigued drivers failed to report insufficient sleep as the underlying cause of a SPAD (Filtness and Naweed, 2016).

3.2.1.5. Disruption of schedule

Finally, disruption of train schedules is yet another consequence of train driver fatigue. A study conducted by Filtness and Naweed (2016) that interviewed drivers, indicated that the drivers had to reprioritise their goals when fatigued. As a result, they drove at a slower pace when fatigued, which lead to disruptions in train schedules (Filtness and Naweed, 2016).

3.2.2. Impairment of critical skills and functions

It has been established that performance degrades with fatigue, particularly at night-time when workers are five times more vulnerable to lapses in vigilance (Akerstedt and Lanstrom, 1998). In addition, Dinges et al. (1997) reveal that 4-6 hours of sleep per day induces a state of sleep debt, which significantly compromised performance (Dinges et al., 1997).

In addition, fatigue has also been associated with cognitive impairments. Five hours of sleep or less per night induced cognitive impairments, increased sleepiness and physical complaints (Bendak and Rashid, 2020). In addition, a study conducted by Filtness and Naweed (2016) revealed that train drivers described themselves as experiencing cognitive impairments, namely impaired judgement and inattention, when fatigued (Filtness and Naweed, 2016). Moreover, mental capacity, information integration and problem solving are also impaired. Fatigue has been associated with a decline in problem-solving, reasoning and psychomotor skills. It also makes individuals more prone to false responses. In certain circumstances, fatigue may prompt microsleeps, which are short involuntary sleep lapses that may result in perceptual illusions (Caldwell, 2012; National Research Council, 2011).

Importantly, fatigue has adverse effects on the prefrontal cortex, a brain region responsible for executive cognitive functions such as thinking, verbal fluency and emotional regulation, all of which are skills that are pivotal for safe and efficient operational performance. Furthermore, fatigue negatively impacts other brain regions responsible for memory and learning. As a result, fatigue may increase the likelihood of human error in the railway industry, as both of these skills are critical for safe operational performance (Gunzelmann and Gluck, 2009; Latorella and Prabhu, 2000; Van Leeuween et al., 2013).

Also, fatigue is associated with a narrower attention span. As a result, timing and accuracy forecasting deteriorates with fatigue, a skill which is critical for the train-driving task (Caldwell, 2012; National Research Council, 2011).

Fatigue caused by insufficient sleep is associated with emotional dysregulation, namely abnormal emotional expression, recognition and reactivity (Beattie et al., 2015). In addition, fatigue promotes emotional instability by increasing agitation, anger and hostility. It also reduces affability, happiness and empathy (Gordon, 2013). Reactivity to troublesome situations is also increased (Gordon, 2013). Additionally, sleep-deficient persons are less capable of appreciating humour and are poorer at resolving interpersonal conflicts (Killgore et al., 2006; Gordon and Chen, 2014). Lastly, insufficient sleep has been linked to mood disorders such as depression, thereby encouraging social dysfunction and as a result promoting mental health deterioration (Irwin, 2015; Beattie et al., 2015).

3.2.3. Effects to health and well-being

Fatigue may have long-term health impacts on employees. It is associated with a notable increase in sick leave and a deterioration in work performance. Psychological stress, cardiovascular issues, as well as self-rated health issues can be the outcome of overtime work and extended workday duration. Thus, this demonstrates that fatigue serves as a double-edged sword that adversely impacts employee health and well-being, while having operational ramifications (Härmä, 2006).

Insufficient sleep is a major contributor to various chronic disorders, including cardiovascular disease, hypertension, diabetes and septicaemia, which are reported to be leading causes of death globally. For instance, insufficient sleep has been reported to be a contributor to 7 of the 15 leading causes of death in the United States (Kochanek et al., 2014). Sleep deprivation or sleep disruption may have a deleterious impact on an individual's mental and physical health. A pronounced reduction in brain activation occurs in the absence of sufficient sleep, with deactivation being the most pronounced in brain regions responsible for higher-order brain functions such as cognitive processing, arousal and emotion (Mullins et al., 2014). Restricted sleep has extensive adverse effects on body systems, including the nervous system, immune system, cardiovascular system and endocrine system. It has been linked to a myriad of diseases in both adults and children. For instance, it has been implicated in obesity, abnormal glucose tolerance and cardiovascular disease, including hypertension (Institute of Medicine, 2006).

Furthermore, insufficient sleep has been linked to increased susceptibility to infectious and inflammatory diseases, specifically the common cold, flu, shingles and Human Immunodeficiency Virus (HIV)-related complications (Irwin, 2015). In addition, sleep-deficient persons are more prone to coronary artery calcification, decreased insulin sensitivity and defective appetite control, conditions associated with coronary heart disease, diabetes and obesity, respectively (Gangwisch, 2009; Patel, 2009; Touma and Pannain, 2011). Finally, hormonal dysregulation is reported to be a symptom of sleep issues due to compromised stress responses and energy homeostasis (Van Cauter et al., 2007).

3.3. Self-management of fatigue

3.3.1. Measuring and predicting fatigue

In order to effectively self-manage fatigue, train drivers must be able to self-assess their levels of fatigue to predict potential performance deficits via various methods and technologies that are generally classified into objective and subjective fatigue assessment methods (Bendak and Rashid, 2020). The proposed methods require minimal levels of interventions and assistance. However, training drivers on how to use certain technology-based measurement methods may be necessary.

3.3.1.1. Wrist-worn actigraphy

According to MacLean et al. (2003), managing sleep by obtaining sufficient sleep that is aligned with circadian rhythms is unparalleled. A good night's sleep is superior to other countermeasures that address fatigue while operating (MacLean et al., 2003). Monitoring fatigue by evaluating sleep quantity and quality, is a more convenient and useful alternative to real-time cognitive fatigue monitoring tools and fitness for duty testing tools. In theory, managing sleep is the best solution for addressing sleep-related fatigue. Current sleep-monitoring technologies include polysomnography, which is the gold standard for sleep evaluation. However, this method depends on a considerable amount of equipment, as well as the attachment of electrodes to the skull. As a consequence, polysomnography is considered to a be relatively less practical method of evaluating sleep due to difficulties in implementing it at home and in the workplace (Caldwell et al., 2019).

Fortunately, the availability of wrist-worn actigraphs has facilitated the provision of an objective fatigue assessment method that is more convenient for evaluating fundamental sleep parameters (Sadeh and Acebo, 2002; Morgenthaler et al., 2007). A wrist-worn actigraph monitors body movements over an extended period of time, collecting and processing information that is used to inform the user of variables such as their sleep quantity, quality and sleep/wake cycle. They are relatively more accurate than manual sleep diaries, which require individuals to complete the diary on a daily basis to reliably evaluate and monitor sleep. Consequently, sleep diaries are subject to inaccuracies that may render sleep data collected unreliable (Martin and Hakim, 2011).

In recent years, there has been a rapid emergence of wearables and mobile applications that incorporate the concept of wrist-worn actigraphs. These devices provide feedback and advice on how to improve sleep hygiene to improve sleep quality and quantity **(**Civil Aviation Safety Authority Australia, 2014; Hao et al., 2013). In particular, specialists such as Fatigue Science provide advice catered to transport.

In theory, data collected from wrist-worn actigraphs may form the foundation of fitness-for-duty programs, that rely on evaluating whether an employee has obtained the sleep necessary for recovery from work-induced fatigue (Dogen and Mollicone, 2003). Despite the potential effectiveness of this theoretical possibility, ethical and legal concerns of wearables in the workplace may impede the use of the data from wrist-worn actigraphs to inform organisational decisions and programs, as tracking employee data and activity poses a major ethical and legal concern for employers.

3.3.1.2. Self-rating scales

Self-rating scales are quick and simple subjective methods of measuring fatigue. They can be used by drivers to self-assess their own, as well as other drivers' levels of fatigue before and during work. They are based on valid and reliable survey questions that evaluate sleepiness or the need for recovery (Akerstedt et al., 2014; van Veldhoven and Broersen, 2003). The Karolinska Sleepiness Scale (KSS) and the Samn-Perelli Checklist are two examples of well-known, validated subjective self-rating scales used to assess fatigue (International Civil Aviation Organisation, 2015; Samn and Perelli, 1982). In spite of their ease of use and reliability, self-rating scales are associated with limitations. Unreliable results may be the outcome of the self-assessment of fatigue-induced performance declines (Tremaine et al., 2010). Thus, one must be mindful of the limitations associated with these fatigue assessment tools. Fortunately, the aforementioned limitation can be addressed to a certain extent by adequately training users to identify physical, mental and emotional fatigue-induced symptoms in themselves and others (Lerman et al., 2012). Moreover, peer-rating scales is a relatively new, subjective method of assessing peer fatigue, where employees are required to provide fatigue rating scores for their peers on a regular basis. Such a method of assessing fatigue has facilitated changes from a reactive to a more proactive organisational fatigue management culture (Gaydos et al., 2013).

3.3.1.3. National Aeronautics and Space Administration-Psychomotor Vigilance Task

National Aeronautics and Space Administration - Psychomotor Vigilance Task (NASA-PVT) is a visual, objective, performance -based fatigue monitoring technology used to assess fatigue based on the performance on secondary tasks, specifically, reaction time (Arsintescu et al., 2019). This tool can be used by users to assess their levels of fatigue before starting duty or during breaks. It is considered to be a relatively quick, convenient and non-invasive method of assessing fatigue as the assessment is completed on a touchscreen hand-held device that employs integrated performance measures to evaluate fatigue levels. Based on the premise that performance declines with fatigue, the NASA-PVT would detect performance declines on secondary tasks, consequently functioning as an early warning for imminent declines in actual performance (Balkin et al., 2004). The visual test monitors reaction time deterioration over a 5-minute period via inter-stimulus intervals that vary from 2 seconds to 10 seconds (Arsintescu et al., 2019). Studies have indicated the validity of PVTs to be comparable with other assessments of sleep-related performance deficits (Jay et al., 2005;

Dogen and Mollicone, 2014). Nevertheless, age-dependent variation in response times is a major limitation associated with using this method of fatigue measurement.

3.3.2. Managing fatigue

3.3.2.1. Education

In order to facilitate effective fatigue self-management at work and at home, employees must be educated about fatigue causes, consequences and countermeasures. This is owing to the fact that education is the only practical way of addressing the impact of non-work-related factors that contribute to fatigue onset, through an appeal to enlightened self-interest (Gander et al., 1998).

A study conducted by Gander et al. (2005) reported that the delivery of a fatigue management program to light and heavy vehicle drivers resulted in an effective change in fatigue management strategies employed by 50% of the drivers at home and at work (Gander et al., 2005). In addition, Arboleda et al. (2003) reported that fatigue training significantly improved truck drivers' perception of organisational safety climate (Arboleda et al., 2003).

Education helps manage fatigue by providing a common knowledge base for developing a FRMS. By helping employees develop fatigue management strategies, especially strategies that improve sleep quality, an organisation may boost safety and productivity within the workplace, as well as driver health and well-being outside the workplace (Gander et al., 2011).

Studies have emphasised the importance of training employees, management and safety professionals in fatigue management (Ali et al., 2014; Gander et al., 2011; Smith et al., 2018). However, the knowledge base i.e. the education content and depth of knowledge, required by different levels in the organisation may vary according to the individuals' role in the organisations FRMS (Gander et al., 2011). The Office of Rail and Road suggests using various methods of education and training employees, namely fatigue management training, guidance notes and documents, risk awareness (British Office of Rail Regulations, 2012).

There are various barriers associated with the implementation of a fatigue education program. For instance, ethnicity and culture impact the type of educational program implemented. This is owing to the fact that educational programs that work in one setting may not be able to be replicated in a similar organisation in a different country, or in an organisation with a different ethnic mix of employees (Gander et al., 2011). In addition, lack of integration of fatigue management training into an organisation's policy, limits the effectiveness of the aforementioned educational programs (Smith et al., 2018).

3.3.2.2. Managing fatigue at work

3.3.2.2.1. Breaks

It has been established that time away from a task increases attention and alertness (Caldwell et al., 2012). They increase driver alertness by reducing the monotony and highly automated nature of driving. Firstly, through allowing physical activity and changes in posture (Caldwell et al., 2003; Dijkman et al., 1997). Secondly, breaks allow for a mental break from the task at hand (Galinsky et al., 2007; Heslegrave and Angus, 1985). Lastly, social interactions during breaks enhance their benefit, particularly in the early morning circadian nadir (Dijkman et al., 1997). However, it is important to note that the alerting effects of breaks are temporary. As a result, it is recommended that shorter breaks that are approximately 10 minutes in length be taken every hour, rather than longer breaks that are taken less frequently (Caldwell et al., 2009). Moreover, stretching during breaks is recommended to improve circulation and relieve muscle tightness caused by being seated for long periods of time (Gertler et al., 2002).

3.3.2.2.2. Naps

Napping is commonly used by shift workers during work and before overnight duties to help combat work-related fatigue (UK-CAA, 2007; Gregory et al., 2010).
Naps following long duration of continuous wakefulness are known to increase alertness, preserve cognitive performance and reduce both objective and subjective sleepiness (Bendak and Rashid, 2020). A nap is considered to be a more superior method of managing fatigue, relative to other fatigue management strategies, as not only does it effectively maintain alertness and performance, but it also addresses insufficient sleep due to sleep deprivation. However, it is important to note that naps should not be used as substitute for a good night's sleep.

Napping at work is particularly important and effective for workers that have to maintain high levels of alertness and vigilance and those that have to make prompt decisions, as it improves attention, vigilance and reaction time (EUROCONTROL, 2018; Vgontzas et al., 2007).

In the event where there is a place available within the workplace to nap, napping in the lunch break is recommended. Particularly, during the mid-afternoon period when an individual's alertness naturally drops. Naps that are 10-30 minutes in length are recommended. Importantly, these naps should not exceed 30 minutes to avoid sleep inertia. Prior to taking a nap, one should avoid sleeping aids or consuming a heavy meal as this may impair one's ability to wake up from their nap. In addition, the consumption of nicotine in the form of cigarettes should also be avoided due to nicotine's stimulating effect, which interferes with sleep onset (EUROCONTROL, 2018).

The only disadvantage associated with napping as a countermeasure is sleep inertia, a transition state between sleep and wakefulness, characterised by reduced performance and alertness. Sleep inertia lasts for approximately 35 minutes after awakening (Hilditch and McHill, 2019). It is a significant concern in jobs that necessitate skilled performance immediately after a nap. Therefore, the pros and cons of napping as a countermeasure must be balanced to determine whether this countermeasure should be implemented in the workplace, especially for train drivers. Power naps, a combination of napping and caffeine, is an effective method to overcome sleep inertia. It involves a person consuming caffeine immediately prior to the nap, then napping for a maximum of 20-30 minutes (EUROCONTROL, 2018).

3.3.2.2.3. Adjusting light at work

Light is a doubled-edged sword that has the potential to exert positive or negative effects on performance and cognitive function, depending on time of exposure and the type of exposure (Fisk et al., 2018). Therefore, one must consider light's direct, acute effects on arousal as well as its indirect, delayed effects on circadian rhythm when used as a fatigue management technique. Adjusting light at work can be used to combat fatigue, due to its immediate but temporary effects on alertness and performance. Light mediates its alerting effects by downregulating the production of melatonin, a sleep-promoting hormone that is released in the evening. It may be used as a fatigue countermeasure during the daytime and nighttime, as it exerts its alerting effects in a manner that's independent of the time of day (Cajochen, 2007). Thus, it can be used in the daytime to improve alertness and performance in sleep deprived individuals, as the alerting effects of light will counteract the sleep-promoting effects of the dark. Light of a short wavelength, especially blue light, with an illumination level of 100-200 lux is recommended. However, normal room lighting contains enough short wavelength energy to be effective (Caldwell et al., 2009). Light levels of 100-200 lux were found to increase subjective alertness and decrease slow eye movements (Cajochen, 2007; Caldwell et al., 2012; Lockley ey al., 2006).

3.3.2.2.4. Adjusting temperature at work

Adjusting temperature at work may be used to temporarily combat fatigue. Drivers can adjust temperature through opening the window or turning on the air conditioning. Interview studies with train drivers indicated that they found exposure to thermal stimuli, through opening windows and turning on the air conditioning, to be an effective measure to overcome driver fatigue (Gershon et al., 2011; Pylkkonen et al., 2015). In addition, multiple studies have demonstrated that driver exposure to thermal stimuli significantly increased subjective wakefulness (Landstom et al., 1999, 2002; Schmidt et al., 2017). Drivers rated subjective fatigue to be notably lower when exposed to thermal stimulus. Also, they preferred driving with the stimulus (Schmidt and Bullinger, 2019). Thermal stimuli increase alertness by counteracting the monotony and lack of stimulation associated with the driving task which negatively impacts driver alertness. Altogether, studies recommend a cold thermal stimulus, between 10-18 degrees to the face, for a duration that that is no shorter than 2 minutes, but no longer than 6 minutes. The thermal stimulus should be no shorter than 2 minutes, as this temperature is the minimum required to activate the sympathetic nervous system (Van Veen et al., 2014). However, the thermal stimulus should be no longer than 6 minutes to prevent habituation effects that have been observed in other studies (Reyner and Horne, 1998).

The use of thermal stimulation as a fatigue countermeasure is associated with limitations. For instance, drivers must be repetitively exposed to the stimulus for prolonged alerting effects. Moreover, and more importantly, whether the thermal stimulus will still have alerting effects following a certain number of repetitions, is still open to question (Schmidt and Bullinger, 2019).

3.3.2.2.5. Playing music in the background

Due to the monotonous nature of the train driving task playing music is a method commonly used to manage fatigue while driving. Listening to music helps manage fatigue through increasing cognitive load, which in the case of a train driver is often necessary to overcome the monotonous nature of driving. Trumbo et al. (2017) suggests mitigating driver fatigue using a song naming game (Trumbo et al., 2017).

3.3.2.2.6. Driving while standing up

Driving while standing up is a strategy commonly used by train drivers to combat fatigue. Despite the fact that it isn't formally discussed in the literature as a train driver fatigue countermeasure, drivers find this method effective for increasing alertness. Perhaps by facilitating changes in posture through standing up and moving about, the monotony and highly automated nature of the train driving task is reduced (Caldwell et al., 2003; Dijkman et al., 1997).

3.3.2.3. Managing sleep

3.3.2.3.1. Avoiding caffeine

Caffeine, a drug found in coffee, tea, caffeinated soft drinks and a variety of over the counter (OTC) drugs, including cold relief tablets and Paracetamol, is the most popular and safest fatigue management strategy for addressing mental fatigue. Its alerting-effects have been well established (O'Callaghan et al., 2018; Fulgoni et al., 2015; Zwyghuizen-Doorenbos et al., 1990). However, managing its consumption is important for managing sleep. Avoiding caffeine consumption is important for managing sleep. Managing caffeine intake in the hours before bedtime is crucial for preventing sleeping difficulties, such as sleep initiation and sleep fragmentation. Due to the fact that caffeine has the ability to remain in the body for up to 6 hours, caffeine consumption should be avoided 4-6 hours before bedtime (EUROCONTROL, 2018). However, the time may vary due to variations in the elimination of caffeine from one individual to another. The mean half-life of caffeine in the plasma of healthy individuals is approximately 5 hours. However, its elimination half-life may range between 1.5 and 9.5 hours (Institute of Medicine, 2001).

3.3.2.3.2. Avoiding alcohol

Although known as a sleep-promoter, commonly used by individuals that have insomnia to reduce sleep latency, its consumption up to 4 hours before bedtime may has adverse effects on sleep quality. Alcohol exerts its negative effects by suppressing rapid eye movement (REM) sleep (Ebrahim et al., 2013; Troxel et al., 2015; Ramakrishnan and Scheid, 2007). As a consequence, sleep obtained following alcohol consumption is relatively less restorative and can cause sleep fragmentation. Daytime sleepiness and fatigue may be the outcome of sleep disruption. Therefore, it is suggested that alcohol consumption is avoided up to 6 hours before bedtime to avoid sleep disruption as later afternoon drinking, also referred to as "happy hour" drinking may cause sleep disruption, in spite of the fact that alcohol is no longer in ounces system at bedtime (Landolt et al., 1996).

3.3.2.3.3. Managing nutrition

Managing nutrition is crucial for managing sleep quality and duration. It can be managed by eating a well-balanced diet, avoiding the consumption of heartburn-causing foods (e.g spicy foods and tomato products), avoiding heavy meals before bedtime and avoiding going to sleep hungry (EUROCONTROL, 2018). Diets deficient in particular nutrients may result in sleep fragmentation. Ji et al. (2017) reported an association between sleep quantity and micronutrients. A positive relationship was reported between sleep quantity and iron, zinc and magnesium. Whereas a negative relationship was reported with copper, potassium and vitamin B12 (Ji et al., 2017).

The consumption of spicy food prior to bedtime disrupts sleep by increasing sleep latency and reducing sleep quality. Furthermore, spicy food may cause heartburn making falling asleep difficult and causing middle-of-the-night discomfort. (Edwards et al., 1992). In addition, the consumption of heavy meals prior to bedtime adversely impacts sleep quality in healthy individuals, particularly in women (Crispim et al., 2011).

Thus, eating a well-balanced diet containing all necessary nutrients, is recommended to ensure good quality sleep. Heavy meals should be avoided 2 hours prior to bedtime. Conversely, sleeping on an empty stomach should be avoided as well. Spicy food or unfamiliar foods that may give rise to heartburn should be avoided 2 hours before bedtime as well. In the event where an individual is facing difficulties falling asleep, low protein-high carbohydrate (found in juice, cookies), L-tryptophan (found in warm milk, eggs, cottage cheese, chicken, turkey and cashews) or melatonin (found in oats, sweetcorn, rice, ginger, tomatoes, bananas and barley)-containing bedtime snacks are recommended an hour before bedtime, as these bedtime snacks induce sleep. Evidence has suggested that high carbohydrate diets and foods containing melatonin, tryptophan and phytonutrients may improve sleep quality and quantity. Herbal teas, including camomile, catnip, anise or fennel tea can be used as alternatives to milk and other dairy products (EUROCONTROL, 2018; Binks et al., 2020).

3.3.2.3.4. Avoiding smoking

Nicotine is a stimulant drug found in cigarettes, cigars, pipe tobacco and chewing tobacco. Electronic cigarettes also contain nicotine. The consumption of nicotine in any form, an hour prior to bedtime should be avoided as it may cause sleep disruptions and reduce sleep quantity (Phillips and Danner, 1995). The consumption of nicotine is associated with insomnia-like symptoms such increased sleep onset latency, fragmented sleep, problems with waking up and increased daytime sleepiness (Jaehne et al., 2009). Moreover, disrupted sleep is a symptom of nicotine withdrawal, a phenomenon experienced by smokers when they go to sleep. Nicotine’s stimulating effects are owing to its action on numerous neurotransmitter systems that regulate sleep and mood.

3.3.2.3.5. Exercise

Exercise has been demonstrated to be an effective countermeasure for managing sleep. Uchida et al. (2012) established exercise’s role at inducing restful sleep (Uchida et al., 2012). In addition, Stepanski and Wyatt (2003) have reported that exercising regularly is associated with improved sleep quantity and quality (Stepanski and Wyatt, 2003). Exercise has sleep-promoting effects. It enhances one’s ability to fall asleep and improves sleep quality and duration, by augmenting one’s ability to stay asleep during the night (Caldwell et al., 2019).

However, before considering the use of exercise as a fatigue countermeasure, one must be mindful of its short-term stimulating effects. If practised immediately before bedtime, or up to 3 hours before bedtime, it may have a disruptive effect on sleep. This disruptive effect is due to the increase in body temperature that occurs following exercise. A rise which is coupled with a corresponding fall in temperature, 5-6 hours later (Morin, 2006;

EUROCONTROL, 2018). Exercising in the late afternoon, a few hours before bedtime, is recommended. In particular, morning or day shift workers should preferably exercise following their shift. Conversely, night shift workers should exercise prior to their evening nap. Moderate exercise that raises the heart rate for 20-30 minutes in duration, at least 3 days per week is recommended. For that reason, cardiovascular exercise, also known as aerobic exercise, including walking, jogging, running, cycling or swimming, is recommended. Excessive and strenuous exercise is not recommended as it can lead to soreness that can disrupt sleep (EUROCONTROL, 2018).

3.3.2.3.6. Sleep hygiene

Adequate sleep hygiene habits and practices are crucial for sleep initiation and sleep maintenance. Recommended sleep hygiene habits and practices include, adhering to a consistent sleep/wake schedule, establishing a consistent bedtime routine, creating a comfortable sleep environment by adjusting temperature and lighting, using the bedroom for sleep-compatible activities, avoiding light-emitting technologies and practising sleep-inducing activities such as listening to relaxing music and reading before bedtime (Suni, 2020).

3.3.2.3.7. Over the counter medication

OTC medications are medications that can be obtained without a prescription. They are an alternative to hypnotic medications that require prescriptions (Caldwell et al., 2019). Diphenhydramine and doxylamine are sleep-promoting compounds that are commonly found in antihistamines. Although antihistamines are not specifically designed for inducing sleep, their drowsiness-inducing effects has encouraged their use as sleep aids. Their sleep-promoting effects have been reported to be modest relative to most prescription sleep aids (Richardson et al., 2002).

However, the effectiveness of OTC drugs at promoting sleep is disputed, as various studies have reported that diphenhydramine and doxylamine succinate reduce sleep quality (Belenky et al., 2003; Caldwell et al., 2000; Caldwell and Gilreath, 2001).

Prior to employing this method for managing sleep, one must be aware of the side effects associated with these drugs. Side effects include, dizziness, confusion and dry mouth. In addition, due to the fact that the half-life of these drugs can reach up to 8 hours, next day carry over effects must be considered. Thus, a doctor must be consulted prior to the use of OTC medication or herbs for managing sleep (Katayose et al., 2012; Ringdahl et al., 2004).

3.3.2.3.8. Herbs

Valeriana officinalis L., also known as Valerian, is a herb commonly used to manage sleep. Valerian root extract is available as a supplement in capsule or liquid form. It can also be consumed as a tea. A variety of studies have reported its mild-sedative properties (Fernández, 2004) that are mediated via its ability to induce calmness, by inhibiting GABA degradation and improving stress responses (Benke et al., 2009; Houghton, 1999; Murphy et al., 2010). Despite these effects, Valerian's clinical efficacy is not sufficient for the treatment of insomnia (Taibi et al., 2007).

3.3.2.3.9. Acupuncture

Although there is a limited number of studies that support the effectiveness of acupuncture as a method for managing sleep, the use of acupuncture to treat insomnia has been reported (Lee et al., 2008; Zhao, 2013; Ernst et al., 2011; Cheuk et al., 2012). Acupuncture has been suggested as a strategy for improving sleep tand is not associated with any side effects. Literature has indicated that acupuncture upregulates the production of γ-amino butyric acid. This upregulation is associated with better quality sleep (Cao et al., 2009). Moreover, it has been described as having a mild efficacy when employed for several weeks (Fu et al., 2017; Zhao, 2013).

3.3.2.3.10. Meditation

Meditation has also been suggested as an alternative method of treating insomnia caused by uncontrolled cognitive arousal. It mediates its effects by reducing anxiety associated with sleep and reducing arousal (Ong and Sholtes, 2010). Mindfulness meditation has been associated with reduced sleep-related stress (Hubbling et al., 2014). In addition, a study conducted by Black et al. (2015) demonstrated that mindfulness meditation has more significant improvement in insomnia, depression and fatigue symptoms in individuals, compared to sleep hygiene education. However, only two controlled studies have investigated its effects on sleep. As a consequence, further research is required to confirm the effectiveness of meditation as a sleep management strategy (Bonnet and Arand, 2010).

3.3.2.3.11. Cognitive behavioural therapy

Behavioural therapies have been used to treat insomnia (Morin and Benca, 2012). Stimulus regulation and progressive muscle relaxation are cognitive behavioural therapies commonly used to manage sleep. Cognitive behavioural therapy (CBT) has been reported to improve sleep by increasing sleep pressure and enhancing homeostatic sleep regulation, through changing sleep misconceptions (Cervena et al., 2004). In particular, stimulus control behavioural therapy facilitates positive associations between the bedroom and sleep. Practising progressive muscle relaxation helps reduce muscle tension. Imagery training reduces sleep-disrupting thoughts and tension. CBT can be delivered through various modes including, individually, in groups or online. However, several CBT treatments may be required to see positive results. An average of 6 hours of therapy, which is the equivalent of 4-8 CBT sessions may be required (Anderson, 2018).

4. Methodology

The developed pilot questionnaire was designed to assess fatigue and its self-management in train drivers by determining fatigue levels and fatigue causes in train drivers. It also assessed countermeasures currently used by drivers to help combat and measure fatigue at work and at home, as well as their effectiveness. Also, it identified countermeasures train drivers would likely consider using to help combat and measure fatigue. There is currently no validated questionnaire for assessing train driver fatigue self-management within the rail industry. Variability in the levels and causes of fatigue, as well as the different approached employed by train drivers to self-manage and measure fatigue at work and at home, were expected between respondents due to the dynamic nature of the current research topic and the vast number of fatigue management methods. In addition, differences in the willingness of drivers to use certain methods to manage and measure fatigue were expected.

The pilot questionnaire was voluntary and anonymous. Participants could stop participation in the study at any time or refuse the use of their data for the study, without giving reasons. The data is in accordance with the General Data Protection Regulation 2016 (GDPR) and the Data Protection Act 2018. The questionnaire was stored on the google cloud platform associated to the TU Dublin account only for the duration of the questionnaire. It was then downloaded and removed from the cloud server. All data was encrypted and stored on a password protected data server owned by TUD and retained in accordance with TUD data protection policy.

4.1. Questionnaire development and validation

Key areas were identified following a review of peer review sources and industry fatigue management documents. Following a comprehensive literature review on the causes, consequence and self-management of fatigue, a draft questionnaire that assessed fatigue and its self-management in train drivers was devised.

An initial draft of the pilot questionnaire was assessed for face and content validation. First, face and content validity were assessed to gain an expert judgement on the operationalisation of the pilot questionnaire, to determine whether the questionnaire measures what it is intended to measure and to determine the degree to which the assessment instrument is relevant to, and respective of the targeted construct it is designed to measure. Due to the fact that the questionnaire used in this study was only aimed for piloting, face validity and content validity were assessed by two experts, a rail industry expert and an external expert, both of which had experience within the area of human factors, particularly in the research area of fatigue. Prior to the analysis by the experts, content validity was established, in part, during the development phase of the draft questionnaire, when an extensive literature on the causes, consequence and self-management of fatigue was devised to identify key areas and inform questionnaire questions. Then, face validity and content validity by the two experts. The experts were contacted via email for comments on the draft questionnaire. A Microsoft word document version of the draft questionnaire was sent via email, with a brief outline of the study. Experts assessed face validity by evaluating the appearance of the questionnaire in terms of relevance, feasibility, readability, consistency of style and formatting, and the clarity of the language used. Moreover, content validity was assessed by reviewing the content of the questionnaire, assessing each question within the questionnaire individually and providing comments on the face and content validity of the questionnaire. Comments were collected and the questionnaire was adjusted as appropriate.

Following amendments to the draft questionnaire, the pilot questionnaire was developed, see **Attachment 1**. Next, pilot questionnaire readability was assessed to evaluate the ease with which a reader can understand the pilot questionnaire. Readability was evaluated using the Flesch-Kincaid Grade Level, Flesch Reading Ease and Gunning Fog Index to assess the readability level of the pilot questionnaire. The Flesch tests and Gunning Fog Index were selected as they are tools that adequately assess readability for all sectors and disciplines and aimed at business, respectively.

Finally, after assessing the readability of the pilot questionnaire, the questionnaire was piloted, and its reliability was assessed. Reliability was assessed to examine the extent to which the questionnaire yielded the same results on repeated trials, to ensure the stability and consistency of scores over time and across respondents. Reliability was determined by comparing the consistency of the responses between respondents.

4.2. The pilot questionnaire

The pilot questionnaire was conducted online on google forms (www.google.com/forms/about/). With the assistance of the partner rail organisation, the pilot questionnaire was distributed using a chain sampling method, also known as the “snowball sampling” method. This method involves participants recruiting other participants using their own social networks. The aforementioned recruitment approach was useful for reaching hard-to-reach individuals. The questionnaire was distributed via a link emailed to respondents. It began on August 18th, 2020 and closed on August 29th, 2020. It took approximately 10 min to complete the questionnaire. Its inclusion criteria included, past or present train drivers, respondents at least 18 years old, respondents able to read English and respondents that have completed the entire questionnaire.

The pilot questionnaire was divided into the following four sections:

Section 1. Introduction and background information, included questions that determined demographic information, namely age and the type of service driven (commuter, intercity, mix, other), assessed sleep quantity and quality, current levels of fatigue and lastly the causes contributing to sleep quality and fatigue.

Section 2. Managing fatigue at work, questioned methods respondents currently use to manage fatigue at work, their effectiveness and their willingness to use particular countermeasures to manage fatigue at work. The questions in this section addressed countermeasures such as breaks, naps, adjusting environmental conditions (increasing light, playing music in the background and reducing temperature), driving while standing up and education.

Section 3. Managing sleep, included questions about methods currently used to manage sleep, their effectiveness and their willingness to use certain countermeasures to manage their sleep. Furthermore, the impact of diet and smoking, as well as the extent to which respondents set limits for their diet was questioned. The questions in this section addressed specific sleep hygiene habits and practice, diet habits (the consumption of caffeine, alcohol and particular foods), smoking, exercise, non-prescription sleep aids (over-the-counter medications, herbs and acupuncture) and behavioural strategies (CBT-based techniques and meditation).

Section 4. Measuring fatigue, questioned whether their levels of fatigue were being monitored at work, their willingness to assess fatigue levels at work, whether they monitored their sleep using sleep diaries and their willingness to do so.

The data collected from the respondents was used to inform and address the following fatigue-related questions:

- Sleep quantity and quality, as well as fatigue levels;
- Factors contributing to current sleep quality and fatigue levels;
- Methods currently used to manage fatigue at work and to improve sleep;
- Methods respondents thought were effective at managing fatigue at work and improving sleep;
- How likely respondents would consider using particular methods to manage fatigue at work and improve their sleep;
- Whether respondents monitored their levels of sleep using sleep diaries; and
- How likely respondents would consider assessing their fatigue levels at work and use sleep diaries to monitor and manage their sleep.

4.3. Data collection and pilot questionnaire data analysis

Pilot questionnaire data was collected on google forms, then exported and analysed in Microsoft Excel (Version 16.40). Figure and tables were also produced in Microsoft Excel. Measures of central tendencies (mean and median and mode) and dispersion (standard deviation were reported for numeric variables of interest.

5. Results & Discussion

5.1. Establishing the validity and reliability of the pilot questionnaire

5.1.1. Face validity

The face validity of the pilot questionnaire was established by gaining an expert judgement on the operationalisation of the questionnaire by an industry expert and an external expert, both of which had experience within the area of human factors, particularly in the research area of fatigue. Both experts responded to the email request for comments. They reviewed the questionnaire questions and agreed that its presentation and relevance were acceptable. Moreover, they agreed that the questionnaire was a valid tool that adequately determined the presence and cause of fatigue in train drivers, identified the countermeasures currently used by drivers to help combat and measure fatigue at work and at home and their effectiveness, and identified countermeasures they would likely consider using to help combat and measure fatigue, in a feasible, readable, unambiguous, clear-written and consistent manner.

Minor comments made about the layout and questionnaire instructions prompted the current layout and format of the questionnaire. Adjustments were made to the layout of the questionnaire e.g. the questionnaire was divided into 4 sections, the introduction and background (**Section 1**), managing fatigue in work (**Section 2**), managing sleep and measuring fatigue (**Section 3, 4**). Matrix scale questions replaced repetitive closed-ended questions that share answer choices. The matrix rows asked the responses about various countermeasures, while columns asked for a rating response. Furthermore, instructions were added to checkbox questions. Finally, the length of the questionnaire was judged to be relatively long, however no questions were omitted from the questionnaire, as they were all considered to be of relevance and importance to accurately address the aims of the questionnaire.

5.1.2. Content validity

A judgement approach was taken to establish content validity of the pilot questionnaire. First, an extensive literature review was compiled on the causes, consequences and self-management of fatigue to extract the relevant information required to inform the questions of the questionnaire. Then, the content of the literature review, as well as the content of the questionnaire was validated by the same experts, that reviewed each question within the questionnaire individually and provided comments on the content validity of the questionnaire.

Comments were made about grammatical errors, the need for explanatory notes and the addition of a section that questioned fatigue measurement. This prompted the content of the present pilot questionnaire **(see Attachment 1).** Amendments to the draft questionnaire included grammatical adjustments, the addition of explanatory notes in questions that facilitated the transition from one idea to another idea, defined specific words or provided additional information about a particular concept. In addition, various questions were added, such as questions that assessed sleep quantity and quality, as well as a question that determined the type of service the train drivers drove. Importantly, as mentioned above, none of the questions were eliminated as they were all seen as essential for the validity of the questionnaire.

5.1.3. Readability

Questionnaire readability was evaluated using the Flesch-Kincaid Grade Level, Flesch Reading Ease and Gunning Fog Index to assess the readability level of the pilot questionnaire. The questionnaire scored Flesch Kincaid Readability Level, Flesch Reading Ease and Gunning Fog Index scores of 6.5, 8.4 and 60 respectively, indicating that the average reader must have a grade 8 level (schooling age of 13-14) of reading, or above, in order to understand the questionnaire. Thus, this indicates that the questionnaire is of standard and acceptable readability level and that in theory, the survey should be readable for 100% of the train drivers.

5.1.4. Reliability

Lastly, reliability was determined by comparing the consistency of the responses obtained by the pilot questionnaire. A comparison of the responses for each question indicated that the responses obtained showed a high agreement and as a consequence were relatively consistent. The questionnaire yielded consistent and similar results under relatively consistent conditions. A minimum agreement of 50% was obtained for each question, indicating that the pilot questionnaire is relatively reliable. Thus, this suggests that the pilot questionnaire has an acceptable inter-rater reliability.

5.2. Piloting the questionnaire

5.2.1. Section 1

Section 1 of the pilot questionnaire was concerned with determining the respondents' demographic information, including train driver age range and the type of service driven (commuter, intercity, mix of commuter and intercity or other) to gain a better understanding of the target population. Moreover, it assessed self-reported sleep quality and fatigue levels to establish the fatigue levels of questionnaire respondents.

Table 5.1 summarises the demographics of the pilot questionnaire respondents. A total of 14 train driver met the study inclusion criteria of being past or present train drivers, respondents at least 18 years old, able to read English and having completed the entire questionnaire. The gender of the target population was not questioned as the female train driver cohort within the rail organisation is too small to be identified. The majority of the train drivers belonged to the 40-50 age group (71%), while the remainder (29%) belonged to the 25-39 age group. The age distribution was unimodal, with a single peak appearing at the 40-50 age group. The mean age of the respondents was 41 years of age. In terms of services driven, responses were relatively diverse. An equal percentage of train drivers drove commuter or intercity only, each representing 21% of drivers. Approximately a third (36%) of drivers drove a mix of services, with the majority driving a mix of commuter and intercity, and a single respondent (7%) driving a mix of commuter and Tara freight train. 21% of drivers drove DART.

Table 5. 1 Demographics of pilot questionnaire respondents

Characteristics	N	%
Overall	**14**	
Age (yr.)		
18-24	0	0
25-39	4	28.6
40-50	10	71.4
60 +	0	0
Service driven		
Commuter	3	21.4
Intercity	3	21.4
Mix of Commuter and Intercity	4	28.6
Other	4	28.5
DART	*3*	*21.4*
Commuter and Tara freight train	*1*	*7.1*

Self-reported sleep quality and fatigue levels were assessed to establish the fatigue levels of questionnaire respondents. **Table 5.2** outlines the quality and quantity of sleep obtained by train drivers. In terms of the number of hours slept per night, the majority of the train drivers slept an average of 6-8 h per night, the recommended daily amount. Only 21% slept less than the recommended amount, reporting 4-6 h per night and 7% (one driver) slept more than the recommended amount, reporting 8-10 h per night. A total of 72% of train driver reported that it takes them 0-15 min or 15-30 min to fall asleep, while 21% of the respondents reported that it took them more than 60 min to fall asleep. A little less than half (43%) of train drivers woke up between 0-1 times during the night but more than half of drives (57%) woke up between 2-3 times during the night. None of the drivers woke up more than three times during the night. The average number of times respondents were woken up at night was 2 times. After waking up during the night, the majority of the respondents reported that their total time awake after waking up during the night was between 0-30 min. Only a single respondent (7%) reported that he was awake for more than 60 min. A little less than half of drivers (43%) reported that they experienced problems with sleep on 0-1 nights per week. Approximately a third (35%) experienced problems with sleep 2-3 nights per week. Surprisingly, 20% of respondents experienced problems with sleep nearly every night of the week, reporting sleep problems 5-7 nights of the week, suggesting the presence of an underlying medical condition or other personal circumstances impacting their ability to sleep properly. A third of train drivers reported no problems with sleep or having problems with sleep for less than 1 mo. More than half of train drivers (57%) reported experiencing problems with sleep for more than 1 year.

Table 5. 2 The quality and quantity of sleep obtained by respondents.

Characteristic	N	%
Overall	**14**	
Hours slept per night (h)		
Less than 4	0	0
4-6	3	21.4
6-8	10	71.4
8-10	1	7.1
> 10	0	0
Length of time it takes to fall asleep (min)		
0-15	5	35.7
16-30	5	35.7
31-45	0	0
46-60	1	7.1
≥ 60	3	21.4
No. of times woken up during the night		
0	1	7.1
1	5	35.7
2	3	21.4
3	4	28.6
4	1	0
5	0	0
> 5	0	0
Length of time awake in total after waking up during the night (min)		
0-15	10	71.4
16-30	3	21.4
31-45	0	0
46-60	0	0
≥ 60	1	7.1
No. of nights a week experience problems with sleep		
0-1	6	42.9
2	3	21.4
3	2	14.3
4	0	0
5-7	3	21.4
Length of time have had problems with sleep (mo.)		
No problems/ < 1	5	35.7
1-2	0	0
3-6	1	7.1
7-12	0	0
> 1 yr.	8	57.1

Next, sleep quality and fatigue level ratings were assessed to gain a subjective insight on train driver's self-reported fatigue levels. **Table 5.3** summarises respondents' rating of sleep quality and fatigue levels. Half the train drivers rated their sleep quality as being 3, i.e. of average quality. 14% rated their sleep quality as being 1 or 2, i.e. below average, whereas approximately a third (35%) rated their sleep quality as being 4 or 5, i.e. above average. The mean rating of sleep quality was 3.3 ± 1.1, indicating relatively moderate sleep quality among drivers. Thus, this data indicates that most drivers (85%) rated their sleep quality as being average or above average.

Furthermore, more than half of drivers (57%) of respondents rated their fatigue levels as being 1 or 2, i.e. not fatigued at all or not so fatigued and a further third (36%) were somewhat fatigued. Only one driver (7%) rated his fatigue levels as being 4, i.e. very fatigued. The mean rating of fatigue levels was 2.4 ± 0.8, indicated relatively low levels of fatigue among train drivers.

Table 5. 3 Respondents' rating of sleep quality and fatigue levels.

Characteristic	N	%
Overall	**14**	
Rating of current sleep quality (1=very poor; 5=very good)		
1	1	7.1
2	1	7.1
3	7	50
4	3	21.4
5	2	14.3
Rating of current fatigue levels (1=not fatigued at all; 5=extremely fatigued)		
1	2	14.3
2	6	42.9
3	5	35.7
4	1	7.1
5	0	0

Finally, the causes contributing to the train drivers' current sleep quality and fatigue levels were examined using an open-ended question, with the intention of understanding the factors contributing to the presence or lack of fatigue. **Figure 5.1** illustrates the factors contributing to respondents' sleep quality and fatigue levels. Factors are classified into work-related contributory factors and non-work-related contributory factors.

The preliminary findings of the questionnaire suggest that the quality and quantity of sleep experienced by the majority of the train drivers is adequate and within the range of recommended daily limits, with the exception of the minority (3 drivers) that have been experiencing long-term (more than 1 yr.) problems with sleep nearly every night of the week. A more in-depth analysis of these 3 respondents revealed that shift work contributed to the poor sleep quality of 2 drivers, whereas personal or genetic causes contributed to the third driver's poor quality of sleep, reporting that he has "never been a good sleeper since his teen years". Moreover, the current fatigue levels of train drivers indicate that fatigue levels are relatively low among train drivers. In general, poorer quality sleep and lower fatigue levels were more prevalent in the 40-50 age range group.

Due to the fact that poor sleep quality and fatigue levels can be attributed to work-related and non-work-related factors, the underlying cause of fatigue cannot be accurately elucidated. Future studies must determine the underlying causes of fatigue in the minority experiencing persistent sleep problems and high fatigue levels. Importantly, this data does highlight the need for the rail organisation to reconsider its FRMS, as drivers experiencing such high levels of fatigue may pose a threat to their own health and safety, as well as the health and safety of passengers. In the event where further studies reveal work-related factors to be the underlying causes contributing to these fatigue levels, amendments to the FRMS are essential, including changes to rosters or hiring additional drivers. On the other hand, if non-work-related factors are the primary causes, the organisation must ensure that train drivers are appropriately equipped with the educated required to adequately self-manage their fatigue.

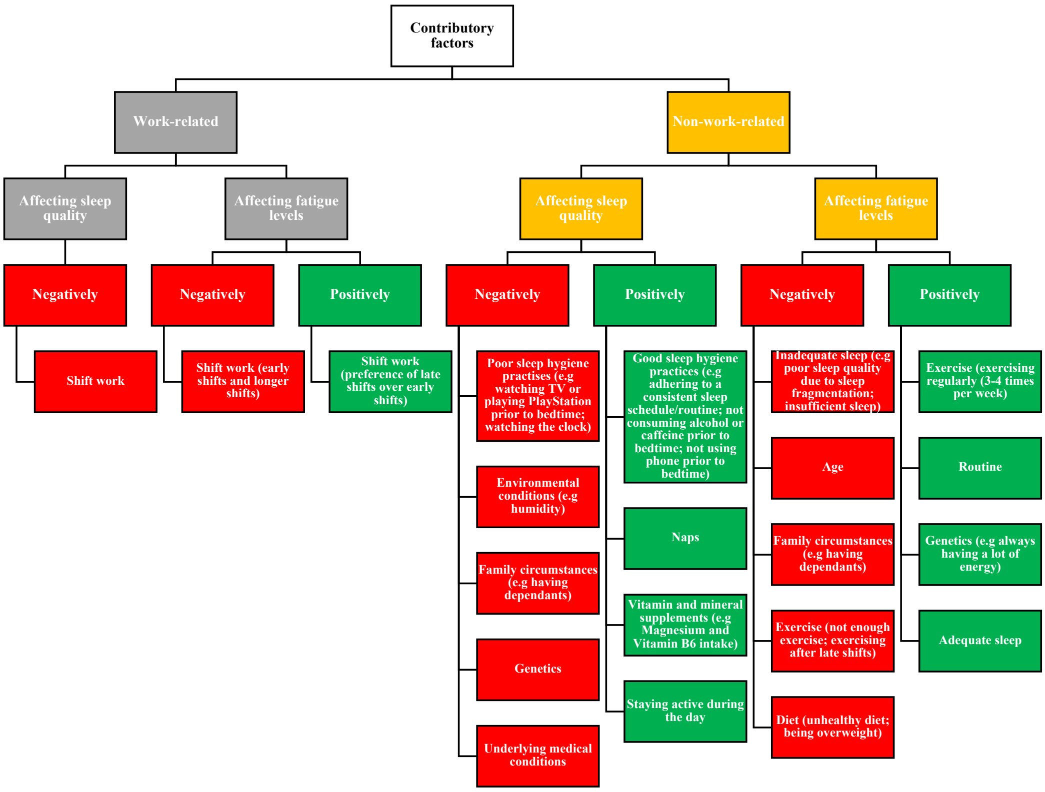

Figure 5. 1 Factors contributing to respondents' current sleep quality and fatigue levels.

5.2.2. Section 2

Section 2 was concerned with managing fatigue at work. It assessed methods currently used by train drivers to manage fatigue at work and their effectiveness, as illustrated in **Figure 5.2**. Furthermore, the perceived effectiveness of particular methods used for managing fatigue at work was examined as well, as per **Figure 5.3**.

In order to analyse methods train drivers currently use to manage fatigue at work, drivers were questioned about the frequency at which they used various countermeasures to manage fatigue at work, see **Figure 5.2**. These methods included, short breaks (breaks that are 2-5 min in duration), longer breaks (breaks that are 15-30 min in duration), adjusting environmental work conditions through reducing temperature or increasing light levels, driving while standing up and naps.

According to the data generated, only 14% of train drivers, all of which drove intercity or a mix of commuter and intercity services, answered “sometimes” to having an opportunity to take a short break during a train journey. The remainder, a total of 86% answered “almost never” or “once in a while” to taking short breaks. In terms of longer breaks, the majority (43%) answered “sometimes” to having an opportunity to take longer breaks between services. A further 29% answered “frequently” and one driver (7%) answered “almost all the time”. 14% took longer breaks once in a while, while only one respondent (7%) almost never had an opportunity to take breaks between services.

With regards to activities performed during journey rest breaks, i.e. short breaks, social interaction was the most popular activity done in rest breaks during journeys, followed by physical activity, mental breaks and eating or drinking. A total of 64.3% of train drivers reported “sometimes” or “frequently” getting up and moving around in a train journey, while 21.4% reported “once in a while” and 14.3% “reported never”. On the other hand, eating or drinking was the most popular activity performed during rest breaks between services, i.e. longer breaks, followed by social interaction, mental break and physical activity, which as the least popular activity.

Reducing temperature through opening windows or using air conditioning seemed to be the most popular method used by train drivers to manage fatigue at work. The majority of drivers (64%) reported reducing temperature “frequently”, while the remainder, a further 36%

reduced temperature almost all the time. Increasing light levels was not as popular as reducing temperature for managing fatigue at work. Half of the drivers answered, “almost never” increased light levels to help manage fatigue at work, while 14% answered “once in a while” and the remaining 36% “sometimes”.

Driving while standing up to manage fatigue at work was less popular than reducing temperature but more popular than increasing light levels. More than half (57%) of train drivers frequently drove while standing up to manage fatigue, while a further 14% sometimes drove while standing up. Approximately a third (29%) almost never drove while standing up.

The majority of the train drivers, a total of 64% napped frequently i.e. two or three times per week or almost all the time i.e. everyday. 22% of train drivers never napped. A further analysis of the factors that made train drivers more or less likely to consider napping revealed that shift work made drivers more likely to consider napping, especially early shifts. Conversely, shift work, particularly late shifts, difficulties falling asleep at night and lifestyle factors, namely dependents and chores at home, were factors that made drivers less likely to consider napping.

Surprisingly, when asked how likely respondents would consider napping midway through a shift for 10-30 min to help manage fatigue at work, the majority of respondents (72%) reported they were “not likely at all” or “not so likely” to consider napping midway through a shift for 10-30 min. An unfavourable nap environment, shift length and rest break length made this group of drivers less likely to consider taking a nap midway through as shift. On the other hand, to maintaining alertness and longer breaks made drivers that more likely to consider taking a nap midway through a shift.

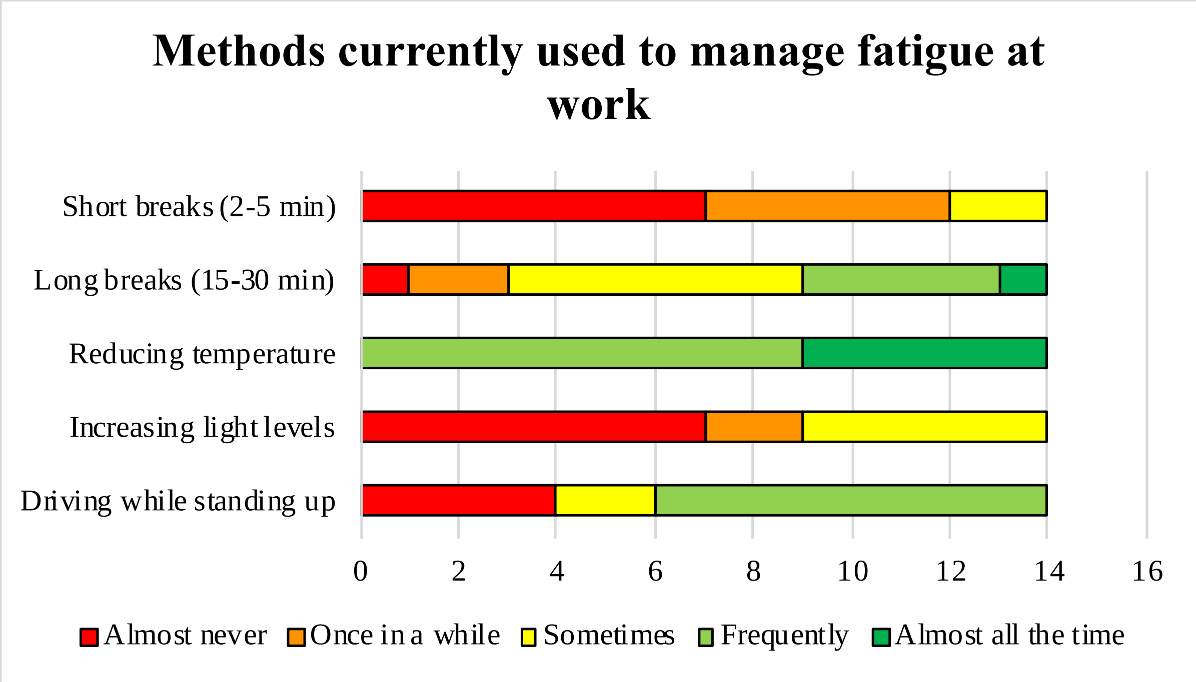

Figure 5. 2 Methods currently used by respondents to manage fatigue at work.

Next, the effectiveness of commonly used methods for managing fatigue at work were examined, see **Figure 5.3**. In particular, methods such as adjusting environmental work conditions and driving while standing up were assessed. Unsurprisingly, reducing temperature by opening the window or using the air conditioner was perceived as the most effective method for managing fatigue at work, as well as the most popular method currently used to manage fatigue at work, as established above. Most of the train drivers (93%) rated it as being “very effective” or “extremely effective”. Moreover, increasing light levels was not perceived to be as effective as reducing temperature. Half of the train drivers (50%) rated its effectiveness as being “not effective at all” or “not so effective”. A third option, namely “playing music in the background” was added. Although playing music in the cab is prohibited, this option was added to gauge its level effectiveness, with the intention of proposing this method of fatigue self-managing fatigue to the organisation’s management, if deemed effective by train drivers.

Importantly, playing music in the background was rated relatively highly. The results indicate that it is perceived to be less effective than reducing temperature but more effective than increasing light levels. More train drivers perceived playing music in the background to be effective, relative to increasing light levels. Most train driver (72%) perceived it to be “very effective" or "extremely effective", compared to 29% that perceived increasing light level to be "very effective".

57% of train drivers reported currently using driving while standing up as a method to help manage fatigue at work, as indicated previously. Unsurprisingly, the majority of driver (79%) perceived driving while standing up to be "very effective" or "extremely effective".

Education as a countermeasure for managing fatigue at work, was the last method examined for managing fatigue at work. All train drivers reported being educated about fatigue causes, consequences and countermeasures by their organisation. The mean of the quality of the education provided was 3.8 ± 0.9, indicating that the quality of the education provided is rated by train driver as being relative good. The mean rating of the usefulness of the education provided was 3.8 ± 0.8, suggesting that train drivers found the education provided moderately useful.

In addition, train drivers were questioned about the extent to which they agree with the statement "It's okay to show up to work while extremely fatigued", to indirectly gauge their levels of fatigue education and awareness. Nearly all respondents disagreed with the idea of showing up to work while extremely fatigued. When asked to rate their current ability to resist fatigue, all train drivers rated their ability to resist fatigue as good, very good or excellent. This suggests that their self-reported resistance to fatigue is average or above average. 14% reported an excellent ability to resist fatigue. Both of these drivers were in 40-50 age range and drove a mix of commuter and intercity services.

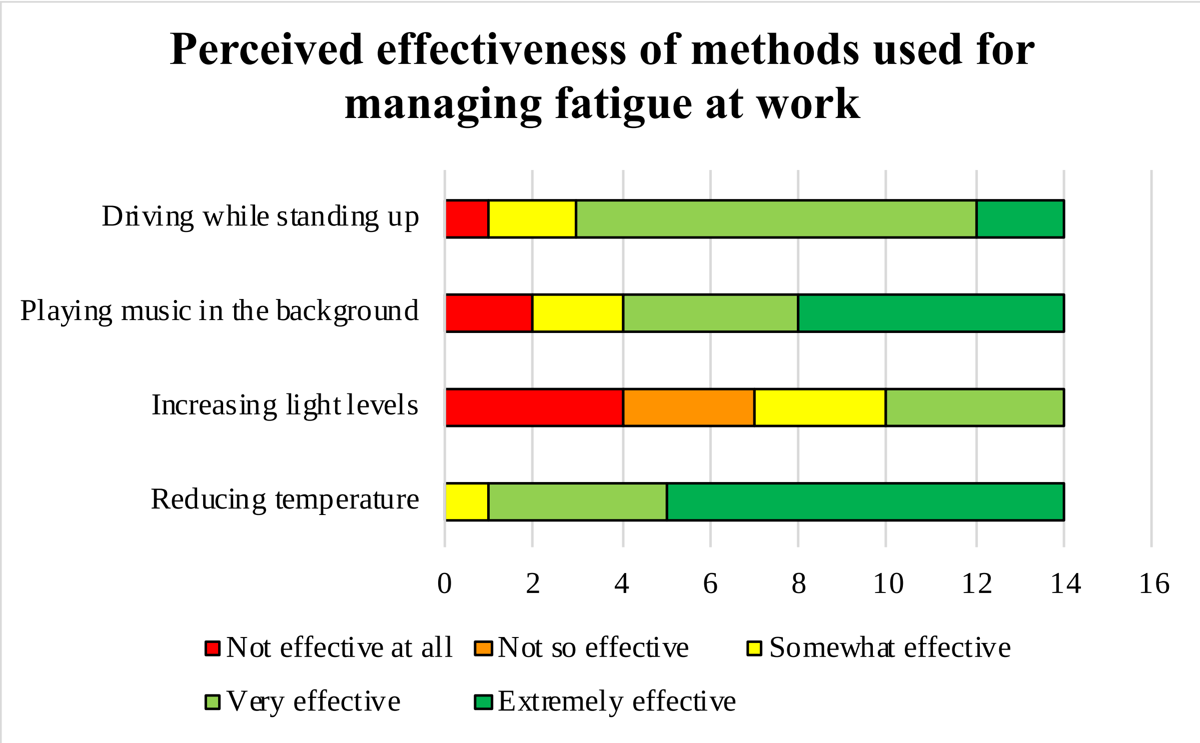

Figure 5. 3 Perceived effectiveness of methods used for managing fatigue at work.

Finally, when train drivers were asked about countermeasures they used to manage their fatigue at work, other than those discussed already in the questionnaire, a variety of responses were obtained. **Table 5.4** summarises other countermeasures used by respondents to manage fatigue at work.

The findings of this section shed light on the effectiveness of playing music in the background as a method to manage fatigue at work, a method currently prohibited in the rail organisation. This finding is in agreement with current studies that recommend the use of music to counteract the monotony of the driving task (Trumbo et al., 2017). Such a finding may contribute to the introduction and implementation of this countermeasure in future. In addition, the study highlights the importance of providing drivers with more frequent break, or alternatively longer breaks, which can be achieved through hiring more drivers or amendments to roster.

Table 5. 4 Other countermeasures used by respondents to manage fatigue.

Managing fatigue at work	**Managing sleep**
Caffeine	Drinking a glass of milk
Drinking water	Sex 2-3 times per week
Washing face with very cold water	Avoiding exercise 2-3 h prior to bedtime
Redirecting gaze from primary task of looking out at the line ahead to checking the dash gauges and systems giving the location for 1-2 s	Clearing the mind (one driver suggested completing outstanding household tasks before bed to clear his mind)
Singing or singing to oneself	
Writing out shift on a piece of paper	
Risk-triggered commentary	

5.2.3. Section 3

Section 3 addresses managing sleep, specifically sleep hygiene habits and practises used by train drivers to manage their sleep, as per **Figure 5.4**. Drivers were also asked about their diet habits (the consumption of caffeine, alcohol and particular foods prior to bedtime) and whether they smoked or exercised. In addition, the frequency at which they used non-prescription sleep aids (over-the-counter medications, herbs and acupuncture) or behavioural strategies (CBT techniques and meditation) to manage their sleep was asked as well. Furthermore, drivers were asked to rate the effectiveness of particular countermeasures and their willingness to use certain countermeasures to manage their sleep, as illustrated in **Figure 5.5** and **Figure 5.6**, respectively. Finally, the impact of diet and smoking, as well as the extent to which they set limits for their diet was questioned, as per **Figure 5.7** and **Figure 5.8**, respectively.

According to **Figure 5.4**, all train drivers reported using some form of sleep hygiene habits and practices to manage their sleep. A total of 21% of train drivers adhered to a consistent bedtime routine or sleep/wake schedule, indicating that consistency is the least popular habit practiced by train drivers to manage sleep.

Creating an adequate sleep environment was the most popular sleep hygiene method used to manage sleep. Nearly all train drivers employed sleep hygiene habits and practices that created a suitable sleep environment to manage their sleep. Most respondents (79%) created a comfortable sleep environment, a 36% used their bedroom for sleep-compatible activities, 29% avoided using light-emitting electronics, namely TV, computer, tablets or smartphones before bed, more than half (57%) reported setting the bedroom temperature to a comfortable temperature (this included increasing or reducing the temperature), and nearly all (93%) made their bedroom as dark as possible.

Activities, namely, reading or listening to relaxing music prior to bedtime were less popular than methods used to create a suitable sleep environment but more popular than consistency. More than half (64%) of the respondents used sleep-inducing activities such as reading before bed or listening to relaxing music, to manage their sleep. More than a third (36%) read before bedtime, while less than a third (29%) listened to relaxing music. Only one train driver (7%) reported using “other” sleep hygiene habits and practices to manage his sleep, reporting that he listened to podcasts to help manage sleep.

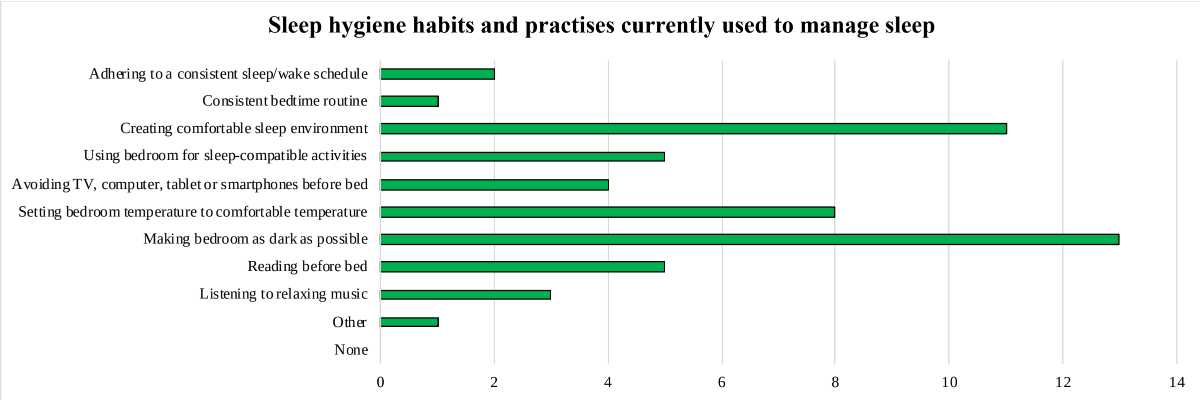

Figure 5. 4 Sleep hygiene habits and practices currently used to manage sleep.

When asked about their diet habits, 28% of respondents consumed caffeine once a week, less than once a week or never consumed caffeine. 43% had caffeine two or three times a week, while 29% had coffee every day. Most respondents (79%) reported consuming alcohol two days or less per week, while 21% of respondents never consume alcohol. None of the respondents consumed alcohol more than 2 days per week. The majority (86%) of train drivers didn't consume heavy meals 2 h prior to bedtime on a regular basis. 86% consumed heavy meal once a week, less than once a week or never consumed heavy meals two h prior to bedtime. Only 14% consumed heavy meals two or three times a week. None of the drivers consumed heavy meals every day. Similarly, most of the drivers (86%) didn't regularly consume spicy food 2 h prior to bedtime. 14% consumed spicy food once a week, 7% less than once a week and more than half (65%) never consumed spicy food prior to bedtime.

The questionnaire data revealed that only one train driver (7%) was a smoker. As a consequence, this variable was not considered further. When asked about the frequency at which the respondents exercised, the majority of train drivers (72%) exercised at least two or three times per week, 43% of this group exercised two or three times per week and a further 29% exercised every day. Less than a third (29%) of respondents exercised once a week, less than once a week or never exercised. Cardiovascular exercise such as walking, jogging, running, swimming or biking was the most popular type of exercise, practiced by 93% of train drivers, followed by strength, including lifting weights or working with resistance bands, which was practiced by 43% and flexibility such as stretching, yoga or Pilates, which was practiced by 29% of drivers.

None of the train drivers used non-prescription sleep aids, namely over-the-counter medication, herbs and acupuncture, manage their sleep. Lastly, the frequency at which behavioural strategies, such as CBT-based techniques and meditation was assessed. The data obtained indicates that behavioural strategies for managing sleep are relatively unpopular methods for managing sleep among train drivers. Nearly all respondents (93%) reported never using CBT techniques developed during CBT sessions. Similarly, most respondents (72%) never used meditation to help manage their sleep. Only 14% of train drivers practiced meditation less than once a week or two to three times a week.

When train drivers were asked to rate the effectiveness of particular countermeasures, as illustrated in **Figure 5.5**, changing sleep habits and practices was perceived to be less effective for managing sleep than avoiding certain foods and drinks and exercise, but more effective than behavioural therapies and sleep aids. A total of half of the train drivers perceived changing sleep habits and practices to be “very effective” or “extremely effective” for managing sleep. Over a third (36%) rated it as being “somewhat likely”. Practicing cardiovascular exercise for managing sleep was perceived to be less effective than avoiding certain foods and drinks. 71% of train drivers rated it as being “very effective” or “extremely effective”.

Avoiding particular foods and drinks before bed were perceived as the most effective methods used for managing sleep. Avoiding heavy meals and spicy food before bed was perceived as the most effective method, with nearly all train drivers, a total of 93%, reporting it as being “very effective” or “extremely effective, followed by avoiding alcohol and caffeine before bed, each of which were rated as being “very effective” or extremely effective” by 79% of train drivers.

Sleep aids such as herbs and acupuncture were perceived to be the least effective means of managing sleep. Using herbs to manage sleep was perceived to be more popular than acupuncture, with approximately a third (36%) rating herbs as being “not effective at all” or “not so effective”, compared to the 43% that rated acupuncture. A further 50% rated herbs as being “somewhat effective” and 14% rated them as “very effective”. On the contrary, only 57% reported acupuncture as being “somewhat effective”.

Behavioural therapies such as CBT techniques and meditation were perceived to be relatively less effective than all the other methods of managing sleep, except sleep aids. Meditation was perceived to be more effective than CBT, with more than a third (36%) rating meditation it as being ”very effective” or ”extremely effective” and a further 14% reporting it as being “not effective at all” compared to CBT which was rated as being “very effective” or “extremely effective by 36% but rated as being “not effective at all” or “not so effective” by 21% of train drivers.

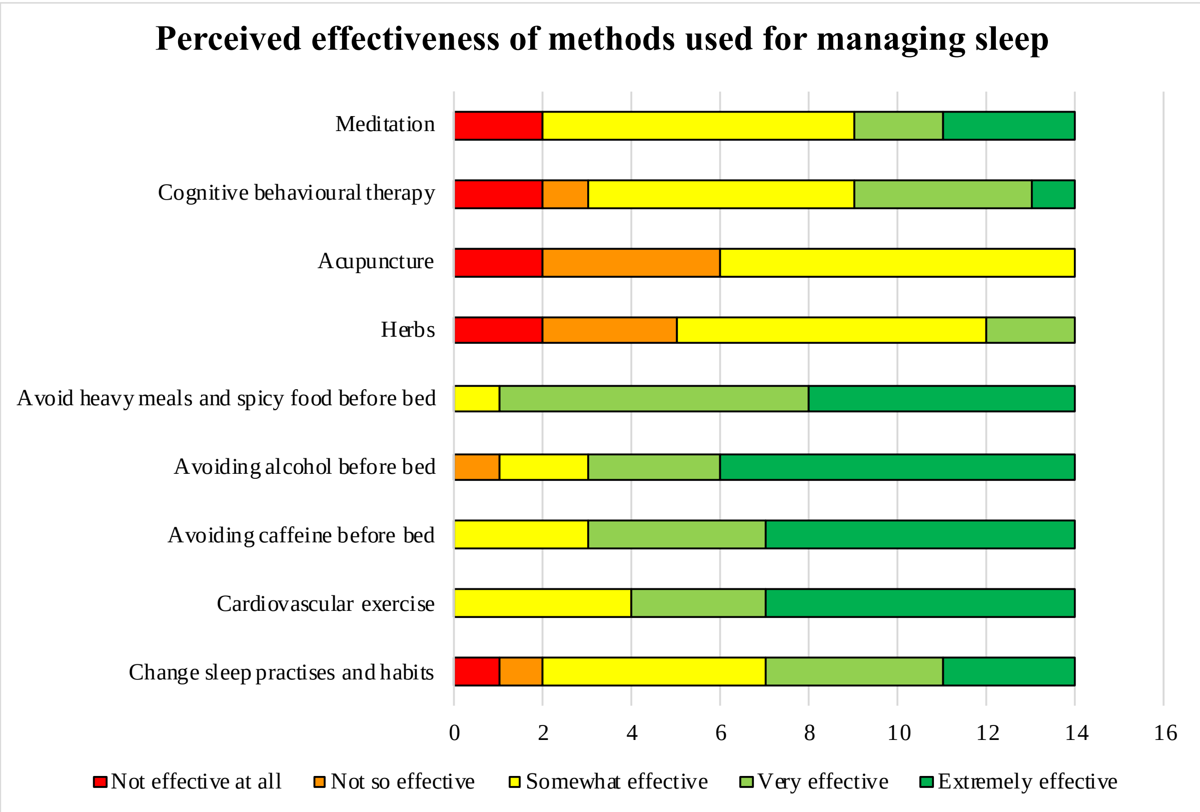

Figure 5. 5 Perceived effectiveness of methods used for managing sleep.

When train drivers were asked to rate their willingness to use specific countermeasures to manage sleep, as illustrated in **Figure 5.6**, avoiding certain foods and drinks was the most popular method, followed by cardiovascular exercise and changing sleep practices and habits. Behavioural therapies and sleep aids were the least popular methods.

Half of the train drivers reported answered “very likely” or “extremely likely” to considering changing sleep practices and habits to help manage their sleep, 29% answered “somewhat likely” to considering changing sleep practices and habits. All the train drivers would consider practising cardiovascular exercise to manage their sleep. Most of the drivers (64%)

would “very likely” or “extremely likely” consider using cardiovascular exercise, while the remaining 36% would “somewhat likely” consider it. Avoiding particular foods and drinks before bed was the most likely method train drivers would consider using to manage their sleep. Avoiding heavy meals and spicy food before bed was the most popular method, with nearly all train drivers, a total of 71%, reporting that they would “very likely” or “extremely likely” consider avoiding heavy meals and spicy food prior to bedtime, followed by avoiding alcohol and caffeine before bed. 79% of drivers would “very likely” or extremely likely” consider avoiding alcohol and caffeine before bed. Sleep aids such as herbs and acupuncture were the least likely method train drivers would consider using to manage their sleep. Train drivers were more willing to use herbs than acupuncture to manage their sleep, with 14% reporting that they would “very likely” or “extremely likely” consider using herbs, compared to the 7% that would “very likely” consider acupuncture. A further 43% were “somewhat likely” to consider herbs, compared to the 36% that would “somewhat likely” consider acupuncture. With undesirable consequences associated with the use of OTC sleep aids in mind, nearly all train drivers (93%), reported that they would not consider using them to manage their sleep. Only one respondent (7%) answered “maybe” to using OTC sleep aids to manage his sleep. Train drivers were less likely to consider using behavioural therapies to manage their sleep compared to the other methods discussed, with the exception of sleep aids. Drivers were more likely to consider meditation than CBT. 50% reported that they would “very likely” or “extremely likely” consider meditation, relative to the 43% that would consider CBT-based techniques.

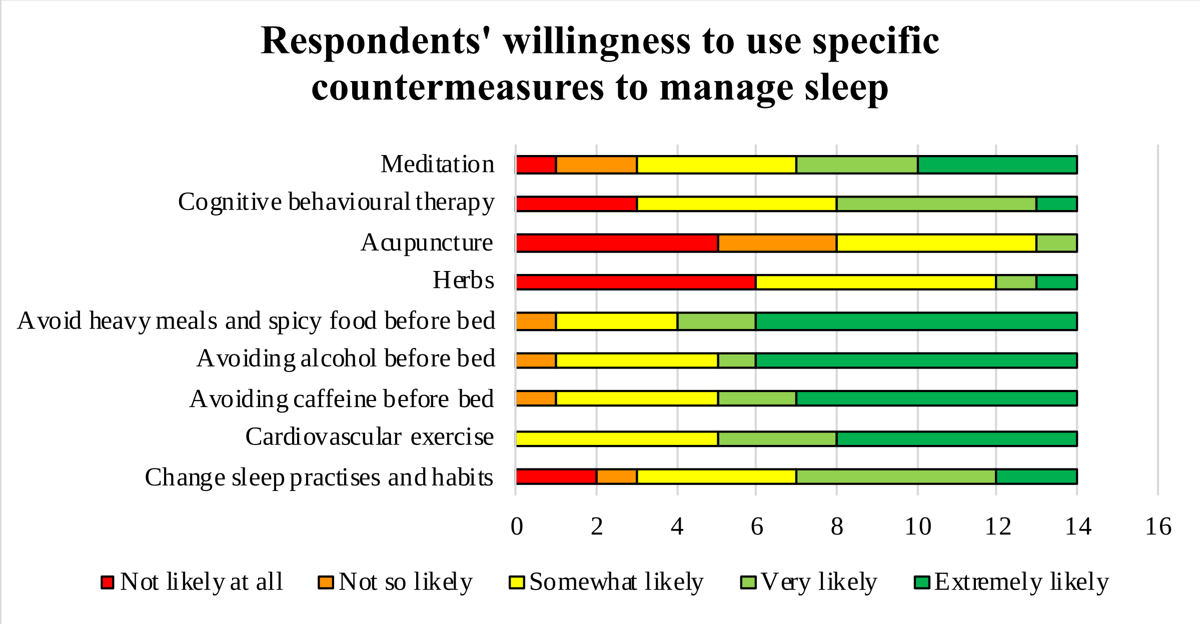

Figure 5. 6 Respondents' willingness to use specific countermeasures to manage sleep.

Finally, an analysis of the impact of diet on sleep quality and quantity and the extent to which train drivers set limits for their diet, as illustrated in **Figure 5.7** and **Figure 5.8**, respectively, revealed that, caffeine had the highest impact on sleep, followed by alcohol, spicy food and heavy meals. The majority of train drivers (72%) reported that caffeine had "quite an impact" or an "extreme impact" on their sleep quality and quantity, while 14% reported "some impact" on sleep. Similarly, more than half of drivers (57%) reported that alcohol had "quite an impact" or an "extreme impact" on their sleep quality and quantity, while 22% reported "some impact". Less than half of drivers (43%) reported that heavy meals had "quite an impact" or an "extreme impact" on their sleep, compared to the 57% that was reported for spicy food.

When asked to rate the extent to which train drivers set limits for the consumption of caffeine and alcohol, the majority of respondents (43%) answered "not at all" or "a little bit" to setting limits for the consumption of caffeine, 22% reported setting some limits and 35% reported setting "quite a bit" or "a tremendous amount" of limits. Less than 14% of drivers answered "not at all" or "a little bit" to setting limits for the consumption of alcohol, while 36% set some limits and 50% set "a tremendous amount" of limits on alcohol intake.

Thus, the data generated is in agreement with literature indicating the adverse impact consuming caffeine, alcohol or spicy food prior to bedtime has on sleep quality and quality

(Ebrahim et al., 2013; Troxel et al., 2015; Ramakrishnan and Scheid, 2007; O'Callaghan et al., 2018; Fulgoni et al., 2015; Zwyghuizen-Doorenbos et al., 1990; Edwards et al., 1992). In addition, the data highlight the importance of setting limits for dietary items that have a profound impact on sleep quality and quality. It suggests that drivers should limit their intake caffeine, alcohol and spicy prior to bedtime as they have the highest impact on sleep quality and quantity.

Lastly, when train drivers were asked about countermeasures they used to manage their sleep, other than those previously discussed in the questionnaire, a variety of responses were obtained. **Table 5.4** summarises other countermeasures used by respondents to manage fatigue at work.

To sum up, the findings of this study may assist the rail organisation in identify novel methods used to manage sleep through identifying methods currently used by train drivers and their effectiveness. Importantly, the data suggests that a relationship may exist between the perceived effectiveness of a countermeasure and the frequency at which it is used. This emphasizes the importance of assessing the effectiveness of fatigue management strategies in order to predict the methods train drivers are most likely to use to manage fatigue.

In addition, these findings highlight a major issue faced by train drivers, specifically, the adverse impact of shift work on their ability to adhere to a consistent sleep/wake schedule and bedtime routine, an issue that has been discussed in the literature (Stepanski and Wyatt, 2003).

Furthermore, the open-ended questions that gathered information about countermeasures, used by drivers to manage fatigue (other than those discussed in the pilot questionnaire), enabled the identification of novel fatigue management strategies that can be recommended to other drivers by the organisation's management, to facilitate fatigue management. Importantly, the findings of this study can inform future education content as well as future management decisions.

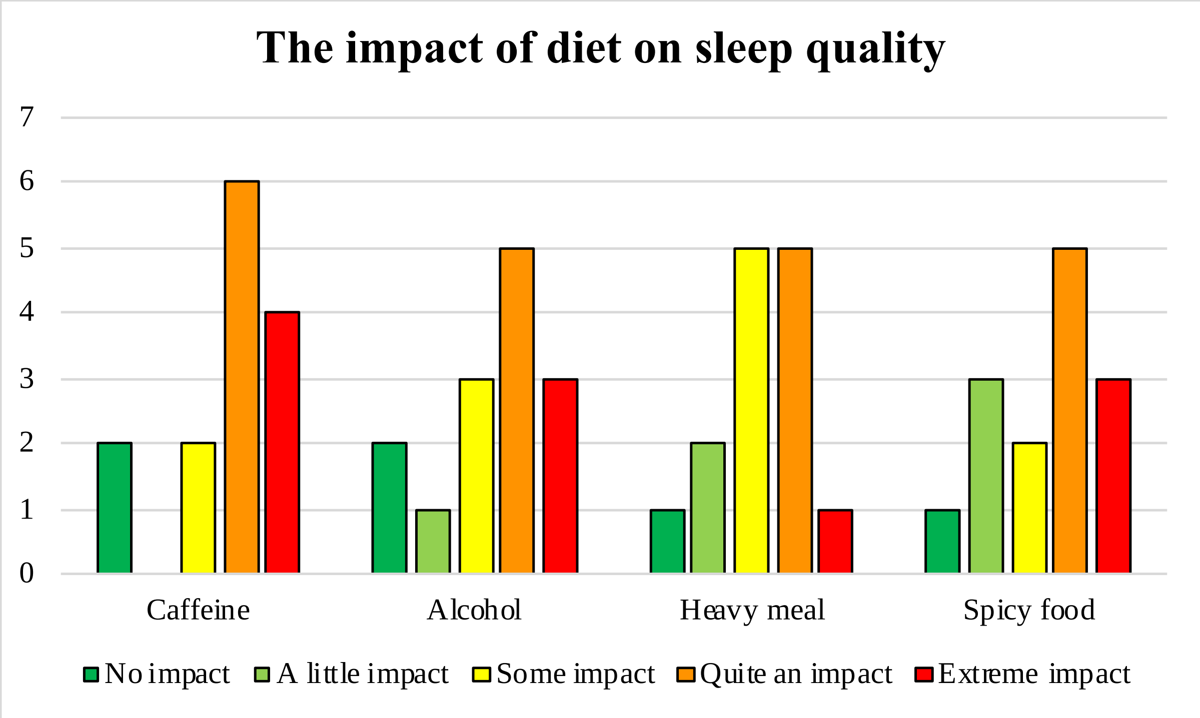

Figure 5. 7 The impact of diet on sleep quality.

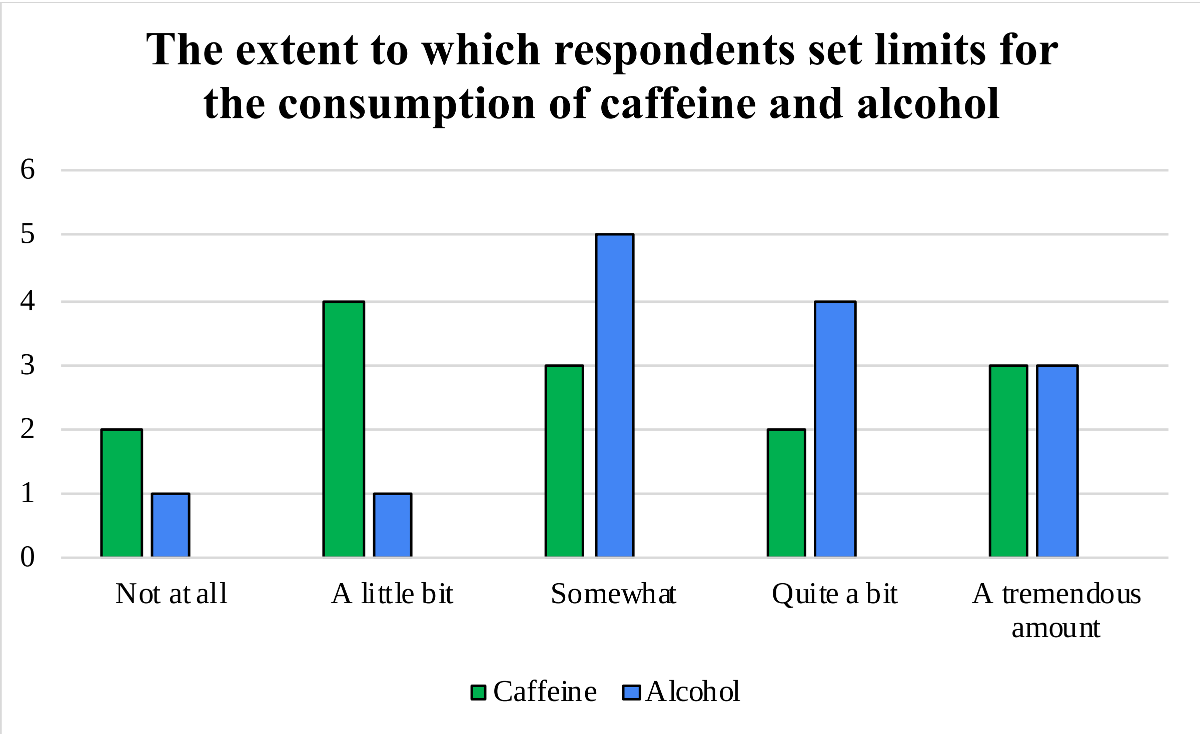

Figure 5. 8 The extent to which respondents set limits for the consumption of caffeine and alcohol.

5.2.4. Section 4

Lastly, section 4 was concerned with measuring fatigue, specifically asking train drivers whether their levels of fatigue were currently being monitored and their willingness to assess fatigue levels at work. Moreover, drivers were question on whether they monitored their sleep using sleep diaries e.g. sleep watches and their willingness to do so.

The questionnaire data revealed that the majority of train drivers (64%) reported that their levels of fatigue were not being monitored at work. Less than a third (29%) were not sure if their levels of fatigue were being monitored. Only one respondent (7.1%) reported that his levels of fatigue were currently being monitored at work. Less than half of the train drivers (43%) answered “yes” to measuring their fatigue levels at the beginning and at the end of the shift, i.e. would consider assessing their fatigue levels at the beginning and at the end of the shift. A further third (36%) answered “maybe”, i.e. may consider assessing their fatigue levels and 21% answered “no”, i.e. would not consider assessing their fatigue levels at the beginning and at the end of the shift.

When asked about the use of sleep diaries, most train drivers (79%) reported “never” using or “rarely” using sleep diaries such as smartwatches to monitor and manage their sleep. A further 14% reported using them sometimes. Only one driver (7.1%) always used sleep diaries to monitor and manage his sleep. A further analysis of the demographics of the train drivers that used sleep diaries revealed that the respondent that always used sleep diaries was within the 40-50 age group, while the two respondents that used them sometimes were within the 25-39 age range. When asked how likely they were to consider using daily sleep diaries to monitor and manage your sleep, the results obtained appeared to be quite promising, with more than a third (36%) of train drivers reporting that they were “very likely” or “extremely likely” to consider using them to monitor and manage their sleep. 60% of these drivers were within the 40-50 age range, while 40% were in the 25-39 age range. 21% of train drivers were “somewhat likely” to consider using sleep diaries, but the majority of train drivers (43%) were “not likely at all” to consider using sleep diaries to monitor and manage their sleep. Within this group, 67% of the train drivers represented the 40-50 age range, while a third (33%) represented the 25-39% age range.

Thus, this data seems to suggest that younger train drivers are more likely to consider using sleep diaries to monitor and manage their sleep, particularly drivers within the 25-39 age group. Altogether, the findings of this section suggest that the majority of drivers may engage in measuring their levels of fatigue at the beginning and end of the shift. Also, they may consent to using sleep diaries such as sleep watches to self-manage their sleep.

6. Limitations and Future Directions

This study is limited to rail services serving the Dublin area, namely commuter, intercity, DART and Tara freight services. The time constraints and difficulties faced in gathering data during this pandemic has impacted this study's ability to generate statistically significant and representative cohort. In future, the pilot questionnaire should be adapted to include all districts, including Northern, Waterford, Cork, Galway and Limerick to generate more representative findings.

Additional demographic questions should be included into the pilot questionnaire, including a question that asks drivers about their years of experience in driving and the presence of dependents to elucidate potential sources of fatigue. Furthermore, chronotype should also be assessed to determine driver preference for early or late shifts, as well as the presence of underlying medical conditions, to gain a clear understanding of the target population.

Further studies should consider assessing other countermeasures for managing fatigue at work and managing sleep, with a particular emphasis on the methods (other than those addressed in the pilot questionnaire) deemed effective by train drivers.

This study is limited to the methods used to manage fatigue at work addressed in the questionnaire, namely, short/long breaks, naps, reducing temperature, increasing light levels, playing music in the background and driving while standing up. Future studies should assess the effectiveness of caffeine and water as methods of managing fatigue at work.

The findings of this study may be used to inform the fatigue education program within the rail organisation. However, it is important to note that if the organisation recommends measuring and monitoring fatigue levels using sleep diaries e.g. smartwatches to train drivers as a method of managing sleep, the sleep data generated will be of no use to the organisation as they ethically and legally cannot access this information. Nonetheless, smartwatches should be strongly recommended to train drivers as they serve as a convenient tool that assists in monitoring and managing sleep by facilitating the collection of sleep data automatically.

In future, the statistically significant and representative data gathered from the pilot questionnaire should be used to inform the organisation's FRMS. In particular, work-related causes of fatigue that have been implicated as being contributors to train driver fatigue levels should be considered.

Finally, the willingness of train drivers to engage in sleep contracts that make obtaining sufficient sleep prior to attending work a formal requirement, should be assessed. This may encourage employee commitment to obtain sufficient sleep during recovery hours (Holmes et al., 2006).

7. Conclusion

In conclusion, this study expands our knowledge of train driver fatigue self-management strategies by developing and validating a pilot questionnaire that accurately assesses train driver fatigue and various self-management strategies. Face validation, content validation and reliability analysis, confirm that the questionnaire is a valid tool that adequately assesses fatigue, identifies countermeasures used, their effectiveness and the willingness of train drivers to use particular countermeasures to help combat fatigue. The findings of the pilot questionnaire will shed light on the most effective fatigue management strategies currently used by drivers. They will also inform FRMS in rail organisations by enlightening management on the particular countermeasures train drivers will likely employ to manage their fatigue.

8. References

Åkerstedt, T. (1991). Shift Work and Sleep Disturbances. In *Sleep and Health Risk* (pp. 265–278). Springer Berlin Heidelberg. https://doi.org/10.1007%2F978-3-642-76034-1_32

Akerstedt, T. (2000). Consensus statement: fatigue and accidents in transport operations. *Journal of Sleep Research*, *9*(4), 395. https://doi.org/10.1046/j.1365-2869.2000.00228.x

Akerstedt, T., Anund, A., Axelsson, J., & Kecklund, G. (2014). Subjective sleepiness is a sensitive indicator of insufficient sleep and impaired waking function. *Journal of Sleep Research*, *23*(3), 240–252. https://doi.org/10.1111/jsr.12158

Ali, S., Chalder, T., & Madan, I. (2014). Evaluating interactive fatigue management workshops for occupational health professionals in the United Kingdom. *Safety and Health at Work*. https://doi.org/10.1016/j.shaw.2014.07.002

Anderson, K. N. (2018). Insomnia and cognitive behavioural therapy-how to assess your patient and why it should be a standard part of care. In *Journal of Thoracic Disease*. https://doi.org/10.21037/jtd.2018.01.35

Angus, R. G., Pigeau, R. A., & Heslegrave, R. J. (1992). *Sustained-Operations Studies: From the Field to the Laboratory BT - Why We Nap: Evolution, Chronobiology, and Functions of Polyphasic and Ultrashort Sleep* (C. Stampi (ed.); pp. 217–241). Birkhäuser Boston. https://doi.org/10.1007/978-1-4757-2210-9_14

Anund, A., Fors, C., Kecklund, G., van Leeuwen, W. M. A., & Åkerstedt, T. (2015). *Countermeasures for fatigue in transportation - A review of existing methods for drivers*. 65.

Arboleda, A., Morrow, P. C., Crum, M. R., & Shelley, M. C. (2003). Management practices as antecedents of safety culture within the trucking industry: similarities and differences by hierarchical level. *Journal of Safety Research*, *34*(2), 189–197. https://doi.org/https://doi.org/10.1016/S0022-4375(02)00071-3

Arnold, P. K., & Hartley, L. R. (2001). Policies and practices of transport companies that promote or hinder the management of driver fatigue. *Transportation Research Part F: Traffic Psychology and Behaviour*, *4*(1), 1–17. https://doi.org/10.1016/S1369-8478(01)00010-9

Arsintescu, L., Mulligan, J. B., & Flynn-Evans, E. E. (2017). Evaluation of a Psychomotor Vigilance Task for Touch Screen Devices. *Human Factors*, *59*(4), 661–670. https://doi.org/10.1177/0018720816688394

Balkin, T. J., Horrey, W. J., Graeber, R. C., Czeisler, C. A., & Dinges, D. F. (2011). The challenges and opportunities of technological approaches to fatigue management. *Accident Analysis & Prevention*, *43*(2), 565–572. https://doi.org/https://doi.org/10.1016/j.aap.2009.12.006

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

Benke, D., Barberis, A., Kopp, S., Altmann, K.-H., Schubiger, M., Vogt, K. E., Rudolph, U., & Möhler, H. (2009). GABA A receptors as in vivo substrate for the anxiolytic action of valerenic acid, a major constituent of valerian root extracts. *Neuropharmacology*, *56*(1), 174–181. https://doi.org/10.1016/j.neuropharm.2008.06.013

Beurskens, A. J. H. M., Bültmann, U., Kant, Ij., Vercoulen, J. H. M. M., Bleijenberg, G., & Swaen, G. M. H. (2000). Fatigue among working people: validity of a questionnaire measure. *Occupational and Environmental Medicine*, *57*(5), 353–357. https://doi.org/10.1136/oem.57.5.353

Binks, H., Vincent, G. E., Gupta, C., Irwin, C., & Khalesi, S. (2020). *Effects of Diet on Sleep : A Narrative Review*. 1–18.

Black, D. S., O'Reilly, G. A., Olmstead, R., Breen, E. C., & Irwin, M. R. (2015). Mindfulness meditation and improvement in sleep quality and daytime impairment among older adults with sleep disturbances: a randomized clinical trial. *JAMA Internal Medicine*, *175*(4), 494–501. https://doi.org/10.1001/jamainternmed.2014.8081

Bonnet, M. H., & Arand, D. L. (2010). Hyperarousal and insomnia: State of the science. In *Sleep Medicine Reviews*. https://doi.org/10.1016/j.smrv.2009.05.002

Boubekri, M., Cheung, I. N., Reid, K. J., Wang, C. H., & Zee, P. C. (2014). Impact of windows and daylight exposure on overall health and sleep quality of office workers: A case-control pilot study. *Journal of Clinical Sleep Medicine*. https://doi.org/10.5664/jcsm.3780

Cain, N., & Gradisar, M. (2010). Electronic media use and sleep in school-aged children and adolescents: A review. In *Sleep Medicine*. https://doi.org/10.1016/j.sleep.2010.02.006

Cajochen, C. (2007). Alerting effects of light. *Sleep Medicine Reviews*, *11*(6), 453–464. https://doi.org/10.1016/j.smrv.2007.07.009

Caldwell, J. A. (2012). Crew Schedules, Sleep Deprivation, and Aviation Performance. *Current Directions in Psychological Science*, *21*(2), 85–89. https://doi.org/10.1177/0963721411435842

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

Caldwell, J. A., Mallis, M. M., Caldwell, J. L., Paul, M. A., Miller, J. C., & Neri, D. F. (2009). Fatigue countermeasures in aviation. *Aviation, Space, and Environmental Medicine*, *80*(1), 29–59. https://doi.org/10.3357/asem.2435.2009

Caldwell, J. A., Smythe, N. K., Leduc, P. A., & Caldwell, J. L. (2000). Efficacy of Dexedrine for maintaining aviator performance during 64 hours of sustained wakefulness: a simulator study. *Aviation, Space, and Environmental Medicine*, *71*(1), 7–18.

Caldwell, J. L., & Gilreath, S. R. (2001). Work and sleep hours of U.S. Army aviation personnel working reverse cycle. *Military Medicine*, *166*(2), 159–166.

Caldwell, J. L., Prazinko, B. F., Rowe, T., Norman, D., Hall, K. K., & Caldwell, J. A. (2003). Improving daytime sleep with temazepam as a countermeasure for shift lag. *Aviation, Space, and Environmental Medicine*, *74*(2), 153–163.

Cao, H., Pan, X., Li, H., & Liu, J. (2009). Acupuncture for treatment of insomnia: a systematic review of randomized controlled trials. *Journal of Alternative and Complementary Medicine (New York, N.Y.)*, *15*(11), 1171–1186. https://doi.org/10.1089/acm.2009.0041

Cercarelli, L. R., & Ryan, G. A. (1996). No Title. *Long Distance Driving Behaviour of Western Australian Drivers*, 35–45.

Cervena, K., Dauvilliers, Y., Espa, F., Touchon, J., Matousek, M., Billiard, M., & Besset, A. (2004). Effect of cognitive behavioural therapy for insomnia on sleep architecture and sleep EEG power spectra in psychophysiological insomnia. *Journal of Sleep Research*. https://doi.org/10.1111/j.1365-2869.2004.00431.x

Chang, A. M., Aeschbach, D., Duffy, J. F., & Czeisler, C. A. (2015). Evening use of light-emitting eReaders negatively affects sleep, circadian timing, and next-morning alertness. *Proceedings of the National Academy of Sciences of the United States of America*. https://doi.org/10.1073/pnas.1418490112

Cheuk, D. K., Yeung, W.-F., Chung, K., & Wong, V. (2012). Acupuncture for insomnia. *Cochrane Database of Systematic Reviews*. https://doi.org/10.1002/14651858.cd005472.pub3

Chung, K.-F., Yeung, W.-F., Ho, F. Y.-Y., Yung, K.-P., Yu, Y.-M., & Kwok, C.-W. (2015). Cross-cultural and comparative epidemiology of insomnia: the Diagnostic and statistical manual (DSM), International classification of diseases (ICD) and International classification of sleep disorders (ICSD). *Sleep Medicine*, *16*(4), 477–482. https://doi.org/10.1016/j.sleep.2014.10.018

Civil Aviation Authority, U. (2007). *CAA PAPER 2005/04 Aircrew Fatigue: A Review of Research Undertaken on Behalf of the UK Civil Aviation Authority*.

Civil Aviation Safety Authority (CASA) Australia. (2014). *Biomathematical Fatigue Model Guidance Document*. *March*. http://wwwtest.casa.gov.au/wcmswr/_assets/main/aoc/fatigue/fatigue_modelling.pdf

Crispim, C. A., Zimberg, I. Z., dos Reis, B. G., Diniz, R. M., Tufik, S., & de Mello, M. T. (2011). Relationship between food intake and sleep pattern in healthy individuals. *Journal of Clinical Sleep Medicine : JCSM : Official Publication of the American Academy of Sleep Medicine*, *7*(6), 659–664. https://doi.org/10.5664/jcsm.1476

Dawson, D., Ian Noy, Y., Härmä, M., Kerstedt, T., & Belenky, G. (2011). Modelling fatigue and the use of fatigue models in work settings. *Accident Analysis and Prevention*. https://doi.org/10.1016/j.aap.2009.12.030

Dijkman, M., Sachs, N., Levine, E., Mallis, M., Carlin, M. M., & Gillen, K. A. (1997). Effects of reduced stimulation on neurobehavioral alertness depend on circadian phase during human sleep deprivation. *Sleep Res*, 26–265.

Dongen, H. P. A. Van, & Mollicone, D. (2013). *Field Study on the Efficacy of the New Restart Provision for Hours of Service*.

Drake, C. L., Roehrs, T., Richardson, G., Walsh, J. K., & Roth, T. (2005). Shift Work Sleep Disorder: Prevalence and Consequences Beyond that of Symptomatic Day Workers. *Journal of Clinical Sleep Medicine*. https://doi.org/10.5664/jcsm.26302

Drake, C., Roehrs, T., Shambroom, J., & Roth, T. (2013). Caffeine effects on sleep taken 0, 3, or 6 hours before going to bed. *Journal of Clinical Sleep Medicine : JCSM : Official Publication of the American Academy of Sleep Medicine*, *9*(11), 1195–1200. https://doi.org/10.5664/jcsm.3170

Dunn, N., & Williamson, A. (2012). Driving monotonous routes in a train simulator: the effect of task demand on driving performance and subjective experience. *Ergonomics*, *55*(9), 997–1008. https://doi.org/10.1080/00140139.2012.691994

Ebrahim, I. O., Shapiro, C. M., Williams, A. J., & Fenwick, P. B. (2013). Alcohol and sleep I: effects on normal sleep. *Alcoholism, Clinical and Experimental Research*, *37*(4), 539–549. https://doi.org/10.1111/acer.12006

Edwards, S. J., Montgomery, I. M., Colquhoun, E. Q., Jordan, J. E., & Clark, M. G. (1992). Spicy meal disturbs sleep: an effect of thermoregulation? *International Journal of Psychophysiology : Official Journal of the International Organization of Psychophysiology*, *13*(2), 97–100. https://doi.org/10.1016/0167-8760(92)90048-g

Ernst, E., Lee, M. S., & Choi, T. Y. (2011). Acupuncture for insomnia? An overview of systematic reviews. In *European Journal of General Practice*. https://doi.org/10.3109/13814788.2011.568475

EUROCONTROL. (2018). *Fatigue and Sleep Management*.

Fan, J., & Smith, A. P. (2018). A preliminary review of fatigue among rail staff. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2018.00634

Fernández, S., Wasowski, C., Paladini, A. C., & Marder, M. (2004). Sedative and sleep-enhancing properties of linarin, a flavonoid-isolated from Valeriana officinalis. *Pharmacology Biochemistry and Behavior*, *77*(2), 399–404. https://doi.org/https://doi.org/10.1016/j.pbb.2003.12.003

Fisk, A. S., Tam, S. K. E., Brown, L. A., Vyazovskiy, V. V, Bannerman, D. M., & Peirson, S. N. (2018). Light and Cognition: Roles for Circadian Rhythms, Sleep, and Arousal. *Frontiers in Neurology*, *9*, 56. https://doi.org/10.3389/fneur.2018.00056

Fossum, I. N., Nordnes, L. T., Storemark, S. S., Bjorvatn, B., & Pallesen, S. (2014). The Association Between Use of Electronic Media in Bed Before Going to Sleep and Insomnia Symptoms, Daytime Sleepiness, Morningness, and Chronotype. *Behavioral Sleep Medicine*. https://doi.org/10.1080/15402002.2013.819468

Fu, C., Zhao, N., Liu, Z., Yuan, L. H., Xie, C., Yang, W. J., Yu, X. T., Yu, H., & Chen, Y. F. (2017). Acupuncture Improves Peri-menopausal Insomnia: A Randomized Controlled Trial. *Sleep*. https://doi.org/10.1093/sleep/zsx153

Fulgoni, V. L., Keast, D. R., & Lieberman, H. R. (2015). Trends in intake and sources of caffeine in the diets of US adults: 2001-2010. *American Journal of Clinical Nutrition*. https://doi.org/10.3945/ajcn.113.080077

Galinsky, T., Swanson, N., Sauter, S., Dunkin, R., Hurrell, J., & Schleifer, L. (2007). Supplementary breaks and stretching exercises for data entry operators: a follow-up field study. *American Journal of Industrial Medicine*, *50*(7), 519–527. https://doi.org/10.1002/ajim.20472

Gander, P. H., Marshall, N. S., Bolger, W., & Girling, I. (2005). An evaluation of driver training as a fatigue countermeasure. *Transportation Research Part F: Traffic Psychology and Behaviour*. https://doi.org/10.1016/j.trf.2005.01.001

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

Gander, P., Waite, D., Mckay, A., Seal, T., & Millar, M. (1998). An Integrated Fatigue Management Programme for Tanker Drivers. In *Managing Fatigue in Transportation*. https://doi.org/10.1016/b978-008043357-8/50022-4

Gawron, V. J. (2016). Summary of Fatigue Research for Civilian and Military Pilots. *IIE Transactions on Occupational Ergonomics and Human Factors*. https://doi.org/10.1080/21577323.2015.1046093

Gaydos, S. J., Curry, I. P., & Bushby, A. J. R. (2013). Fatigue assessment: Subjective peer-to-peer fatigue scoring. *Aviation Space and Environmental Medicine*. https://doi.org/10.3357/ASEM.3728.2013

Gershon, P., Shinar, D., Oron-Gilad, T., Parmet, Y., & Ronen, A. (2011). Usage and perceived effectiveness of fatigue countermeasures for professional and nonprofessional drivers. *Accident Analysis & Prevention*, *43*(3), 797–803. https://doi.org/https://doi.org/10.1016/j.aap.2010.10.027

Gertler, J., DiFiore, A., & Raslear, T. (2012). Fatigue status of the U.S. railroad industry. In *Employee Fatigue in the U.S. Railroad Industry: In-Depth Analyses*.

Gertler, J., DiFiore, A., & Raslear, T. (2014). Fatigue status of the U.S. railroad industry. In *Employee Fatigue in the U.S. Railroad Industry: In-Depth Analyses*.

Gertler, J., Popkin, S., Nelson, D., & O'Neil, D. (2002). *Transit Cooperative Research Program Report 81: Toolbox for Transit Operator Fatigue*.

Goode, J. H. (2003). Are pilots at risk of accidents due to fatigue? *Journal of Safety Research*. https://doi.org/10.1016/S0022-4375(03)00033-1

Gregory, K. B., Winn, W., Johnson, K., & Rosekind, M. R. (2010). Pilot fatigue survey: exploring fatigue factors in air medical operations. *Air Medical Journal*, *29*(6), 309–319. https://doi.org/10.1016/j.amj.2010.07.002

Hao, T., Xing, G., & Zhou, G. (2020). iSleep: Unobtrusive Sleep Quality Monitoring using Smartphones. *ACM Transactions on Sensor Networks*, *16*(3), 1–32. https://doi.org/10.1145/3392049

Härmä, M., Tenkanen, L., Sjöblom, T., Alikoski, T., & Heinsalmi, P. (1998). Combined effects of shift work and life-style on the prevalence of insomnia, sleep deprivation and daytime sleepiness. *Scandinavian Journal of Work, Environment and Health*. https://doi.org/10.5271/sjweh.324

Heslegrave, R. J., & Angus, R. G. (1985). The effects of task duration and work-session location on performance degradation induced by sleep loss and sustained cognitive work. *Behavior Research Methods, Instruments, & Computers*, *17*(6), 592–603. https://doi.org/10.3758/BF03200971

Hilditch, C. J., & McHill, A. W. (2019). Sleep inertia: current insights. *Nature and Science of Sleep*, *11*, 155–165. https://doi.org/10.2147/NSS.S188911

Hirshkowitz, M. (2013). Fatigue, sleepiness, and safety: Definitions, assessment, methodology. In *Sleep Medicine Clinics*. https://doi.org/10.1016/j.jsmc.2013.04.001

Holmes, A., Baker, A., & Jackson, P. (2006). *Viability of Using Sleep Contracts as a Control Measure in Fatigue Management*.

Houghton, P. J. (1999). The scientific basis for the reputed activity of Valerian. *The Journal of Pharmacy and Pharmacology*, *51*(5), 505–512. https://doi.org/10.1211/0022357991772772

Hubbling, A., Reilly-Spong, M., Kreitzer, M. J., & Gross, C. R. (2014). How mindfulness changed my sleep: Focus groups with chronic insomnia patients. *BMC Complementary and Alternative Medicine*. https://doi.org/10.1186/1472-6882-14-50

Institute of Medicine. (2001). *Caffeine for the Sustainment of Mental Task Performance*. National Academy Press.

Institute of Medicine. (2006). *Sleep Disorders and Sleep Deprivation: An Unmet Public Health Problem*. https://doi.org/10.17226/11617

International Civil Aviation Organization. (2015). *Fatigue Management Guide for Airline Operators*.

Jaehne, A., Riemann, D., Hornyak, M., Loessl, B., & Ba, Z. (2009). Effects of nicotine on sleep during consumption , withdrawal and replacement therapy. *Sleep Medicine Reviews*, *13*, 363–377. https://doi.org/10.1016/j.smrv.2008.12.003

Jay, S., Dawson, D., Ferguson, S., & Lamond, N. (2008). Driver fatigue during extended rail operations. *Applied Ergonomics*, *39*, 623–629. https://doi.org/10.1016/j.apergo.2008.01.011

Ji, X., Grandner, M. A., & Liu, J. (2017). The relationship between micronutrient status and sleep patterns: a systematic review. *Public Health Nutrition*, *20*(4), 687–701. https://doi.org/10.1017/S1368980016002603

Kant, I. J., Bültmann, U., Schröer, K. A. P., Beurskens, A. J. H. M., Van Amelsvoort, L. G. P. M., & Swaen, G. M. H. (2003). An epidemiological approach to study fatigue in the working population: The Maastricht Cohort Study. *Occupational and Environmental Medicine*. https://doi.org/10.1136/oem.60.suppl_1.i32

Katayose, Y., Aritake, S., Kitamura, S., Enomoto, M., Hida, A., Takahashi, K., & Mishima, K. (2012). Carryover effect on next-day sleepiness and psychomotor performance of nighttime administered antihistaminic drugs: a randomized controlled trial. *Human Psychopharmacology*, *27*(4), 428–436. https://doi.org/10.1002/hup.2244

Landolt, H. P., Roth, C., Dijk, D. J., & Borbély, A. A. (1996). Late-afternoon ethanol intake affects nocturnal sleep and the sleep EEG in middle-aged men. *Journal of Clinical Psychopharmacology*, *16*(6), 428–436. https://doi.org/10.1097/00004714-199612000-00004

Landström, U., Englund, K., Nordstrom, B., & Stenudd, A. (1999). Laboratory Studies on the Effects of Temperature Variations on Drowsiness. *Perceptual and Motor Skills*, *89*(3_suppl), 1217–1229. https://doi.org/10.2466/pms.1999.89.3f.1217

Landström, U., Englund, K., Nordström, B., & Stenudd, A. (2002). Use of temperature variations to combat drivers' drowsiness. *Perceptual and Motor Skills*, *95*(2), 497–506. https://doi.org/10.2466/pms.2002.95.2.497

Larue, G. S., Rakotonirainy, A., & Pettitt, A. N. (2011). Driving performance impairments due to hypovigilance on monotonous roads. *Accident; Analysis and Prevention*, *43*(6), 2037–2046. https://doi.org/10.1016/j.aap.2011.05.023

Lee, M. S., Shin, B. C., Suen, L. K. P., Park, T. Y., & Ernst, E. (2008). Auricular acupuncture for insomnia: A systematic review. In *International Journal of Clinical Practice*. https://doi.org/10.1111/j.1742-1241.2008.01876.x

Lee, S., & Kim, J. K. (2018). Factors contributing to the risk of airline pilot fatigue. *Journal of Air Transport Management*. https://doi.org/10.1016/j.jairtraman.2017.12.009

Lerman, S. E., Eskin, E., Flower, D. J., George, E. C., Gerson, B., Hartenbaum, N., Hursh, S. R., & Moore-Ede, M. (2012). Fatigue risk management in the workplace. *Journal of Occupational and Environmental Medicine*, *54*(2), 231–258. https://doi.org/10.1097/JOM.0b013e318247a3b0

Lockley, S. W., Evans, E. E., Scheer, F. A. J. L., Brainard, G. C., Czeisler, C. A., & Aeschbach, D. (2006). Short-wavelength sensitivity for the direct effects of light on alertness, vigilance, and the waking electroencephalogram in humans. *Sleep*, *29*(2), 161–168.

MacLean, A. W., Davies, D. R. T., & Thiele, K. (2003). The hazards and prevention of driving while sleepy. *Sleep Medicine Reviews*, *7*(6), 507–521. https://doi.org/10.1016/s1087-0792(03)90004-9

Martin, J. L., & Hakim, A. D. (2011). Wrist actigraphy. *Chest*, *139*(6), 1514–1527. https://doi.org/10.1378/chest.10-1872

Morgenthaler, T., Alessi, C., Friedman, L., Owens, J., Kapur, V., Boehlecke, B., Brown, T., Chesson, A., Coleman, J., Lee-Chiong, T., Pancer, J., & Swick, T. J. (2007). Practice parameters for the use of actigraphy in the assessment of sleep and sleep disorders: An update for 2007. *Sleep*. https://doi.org/10.1093/sleep/30.4.519

Morin, A. K. (2006). Strategies for treating chronic insomnia. *The American Journal of Managed Care*, *12*(8 Suppl), S230-45.

Morin, C. M., & Benca, R. (2012). Chronic insomnia. *The Lancet*, *379*(9821), 1129–1141. https://doi.org/https://doi.org/10.1016/S0140-6736(11)60750-2

Murphy, K., Kubin, Z. J., Shepherd, J. N., & Ettinger, R. H. (2010). Valeriana officinalis root extracts have potent anxiolytic effects in laboratory rats. *Phytomedicine : International Journal of Phytotherapy and Phytopharmacology*, *17*(8–9), 674–678. https://doi.org/10.1016/j.phymed.2009.10.020

Naweed, A., Hockey, G. R. J., & Clarke, S. D. (2013). Designing simulator tools for rail research: the case study of a train driving microworld. *Applied Ergonomics*, *44 3*, 445–454.

Naweed, A., Rainbird, S., & Chapman, J. (2015). Investigating the formal countermeasures and informal strategies used to mitigate SPAD risk in train driving. *Ergonomics*. https://doi.org/10.1080/00140139.2014.1001448

O'Callaghan, F., Muurlink, O., & Reid, N. (2018). Effects of caffeine on sleep quality and daytime functioning. *Risk Management and Healthcare Policy*, *11*, 263–271. https://doi.org/10.2147/RMHP.S156404

Office of Rail Regulation. (2012). Managing Rail Staff Fatigue. *British Office of Rail Regulation*, *January*, 1–81. http://www.rssb.co.uk/improving-industry-performance/human-factors/human-factors-tools-and-resources

Ong, J., & Sholtes, D. (2010). A mindfulness-based approach to the treatment of insomnia. *Journal of Clinical Psychology*. https://doi.org/10.1002/jclp.20736

Peppard, P. E., Young, T., Barnet, J. H., Palta, M., Hagen, E. W., & Hla, K. M. (2013). Increased prevalence of sleep-disordered breathing in adults. *American Journal of Epidemiology*, *177*(9), 1006–1014. https://doi.org/10.1093/aje/kws342

Petre, A. (2020). *9 Natural Sleep Aids That May Help You Get Some Shut-Eye*. Healthline. https://doi.org/28/08/20

Phillips, B. A., & Danner, F. J. (1995). Cigarette smoking and sleep disturbance. *Archives of Internal Medicine*, *155*(7), 734–737.

Phillips, R. O. (2014). *What is fatigue and how does it affect the safety performance of human transport operators?* (Issue October 2014). Norwegian Centre for Transport Research. https://www.toi.no/getfile.php?mmfileid=38953

Phillips, R. O. (2015). A review of definitions of fatigue - And a step towards a whole definition. *Transportation Research Part F: Traffic Psychology and Behaviour*. https://doi.org/10.1016/j.trf.2015.01.003

Phillips, R. O., & Sagberg, F. (2010). *Helping train drivers pass signals safely: Lessons from ten case studies*. https://www.toi.no/getfile.php/1314854-1284448326/Publikasjoner/TØI rapporter/2010/1066-2010/1066-2010-nett.pdf

Pylkkönen, M., Sihvola, M., Hyvärinen, H. K., Puttonen, S., Hublin, C., & Sallinen, M. (2015). Sleepiness, sleep, and use of sleepiness countermeasures in shift-working long-haul truck drivers. *Accident; Analysis and Prevention*, *80*, 201–210. https://doi.org/10.1016/j.aap.2015.03.031

Ramakrishnan, K., & Scheid, D. C. (2007). Treatment options for insomnia. *American Family Physician*, *76*(4), 517–526.

Reis, C., Mestre, C., Canhão, H., Gradwell, D., & Paiva, T. (2016). Sleep complaints and fatigue of airline pilots. *Sleep Science*. https://doi.org/10.1016/j.slsci.2016.05.003

Reyner, L. A., & Horne, J. A. (1998). Evaluation "in-car" countermeasures to sleepiness: cold air and radio. *Sleep*, *21*(1), 46–50.

Richardson, G. S., Roehrs, T. A., Rosenthal, L., Koshorek, G., & Roth, T. (2002). Tolerance to daytime sedative effects of H1 antihistamines. *Journal of Clinical Psychopharmacology*, *22*(5), 511–515. https://doi.org/10.1097/00004714-200210000-00012

Ringdahl, E. N., Pereira, S. L., & Delzell, J. E. J. (2004). Treatment of primary insomnia. *The Journal of the American Board of Family Practice*, *17*(3), 212–219. https://doi.org/10.3122/jabfm.17.3.212

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 and Prevention*. https://doi.org/10.1016/j.aap.2011.09.020

Sadeh, A., & Acebo, C. (2002). The role of actigraphy in sleep medicine. *Sleep Medicine Reviews*, *6*(2), 113–124. https://doi.org/https://doi.org/10.1053/smrv.2001.0182

Samn, S., & Perelli, L. (1982). *Estimating Aircrew Fatigue: A Technique with Application to Airlift Operations*. 29.

Schmidt, E., & Bullinger, A. C. (2019). Mitigating passive fatigue during monotonous drives with thermal stimuli : Insights into the e ff ect of di ff erent stimulation durations. *Accident Analysis & Prevention*, *126*(April 2017), 115–121. https://doi.org/10.1016/j.aap.2017.12.005

Schmidt, E., Decke, R., Rasshofer, R., & Bullinger, A. C. (2017). Psychophysiological responses to short-term cooling during a simulated monotonous driving task. *Applied Ergonomics*, *62*, 9–18. https://doi.org/https://doi.org/10.1016/j.apergo.2017.01.017

Scofield, H., Roth, T., & Drake, C. (2008). Periodic limb movements during sleep: population prevalence, clinical correlates, and racial differences. *Sleep*, *31*(9), 1221–1227. https://pubmed.ncbi.nlm.nih.gov/18788647

Shen, J., Barbera, J., & Shapiro, C. M. (2006). Distinguishing sleepiness and fatigue: Focus on definition and measurement. *Sleep Medicine Reviews*. https://doi.org/10.1016/j.smrv.2005.05.004

Smith, A., Jones, G., Evans, D., & Bowen, G. (2018). Training to prevent and manage fatigue in the rail industry. In *Contemporary Ergonomics and Human Factors*.

Stepanski, E. J., & Wyatt, J. K. (2003). Use of sleep hygiene in the treatment of insomnia. *Sleep Medicine Reviews*, *7*(3), 215–225. https://doi.org/10.1053/smrv.2001.0246

Suni, E. (2020). *Sleep hygiene*. Sleep Foundation. https://www.sleepfoundation.org/articles/sleep-hygiene

Taibi, D. M., Landis, C. A., Petry, H., & Vitiello, M. V. (2007). A systematic review of valerian as a sleep aid: Safe but not effective. In *Sleep Medicine Reviews*. https://doi.org/10.1016/j.smrv.2007.03.002

Tremaine, R., Dorrian, J., Lack, L., Lovato, N., Ferguson, S., Zhou, X., & Roach, G. (2010). The relationship between subjective and objective sleepiness and performance during a simulated night-shift with a nap countermeasure. *Applied Ergonomics*, *42*(1), 52–61. https://doi.org/10.1016/j.apergo.2010.04.005

Troxel, W. M., Shih, R. A., Pedersen, E., Geyer, L., Fisher, M. P., Griffin, B. A., Haas, A. C., Kurz, J. R., & Steinberg, P. S. (2015). *Sleep in the Military: Promoting Healthy Sleep Among U.S. Service members*. RAND Corporation. http://www.jstor.org/stable/10.7249/j.ctt15zc8f8

Trumbo, M. C., Jones, A. P., Robinson, C. S. H., Cole, K., & Morrow, J. D. (2017). Name that tune: Mitigation of driver fatigue via a song naming game. *Accident Analysis and Prevention*. https://doi.org/10.1016/j.aap.2017.09.002

Uchida, S., Shioda, K., Morita, Y., Kubota, C., Ganeko, M., & Takeda, N. (2012). Exercise effects on sleep physiology. *Frontiers in Neurology*, *3*, 48. https://doi.org/10.3389/fneur.2012.00048

Van Dongen, H. P. A., & Dinges, D. F. (2000). Circadian Rhythms in Fatigue, Alertness and Performance. In *Principles and Practice of Sleep Medicine*. https://doi.org/10.1002/ppul.1065

Van Veen, S., Vink, P., & Franz, M. (2014). *Enhancing the Vigilance of Car Drivers: a Review on Fatigue Caused by the Driving Task and Possible Countermeasures*.

van Veldhoven, M., & Broersen, S. (2003). Measurement quality and validity of the "need for recovery scale." *Occupational and Environmental Medicine*, *60 Suppl 1*(Suppl 1), i3–i9. https://doi.org/10.1136/oem.60.suppl_1.i3

Vgontzas, A. N., Pejovic, S., Zoumakis, E., Lin, H. M., Bixler, E. O., Basta, M., Fang, J., Sarrigiannidis, A., & Chrousos, G. P. (2007). Daytime napping after a night of sleep loss decreases sleepiness, improves performance, and causes beneficial changes in cortisol and interleukin-6 secretion. *American Journal of Physiology. Endocrinology and Metabolism*, *292*(1), E253-61. https://doi.org/10.1152/ajpendo.00651.2005

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

Wang, T. C., & Chuang, L. H. (2014). Psychological and physiological fatigue variation and fatigue factors inaircraft line maintenance crews. *International Journal of Industrial Ergonomics*. https://doi.org/10.1016/j.ergon.2013.11.003

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

Yazdi, Z., Sadeghniiat-Haghighi, K., Loukzadeh, Z., Elmizadeh, K., & Abbasi, M. (2014). Prevalence of Sleep Disorders and Their Impacts on Occupational Performance: A Comparison between Shift Workers and Nonshift Workers. *Sleep Disorders*, *2014*, 870320. https://doi.org/10.1155/2014/870320

Young, S. L., & Hashemi, L. (1996). Fatigue and Trucking Accidents: Two Modes of Accident Causation. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *40*(18), 952–956. https://doi.org/10.1177/154193129604001819

Zhao, K. (2013). Chapter Eleven - Acupuncture for the Treatment of Insomnia. In B.-Y. Zeng, K. Zhao, & F.-R. B. T.-I. R. of N. Liang (Eds.), *Neurobiology of Acupuncture* (Vol. 111, pp. 217–234). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-411545-3.00011-0

Zwyghuizen-Doorenbos, A., Roehrs, T. A., Lipschutz, L., Timms, V., & Roth, T. (1990). Effects of caffeine on alertness. *Psychopharmacology*, *100*(1), 36–39. https://doi.org/10.1007/BF02245786

Introduction & background information

The questions below are designed to get your input on the self-management of train driver fatigue. Please answer the questions in respect of your knowledge and experiences.

Participation in this study is entirely voluntary and your replies will remain anonymous. As a participant, you can stop your participation in the study at any time or refuse the use of your data for the study, without giving reasons. Our data will be in accordance with the General Data Protection Regulation 2016 (GDPR) and the Data Protection Act 2018.

This survey will be stored on the google cloud platform associated to the TU Dublin account only for the duration of the survey. Then downloaded and removed from the cloud server. All research data will be encrypted and stored on a password protected system or in a secure location (e.g locked filing cabinet, or data server owned by TU Dublin) in accordance with TU Dublin data protection policy.
All research data will be retained in accordance with TU Dublin data retention policy.

By completing this survey you are confirming that:
1. you are 18 years or older and are competent to provide consent
2. you understand that you are free to withdraw from the study at any time without giving a reason for withdrawal or to decline to answer any particular questions in the study without any consequences
3. you consent to the information collected for the purposes of this research study, once anonymised (so that you cannot be identified), to be used for research purposes related to the project
4. you freely and voluntarily agree to be part of this research study, though without prejudice to your legal and ethical rights
* Required

1. What is your age? *

Mark only one oval.

- 18-24
- 25-39
- 40-50
- 60 plus

2. Do you mainly drive commuter or intercity services, or a mix? *

Mark only one oval.

- Commuter
- Intercity
- Mix
- Other: ____________________

3. How many hours of sleep do you normally get per night? *

Thinking about a typical night in the last month...

Mark only one oval.

- Less than 4 hours
- 4-6 hours
- 6-8 hours
- 8-10 hours
- More than 10 hours

4. How long does it take you to fall asleep? *

Mark only one oval.

- 0-15 minutes
- 16-30 minutes
- 31-45 minutes
- 46-60 minutes
- More than 60 minutes

5. On average, how many times do you wake up during the night? *

Mark only one oval.

- 0
- 1
- 2
- 3
- 4
- 5
- More than 5

6. If you then wake up one or more times during the night, how long are you awake in total? *

Mark only one oval.

- 0-15 minutes
- 16-30 minutes
- 31-45 minutes
- 46-60 minutes
- More than 60 minutes

7. How many nights a week do you have a problem with your sleep? *

Mark only one oval.

- 0-1
- 2
- 3
- 4
- 5-7

8. How long have you had a problem with your sleep? *

Mark only one oval.

- I don't have a problem/ less than1 month
- 1-2 months
- 3-6 months
- 7-12 months
- More than 1 year

9. Rate your current sleep quality. *

Mark only one oval.

	1	2	3	4	5	
Very poor						Very good

10. What do you think has contributed to your good, or poor quality of sleep at the moment? *

11. Rate your current level of fatigue. *

Mark only one oval.

	1	2	3	4	5	
Not fatigued at all						Extremely fatigued

12. What do you think has contributed to your fatigue, or lack of fatigue at the moment? *

Managing fatigue at work

13. How often do you have an opportunity to take a short rest break (2-5 minutes) during a train journey? *

Short breaks can increase alertness by reducing monotony of automated or tedious tasks and allowing moderate levels of physical activity.

Mark only one oval.

- Almost never
- Once in a while
- Sometimes
- Frequently
- Almost all the time

14. What do you do in rest breaks during journeys? *

Indicate all that apply.

Check all that apply.

- [ ] Physical activity
- [ ] Mental break
- [ ] Social interaction
- [ ] Eat/drinking

Other: [ ] ______

15. How often do you get up and move around in a train journey? *

Mark only one oval.

- Almost never
- Once in a while
- Sometimes
- Frequently
- Almost all the time

16. How often do you have an opportunity to take a longer rest break (15-30 minutes) between services? *

Mark only one oval.

- Almost never
- Once in a while
- Sometimes
- Frequently
- Almost all the time

17. What do you do in rest breaks between services? *

Indicate all that apply.

Check all that apply.

- [ ] Physical activity
- [ ] Mental break
- [ ] Social interaction
- [ ] Eat/drinking

Other: [ ] ______________________

18. How often do you nap per week? *

A nap during long periods of continuous wakefulness can improve alertness and performance.

Mark only one oval.

- Never
- Less than once a week
- Once a week
- Two or three times a week
- Everyday

19. How likely are you to consider napping midway through a shift for 10-30 minutes? *

Mark only one oval.

- Not likely at all
- Not so likely
- Somewhat likely
- Very likely
- Extremely likely

20. What makes you more or less likely to take a nap? *

21. How effective do you think each of these countermeasures would be at managing fatigue at work? *

Adjusting environmental work conditions e.g increasing light, playing music in the background and reducing temperature through opening windows or a/c, are methods used to increase alertness. 1 = Not effective at all ; 5 = Extremely effective

Mark only one oval per row.

	1	2	3	4	5
Driving while standing up					
Increasing light levels					
Playing music in the background					
Reducing the temperature through opening windows or air conditioning					

22. How often do you use each of these countermeasures to manage fatigue at work? *

Mark only one oval per row.

	Almost never	Once in a while	Sometimes	Frequently	Almost all the time
Driving while standing up					
Increasing light levels					
Reducing the temperature through opening windows or air conditioning					

23. Does your organisation educate you about fatigue e.g fatigue causes, consequences and countermeasures? *

Mark only one oval.

- Yes
- No

24. Rate the quality of the education provided?

Mark only one oval.

	1	2	3	4	5	
Poor	◯	◯	◯	◯	◯	Excellent

25. How useful was the education provided?

Mark only one oval.

	1	2	3	4	5	
Not useful at all	◯	◯	◯	◯	◯	Extremely useful

26. To what extent do you agree with this statement: It's okay to show up to work while extremely fatigued.

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree or diasgree
- ◯ Agree
- ◯ Strongly agree

27. Rate your current ability to resist fatigue. *

Mark only one oval.

- ◯ Poor
- ◯ Fair
- ◯ Good
- ◯ Very good
- ◯ Excellent

28. What countermeasures (other than those mentioned in the survey) do you use to manage fatigue at work? *

Managing your sleep

29. Which of the following sleep hygiene practices and habits do you use to improve sleep? *

Sleep hygiene refers to the different practices and habits that are necessary to have good night-time sleep quality and full daytime alertness. Indicate all that apply.

Check all that apply.

- [ ] None
- [ ] Adhering to a consistent sleep/wake schedule
- [ ] Using bedroom only for sleep-compatible activities
- [ ] Having a consistent pre-bedtime routine
- [ ] Creating a comfortable sleep environment
- [ ] Avoiding television, computer, tablet or smartphone screens before bed
- [ ] Setting the bedroom temperature to a comfortably cool/warm temperature
- [ ] Making the bedroom as dark as possible
- [ ] Reading a little before bed
- [ ] Listening to relaxing music

Other: [ ] ____________________

30. How often do you consume caffeine? *

Caffeine, found coffee, tea, caffeinated soft drinks and/or chocolate, is a very popular and frequently consumed drug that when consumed in the hours before bed can disrupt the ability to fall and stay asleep.

Mark only one oval.

- Never
- Occasionally but not everyday
- 1-3 servings daily
- 3-5 servings daily
- More than 5 servings daily

31. How often do you consume alcohol? *

Alcohol is known to shorten the time to fall asleep, but also have a negative impact on the quality of sleep when consumed before bed.

Mark only one oval.

- Never drink
- 2 days or less per week
- 3 days per week
- 4 or more days per week

32. How often do you consumer the following foods immediately prior to bedtime (within 2 hours of bedtime)? *

Mark only one oval per row.

	Never	Less than once a week	Once a week	Two or three times a week	Everyday
Heavy meal					
Spicy food					

33. Do you smoke cigarettes? *

Mark only one oval.

- Yes
- No

34. How often do you exercise per week? *

Mark only one oval.

- Never
- Less than once a week
- Once a week
- Two or three times a week
- Everyday

35. What type of exercise do you do? *

Indicate all that apply.

Check all that apply.

- [ ] None
- [ ] Cardiovascular e.g walking, jogging, running, swimming or biking
- [ ] Strength e.g lifting weights or working with resistance bands
- [ ] Flexibility e.g stretching, yoga or Pilates
- [ ] Balance e.g exercises using balance board/stability ball, yoga or Pilates

36. How often do you use non-prescription sleep aids? *

Non-prescription sleep aids such as over-the-counter medications, herbs and acupuncture are commonly used to promote sleep. However, they are potentially disruptive to sleep and their sleep-promoting effects have been unproven.

Mark only one oval.

- Never
- Less than once a week
- Once a week
- Two or three times a week
- Everyday

37. Which non-prescription sleep aids do you use to manage your sleep? *

Indicate all that apply.

Check all that apply.

- None
- Over-the-counter medication
- Herbs
- Acupuncture

Other: __________

38. How often do you use the following behavioural strategies to manage your sleep? *

Behavioural strategies such as cognitive behavioural therapy and meditation/ mindfulness help to improve sleep. Cognitive behavioural therapy is a psychological technique that can help you manage your problems by changing the way you think and behave to optimise sleep. Meditation is a practice where an individual uses technique such as mindfulness or focusing the mind on a particular object, to develop attention and awareness and achieve a mentally clear and emotionally calm and stable state.

Mark only one oval per row.

	Never	Less than once a week	Once a week	Two or three times a week	Everyday
CBT techniques developed during CBT sessions					
Meditation					

39. How effective do you think each of these countermeasures would be at managing sleep? *

1 = Not effective at all ; 5 = Extremely effective

Mark only one oval per row.

	1	2	3	4	5
Change sleep practises and habits					
Cardiovascular exercise (20-30 minutes at least 3x per week)					
Avoid consuming caffeine in the hours before bed					
Avoid drinking alcohol in the hours before bed					
Avoid heavy meals and unfamiliar/spicy food 2 hours before bed					
Avoid smoking before bed					
Herbs					
Acupuncture					
Cognitive behavioural therapy					
Meditation					

40. How likely are you to consider the following countermeasures to help manage your sleep? *

1 = Not likely at all ; 5 = Extremely likely

Mark only one oval per row.

	1	2	3	4	5
Change sleep practises and habits	◯	◯	◯	◯	◯
Cardiovascular exercise (20-30 minutes at least 3x per week)	◯	◯	◯	◯	◯
Avoid consuming caffeine in the hours before bed	◯	◯	◯	◯	◯
Avoid drinking alcohol in the hours before bed	◯	◯	◯	◯	◯
Avoid heavy meals and unfamiliar/spicy food 2 hours before bed	◯	◯	◯	◯	◯
Avoid smoking before bed	◯	◯	◯	◯	◯
Herbs	◯	◯	◯	◯	◯
Acupuncture	◯	◯	◯	◯	◯
Cognitive behavioural therapy	◯	◯	◯	◯	◯
Meditation	◯	◯	◯	◯	◯

41. Keeping the unfavourable/undesirable effects of over-the-counter sleep aids in mind, would you consider using them to manage your sleep? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe

42. To what extent do you set limits for the following: *

Mark only one oval per row.

	Not at all	A little bit	Somewhat	Quite a bit	A tremendous amount
Consuming caffeine	◯	◯	◯	◯	◯
Consuming alcohol	◯	◯	◯	◯	◯
Smoking cigarettes	◯	◯	◯	◯	◯

43. How much does the consumption of the following items prior to bedtime impact your sleep quality and duration : *

1 = No impact on sleep at all ; 5 = Extreme impact on sleep

Mark only one oval per row.

	1	2	3	4	5
Caffeine	◯	◯	◯	◯	◯
Alcohol	◯	◯	◯	◯	◯
Heavy meal	◯	◯	◯	◯	◯
Spicy food	◯	◯	◯	◯	◯

44. How much does smoking cigarettes prior to bedtime impact your sleep quality and duration? *

Mark only one oval.

	1	2	3	4	5	
No impact on sleep at all	◯	◯	◯	◯	◯	Extreme impact on sleep

45. What countermeasures (other than those mentioned in this survey) do you use to manage your sleep? *

Measuring Fatigue

Measuring fatigue is becoming more frequent for safety critical operators.

46. Is your level of fatigue currently being monitored at work?

Mark only one oval.

- Yes
- No
- Maybe

47. Would you consider assessing your fatigue levels at the beginning and at the end of the shift?

Mark only one oval.

- Yes
- No
- Maybe

48. How often do you use daily sleep diaries (e.g smartwatches) to monitor and manage your sleep?

Mark only one oval.

- Never
- Rarely
- Sometimes
- Often
- Always

49. How likely are you to consider using daily sleep diaries (e.g smartwatches) to monitor and manage your sleep?

Mark only one oval.

	1	2	3	4	5	
Not likely at all						Extremely likely