The Determinants of Sleep Quality in the Mining Industry

by

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Abstract

The purpose of this study was to determine the current state of self-reported sleep quality in workers of the mining industry and identify the factors that affect sleep in this sample. A large-scale questionnaire was administered to 2,224 workers of the mining industry with operations in Ontario. A modified version of the Pittsburgh Sleep Quality Index (mPSQI) was used to determine sleep quality and quantity. A total of 84% of participants self-reported poor sleep quality with an average mPSQI score of 6.43 (± 3.07). The average sleep duration of participants was 6hr:05min (± 1hr:03min), which is lower than the recommended 7-8 hrs of sleep. Participants engaging in hazardous drug and alcohol use, screening positive for mental health concerns, stress and fatigue, experiencing workplace burnout and working shifts, self-reported worst sleep quality. Finally, depression, personal burnout, fatigue, PTSD, shiftwork, diagnosis of a chronic disease and hazardous drug use were significant predictors of poor subjective sleep quality, accounting for 37.1% of the total variance of sleep quality ($R^2 = 0.371$, $F(7, 1572) = 131.78$, $p \leq 0.000$). These data will assist in developing targeted strategies and interventions for workers to achieve better sleep quality, overall wellbeing and a safer workplace.

Keywords

Sleep Quality, Sleep Quantity, Health Behaviors, Personal Factors, Work-Related Factors, Mining.

Co-Authorship Statement

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List of Acronyms

ACTH – Adrenocorticotropic Hormones

ANOVA – Analysis of Variance

AUDIT – Alcohol Use Disorder Identification Test

BAI – Beck Anxiety Inventory

BDI - II – Beck Depression Inventory

BMI – Body Mass Index

CBI – Copenhagen Burnout Inventory

CI – Confidence Interval

CSEP – Canadian Society for Exercise Physiology

DAST-20 – Drug Abuse Screening Test

DSM-5– Diagnostic and Statistical Manual of Mental Disorders 5th Edition

EEG – Electroencephalogram

ERI – Effort-Reward Imbalance

FSS – Fatigue Severity scale

GH – Growth Hormones

MANOVA – Multivariate Analysis of Variance

MiHR - Mining Industry Human Resources

mPSQI – Modified Pittsburgh Sleep Quality Index

MSLT – Multiple Sleep Latency Test

NIOSH – National Institute for Occupational Safety and Health

NREM – Non-Rapid Eye Movement

OHI – Obstructive Apnea or Hypopnea Index

OR – Odd Ratio

PSQI – Pittsburgh Sleep Quality Index

PSS – Perceived Stress Scale

PTSD – Posttraumatic Stress Disorder

RAS – Relationship Assessment Scale

REM – Rapid Eye Movement

RHT – Retonohypothalamic Tract

SCN – Suprachiasmatic Nuclei

SDB – Sleep Disordered Breathing

SWA – Slow Wave Activity

SWS – Slow Wave Sleep

TIB – Time in Bed

TST – Total Sleep Time

Chapter 1: Introduction and Literature Review

Sleep quality and quantity are influenced by many factors including those related to lifestyle behaviours as well as personal and occupational factors. Factors that negatively impact sleep quality and quantity can in turn be detrimental to human function and performance at work (Lowden, Kecklund, Axelsson & Åkerstedt, 1998; Medeiros, Mendes, Lima & Araujo, 2001; Lamond, Dorrian, Roach, McCulloch, Holmes, Burgess, Fletcher & Dawson, 2003; Lockley, Barger, Ayas, Rothschild, Czeisler & Landrigan, 2007; Swanson, Arnedt, Rosekind, Belenky, Balkin & Drake, 2011; Lemke, Apostolopoulos, Hege, Sönmez & Wideman, 2016). Although the effects of many lifestyle behaviours, personal factors, and work-related factors have been investigated, many of the studies have focused primarily on the general population, on specific sub-populations (children, healthy adults, older adults) or specific occupations (physicians, nurses, police officers). Although it is generally accepted that sleep quality and quantity affect performance in the workplace, there are still areas of inquire that are under-investigated in the occupational health and safety context. Whether and how these factors impact workers within the mining industry remain to be fully elucidated (Dennie et al, 2018). The mining industry is of particular interest as the workers in these specific occupations are exposed to challenging working conditions which in turn increases their vulnerability to experiencing an occupational injury (Halvani, Zare & Mimohammadi, 2009). Accordingly, this specific research project explored the association between health behaviours, personal factors, and work-related factors and sleep quality and quantity of workers within the mining industry. The outcomes of this research project are expected to provide evidence that can lead to targeted strategic interventions designed to improve sleep quality and the general wellbeing of workers in the mining industry.

This is particularly important as mining is amongst the largest employer in the province of Ontario, more specifically Northern Ontario, as well as nationally in Canada.

1.1 The Canadian Mining Industry

The mining industry in Canada contributes significantly to the country's economy and supports a number of firms and sectors that supply mining equipment and services (The Mining Association of Canada, 2017). Additionally, Canada is endowed with thirteen major minerals and metals, making it amongst the top five countries in global production. The total value of mining in Canada wide was $40.8 billion in 2016 according to the The Mining Association of Canada (2017). Furthermore, the minerals sector contributed $97 billion to the country's total GDP in 2018 (The Mining Association of Canada, 2019). As of 2016, there were a total of 1201 mining establishments in Canada (The Mining Association of Canada, 2017). Within these establishments, it was estimated that the industry itself employed about 403,000 and 409,000 people across the country accounting for approximately one in every forty-five jobs in Canada in 2016 and 2019 respectively (The Mining Association of Canada, 2017). Within this cohort of workers in 2016, only 17% were female and 5% self-identified as Indigenous (The Mining Association of Canada, 2017). The Mining Industry Human Resources (MiHR) Council estimates that 25% of the current workforce in the mining industry will retire by 2027, which will lead to a significant loss of industry knowledge and experience (The Mining Association of Canada, 2017). Furthermore, the mining industry in Canada will require approximately 87,000 workers in order to replace those retiring in the next decade.

1.2 The Mining Industry in Ontario

Ontario is home to forty operating mine sites (Ontario Ministry of Energy, Northern Development and Mines, 2018). In 2017, the province alone produced 9.9 billion dollars' worth of minerals (cobalt, copper, zinc, gold, nickel platinum group metals, and silver) making Ontario the leading producer of minerals in Canada (Ontario Mining Association, 2017). Additionally, numerous non-metals are mined, such as diamonds, gemstones, lime, nepheline syenite, quartz, salt, sand and gravel, stone, and sulfur (Ontario Mining Association, 2017). The elevated level of minerals in underground rocks within the Sudbury region was suggested to be the result of a giant meteorite hitting the region of Sudbury (Dennie, 2017). Although mining is spread across the province it is mostly concentrated in Northern Ontario (Ontario Ministry of Labour, 2014). Toronto is known as the global centre for mining finance (The Mining Association of Canada, 2017). In 2017, about 21,500 people were employed directly by the mining industry in Ontario and an additional 50,000 people were employed indirectly (Workplace Safety North, 2017). The mining industry in Ontario accounts for 11.2% of employment for Indigenous people (Ontario Mining Association, 2017). The city of Greater Sudbury is home to one of the largest mining complexes in the world comprised of six mines, a mill, a smelter, and a refinery, which employs approximately 4,000 Sudburians (Vale, 2017).

Continuous improvement in the occupational health and safety frameworks in the Canadian mining industry is a cornerstone to the long-term sustainability of this industry. The need for research to further understand the risk factors, hazards as well as the protective factors and preventative measures that ensure the physical and psychological wellness of the mining workforce remains a high priority. In this context, the current comprehensive study was designed to highlight the potential contribution of sleep quality to workplace health and safety of workers in the mining industry.

1.3 Defining Sleep

Sleep is a necessary behavioral state that returns periodically, runs on a 24-hour cycle and is manifested in all living organisms. It is characterized by a loss of consciousness, reduced sensorial activity and rested muscle tone (Dardel & Léger, 2016). Contrary to the awaken state, when an individual is asleep, they have limited ability to react to stimuli in their external environment, and contrary to a coma, sleep is reversible and is necessary for survival (Dardel &Léger, 2016). Although there are still many gaps in the knowledge and understanding of the underlying mechanisms of sleep, research has found that this state of unconsciousness is divided in 2 categories, which can be characterised by their physiological components; 1) rapid eye movement (REM) and 2) Non-REM (NREM) sleep.

REM sleep can be characterized by paralyzed or extremely relaxed muscles, and bursts of rapid and episodic eye movements (Carskadon & Dement, 2005). In humans, REM sleep is also accompanied by muscle twitches and cardiorespiratory irregularities (Carskadon & Dement, 2005). Psychologically, REM sleep is known as the dreaming period, therefore, it is during this time that individuals will experience vivid dreams and recall about 80% of these dreams (Carskadon & Dement, 2005). REM sleep accounts for approximately 25% of total sleep time, reoccurs every 90 to 120 minutes with episodes being longer during the second half of the night (Solms, 2000).

Non-REM sleep (NREM) is characterized by a K-complex, sleep spindles and slow wave activity (SWA) on an electroencephalogram (EEG) (Roth, 2009). NREM is subdivided in four stages that can be further identified along the measurement axis of the EEG. Stage 1 and 2 are known as light sleep, compared to stages three and four that are further identified as deep sleep. Sleep stages in NREM are therefore parallel with the depth of sleep (Carskadon & Dement, 2005). Stage 3 of NREM contains approximately 20% of SWA, compared to stage four, where more that 50% of SWA occurs (Roth, 2009). Combined, stage three and four of NREM sleep make up what is known as slow wave sleep (SWS). SWS is thought to play an important role in cerebral restoration and recovery in humans, along with consolidating sleep (Horne, 1992; Benington & Heller, 1995; Dijk, Groeger, Deacon & Stanley, 2006).

The sleep cycle and the duration of the cycle is regulated by an individual's circadian or biological rhythm, which is a daily rhythmic activity cycle that runs on an approximate 24-hour interval (Saurabh & Sassone-Corsi, 2012). This rhythm influences when a person sleeps, rises, eats, and regulates multiple physiological processes within the human body (Saurabh & Sassone-Corsi, 2012). This internal clock relies on environmental stimuli such as light exposure and temperature in order to be synchronized (Froy, 2009). Proper synchronization of the circadian rhythm is crucial as it allows the body to adapt behaviorally and physiologically to its environment and helps maintain general homeostasis (Froy, 2009).

The circadian rhythm is controlled by the hypothalamus, which is nested in the centre brain below the thalamus. The hypothalamus is a key component as it regulates various body functions such as hunger, thirst and body temperature by governing the pituitary gland and other downstream endocrine functions to achieve homeostatic balance (Lechan & Toni, 2016). More specifically, the part of the hypothalamus that directly controls the circadian rhythm is known as the suprachiasmatic nuclei (SCN), or the master clock (Froy, 2009). The SCN is located on the ventral portion of the base of the hypothalamus and above the optic chiasm and contains clusters of 10 000 GABAergic neurons (Hastings, O'Neil & Maywood, 2007). The SCN is responsible for the regulation of peripheral clocks that are found in the human body, in areas such as the stomach, the kidneys, the liver, the muscles, the adipocyte cells, etc. Furthermore, the SCN controls endocrine cycles, particularly the metabolic rhythm via two means (Hastings and al., 2007). First, by the anatomical connections to the centers controlling sleep and wakefulness. The SCN determines the timing of sleep and thereby, the timing of sleep-dependent events such as nocturnal secretion of the growth hormone (Hastings and al., 2007). Second, the SCN controls the endocrine cycle through the connections to the neuroendocrine and autonomic systems, as the SCN can manage hormonal and other rhythms that are independent from sleep, allowing the rhythms to be under constant routines (Hastings and al., 2007).

The SCN is regulated by the resetting signals of daylight. Considering that humans are diurnal, daylight is crucial in order to help the SCN hold its synchronization to properly regulate the human body (Froy, 2009). The daylight is absorbed through the retina and is transmitted to the SCN via the retonohypothalamic tract (RHT). This allows the SCN to dictate the synchronization of peripheral clocks found in the human body by humoral factors or autonomic innervation (Froy, 2009). Consequently, tissue specific hormone expression and secretion along with metabolic pathways exhibit circadian oscillation. Furthermore, the SCN is also responsible for locomotor activity, sleep-wake cycle, and regulation of both blood pressure, and body temperature. It is important to note that food and nutrient intake affects either the peripheral clocks or the central clock in the SCN (Froy, 2009). Therefore, it is possible to conclude that although the master clock found in the SCN is responsible for synchronization of the peripheral clocks, alterations to the peripheral clocks can consequently in turn affect the oscillation of the master clock). Collectively, health behaviors, personal factors and work-related factors are thought to influence the circadian rhythm and the sleep architecture (ex. alcohol consumption affects sleep architecture compared to shiftwork that affects the circadian rhythm). This topic will be described later in the literature review.

1.3.1 Sleep Quality versus Sleep Quantity

Good sleep quality is linked to many positive outcomes such as better overall health and wellbeing, less daytime sleepiness and better psychological functioning (Hyyppa & Kronholm, 1989). Defining good sleep and sleep quality can be subjective and measuring this complex construct can be challenging (Buysse, Reynolds, Monk, Berman & Kupfer, 1988; Åkerstedt, Hume, Minors & Waterhouse, 1994) There are advantages and disadvantages to using self-reports of sleep quality in sleep studies. For instance, a study by Ākerstedt et al. (2016) found that although women are more likely to complain of subjective "poor" sleep quality, polysomnography data suggests worst sleep in men. Therefore, since sleep quality is such a subjective measure, everyone has their own interpretation of what "good" or "poor" sleep quality might be. Kryger (2017) states that after a good night of sleep one should feel wide awake and alert shortly after waking up and remain so for the rest of the day. Additionally, general mood is good and there is no need to take a nap (Kryger, 2017).

Sleep quantity refers to the total number of hours slept per night (Kryger, 2017). The amount of sleep needed per night varies with age (Kryger, 2017). The recommended 7 to 8 hours of sleep per night for adults 20-65 years of age does not nearly suffice for young children, who need more hours of sleep (Kryger, 2017; Canadian Sleep Society, 2018).

Today, sleep deprivation has become an epidemic, as Americans sleep on average 1.5 hours less than the recommended 7 to 8 hours per night (Ford, Cunningham & Croft, 2015). In the early 1960's, individuals slept on average 8.45 hours per night (Ford et al., 2015). By the year 1995, sleep duration decreased to an average of 7 hours per night, and by the year 2004, Americans slept on average 6 hours per night (Ford et al., 2015). Therefore, within a 50-year time frame, there has been a reduction of sleep duration of almost 3 hours per night. Studies also suggest that technology also plays a role in the reduction of sleep duration. In fact, in a study by Adams et al., (2013) they reported that nearly half of their sample (N = 236) reported waking up during the hours of the night to answer text messages or other notifications. Studies have also shown that exposure to bright lights emmited from electronic devices supresses the secretion of melatonin, a neurotransmitter that is crucial for onset and maintenance of sleep (Cajochen et al., 2011; Wood et al., 2012; Chellappa et al., 2013). This is of concern since poor sleep quality and reduced sleep quantity have been linked to daytime dysfunctions, which will be discussed in section 1.3.2. Occasionally, sleep quantity will be used to determine sleep quality, however it is important to understand the difference between the two concepts as they do not have the same meaning.

Sleep quantity can be measured objectively using actigraphy, which is a method that monitors human rest and activity usually via a wristwatch, or subjectively via self-reports (Kryger, 2017). Self-reporting the number of hours slept per night may seem like a simple task but accurately doing so is a challenge because it can sometimes depend on a person's ability to accurately recall. For example, individuals that subjectively reported sleeping 6 hours per night or less had corresponding longer sleep durations measured objectively. Similarly, those subjectively reporting sleeping 8 hours per night or more were more likely to overestimate their sleep duration when compared with actigraphy data (Girschik et al., 2012).

1.3.2. Consequences of Sleep Deprivation

Sleep deprivation can be described as a complete lack of sleep during a certain period, or a shorter than optimal sleep time (Bonnet & Arand, 2003). Sleep deprivation can be acute or chronic, but either way, consequences of sleep deprivation can be severe. Sleep deprivation has multiple effects on performance and the symptoms include: longer reaction time, lapses in attention or concentration, memory lapses, errors of omission, poor short-term memory, poor mood (increased fatigue, confusion, stress and irritability), reduced motivation, distractibility, sleepiness, low motivation and poor performance at circadian low points (02:00 to 04:00 and 13:00 to 15:00), when sedentary, on long, difficult or high-paced tasks or in unchanging surroundings especially with reduced lighting (Bonnet & Arand, 2003).

A study by Drake and his colleagues (2001) evaluated the effects of various rhythm of sleep deprivation on cognition. Measuring instruments used in this study included the Multiple Sleep Latency Test (MSLT), the Probe Recall Memory Task, a Psychomotor Vigilance Task, a Divided Attention Task and the Profile of Mood State. Each participant completed 4 conditions of sleep deprivation including; 1) No sleep loss (8 hours time in bed (TIB) for 4 nights; 2300-0700), 2) Slow (6 hours TIB for 4 nights; 0100-0700), 3) Intermediate (4 hours TIB for 2 nights, 0300-0700) and Rapid (0 hours TIB for 1 night). Results showed that rapid sleep loss produced the most significant impairment on tests of alertness, memory, and performance (Drake et al., 2001). Alertness is known as the level of one's readiness to respond to stimuli, (Parent & Cloutier, 2009), compared to attention that is defined as a limited or ensemble of capacities that treat information (Schmidt, 1991). It is important to consider the differences between these cognitive capabilities (i.e. alertness vs attention), since they are not affected by sleep deprivation in a similar way (Drake et al., 2001). For instance, after only one night of 6 hours of sleep, alertness was the first cognitive ability to decline (Drake et al., 2001). Furthermore, it is important to consider that attention is a characteristic of vigilance (Kerkhof & Van Dongen, 2010). Thus, when vigilance abilities are reduced, attention will consequently be affected (Kerkhof & Van Dongen, 2010). Other consequences of poor sleep quantity include physiological based problems including heart disease, high blood pressure, obesity and diabetes (Office of Disease Prevention and Health Promotion, 2017).

In an occupational setting, sleep deprivation can lead workers to have an increased vulnerability to occupational injuries. Some occupations such as the mining, forestry and pulp and paper industries have challenging working conditions, which when paired with sleep deprivation increase the odds of injuries in the workplace (Halvani, Zare & Mimohammadi, 2009). Large scale accidents such as the Exxon Valdez oil spill in 1989, the Chernobyl disaster in 1986, the nuclear incident at Three Mile Island in 1979 and the American Airlines Flight 1420 Crash in 1999 are examples of terrible incidents that were traced back to workers suffering from sleep deprivation. However, occupational injuries or accidents due to sleep deprivation are not always as catastrophic, but even smaller scale incidents could be prevented with good sleep.

1.4. The Pittsburgh Sleep Quality Index

The Pittsburgh Sleep Quality Index (PSQI) is an instrument developed in 1988 by Buysse and his colleagues at the University of Pittsburgh (Buysse et al.,1988). This instrument is a reliable, valid, and standardized tool to measure subjective sleep quality and to discriminate between “good” and “poor” sleepers. Additionally, the PSQI was developed to provide an instrument that would be easy for subjects to complete, but also for clinicians and researchers to interpret. Finally, it also provided a useful assessment of a variety of sleep disturbances that might affect the overall sleep quality of individuals (Buysse et al., 1988). Although developed and validated with a population that suffered from clinical depression, studies have shown that the PSQI is an accurate measure of subjective sleep quality in a wide range of populations (Grandner, Kripke, Yoon & Youngstedt, 2006). One caveat is that subjective measures collected from the PSQI may not be well correlated with objective measures of sleep (i.e. actigraphy) (Grandner et al., 2006). However, considering that sleep is difficult to measure objectively, there might be some level of discrepancy between subjective and objective measures of sleep. Finally, the objective measures of sleep do not record the 'feeling' attached to the sleep portion, which is the component mostly reported in subjective measures of sleep quality and should not be discounted in assessing a person's sleep quality.

The PSQI is a 19-item questionnaire that evaluates sleep quality over a period of 30 days (Buyssee et al., 1988). The instrument measures 7 components of sleep quality: sleep quality, sleep latency, sleep duration, sleep disturbances, sleep efficiency, use of sleep medicine, and daytime dysfunction due to sleep (Buysse et al., 1988). Each question in the PSQI is accorded a numerical value that are used to tabulate scores from each component. Once the questionnaire is complete, all component scores are added together to produce the final Global PSQI Component Score that ranges between 0 and 21. Individuals scoring between 0 and 5 are deemed to have "good" sleep quality, and those scoring between 6 and 21 are considered to have "poor" sleep quality (Buysse et al., 1988).

1.5. Health Behaviours and Sleep

Health behaviours are defined as lifestyle choices shaped by an individual's decisions that are also impacted by external influences from the social, cultural, and physical environment

(Statistics Canada, 2016). These behaviors are typically activities to maintain or improve health regardless of the perception of health status (Belloc & Breslow, 1972). Healthy habits such as good sleep, regular meals, physical activity, limiting nicotine and alcohol consumption are typically associated with a good physical health. These variables have also been shown to influence overall health regardless of the economic status of an individual (Belloc & Breslow, 1972).

Although it is known that certain daily lifestyle choices (referred to as health behaviours) influence sleep quality, the relationship between the two can also be bidirectional. Health behaviours affect sleep by altering sleep architecture and patterns, which in turn lead to the sensation of having either "good" or "poor" sleep. On the other hand, reduced sleep duration (less than the recommended 7 to 8 hours per night), and "poor" sleep quality alter the circadian rhythm which in turn can affect the function of some basic physiological systems. The following section will explore the relationship between sleep quality and quantity and certain health behaviours. The health behaviors that will be examined in this study all relate to sleep quality and quantity in their own ways. More specifically, the health behaviors examined are smoking, substance abuse (alcohol, drugs and medication), hours of exercise or physical activity, and hours of sedentary behavior.

1.5.1 Smoking

Smoking negatively influences sleep on a physiological level. In particular, nicotine consumption through cigarettes affects sleep quality in part by altering the secretion of neurotransmitters in the brain. More specifically, nicotine has been shown to stimulate nicotinergic acetylcholine receptors, altering the level of glutaminergic, dopaminergic, and serotonergic secretion in the brain (Jaehne, Loessl, Bárkai, Riemann & Hornyak, 2009). The alterations of neurotransmitter secretion influence sleep onset, maintenance of sleep and the efficiency of REM sleep (Jaehne et al., 2009). Consequently, smokers have less total sleep time, lower sleep efficiency, longer sleep latency, and experience a shift towards lighter stages of sleep throughout the night (Wetter & Young, 1994; Jaehne et al., 2009). Additionally, current smokers have more stage 1 sleep with a decrease in total slow wave sleep when compared to non-smokers (Zhang, Samet & Punjabi, 2006). Furthermore, nicotine use was found to be associated with an increased frequency of insomniac complaints during active smoking and nicotine replacement therapy (Colrain, Trinder & Swan, 2004; Jaehne et al., 2009). Finally, global sleep quality was found to be worse in male ex-smokers and sleep quality was worse in current female smokers versus female non-smokers (Hu, Sekine, Gaina & Kagamimori, 2007). Interestingly, a dose-response relationship was not observed between lifetime exposure to smoking and sleep architecture among smokers (Zhang et al., 2006). In contrast, another study has shown a linear correlation between the number of cigarettes consumed and sleep complaints (Jaehne et al., 2012). It is of no surprise that those who have never smoked are more likely to report a better physical health than those who did smoke (Belloc & Breslow, 1972).

1.5.2 Substance Abuse (Alcohol)

The disruptive effects of over consuming alcohol on sleep are well known. The ingestion of high amounts of alcohol inhibits REM sleep (Stein & Friedmann, 2006) and reduces SWS at moderately high levels of alcohol consumption shortly before bedtime. However, there is no concrete immediate evidence showing the effects of lower alcohol consumption on SWS, but after continuous consumption of low doses of alcohol, there is a decrease in efficiency of SWS (Stein & Friedmann, 2006). Higher dosages of alcohol lead to lower sleep latency, however, this results in a rebound effect causing individuals to experience arousal that is heightened 2-3 hours after sleep onset (Stein & Friedmann, 2006). There appears to be a dose-response relationship between alcohol consumption and the negative impact on sleep (Stein & Friedmann, 2006). A limitation to studying the effects of alcohol on sleep is that most of the REM sleep occurs in the second half of the night and therefore a second dose of alcohol would have to be administered in the later hours of the night to more comprehensively determine the effects of alcohol on REM sleep (Roehrs & Roth, 2001).

In the workplace setting, the impact of alcohol use has traditionally focused on the relationship between consumption and occupational injuries. Although there are inconsistencies in the literature, alcohol consumption has been linked to increased absenteeism, presenteeism and more interpersonal and disciplinary issues (Tynan, Considine, Wiggers, Lewin, James, Inder, Kay-Lambkin, Baker, Skehan, Perkins & Kelly, 2016). Evidence suggests that the prevalence of alcohol-related problems are notably higher in male-dominated industries (Macdonald & Well, 1996; Violanti, Slaven, Charles, Burchfiel, Andrew & Homish, 2011; du Plessis, Corney & Burnside, 2013). More specifically, in the mining industry, one study showed high levels of alcohol use among employees compared to the general Australian population (Lennings, Feeney, Sheehan, Young McPherson & Tucker, 1997). The consumption of alcohol in the mining industry is problematic, however, little attention has been given to the work-characteristics that could be contributing to alcohol use (Tynan et al., 2017). Tynan and his colleagues (2017) found that from their sample of 1457 Australian coal mining workers, 95.7% of males and 89.9% of females reported that they consumed alcohol. From these percentages, 53.4% of males and 34.6% of females reported consuming alcohol at least 2-3 times per week. The alcohol use identification test (AUDIT) classified 45.7% of males and 17.0% of females as engaging in risky or hazardous alcohol use (AUDIT total score of >8) (Tynan et al., 2017). This is a concerning finding in a potentially challenging and dangerous work environment.

1.5.3. Exercise and Physical Activity

The Canadian Society for Exercise Physiology (CSEP) recommends 150 minutes of moderate – to – vigorous intensity physical activity per week for adults between the ages of 18 and 64 years old (CSEP, 2018). This recommended level of activity promotes optimal global health no matter the gender, race, ethnicity or socio-economic status of individuals (CSEP, 2018). The practice of regular exercise is a simple and inexpensive way of mitigating sleep problems (Waterhouse, Drust, Weinert, Edwards, Gregson, Atkinson, Kao, Aizawa & Riley, 2005). Exercise helps to stabilize the circadian rhythm, reduces daytime sleepiness and daytime impairment due to sleep loss (Waterhouse et al., 2005; Gerber, Brand, Holsboer-Trachsler & Pühse, 2010). Furthermore, exercise has been shown to help reduce symptoms of depression and anxiety, as well as lower levels of stress, which are factors are also known to impact sleep onset and frequency of disturbed sleep (Long & Stavel, 1995; Salmon, 2001; Dunn, Trivedi, Kampert, Clark & Chambliss, 2005; Asmundson, Fetzner, DeBoer, Pwers, Otto & Smits, 2013). In brief, exercising can have a beneficial impact on sleep quality and quantity. High intensity exercise is crucial to sleep quality; however, the timing of the exercise is an important contributing factor to sleep response (Driver & Taylor, 2000). Acute exercise before bed has been shown to be benefit thermoregulation of the body, however it increases the odds of experiencing sleep disruptions (Driver & Taylor, 2000). Therefore, acute exercise should be practiced 5-6 hours prior to bedtime and no later than 3 hours before bed to experience optimal sleep quality (Driver & Taylor, 2000).

1.6. Personal Factors and Sleep

Numerous Personal Factors are known to affect sleep quality and quantity. This section will explore the relationship between these factors and sleep quality and quantity. For the purpose of this study, attention will be directed to age, body mass index, health profile, and education, and their influence on sleep quality and quantity.

1.6.1. Age

Sleep architecture changes as humans age. The changes of sleep architecture include longer sleep latency, increase in percentage of stage 1 and 2 SWS and a decrease of REM sleep (Ohayon, Carksadon, Guileminault & Vitiello, 2004). When considering sleep latency, changes from year to year are very subtle and barely noticeable. However, when comparing young adults to older adults, an increase in sleep latency of ten minutes can be observed (Ohayon et al., 2004). A rise in the percentage of stage 1 sleep can be observed between young and older adults, which corresponds with the increased percentage of stage 1 sleep along adulthood (Ohayon et al., 2004). Additionally, an increase in stage 2 sleep can be observed as early as the age of five, through adulthood, and until sixty years of age (Ohayon et al., 2004). REM sleep decreases with age contrary to stage 1 and 2 sleep. During childhood, an increase in REM sleep is observed, followed by a slight decrease in young and middle-aged adults. From adulthood until 60 years of age, REM sleep remains unchanged, however, after the age of 60, it diminishes. (Ohayon et al., 2004).

1.6.2. Body Composition

The body mass index (BMI) is a measure of body composition, specifically body fat, and is calculated using weight in relation to height (kg/m^2). The BMI categories used to estimate a person's body composition are underweight (<18.5 kg/m^2), normal weight (18.6 kg/m^2 - 24.9 kg/m^2), overweight (25.0 kg/m^2 - 29.9 kg/m^2), and obese (>30 kg/m^2). In 2017, the Public Health Agency of Canada reported that 64% of Canadian adults are overweight or obese (2018).

1.6.3. Obesity

Epidemiological studies have shown an inverse relationship over time between sleep quantity and the rates of obesity and diabetes, namely that, while overall sleep quantity decreased, there was an increase in the rates of obesity and diabetes (Knutson, Spiegel, Penev & Van Cauter, 2007). Since the decrease in self-reported sleep quantity has been observed in parallel with the increase in obesity rates, it has been suggested that both factors are related (Van Cauter, Knuon, Leproult & Piegel, 2005). A study by Lui et al., (2013) found that 32% of obese individuals reported subjective sleep disturbances or insufficiency compared to 25.6% of individuals of normal weight (Lui, Croft, Wheaton, Perry, Chapman, Strine, McKnight-Eily & Presley-Cantrell, 2013). Furthermore, multiple population-based studies have shown that short sleep durations are an important, but modifiable risk factor of obesity (Vioque, Torres & Quiles, 2000; Shigeta, Shigeta, Nakazawa, Nakamura & Yoshikawa, 2001; Heslop, Smith, Metcalfe, Macleod & Hart, 2002; Cournot, Ruidavets, Marquié, Esquirol, Baracat & Ferrièeres, 2004; Taheri, Lin, Austin, Young & Mignot, 2004; Singh, Drake, Roehrs, Hudgel & Roth 2005; Vorona, Winn, Babineau, Eng, Feldman & Ware, 2005; Kohatsu, Tsai, Young, VanGilder, Burmeister, Stromquist & Merchant, 2006; Chaput, Després, Bouchard & Tremblay, 2007).

Disruption of the circadian rhythm can have adverse effects on sleep architecture leading in turn to disordered glucose-insulin metabolism, substrate oxidation, leptin and ghrelin concentrations, appetite, food reward, hypothalamic-pituitary-adrenal axis activity and gutpeptide concentration, which can in turn affect energy balance resulting in metabolic disturbances (Westerterp-Plantenga, 2016).

Physiologically, sleep restriction and deprivation has been shown to alter the secretion of ghrelin and leptin, which are responsible for hunger (ghrelin) and satiety (leptin). After two consecutive nights of only 4 hours total time in bed, and with a controlled energy intake via intravenous glucose infusion, subjects exhibited an increase of ghrelin levels (an orexigenic hormone released in the stomach, also known as the hunger hormone), and a decrease of the levels of leptin (a anorexigenic hormone released from adipocytes) (Spiegel, Tasali, Penev & Van Cauter, 2004; Spiegel, Leproult, L'Hermite-Balériaux, Copinschi, Penev & Van Cauter, 2004; Benedict, Hallschmid, Lassen, Mahnke, Schultes, Birgir Schiöth, Born & Lange, 2011). Furthermore, the objective measures of hormonal levels were accompanied with increased self-reports of hunger and appetite, particularly for foods high in carbohydrates (Spiegel et al., 2004).

It is important to note that the association between sleep deprivation and obesity is a bidirectional relationship. Some sleep disorder breathing problems such as obstructed sleep apnea seems to be more prevalent in individuals suffering from excess weight or obesity (Young, Peppard & Taheri, 2005). Obstructive sleep apnea is characterized by a repetitive collapse (apnea) or partial collapse (hypopnea) of the upper airway during sleep. This phenomenon was observed in 50-77% of obese patients with large neck girth and high waste-to-hip circumference (Young et al., 2005). Furthermore, individuals reporting high levels of excessive daytime sleepiness (EDS) were also found to have an Obstructive Apnea or Hypopnea Index (OHI) greater than 15, thus suggesting the presence of sleep apnea. The association between high OHI's and excessive daytime sleepiness suggests that sleep disordered breathing (SDB) reduces sleep quality (Bixler, Vgontzas, Lin, Calhoun, Vela-Bueno & Kales, 2005). However, patients suffering from obesity without the presence of SDB were also found to sleep less than normal weight individuals (Bixler et al., 2005). Although Obstructive Sleep Apnea does lead to excessive daytime sleepiness, obese individuals without SDB are also more likely to experience difficulties with sleep. Obese patients were found to have higher sleep latency, lower percentage of REM sleep and lower levels of sleep efficiency (Resta, Foschino Barbaro, Bonfitto, Giliberti, Depalo, Pannacciulli & De Pergola, 2003). In fact, obese patients without signs and symptoms of Obstructive Sleep Apnea have similar percentage of sleep efficiency, as well as latency to REM as obese patients with Obstructive Sleep Apnea, suggesting that obesity on its own disrupts sleep (Resta et al., 2003).

1.6.4. Health Profile – Chronic Disease

The relationship between insufficient sleep and the development of chronic diseases, especially diabetes, high blood pressure, and obesity has been documented (Ayas, White, Al-Delaimy, Manson, Stampfer, Speizer, Oatel & Hu, 2003; Van Cauter, Holmbäck, Knutson, Leproult, Miller, Nedeltcheva, Pannain, Penev, Tasali & Spiegel, 2007). A large-scale study conducted by Liu et al., (2013) in the United States, found an association between sleep insufficiency and chronic disease. For participants with at least one chronic disease (diabetes, coronary heart disease, high blood pressure, asthma, arthritis), 42.0% reported experiencing sleep insufficiency in the past 1-13 days, 17% indicated 14-29 days of sleep insufficiency, 10.4% reported sleep insufficiency every day for the past 30 days whereas only 30.6% indicated no sleep insufficiency (Lui et al., 2013). Sleep deprivation or shorter sleep decreases efficiency of the endocrine, immune, and metabolic systems increasing the chances of developing a chronic disease (Spiegel, Leproult & Van Cauter, 1999; Knutson et al., 2004).

1.6.4.1. Cardiovascular Disease

Heart disease is the second leading cause of death in Canada (Public Health Agency of Canada, 2017). In Western countries, sleep deprivation has become frequent and epidemiological studies have shown its association with cardiovascular disease, a link that is however poorly understood (Altevogt & Colten, 2006; Verdecchia, Angeli, Borgioni, Gattobigio & Reboldi, 2007; Dettoni, Consolim-Colombo, Drager, Rubira, de Souza, Irigoyen, Mostarda, Borile, Drieger, Joreno & Lorenzi-Filho, 2012). In a study published in 2012, Dettoni et al. assigned two different sleep conditions to 11 healthy males. The first sleep condition exposed the males to 5 days of sleeping for 7 to 8 hours per day, and the second required them to sleep between 3 and 5 hours per day (Dettoni et al., 2012). Both conditions were separated by a two-day transition period. Results showed that the resting heart rate, systolic and diastolic blood pressure, respiratory rates and cholesterol levels remained similar between the two sleeping conditions. However, an increase of plasma norepinephrine levels, an increase in sympathetic and a decrease in parasympathetic modulation of the autonomic cardiac balance were observed in the partial sleep deprivation condition (Dettoni et al., 2012). Additionally, changes in heart rate variability and blood pressure were observed during the two-day transition period that participants were subjected to between both conditions (Dettoni et al., 2012). Another study found that mortality risk from heart disease is increased in males sleeping less than six hours per day and in women sleeping longer than 9 hours per day, when compared to males and females sleeping between 7 and 7.9 hours per day (Amagai, Ishikawa, Gotoh, Doi, Kayaba, Nakamura & Kajii, 2004). Therefore, it appears that sleep deficiency as well as too much sleep are both risk factors for mortality linked to heart disease. It is also crucial to note that different types of sleep apnea have also been linked to cardiovascular disease (Javaheri, Barbe, Campos-Rodriguez, Dempsey, Khayat, Javaheri, Malhotra, Martinez-Garcia, Mehra, Pack, Polotsky, Redline & Somers, 2017). Sleep related breathing disorders have been associated with a number of perturbations that include intermittent hypoxia, oxidative stress, sympathetic activation, and endothelial dysfunction, all of which are mediators of cardiovascular disease (Javaheri et al., 2017).

1.6.4.2. Diabetes

In 2016, 9.2% of the Canadian population was living with diabetes (Diabetes Charter for Canada, 2016) and this number is anticipated to increase as the demographics change. There is evidence in the literature linking sleep disturbances and diabetes. For instance, a study examining the effects of sleep debt on glucose metabolism showed that sleep restriction impaired glucose tolerance and significantly reduced the acute insulin response to glucose (Spiegel, Leproult & Van Cauter, E., 1999). The physiological process that affects glucose tolerance post sleep deprivation is complex, including the decrease of brain glucose utilization, changes in the sympathovagal balance and an increase in cortisol and extended night-time growth hormone (GH) secretion (Knutson et al., 2007). Epidemiological studies have shown that individuals that experience difficulty-maintaining sleep or have short sleep duration are at greater risk of developing diabetes (Ayas et al., 2003; Mallon, Broman & Hetta, 2005; Chaput, Després, Bouchard, Astrup & Tremblay, 2009). Results from a 10-year longitudinal study showed that individuals who slept 5 hours per night or less were at heightened risk of developing diabetes (OR 1.57, 95% CI: 1.28-1.29) compared to individuals who slept 8 hours per night (OR 1.18, 95% CI: 0.96-1.44) (Ayas et al., 2003). However, this association was not significant after adjusting for obesity and other confounding factors meaning that the risk of developing diabetes is increased when suffering from obesity. Nevertheless, sleep quality is a significant determining factor in the development of diabetes whether the link is direct or indirect via other factors such as obesity (Ayas et al., 2003).

1.6.5. Health Profile – Mental Health

In 2012, approximately 10% of the Canadian population aged 15 years or older reported experiencing symptoms of either major depression, bipolar disorder, general anxiety disorder, and abuse of or dependence on alcohol, cannabis or other drugs (Statistics Canada, 2013). Individuals who have mental health concerns also commonly report sleep problems and although sleep-wake disorders are also categorized as mental health problems, the current study did not focus on this specific category of mental health concerns. Ford and Kamerow (1989) found a relationship between sleep complaints and psychiatric disorders. The results indicated that 40.9% of participants suffering from insomnia also had a psychiatric disorder (Ford & Kamerow, 1989). Additionally, 46.5% of participants suffering from hypersomnia suffered of a psychiatric disorder compared to only 16.4% of participants with no sleep disorders that also suffered from a psychiatric disorder (Ford & Kamerow, 1989). Similarly, a study by Strine and Chapman (2005), found that individuals with frequent sleep insufficiency were more likely to experience frequent mental distress (24.7%), experience frequent depressive symptoms (20.0%), and experience frequent anxiety (33.7%) compared to individuals who accumulated enough sleep. Another study by Kahn-Greene, Killgore, Kamimori, Balkin & Killgrore (2007), found that sleep deprivation increased rates of anxiety by 16.7%, depression by 25.0%, and paranoia by 12.5%. When treatment was prescribed for insomnia and hypersomnia, the symptoms of psychiatric disorders decreased over a one-year period (Ford & Kamerow, 1989).

1.6.6. Education

Higher levels of education have been shown to be associated with better sleep quality (Stamatakis, Kaplan &Roberts, 2007; Arber, Bote & Meadows, 2009; Krueger & Friedman, 2009; Lee, Choh, Demerath, Knutson, Duren, Sherwood, Sun, Chumlea, Towne, Siervogel & Czerwinski, 2009; Grandner, Patel, Gehrman, Xie, Sha, Weaver & Gooneratne, 2010; Soltani, Haytabakhsh, Najman, Williams, O'Callaghan, Bor, Dingle & Clavarino, 2012). In comparison, individuals that sleep for nine hours or more per day have reportedly lower levels of education (Amagai et al., 2004). More education is thought to lead to better knowledge and understanding of the importance of adopting healthier lifestyles including sleep hygiene and consequently a better health status.

1.7. Work-Related Factors and Sleep

The following section will examine the effects of work-related factors such as work-family interface, stress, burnout, shiftwork and overtime work, type of occupation and physical environment on sleep quality and quantity.

1.7.1. Work-Family Interface

Work-family conflict arises when an individual engaging in one role finds it difficult to also be engaged in the other role (Kossek, Pichler, Bodner & Hammer, 2011). According to a study by Åkerstedt et al., (2002), factors such as high work demands, low decision latitude, low social support at work, high physical load, solitary work, the inability to stop thinking of work, being female, being unmarried, being older than 45 years of age, not performing physical exercise, having a high BMI, and doing most of the chores around the house and at home are all strong determinants of disturbed sleep. When exploring the effects of work-family conflicts on sleep complaints, women who experience strong conflicts were more likely to report sleep complaints when compared to men (Lallukka, Rahkonen, Lahelma & Arber, 2010). Furthermore, a study reported that higher stress experienced during the evening led to higher stress levels at nighttime before bed (Dahlgren, Kecklund & Åkerstedt, 2005). This is troublesome as stress increases cortisol levels, a phenomenon that has been shown to increase sleep latency, particularly in stage 1 sleep, as well as diminish overall sleep quality (Drake, Richardson, Roehrs, Scofield & Roth, 2004).

1.7.2. Occupational Stress

Stress is a physiological response to any threat, which may affect a person's psychological or physical integrity (Parent & Cloutier, 2009). Threats, also known as stressors, can originate from objects, situations, or events that trigger the production of stress hormones (Parent & Cloutier, 2009). From a physiological perspective, sleep is known to be a period of hormonal regulation. During SWS, the secretion of adrenocorticotropic hormone (ACTH) and cortisol is inhibited (Van Reeth, Weibel, Spiegel, Leproult, Dugovic & Maccari, 2000). Therefore, sleep onset is associated with decreased levels of cortisol, which occurs either due to the SWS or a preparatory mechanism associated with sleep onset (Van Reeth et al., 2000). Secretion of ACTH increases during the morning hours, suggesting that this hormone may play a role in timing the end of the sleep period (Van Reeth et al., 2000). When exposed to a stressor, hormonal levels are altered thus affecting sleep architecture (Van Reeth, 2000).

Occupational stress may occur when one is presented with pressures or demands at work that do not match the individual's knowledge, when there is little to no support from co-workers or higher-ranking employees or when the individual has minimal control over their work (World Health Organization, 2017). A study by Knudsen, Ducharme and Roman (2007) examined the effects of occupational stress on 3 measures of sleep quality: difficulty initiating sleep, difficulty-maintaining sleep, and non-restorative sleep. Their results suggest that work overload is significantly associated with all three measures of sleep quality (Knudsen et al., 2007). In fact, 14.2% of participants reported difficulty-initiating sleep (Knudsen et al., 2007). Furthermore, two of the three measures of poor sleep quality were associated with role conflict in the workplace. Role conflict increases troubles initiating sleep by 9.3% and frequency of non-restorative sleep by 29.1%, and although not statistically significant, role conflict also seemed to affect the ability to maintain sleep (Knudsen et al., 2007). The least predictive job stressor was job autonomy, which increased non-restorative sleep by 19.6% (Knudsen et al., 2007). Additionally, a study by Dahlgren et al. (2005) showed that individuals who experience high workplace stress were at greater risk of fatigue, earlier onset of fatigue in the afternoon (1600 hours), anxiety and lower sleep quantity. Finally, in another study that focused on industry type jobs found that sleep complaints were more predominant in males who experienced high psychosocial job strain compared to females (Luckhaupt, Tak & Calvert, 2010).

1.7.3. Burnout

Burnout is defined as a psychological response to chronic emotional and interpersonal job-related stressors (Maslach, 2003). There are three dimensions to burnout including emotional exhaustion, depersonalization, and reduced personal accomplishment (Maslach, 2003). According to the Copenhagen Burnout Inventory (CBI), burnout can also be defined as having a personal, a work-related and a client-related component (Kristensen et al., 2005). The CBI measures the physical and psychological fatigue that a person experiences and not the working status of the individual (Sestili, Scalingi, Cianfanelli, Mannocci, Del Cimmuto, De Sio, Chirarini, Di Muszio, Villari, De Giusti & La Torre, 2018). Individuals that score high on the burnout scale are very likely to have disturbed sleep (Melamed, Ugarten, Shirom, Kahana, Lerman & Froom, 1999; Perski, Grossi, Evengård, Blomkvist, Yilbar & Orth-Gomér, 2002; Grossi, Perski, Ekstedt, Johansson, Lindström & Holm, 2005). A study by Vela-Bueno et al., (2008) of physicians found that women and individuals with no partner were more likely to be in the high burnout group (Vela-Bueno, Moreno-Jiménez, Rodríguez-Muñoz, Olavarrieta-Bernardino, Fernández-Mendoza, De la Cruz-Troca, Bixler & Vgontzas, 2008). Furthermore, individuals in the high burnout group were more likely to experience increased sleep latency greater than 30 minutes (21.1% vs. 5.5%), higher odds of waking up for more than 30 minutes after sleep onset (25.5% vs. 9.4%), and awakening at least 30 minutes earlier than preferred (45.6% vs. 14.5%) (Vela-Bueno et al., 2008). Moreover, individuals in the high burnout group were more likely to express feeling somewhat dissatisfied with their sleep (50% vs. 5.5%) and suffer from daytime impairment (38.2% vs. 7.3%) (Vela-Bueno et al., 2008). Differences in sleep profiles between the high versus low burnout groups were found for sleep quality, sleep latency, sleep duration, daytime dysfunction, and global PSQI scores (Vela-Bueno et al., 2008). In fact, six of the seven component scores of the PSQI indicated poor sleep for the high burnout group thereby suggesting a strong association between burnout and sleep quality (Vela-Bueno et al., 2008).

1.7.4. Work Schedule: Shiftwork and Overtime Work

Shiftwork is described as a phenomenon when 2 or more groups of workers relieve each other during a specific work schedule. During these work hours, 50% of the working hours are performed outside of the typical 8 am – 5 pm timeframe (Hossain et al., 2004). In 2007, Charles, Burchfiel, Fekedulegn, Vila, Hartley, Slaven & Mnatsakanova (2007) studied the effects of shiftwork on sleep in a sample of police officers. Nightshift workers reported sleeping on average 5 to 6.5 hours per night, compared to steady day workers, who slept on average 7 hours or more per night (Charles et al., 2007). Additionally, a study by Drake, Roehrs, Richardson, Walsh & Roth, (2004), uncovered that dayshift workers slept on average 6.8 hours per night, with a sleep efficiency of 91.5% whereas nightshift workers slept on average 6.1 hours per night and had a sleep efficiency of 88.2% (Drake et al., 2004). Finally, rotating shift workers slept on average 6.7 hours per night, with a sleep efficiency of 90.5% (Drake et al., 2004). Finally, Hossain and colleagues (2004) concluded that nightshift negatively affects the sleep-wake-cycle, which further affects sleepiness, fatigue and performance.

Shiftwork has been shown to increase fatigue, sleepiness, and decrease performance, which occur as a result of the failure to achieve adequate restorative sleep. The root cause of inadequate restorative sleep can be characterized by 3 factors: disrupted circadian rhythm, sleep related problems, and social limitations (Hossain et al., 2004). Circadian rhythm disturbance occurs when the individual is unable to adjust or realign their internal clock to the changes in daily routine that are required in shiftwork. Sleep related problems occur as a result of partial and chronic reductions in sleep duration, often seen in shiftwork, therefore affecting an individual's mood and performance (Hossain et al., 2004). From a social perspective, shiftwork alters social life by limiting the possibility to participate in activities during the day because this time period is required to sleep and recover (Costa, 2003; Hossain et al., 2004).

Shift length is another factor that can impact a worker's wellbeing in combination with other factors such as the commute to and from work. For instance, Scott, Hwang, Rogers, Nysse, Dean & Dinges, (2007) conducted a study on the effects of shift length and drowsy driving in hospital nurses. Their results indicate that after shifts of 8.5 hours in length, 15.7% of nurses experienced an episode of drowsy driving. This risk of drowsy driving doubled when nurses worked 12.5 consecutive hours or more (*OR* = 2.00; $p < 0.0001$). Additionally, they found that in 895 nurses, 596 (66.6%) reported experiencing at least 1 episode of drowsy driving during the length of the 4-week long study, and 30 nurses reported experiencing drowsy driving after every shift (Scott et al., 2007). Their results also suggest that nurses experience a drowsy driving experience 1 out of every 4 shifts (Scott et al., 2007). Nightshifts also lead to a significant increase in the risk of drowsy driving (*OR* = 3.96; 95% confidence interval = 3.24 – 4.84) (Scott et al., 2007). These results are troublesome as the average time for a 1-way commute was 27.1 minutes, with 67 nurses reporting commuting times of 60 minutes or greater. Another study by Nokashima, Morikawa, Sakurai, Nakamura, Miura, Ishizaki, Kido, Natuse, Suwazono & Nakagawa (2011), found that longer working hours was associated with shorter sleep durations, impaired sleep efficiency and increased daytime dysfunction. Long and extensive shifts can lead to hazardous commuting to and from work, which can be further exacerbated by poor sleep.

1.7.5. Physical Environment

Physical conditions of work such as strenuous work, tiring postures, exposure to noise/vibration or heat have been found to be risk factors for sleep disturbances (Trinkoff, Storr & Lipscomb, 2001; Parkes, 2015). A study by Parkes (2015) found two characteristics to the work environment that affected sleep quality, namely that unfavourable physical environment led to poor sleep quality, whereas supervisor support was linked to better sleep quality (Parkes, 2015). Lallukka et al. (2010) explored the relationship between sleep complaints and environmental exposures (chemical exposure, heat, vibrations), physical workload (repetitive tasks, heavy lifting, continuous strenuous positions), and 3) computer work (Lallukka et al, 2010). Men who were regularly exposed to high environmental exposure were more likely to experience sleep complaints (OR 3.06; CI 1.76-5.30), compared to women, where the association was slightly reduced (OR 1.57; CI 1.27-1.95) (Lallukka et al., 2010).

1.8. WHO Healthy Workplace Model and Framework

Workplace health and safety in the mining industry and more broadly is influenced by several factors as depicted in the WHO Healthy Workplace Model (World Health Organization, 2010). These factors include the physical work environment, the personal health resources and the psychosocial work environment. This healthy workplace model represents an integrated approach to health and safety in the workplace. This framework considers different dimensions of the worker's health and wellbeing (i.e. health behaviours, personal factors and work-related factors) along with its determinants and the various key players that contribute to ensure a worker's wellbeing (Kortum, 2014). Furthermore, the framework facilitates the application and implementation of comprehensive approaches to achieve an overall healthy workplace, addresses the worker's health holistically and situates strategic interventions at specific levels of the industry. This model has served to frame the research questions and hypotheses of this study as well as to situate the application of the outcomes of this project within the mining industry.

1.9. Questions and Hypotheses

There is abundant evidence in the literature suggesting that health behaviours, personal factors and work-related factors impact sleep. From an occupational safety and health point of view, poor sleep quality leads to decreased productivity and efficiency, decreased attention, and increased odds of experiencing a workplace injury due to reduced ability to react to the external environment. In short, poor sleep quality and quantity leads to increased risk of human error in the workplace and reduced worker wellbeing.

There is currently a lack of data regarding the sleep quality and quantity of workers in the mining industry and even less information regarding the health behaviors, personal factors and work-related factors that influence sleep quality and quantity in this workforce. To address these gaps in knowledge, the following research questions were formulated.

1) What are the trends of self-reported sleep quality and quantity of various workers in the mining industry?

2) What is the relationship between sleep quality and quantity and various health behaviors, personal factors, and work-related factors within the sample of workers in the mining industry?

3) Which health behaviors, personal factors, and work-related factors best predict sleep quality?

The current study aims to test the following specific hypotheses:

1) Dayshift workers will have better overall sleep quality and quantity when compared to workers in other shifts.

2) Underground workers with high physical demands will be more likely to experience poor sleep quality than surface workers with high physical demands.

3) Individuals reporting poor sleep quality will also report higher levels of stress, and will also screen positively for personal, work and colleague burnout.

4) Work-related factors such as poor job satisfaction, high mental demands, afternoon and nightshifts, and the physical work environment will be the greatest work-related predictors of poor sleep.

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CHAPTER 2: METHODOLOGY

This a quantitative cross-sectional study aimed to assess the sleep profiles of workers in the mining industry and how several health behaviours, personal factors and work-related factors may be associated with workers' sleep quality.

2.1. Ethics

This project is part of a large-scale study titled Mining Mental Health and Wellbeing, which was approved by the Research Ethics Board at Laurentian University on May 24th, 2016, REB file number 6008165 (formely 2016-04-12-LUREB).

2.2. Participants

Participants were recruited across Vale Ontario worksites to provide all workers employed in all divisions of the company the opportunity to participate in this study. Research team members travelled to multiple Vale worksites in Ontario to coordinate the self-administered questionnaire, which was administered during work hours to all those who wished to participate. Data were collected during the months of June to October of 2016 from 2,224 participants corresponding to a 54% response rate. Employees and participants commuted to their place of work. None of them engaged in fly-in-fly-out type of work schedules. A pilot study and qualitative portion (Dignard, 2016) to this larger scale study was used to inform and shape the final questionnaire including modifications to the PSQI (see section 2.5 below).

2.3. Data collection

The Mental Health and Well-being Questionnaire (see sections below for full details) was administered to workers of the Vale workforce (Dignard, 2016). After a brief introductory presentation that explained the purpose of the study, the participants were encouraged to read through the invitation letter, consent form and were invited to ask additional questions about their participation prior to starting the questionnaire. Additionally, workers were assured anonymity of the survey, and that only the research team members would have access to their surveys, and that no individual results would be shared. Workers who consented were then given the survey, along with an envelope to insert the completed survey in once completed. Researchers remained on site for the duration of the survey completion in order to answer any questions during this period. Considering the sensitivity of the survey, workers were also given mental health resources should they need to access the services. Multiple sessions were administered everyday and work schedule rotations were taken in consideration to ensure all crews had the possibility of participating in the study. For those who worked underground, the sessions were scheduled on their regular health and safety training days, a time when the workers are at the surface (Dignard, 2016). The spaces in which workers completed the survey were always large and accommodating, to ensure participant privacy. Workers who were not able to attend the session at their worksites or preferred to complete the survey on their own time could schedule to attend one of many sessions held at the Copper Cliff Club (Dignard, 2016). This phase of the data collection occurred almost every weekday for about two and a half months during the summer of 2016, with a few additional sessions held in the Fall of 2016.

2.4. Confidentiality

After each data collection session, the completed surveys were brought to the principal investigator's office and were stored in locked cabinets in a locked office, a space only accessible to the members of the research team. The consent forms were also stored in the same office, in a separate locked cabinet. Surveys were sorted by worksites and numbered accordingly. Complying with Laurentian University's Policy on Managing Confidential Digital Information (March 2015), all digital data were stored on LU approved services (secured internal services) accessible only to research team members.

2.5. The Questionnaire

The 45-page questionnaire was composed of a number of instruments, which included:

1. The Alcohol Use Disorder Identification Test (AUDIT)
2. Beck Anxiety Inventory (BAI)
3. Beck Depression Inventory II (BDI-II)
4. The Copenhagen Burnout Inventory (CBI)
5. Demographics
6. The Drug Abuse Screening Test (DAST-20) and a drug questionnaire
7. Effort-Reward Imbalance Questionnaire (ERI)
8. Fatigue Severity Scale (FSS)
9. Guarding Minds @ Work
10. Job Insecurity Measure
11. The National Institute for Occupational Safety and Health (NIOSH) Generic Job Stress Questionnaire (select subscales)
12. Perceived Stress Scale (PSS)
13. The Pittsburgh Sleep Quality Index (modified) (DV)
14. PCL-5 (the PTSD checklist for DSM-5)
15. Recovery Experience Questionnaire (modified)
16. Relationship Assessment Scale (RAS)
17. Satisfaction with Work-Life Balance Scale
18. Stigma Scale

The instruments used in this current specific study were the following:

1. The Alcohol Use Disorder Identification Test (AUDIT)
2. Beck Anxiety Inventory (BAI)
3. Beck Depression Inventory II (BDI-II)
4. The Copenhagen Burnout Inventory (CBI)
5. Demographics
6. The Drug Abuse Screening Test (DAST-20) and a drug questionnaire
7. Effort Reward Imbalance Questionnaire
8. Fatigue Severity Scale (FSS)
9. Job Insecurity Measure
10. The National Institute for Occupational Safety and Health (NIOSH) Generic Job Stress Questionnaire (select subscales)
11. Perceived Stress Scale (PSS)
12. PCL-5 (the PTSD checklist for DSM-5)
13. The Pittsburgh Sleep Quality Index (modified) (DV)

The following paragraphs will further define the instruments along with the acceptable ranges and cut off points that were gleaned from the literature. Some of the instruments served to assess mental-health related symptoms but were in no way used to diagnose mental health problems.

2.5.1. Alcohol Use Disorder Identification Test (AUDIT)

The Alcohol Use Disorder Identification Test was developed in order to help clinicians screen for excessive drinking, or to identify individuals that would benefit from reducing or ceasing their alcohol consumption (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001). For the purpose of this study, the AUDIT underwent certain modifications that were based on the pilot study (Dignard, 2016). First, question one was modified to fit the consistency of the phrasing of questions three to ten. This then allowed to format the questionnaire in a table format. The second modification was made to question two; since the statements could not be modified, it was simply put as the first question on the questionnaire. Finally, question 9 was separated in two separate questions, which distinguished the respondent from someone else being injured due to alcohol consumption in the workplace. However, this question was still scored as one. These modifications did not in any way affect the way the questionnaire was scored, as they were strictly formatting changes with no content alterations.

The AUDIT is a ten-item questionnaire that evaluates drinking behavior, alcohol consumption, and alcohol-related issues (Saunders, Asland, Babor, De la Fuente, Juan & Grant, 1993). Each question is rated on a five-point Likert Scale that ranges from 0 (Never) to 4 (Daily or almost daily) (Babor et al., 2001). The total score is determined by adding together all of the items, and a score of 8 or more suggests hazardous drinking behavior and possible dependence (Babor et al., 2001). However, it is important to note that the cut off score should not be the only indicator of hazardous drinking. The distribution of points at specific questions should also be taken in consideration when determining the possibility of hazardous alcohol consumption in individuals. Scoring one or more on questions one and three (in the Mining Mental Health questionnaire) suggested hazardous alcohol consumption. Additionally, scoring any points on questions four to six indicated alcohol dependence. Finally, scoring any points on questions seven to ten proposed that the alcohol consumption was causing harm to the individual (Babor et al., 2001). Regardless of these specific details, higher overall scores on the AUDIT suggested hazardous alcohol behavior.

2.5.2. Beck Anxiety Inventory (BAI)

Anxiety is an emotion characterized by feelings of worry and tension, which may in turn be manifested by perceived physical symptoms such as increase in blood pressure, dizziness, sweating, etc. This may in turn lead to avoidance behaviors, which could have consequences on a person's personal and professional life (American Psychological Association, 2017).

The BAI is a self-reported instrument that measures the severity of an individual's anxiety (Beck, Epstein, Brown & Steer, 1988). The BAI was designed to differentiate between the behavioral, emotional, and physiological symptoms that are associated with depression and anxiety (Leyfer, Ruberg & Woodruff-Borden, 2006). This 21-item questionnaire allows participants to rate their symptoms on a four-point Likert Scale that ranges from "Not at all" to "Severely I could barely stand it" during the past month. Each statement is associated with a numerical value ranging from 0 to 3, meaning the final total scores can range between 0 and 63 (Beck & Steer, 1990). A score between 1 and 21 suggests low anxiety, 22 to 35 is associated with moderate anxiety, and those scoring 36 or more potentially have concerning levels of anxiety (Beck & Steer, 1990).

2.5.3. Beck Depression Inventory II (BDI-II)

Depression is characterized by an overwhelming feeling of despair over an extended period of time. Practically all aspects of an individual's life may be affected by depression, including emotions, physical health, relationships and work (Canadian Mental Health Association, 2017a).

The Beck Depression Inventory - II (BDI-II) is the most widely used instrument to screen for potential depression symptoms as well as the severity of current symptoms of depression in a normal adult population (Beck, Steer & Brown, 1996). The BDI-II is made up of 21-items (or symptoms) and have 4 possible statements associated with each. For example, if the item is sadness, participants are asked to choose which of the 4 following statements best relate to their current state of sadness within the last 2 weeks: I do not feel sad, I feel sad much of the time, I am sad all the time, and I am so sad or unhappy that I can't stand it (Beck et al., 1996). Each statement is accorded a numerical value that ranges between 0 and 3. The final score of the BDI-II ranges between 0 and 63 (Beck et al., 1996). The following table shows the distribution of scores per categories of depression symptoms as stated by the Beck Depression Inventory-II.

Table 1. *Distribution of Final Scores and Associated Categories for the Beck Depression Inventory II.*

Scores	Category
1-10	Normal ups and downs of life
11-16	Mild mood disturbances
17-20	Borderline clinical depression
21-30	Moderate depression
31-40	Severe depression
<40	Extreme depression

2.5.4. The Copenhagen Burnout Inventory (CBI)

Burnout is a concept that was first published in the literature by psychiatrist Hebert Freudenberg, and by social psychologist Christina Maslach in the 1970's (Maslach, Schaufeli & Leiter, 2001). In fact, Maslach et al., define burnout as a "psychological syndrome in response to chronic interpersonal stressors on the job" (2001). These job stressors are characterized by three dimensions: overwhelming exhaustion, feelings of cynicism and detachment from the job, and having a sense of ineffectiveness and lack of accomplishment (Maslach et al., 2001).

The CBI is a 19-item questionnaire that is composed of three scales that measure three different sources of burnout: 1) personal, 2) work-related, and 3) client-related (colleague-related) (Kristensen, Borritz, Villadsen & Christensen, 2005). Each statement of the CBI is scored on a 5-point Likert Scale, with possible answers ranging from "Always or To a very high degree" to "Never/Almost never or To a very low degree" (Kristensen et al., 2005). The final score is determined by adding together each items of the CBI. These scores can range between 0 and 100, with a score of 50 suggesting a high degree of burnout (Kristensen et al., 2005). It is to note that the last category "client-related" was changed to "colleague-related" in order to be applicable to this specific population.

2.5.5. Demographics and other characteristics of the participant cohort

General and demographic data such as gender, age, education, ethnicity, marital status, body mass index, hours of exercise per day, hours of sedentary behavior per day, current physical or mental illness and medication use, the number of dependent individuals (children, person with disability, or older adult), and the possibility of currently completing courses or a degree/diploma. about the participants were also collected to be able to describe demographic and general characteristics of the sample population. Additional work-related information was collected, such as occupation, work schedule and location, number of years working in the mining industry, salary and incentives, unions, employment status, amount of time spent working underground, number of injuries that are work-related and the amount of time workers spend commuting to and from work.

2.5.6. Drug Abuse Screening Test (DAST-20)

The Drug Abuse Screening Test (DAST-20) screens for individuals that are abusing drugs, along with the degree of severity of the issue at hand (Skinner, 1982). This instrument is a 20-item questionnaire where respondents are asked to check a "Yes" or "No" option to each statement listed. Each question that is answered "Yes" receives one point, except for questions four and five that are scored in reverse (Skinner, 1982). The final score is determined by adding the scores for each of the statements listed in the DAST-20 (Skinner, 1982). The final score is then placed in severity categories; scores between 1 and 5 indicate low severity, 6 and 10 suggest intermediate severity of drug use, 11 and 15 indicate a substantial severity and scores between 16 and 20 suggest substantial severity of drug use (Skinner, 1982). However, a cut off score of 6 may also be used to determine the risk of drug abuse or dependence (Yudko, Lozhkina & Fouts, 2007).

2.5.7. Effort-Reward Imbalance Questionnaire (ERI)

An effort-reward imbalance occurs when the reward is not proportional to a worker's effort. For instance, a worker's efforts are not acknowledged or compensated either through remuneration or recognition. These situations of imbalance can lead to emotional distress (Siegrist, 1996).

The ERI used in the current study is a 16-item instrument that measures each question on a 4-point Likert scale that ranges from 1 (Strongly Disagree) to 4 (Strongly Agree; Siegrist, Li & Montano, 2014). The first 6-items of the questionnaire measure effort, with possible scores ranging from 6 to 24, and the last 10 items measure reward, with possible scores between 10 and 40 (Siegrist et al., 2014). Some items of the instrument are reversed scored (Siegrist et al., 2014). The Effort-Reward Imbalance is calculated by determining the ratio between the effort and the reward scores (ER Ratio). Participants with an ER ratio greater than 1 are suggested to have more effort per reward (Siegrist et al., 2014).

2.5.8. Fatigue Severity Scale (FSS)

Fatigue is a concept that does not have a clear-cut definition due to the lack of consensus in the literature of how it is defined (Hossain, Reinish, Kayumov, Bhuiya & Shapiro, 2003).

However, the researchers at Toronto Western Hospital's Sleep Research Laboratory and Department of Psychiatry do agree that fatigue is both multidimensional and heterogenous, along with being subjective. Fatigue could be defined as a self-determined "state in which a person feels overwhelmingly exhausted, both physically and mentally, and is unable to relieve this feeling of exhaustion, even with rest" (Hossain et al., 2003).

The Fatigue Severity Scale is a clinical and research instrument that measures the severity of fatigue (Krupp, LaRocca, Muir-Nash & Steinberg, 1989). This nine-item questionnaire is rated on a seven-point Likert Scale that ranges from "Strongly disagree" (value of 1) to "Strongly agree" (value of 7). The final score is calculated by averaging the scores from each item, meaning that this final score can range between 1 and 7 (Krupp et al., 1989). Individuals with an average total score of 4 or more are considered to experience severe fatigue (Learmonth, Dlugonski, Pilutti, Sandroff, Klaren & Motl, 2013).

2.5.9. Job Insecurity Measure

The Job Insecurity Scale was developed by De Witte in the year 2000 and is used to measure the cognitive and affective dimensionalitites of job insecurity (O'Neil & Sevastos, 2013). It is the most popular scale used when measuring job insecurity in a variety of occupations. The Job Insecurity Scale is an 18 item questionnaire. The measure utilizes a 7-point Likert scale that allows to rate every statement from 1 (Very Inaccurate) to 7 (Very Accurate). Greater Scores indicate high insecurity in regards to the job (O'Neil & Sevastos, 2013).

2.5.10. The National Institute for Occupational Safety and Health (NIOSH) Generic Job Stress Questionnaire – Physical Environment Subscale

The NIOSH Generic Job Stress questionnaire is a 19 -subscale questionnaire developed to evaluate job stress (NIOSH, 2014a). For the purpose of this study, the physical environment scale was used to determine the degree of physical environment stress perceived by the workers. The NIOSH physical environment component is a 10-item subscale that is scored using "True" or "False". The environmental components evaluated in this subscale include lighting, noise, temperature, humidity, air quality and circulation, exposure to dangerous substances, and crowded work areas (NIOSH, 2014b).

2.5.11. Perceived Stress Scale (PSS)

Stress is the body and brain's natural response when it is exposed to demands or stressors (National Institute of Mental Health, 2017). Stress can be detrimental to health when it persists for long periods of time (National Institute of Mental Health, 2017). Signs and symptoms of exposure to persistent stress include digestive health issues, headaches, reduced ability to fight sickness, and disrupted sleep (National Institute of Mental Health, 2017). There are also a variety of mental health consequences from stress including anger, irritability and sadness, as well as increased risk of suffering from mental disorders such as anxiety and depression (National Institute of Mental Health, 2017).

The PSS is a psychological instrument used to measure the perception of stress (Cohen, Kamarck & Mermelstein, 1983). The 14-item scale measures the degree to which situations in an individual's life are perceived as stressful and captures the frequency that symptoms of stress have bothered the participant in the last month (Cohen et al., 1983). Each item in the PSS is measured on a 5-point Likert scale ranging from 0 (Never) to 4 (Very Often). It is important to note that questions 4,5,6,7,10 and 13 are reversed scored (Cohen et al., 1983). The score is calculated by adding the scores attributed to each item, and scores will range from 0-56 with higher scores indicating higher perceived stress (Cohen et al., 1983). It is important to note that since the PSS is not a diagnostic tool, there is no cut off score attributed to this instrument (Wolf, Zappavigna, Piper & Nitsch, 2015).

2.5.12. PCL-5 (PTSD Checklist for DSM-5)

Post-traumatic Stress Disorder (PTSD) is a mental illness that affects individuals that have experienced traumatic events (Canadian Mental Health Association, 2017b). Exposure to death or threat of death, serious injury, sexual violence, abuse, accidents, and a variety of other circumstances can lead to the development of PTSD. This traumatic experience may cause a significant amount of distress on an individual, causing them to feel very nervous when re-experiencing the event. Symptoms include but are not limited to flashbacks and vivid nightmares, which may lead to irritability, nervousness, and sleep problems (Canadian Mental Health Association, 2017b).

The PCL-5 is a questionnaire that corresponds to the Diagnostic and Statistical Manual of Mental Disorder, Fifth Edition (DSM-5) (American Psychological Association, 2017) symptom criteria for PTSD. This questionnaire is composed of 20-items that are scored on a five-point Likert scale that ranges from 0 (not at all) to 4 (extremely). The possible overall score for the PCL-5 ranges from 0-80, where higher scores reflect higher severity of PTSD symptoms. However, individuals scoring between 38 and 80 should be subject to additional screening (Weathers et al., 2013).

2.5.13. The Pittsburgh Sleep Quality Index

The Pittsburgh Sleep Quality Index is a validated questionnaire that was developed in 1988 by Daniel Buysse and his colleagues at the University of Pittsburgh (Buysse, Reynolds, Monk, Berman & Kupfer, 1989). Although it was designed to measure sleep quality in a clinical setting, it is often used for research purposes. A study by Grandner, Kripke, Yoon & Youngstedt (2006) evaluated the validity of this instrument in non-clinical populations and showed good internal homogeneity, and strong correlation values between the PSQI and sleep diaries (Grandner et al., 2006). Hence, the PSQI is thought to collect accurate subjective sleep quality information in various populations. Sleep quality has been deemed a clinical construct and is often used in psychiatry and is a complex phenomenon that is difficult to define and measure objectively (Buysse et al., 1989). Some constructs of sleep quality such as sleep depth, sleep latency and arousal during sleep periods can be measured objectively with the help of polysomnography or actigraphy tests (Sadeh, 2011; Westerlund, Lagerros, Kecklund, Axelsson & Åkerstedt, 2016). However, some parts of sleep cannot be measured with technology and reflect subjective interpretations of feelings or experiences during sleep periods (Buysse et al., 1989). The PSQI was developed to produce a reliable, valid and standardized way to measure subjective sleep quality, to differentiate between "good" and "poor" sleepers, to supply researchers and clinicians an index that is easy to interpret and to evaluate sleep disturbances that might affect overall sleep quality (Buysse et al., 1989).

Typically, the PSQI is composed of 19-self rated questions that evaluate 7 components of sleep: sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of sleep medicine, and daytime dysfunction due to poor sleep (Buysse et al., 1989). Together, these 7 components of sleep produce an overall Global PSQI Component Score ranging from 0-21

(Buysse et al., 1989). Individuals scoring between 0-5 are deemed to have "good" sleep quality, and those scoring >5 are considered to have "poor" sleep quality.

2.5.14. Modified Pittsburgh Sleep Quality Index

For the purpose of this study, the PSQI was modified and adapted to better suit the targeted population (mPSQI). In particular, sentence structure for some items was altered, the format of the questionnaire was changed, two questions were removed, resulting in 6 components of sleep being evaluated, and the overall cut off score distinguishing "good" and "poor" sleepers changing to 4. The cut off score was changed to 4 rather than 5. As a research team, we felt that 3 would have been an overestimation of self-reported poor sleep quality and that 5 would have been an underestimation. Therefore, with the removal of 1 component, we felt that 4 was an acceptable cut off for the sample and study. These modifications were based off results from a pilot study conducted collaboratively with industry partners, researchers, and 40 participants, which suggested that some questions were redundant or did not apply to this targeted population of workers. The second modification was the removal of question #2 that states "How long (in minutes) has it taken you to fall asleep each night?" It was decided that this question was redundant, and therefore was removed from the PSQI. In order to calculate sleep latency, the questions "Trouble falling asleep?" was used from the PTSD Checklist. Participants then were asked to select which statement best applied to them (Not at all, A little bit, Moderately, Quite a bit, Extremely). Each variable was coded and interpreted for the PSQI. Therefore, those who had selected "Not at all or A little bit" were coded as 0. Participants who chose "Moderately" were coded as 1. Those who selected "Quite a bit" were coded as 2, and those who chose "Extremely" as 3. This then allowed us to calculate sleep latency in the mPSQI.

Finally, there were also two questions that were removed from the PSQI. The first question asked, “When have you usually gone to bed?” and the second “When have you usually gotten up in the morning?”. These questions were removed as it was deemed difficult for workers of this specific population to report when they usually have gone to bed and woken up due to the shiftwork. This then did not make it possible to calculate the fourth component of the PSQI; Habitual Sleep Efficiency.

To summarize, the mPSQI is an 18-self-rated questionnaire that evaluates 6 components of sleep: sleep quality, sleep latency, sleep duration, sleep disturbances, use of sleep medicine, daytime dysfunction due to poor sleep but not sleep efficiency. Together, these 6 components produced an overall mPSQI Global Component Score ranging between 0-18 rather than 0-21. Those scoring between 0-4 were deemed to have “good” sleep quality versus those scoring >4, which were considered to have “poor” sleep quality. Some studies have reportedly modified the PSQI to better fit the particularities of the study participants but the specifics of these modifications are not well explained (Knutson, Ryden, Mander & Van Cauter, 2006; Mastronarde, Wise, Shade, Olopade, Sharf & The American Lung Association, 2008; Yokoyama, Aoki, Tsujimura, Takao, Namiki & Okuyama, 2011; Walega, Rubin, Banuvar, Shulman & Maki, 2014; Nakamura, Sakurai, Miura, Morikawa, Nagasawa, Ishizaki, Kido, Naruse, Nakashima, Nogawa, Suwazono & Naragawa, 2014).

2.6. Type of Research and Statistical Analysis

This specific project uses a quantitative approach and all statistical analyses were conducted using SPSS Version 24. Descriptive statistics such as means, frequencies, standard deviations, percentages and chi^2 (χ^2) are presented to answer the first research question. The t-test was used to determine if there was a significant difference in sleep quality and quantity within the grouping variables. The analysis of variance (ANOVA) were used to compare sleep quality and quantity (dependent variables) between grouping variables that had more than 2 categories. A MANOVA was used to determine if underground workers compared to above ground workers had higher physically demanding work environments, which in turn would affect their overall sleep quality. Finally, a stepwise regression model was used to a) identify the greatest predictors from all variables of the health behaviors, personal factors and work-related factors and b) only with the work-related factors.

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CHAPTER 3: RESULTS

3.1. First Research Question – What are the trends of self-reported sleep quality and quantity in workers of the mining industry?

A total of 2224 workers from the industry completed the survey representing a response rate of 54%. From the total workforce within this mining company, 2126 participants completed the mPSQI (95.6% response rate relative to number of study participants). Self-reported sleep quality measures from the Pittsburgh Sleep Quality Index indicate that workers are considered to have poor sleep quality with an average Global mPSQI Component Score of 6.43 (± 3.07). From this group of workers, 345 (16% of the sample) had Global mPSQI Component Scores at 4 or below with an average PSQI score of 2.43 (± 0.79), which is considered good sleep quality. Comparatively, 1781 individuals from the sample population (84% of the sample) were classified as having poor sleep quality (i.e. scores above 4) with an average Global mPSQI Component Score of 7.22 (±2.69) (Table 2). Figure 1 shows the distribution of Global mPSQI Component Scores (sleep quality) of the entire sample. While the greatest proportion of participants reported a score of 5, the range of responses was spread out up to a score of 18 (worst possible score on the scale). The average sleep quantity of all workers of the mining industry was 6hr:05min (± 1hr:03min) hours per night. Figure 3 shows the distribution of sleep duration/quantity (e.g. 6hr:00min - 6hr:54min included in category 6hr) revealing again that the greatest proportion of participants sleep 6 hours or less per night.

Sleep quality and quantity of participants were further analyzed according to five specific sectors of the mining industry such as 1) mine sites, 2) milling and smelting, 3) refining, 4) production services and support and 5) Safety, Health, Environment, Human Resources, Corporate Engineering, Finance. No significant differences in sleep quality of workers between the various sectors was observed [F (4, 2111) = 0.821, p = 0.51] (Table 3). A similar analysis for sleep quantity showed that there were significant differences between the sectors [F (4, 2196) = 4.236, p = 0.02] (Table 4). Post hoc comparisons using the Tukey HSD test indicated that the average sleep quantity for the mine site workers (*M* = 6hr:12min, *SD* = 1hr:08min) was slightly lower than the workers in the departments of safety and health, environmental, human resources, corporate, engineering, finance, etc. (*M* = 6hr:20min, *SD* = 1hr:08min). Furthermore, there was a significant difference in the mean sleep quantity of the workers in the refinery (*M* = 6hr:25min, *SD* = 1hr:18min) and those working in the departments of safety and health, environmental, human resources, corporate, engineering, finance, etc. (*M* = 6hr:20min, *SD* = 1hr:08min). There was no significant difference between the other groups.

Table 2. *Average Self-Reported Sleep Quality Scores for Workers Reporting Good versus Poor Sleep Quality*

Sleep Quality	***N***	***M***	***SD***	***p***
Good Sleep Quality	345	2.34	0.79	≤ 0.001
Poor Sleep Quality	1781	7.22	2.69	

Pittsburgh Sleep Quality Index Component Scores
0-4 = Good Sleep Quality
>4 -18 = Poor Sleep Quality
*One sample t-test comparing Good vs Poor Sleep Quality groups.

Table 3. *Trends of Self-Reported Sleep Quality of Workers in Various Sectors Within the Mining Industry*

Worksites	***N***	***M***	***SD***	***p***
Mine site	1069	6.44	3.06	
Milling and Smelting	422	6.27	2.99	
Refining	252	6.66	3.00	0.51
Production Services and Support	153	6.56	3.04	
Safety, Health, Environment, Human Resources, Corporate Engineering, Finance, etc.	220	6.28	3.24	
All Workers	2088	6.43	3.06	

Pittsburgh Sleep Quality Index Component Scores
0-4 = Good Sleep Quality
>4 -18 = Poor Sleep Quality

Table 4. *Trends of Self-Reported Sleep Quantity of Workers in Various Sectors Within the Mining Industry*

Worksites	***N***	***M***	***SD***	***p***
Mine site	1121	6:01	1:00	
Milling and Smelting	440	6:07	1:00	
Refining	255	6:02	1:07	0.02
Production Services and Support	159	6:07	1:09	
Safety, Health, Environment, Human Resources, Corporate Engineering, Finance, etc.	226	6:19	1:08	
All Workers	2201	6:07	1:04	

Self-reported sleep quantity in hours (hr:min)

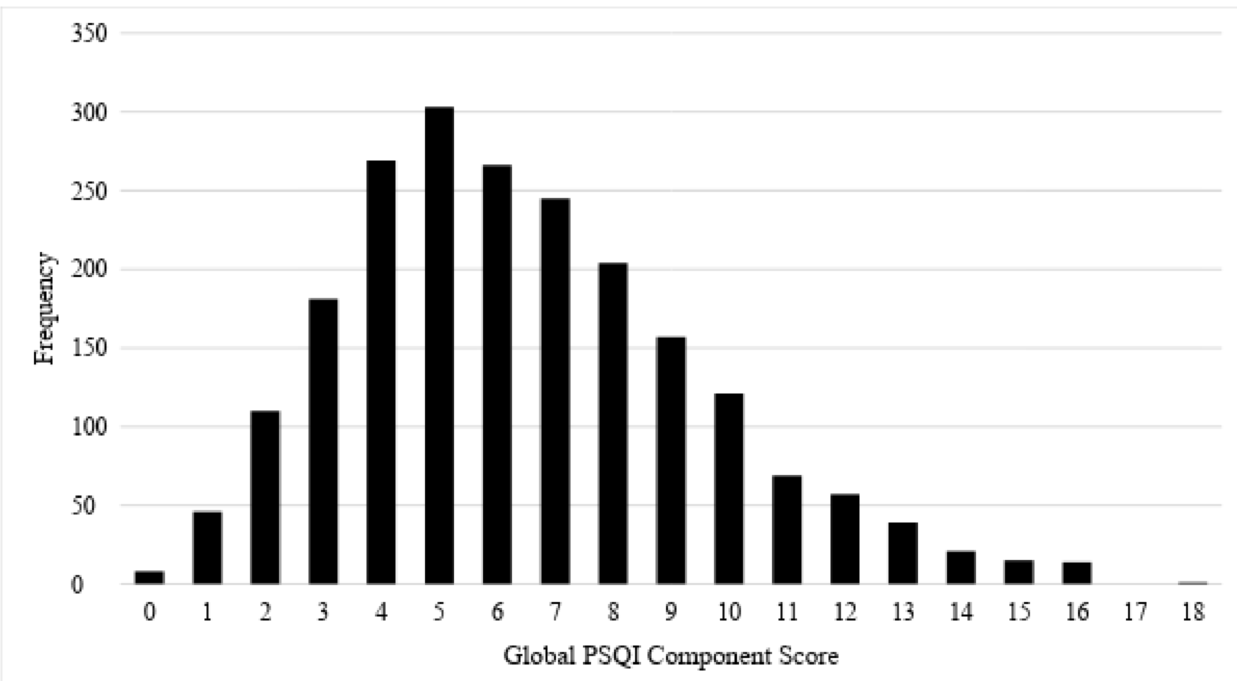

Figure 1. Frequency Distribution of Global Pittsburgh Sleep Quality Index Scores (N = 2126)

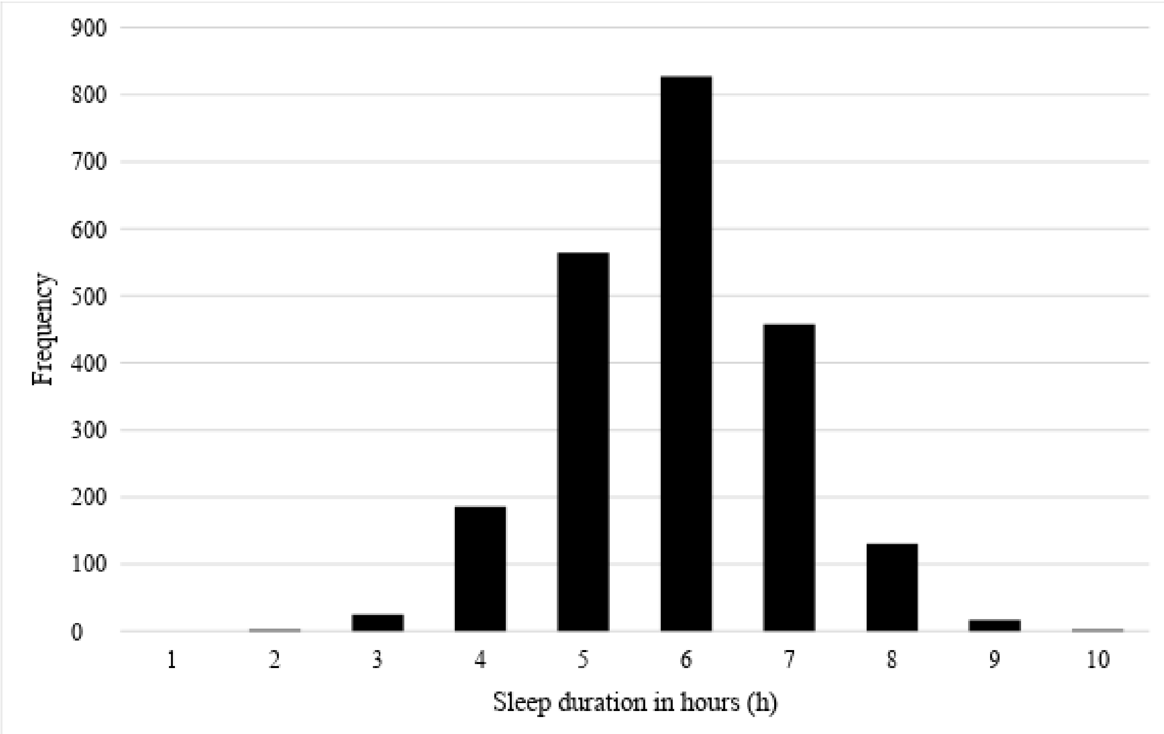

Figure 2. Frequency Distribution of Sleep Duration/Quantity (hr:mm) (N = 2126)

3.2. Second Research Question – What are the sleep quality and quantity trends of workers according to various health behaviors, personal factors, and work-related factors?

3.2.1. Sleep quality relative to health behaviors

Independent sample t-tests were conducted to determine if there were differences in self-reported sleep quality (Global PSQI Component Scores) relative to various health behaviors. The results indicate that participants who engage in hazardous alcohol consumption are significantly more likely to report poor sleep quality (M = 6.94, SD = 3.09) than those who do not engage in such behavior (M = 6.19, SD = 3.00; t (1955) = -4.750, $p \leq 0.001$). Furthermore, participants who engage in hazardous drug behavior are significantly more likely to also report poor measures of self-reported sleep quality (M = 8.57, SD = 3.02) than those who do not partake in hazardous drug behavior (M = 6.43, SD = 3.07; t (1825) = -4.920, $p \leq 0.001$). No differences in sleep quality were observed for all other health behavior variables (i.e. non-smoker vs smoker and meeting physical activity guidelines vs not meeting guidelines). Appendix A displays all independent sample t-test results for the complete set of health behavior variables.

3.2.2. Sleep quality relative to personal factors

Individuals who reported having a previous mental health diagnosis were significantly more likely to report worst overall sleep quality (*M* = 7.74, *SD* = 3.40) than those who did not have a diagnosis (*M* = 6.08, *SD* = 2.88; *t* (613.9) = -9.392, $p \leq 0.001$). Furthermore, self-reported sleep quality was poorer for those who reported having a diagnosis of a physical disease (*M* = 7.15, *SD* = 3.37) compared to those who did not have a diagnosis (*M* = 6.03, *SD* = 2.80; *t* (1281.1) = 7.881, $p \leq 0.001$). Those taking medication for physical (*M* = 7.29, *SD* = 3.28) and mental (*M* = 8.25, *SD* = 3.79) health problems were more likely to report greater Global PSQI Component Scores than those not taking medication (*M* = 6.17, *SD* = 2.95 and *M* = 6.27, *SD* = 2.94 respectively; *t* (769.5) = -6.854, $p \leq 0.001$, *t* (182.38) = -6.56, $p \leq 0.001$). Workers who screened positively for PTSD (*M* = 10.05, *SD* =2.93), depression (*M* = 9.25, *SD* = 2.84), and anxiety (*M* = 10.32, *SD* = 3.04) had significantly poorer overall sleep quality when compared to those who did not screen for these respective mental health concerns (*M* = 6.00, *SD* = 2.78; *M* = 5.62, *SD* = 2.62; *M* = 6.15, *SD* = 2.88; *t* (2059) = -20.309, $p \leq 0.001$, *t* (642.1) = -25.074, $p \leq 0.001$, *t* (2057) = -15.036, $p \leq 0.001$ respectively). Additionally, participants reporting elevated levels of fatigue were more likely to report poor sleep quality (*M* = 6.91, *SD* = 3.03) than those who reported experiencing normal levels of fatigue (*M* = 4.41, *SD* = 2.34; *t* (758.8) = -15.529, $p \leq 0.001$). Finally, those reporting higher levels of stress (*M* = 7.60, *SD* = 3.15) were significantly likely to report worst sleep quality than those who did not experience high stress (*M* = 5.39, *SD* = 2.59; *t* (1934.8) = -17.406, $p \leq 0.001$). No significant differences in sleep quality were observed for all other personal factors (i.e. gender, education, marital status, and income). Appendix B lists all independent sample t-test results for the complete set of personal factors.

3.2.3. Sleep quality relative to work-related factors

Participants who reported working shifts other than days (afternoons, nights and rotating shifts) were significantly likely to report worst overall sleep quality (M = 6.73, SD = 3.00) than those who worked dayshift (M = 6.18, SD = 3.11; t (2115) = 4.043, $p \leq 0.001$). As for personal burnout, participants who screened positively for personal, work, and colleague burnout (M = 8.70, SD = 2.97; M = 7.95, SD = 3.0; M = 7.73, SD = 3.10 respectively) were more likely to have worst self-reported sleep quality than those who did not screen positively for any kind of burnout (M = 5.53, SD = 2.62; M = 5.55, SD = 2.71; M = 6.10, SD = 2.97; t (984.1) = -22.821, $p \leq 0.001$, t (1418.8) = -17.897, $p \leq 0.001$, and t (2095) = -10.025, $p \leq 0.001$ respectively). Finally, individuals who reported having more effort than rewards in the workplace were significantly likely to report worst sleep quality (M = 7.44, SD = 3.07) than those who had more rewards than efforts (M = 5.70, SD = 2.87; t (1716.1) = -12.863, $p \leq 0.001$). No significant differences in sleep quality were observed for all other work-related factors (i.e. salaried vs non-salaried occupation, working underground or not, supervisor vs non-supervisors, and working overtime or not). Appendix C displays all independent sample t-test results for the complete set of work-related factors.

3.2.4. Sleep quantity relative to health behaviors

Independent sample t-test revealed that the sleep quantity for smokers (M = 5 hr:56 min, SD = 1 hr:04 min) was slightly but significantly shorter than for non-smokers (M = 6 hr:07 min, *SD* = 1 hr:02 min) (*t* (2190) = 3.387, $p \leq 0.001$). Furthermore, those who engaged in hazardous alcohol behaviors (*M* = 5 hr:58 min, *SD* = 1 hr:04 min) were more likely to have a mildly shorter sleep duration than those who did not (*M* = 6 hr:08 min, *SD* = 1 hr:02 min; *t* (2019) = 3.066, $p = 0.002$). Finally, participants who reported engaging in hazardous drug behavior (*M* = 5 hr:36 min, *SD* = 1 hr:03 min) were significantly likely to have significantly shorter sleep quantity than those who did not engage in such behavior (*M* = 6 hr:06 min, *SD* = 1 hr:03 min; *t* (1884) = 3.425, $p \leq 0.001$). Sleep quantity was not impacted by physical activity participation. Appendix D displays the results of the independent sample t-tests for all the health behaviors.

3.2.5. Sleep quantity relative to personal factors

Males (*M* = 6 hr:03 min, *SD* = 1 hr:02 min) were more likely to report shorter sleep durations than females (*M* = 6 hr:17 min, *SD* = 1 hr:12 min; *t* (286.6) = 2.838, $p = 0.005$). Participants who had high school and college education (*M* = 6 hr:02 min, *SD* = 1 hr:03 min) were significantly likely to have slightly shorter sleep durations than those with university education (*M* = 6 hr:15 min, *SD* = 1 hr:03 min; *t* (2207) = 4.293, $p \leq 0.001$). Additionally, participants who reported never being diagnosed with a physical disease (*M* = 6 hr:00 min, *SD* = 1 hr:08 min) were more likely to report marginally shorter sleep durations than those with a diagnosis of some sort (*M* = 6 hr:08 min, *SD* = 1 hr:00 min; *t* (1435.3) = -2.710, $p = 0.007$). However, the opposite was observed in terms of being diagnosed with a mental health condition. In particular, participants who reported being diagnosed with a mental health condition (*M* = 6 hr:00 min, *SD* = 1 hr:06 min) were significantly likely to report slightly shorter sleep durations when compared to those with no diagnosis (*M* = 6 hr:06 min, *SD* = 1 hr:02 min; *t* (2199) = 2.052, $p = 0.040$). In regard to taking medication for physical health, those taking prescribed medication (*M* = 5 hr:57 min, *SD* = 1 hr:05 min) were more likely to report shorter sleep durations compared to participants who did not take medication (*M* = 6 hr:06 min, *SD* = 1 hr:02 min; t (2199) = 2.940, $p = 0.003$). Additionally, participants who indicated experiencing difficulty paying their bills (*M* = 5 hr:52 min, *SD* = 1 hr:04 min) were more likely to have shorter sleep quantity than those with no difficulty (*M* = 6 hr:11 min, *SD* = 1 hr:02 min; t (2193) = 6.357, $p \leq 0.001$). Individuals who screened positively for PTSD (*M* = 5 hr:32 min, *SD* = 1 hr:04 min), depression (*M* = 5 hr:39 min, *SD* = 1 hr:04 min), and anxiety (*M* = 5 hr:36 min, *SD* = 1hr :08 min) were significantly likely to self-report shorter sleep durations compared to the participants who screened negatively for PTDS (*M* = 6 hr:09 min, *SD* = 1 hr:01 min), depression (*M* = 6 hr:12 min, *SD* = 1 hr:01 min), and anxiety (*M* = 6 hr:07 min, *SD* = 1 hr:00 min) (t (2123) = 8.432, $p \leq 0.001$, t (643.2) = 9.310, $p \leq 0.001$, and t (2129) = 5.118, $p \leq 0.001$ respectively). Those screening positively for elevated levels of fatigue (*M* = 6 hr:01 min, *SD* = 1 hr:02 min) were significantly more likely to self-report shorter sleep durations than those with normal levels of fatigue (*M* = 6 hr:20 min, *SD* = 1 hr:03 min; t (2171) = 5.552, $p \leq 0.001$). Finally, participants with elevated levels of stress (*M* = 5 hr:54 min, *SD* = 1 hr:04 min) were more likely to report shorter sleep durations compared to those with stress levels below average (*M* = 6 hr:14 min, *SD* = 1 hr:00 min; t (2137) = 7.513, $p \leq 0.001$).

Significant differences in sleep quantity between the BMI categories were observed [F (5, 2159) = 4.977, $p \leq 0.001$]. Post-hoc analyses (Tukey) confirmed participants in the overweight type I category were significantly likely to report shorter sleep durations (*M* = 5:57, *SD* = 1:02) when compared to those in the normal weight category (*M* = 6:12, *SD* = 1:04) ($p = 0.006$).

No differences in sleep quantity were observed for all other personal factors (i.e. marital status, medication for mental health, income). Appendix E displays the results for all the personal factors independent sample t-test analyses.

3.2.6. Sleep quantity relative to work-related factors

Participants who reported working a non-salaried occupation (*M* = 6 hr:00 min, *SD* = 1 hr:02 min) were more likely to have shorter sleep quantity than those with salaried positions (*M* = 6 hr:12 min, *SD* = 1 hr:03 min; t (2188) = 4.143, $p \leq 0.001$). Individuals working shifts other than day shifts (i.e. afternoon and night shift) (*M* = 5 hr:52 min, *SD* = 1 hr :01 min) were significantly likely to report shorter sleep quantity than those who strictly worked days (*M* = 6 hr:14 min, *SD* = 1 hr:03 min; t (2200) = -7.963, $p \leq 0.001$). Participants reporting personal (*M* = 5 hr:44 min, *SD* = 1 hr:03 min), work-related (*M* = 5 hr:48 min, *SD* = 1 hr:03 min), and colleague-related burnout (*M* = 5 hr:54 min, *SD* = 1 hr:07 min) were more likely to report shorter sleep durations than those who did not screen positively for any type of burnout (personal *M* = 6 hr:13 min, *SD* = 1 hr:01 min; work-related *M* = 6 hr:14 min, *SD* = 1 hr:00 min; colleague-related *M* = 6 hr:08 min, *SD* = 1 hr:02 min; t (2184) = 10.036, $p \leq 0.001$, t (2150) = 9.598, $p \leq 0.001$, and t (651.5) = 3.790, $p \leq 0.001$ respectively). Additionally, the participants who reported experiencing more effort than rewards at work (*M* = 5 hr:54 min, *SD* = 1 hr:03 min) were significantly likely to report shorter sleep quantities than those who had more rewards than efforts in the workplace (*M* = 6 hr:13 min, *SD* = 1 hr:02 min; t (2098) = 6.945, $p \leq 0.001$). Finally, those who worked overtime (*M* = 6 hr:02 min, *SD* = 1 hr:02 min) were more likely to report slightly shorter sleep durations than those who did not work overtime (*M* = 6 hr:11 min, *SD* = 1 hr:05 min; t (2203) = 3.171, $p = 0.002$). No differences in sleep quantity were observed for the remainder of the work-related factors (i.e. worksite, underground work, and supervisor). See Appendix F for the independent sample t-test results for all of the work-related factors.

3.3. Third Research Question – Which health behaviors, personal factors or work-related factors can best predict poor measures of sleep quality?

Multiple regression analysis was used to test which health behaviors, personal factors, and work-related factors best predicted sleep quality. The results of the regression analysis indicated that seven predictors explained 37.1% of the variance ($R^2 = 0.371$, F (7, 1572) = 131.78, $p \leq 0.001$). More specifically, it was found that symptoms of depression significantly predicted sleep quality ($\beta = 1.75$, $p \leq 0.001$), as did personal burnout ($\beta = 1.46$, $p \leq 0.001$), fatigue ($\beta = 1.46$, $p \leq 0.001$), PTSD ($\beta = 1.67$, $p \leq 0.001$), shiftwork ($\beta = -0.63$, $p \leq 0.001$), diagnosis of a chronic disease ($\beta = 0.55$, $p \leq 0.001$) and hazardous drug use ($\beta = 1.03$, $p = 0.008$). An assessment of collinearity between these predictor variables was conducted and the results are presented in Table 5. Both tolerance and the variance inflation factor (VIF) were verified to estimate multicollinearity in the regression model. Tolerance levels > 0.1 and VIF levels <10 were deemed to be within acceptable ranges. Based on these parameters, it was concluded that the variables in our model uniquely contribute to predicting poor sleep quality in our participant pool.

Table 5. *Multicollinearity output of Regression Model for Question 3: Which health behaviors, personal factors or work-related factors can best predict poor measures of sleep quality?*

Model Variables	**Tolerance**	**VIF**
Beck Depression Inventory	0.580	1.724
Burnout – Personal	0.649	1.542
Fatigue	0.928	1.078
PTSD	0.721	1.387
Shiftwork	0.987	1.014
Diagnosis of Chronic Disease	0.974	1.026
DAST-20	0.985	1.015

3.4. First Hypothesis - Dayshift workers will have better overall sleep quality and quantity when compared to workers in other shifts

There was a significant difference in the Global mPSQI Scores in dayshift workers (M = 6.18, SD = 3.11) and other shift type workers (M = 6.73, SD = 3.00); t (2115) = 4.043, $p \leq$ 0.001). Although the average Global mPSQI Component Score for dayshift workers was still above the acceptable cut off point of 4, they still had a better overall sleep quality than those working in other types of shifts. Additionally, there was a significant difference in the sleep duration in dayshift workers (M = 6 hr:14min, SD = 1 hr:03min) and other shift type workers (M = 5hr:53min, SD = 1hr:01min); t (2200) = -7.963, $p \leq$ 0.001. Although dayshift workers slept on average 1 hour 45 min less than the recommended 8 hours of sleep per night, they still slept on average 21 minutes longer than other shift type workers.

3.5. Second Hypothesis - Underground workers with high physical demands will be more likely to experience poor sleep quality than surface workers with high physical demands

A 2x3 multivariate analysis of variance was performed on two independent variables: work underground (2 levels, yes or no) and the level of physical demand (low, moderate and high stress levels). The dependent variable was the Global mPSQI Component Score. There was a significant main effect of physical demands variable [$F_{(2,1308)} = 8.94$, $p \leq 0.000$ $\eta_2 = 0.013$] (see Figure 3). Post-hoc comparisons show that workers exposed to high physical demands had higher levels of poor sleep quality (M = 5.80, SD = 0.11) than those exposed to moderate (M = 5.38, SD = 0.13) and low levels of demands (M = 5.10, SD = 0.13). Furthermore, there was a significant interaction effect of physical demand levels and work location (i.e. underground vs above ground) [$F_{(2,1308)} = 3.83$, $p = 0.022$ $\eta_{2=}$ 0.006] (Figure 3). Post-hoc Tukey comparison shows that at low levels of physical demands, above ground workers have better sleep quality than underground workers whereas for moderate and high levels of demands, above ground workers reported worse sleep quality than underground employees.

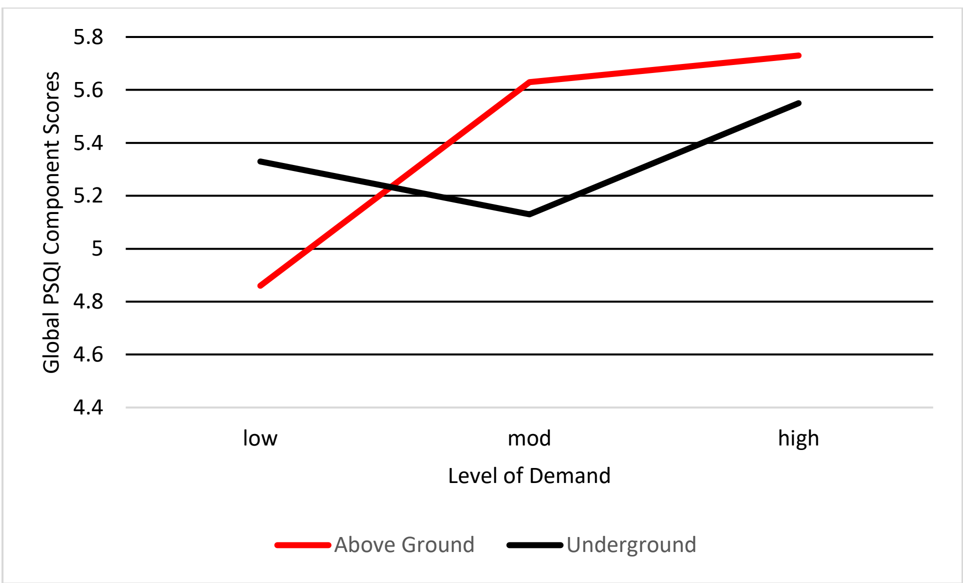

Figure 3. The effect of working above ground versus underground and level of physical demand on Global mPSQI Component Scores.

3.6. Third Hypothesis - Individuals reporting poor sleep quality will also report higher levels of stress, and will also screen positively for personal, work and colleague-related burnout

There was a significant difference in the levels of stress between participants reporting good sleep quality (PSS score *M* = 19.07, *SD* = 6.70) compared to those reporting poor sleep quality (PSS score *M* = 24.84, *SD* = 7.47). Individuals with poor sleep quality were more likely to report higher levels of stress when compared to those with good sleep quality (t (2063) = -16.31, $p \leq 0.001$). For personal burnout, individuals reporting poor sleep had higher burnout scores (CBI score *M* = 41.91, *SD* = 19.84) compared to good sleepers (CBI score *M* = 21.78, *SD* = 15.11; t (1472.34) = -25.21, $p \leq 0.001$). As for work related burnout, poor sleepers had higher levels of burnout (CBI score *M* = 46.38, *SD* = 19.78) compared to good sleepers (CBI score *M* = 29.77, *SD* = 17.40; t (1265.57) = -18.96, $p \leq 0.001$). Finally, for colleague related burnout, poor sleepers had greater levels of burnout (CBI score M = 29.92, *SD* = 24.77) compared to good sleepers (CBI score *M* = 17.57, *SD* = 20.56; t (2095) = -10.86, $p \leq 0.001$).

3.7. Fourth Hypothesis - Work-related factors such as poor job satisfaction, high mental demands, afternoon and nightshifts, and the physical work environment will be the greatest work-related predictors of poor sleep quality

Multiple regression analysis was used to test which work-related factors best predict sleep quality. The analysis revealed that six predictors explained 26.7% of the variance (R^2 = 0.267, F (6, 1907) = 116.54, $p \leq 0.001$). In particular, personal burnout (β = 2.47, $p \leq 0.001$), work-related burnout (β = 0.772, $p \leq 0.001$), low job satisfaction (β = - 0.599, $p \leq 0.001$), commute to work (β = 0.584, $p \leq 0.001$), shift work (β = -0.469, $p \leq 0.001$), and colleague-related burnout (β = 0.468, $p \leq 0.001$) significantly predicted sleep quality. The stressful work environment and high mental demands variables did not specifically emerge as significant predictors of sleep quality (See Table 6 for the results of the multicollinearity output). The results do not indicate multicollinearity between the variables as each are respectively above 0.1 (tolerance) and below 10 (VIF).

Table 6. *Multicollinearity Output of Regression Model for fourth hypothesis: Work-related factors such as poor job satisfaction, high mental demands, afternoon and nightshifts, and the physical work environment will be the greatest work-related predictors of poor sleep quality*

Model Variables	**Tolerance**	**VIF**
Burnout – Personal	0.729	1.371
Burnout – Work-related	0.640	1.564
Job Satisfaction	0.794	1.259
Commute to work	0.978	1.023
Shiftwork	0.963	1.039
Burnout – Colleague	0.870	1.149

CHAPTER 4: DISCUSSION

In the current study, the sleep quality of workers in the mining industry, which is a component of the personal health resources, was investigated because sleep quality is thought to significantly impact the safety and health of workers. The purpose of the study was to describe the sleep profile of workers within this industry, to compare the sleep profile of workers relative to a number of health, personal and work-related variables and to determine the variables that can best predict sleep quality.

The main findings of the study are that more than 84% of workers report poor sleep quality, that most workers sleep less than the recommended 7 to 8 hours per night, that dayshift workers report better sleep quality compared to other shift type workers, that workers reporting higher levels of stress have poorer sleep, and that aboveground workers reporting moderate to high levels of physical stress also report poorer sleep compared to underground workers. Furthermore, variables such as depression, personal burnout, fatigue, PTSD, shiftwork, diagnosis of a chronic disease and hazardous drug use were found to be significant predictors of poor sleep quality. Additionally, when only considering the work-related factors, commute to work, and low job satisfaction were also found to predict poor sleep quality but were not significant predictors when all variables were considered in the regression model. In the next paragraphs, these findings will be further discussed and contextualized.

In the current investigation, the average overall sleep quality of our participant pool of over 2000 workers was 6.4 (mPSQI score). This finding is in line with that reported in another study of 19 workers from the mining industry (Legault et al., 2017). The average PSQI score in that study was 6.3. In terms of sleep duration, our finding that most workers sleep less than the recommended 7 to 8 hours per night is unsurprising and supports current trends reported in the literature for other occupations such as wildland firefighters (McGillis et al., 2017), nurses (Zhang, Punnett, McEnany & Gore, 2016), and police officers (Charles, Burchfiel, Fekedulgen, Bila, Hartley, Slaven, Mnatsakanova & Violanti, 2007). Chronic poor sleep and sleep deprivation is a potential concern for the health and safety of mine workers many of whom operate equipment and perform tasks requiring focus and attention.

In our current study, we found that workers, who engaged in excessive alcohol intake, had hazardous drug behaviors and who smoked reported poorer sleep profiles than workers who did not engage in such behaviors. These findings are in line with many studies in the literature. For instance, Hartwell and colleagues (2015) found that participants with increased alcohol dependence were more likely to report symptoms of insomnia. In addition, alcohol is known to influence sleep architecture and can lead to workers feeling fatigued. Although some individuals may report feeling rested the day following excessive alcohol intake, sleep measurements indicate otherwise (Stein & Friedmann, 2006). As it relates specifically to the mining industry, our data linking poor sleep quality to problematic alcohol intake is of particular concern as there is evidence suggesting that the prevalence of alcohol-related problems in this particular workplace is elevated (Lennings et al., 1997; Macdonald & Well, 1996; Violanti et al., 2011; du Plessis et al., 2013, Tynan et al., 2017). For instance, alcohol use was found to be within the risky or hazardous levels for approximately 63% of the participants from a study in the coal mining industry (Tynan et al., 2017). The multivariate analysis revealed that several health behaviors (illicit drug use and smoking) and personal factors (age, gender and psychological distress) were associated with alcohol use (Tynan et al., 2017). In comparison, our researchers have found that 22.9% of participants in our study engage in risky alcohol consumption (Larivière, Kerekes, Lessel, Smith, Sinclair, Tiszberger & Leduc, 2018).

The relationship between illicit and recreational drug use and poor sleep quality and quantity is well established (Simou, Britton & Leonardi-Bee, 2018; Hsu, Chiu, Chang, Chang & Lane, 2019). Different drugs such as opioids, cannabis and cocaine have various effects on sleep architecture, but commonly they seem to increase sleep disturbances therefore influencing the perception of overall poor sleep quality (Schierenbeck et al., 2008; Hassamal et al., 2016). Previous studies suggest there are differences between the sleep architecture of smokers and non-smokers (Zhang et al., 2006; Zhang et al., 2007). Specifically, smokers were more likely to have increased sleep latency, decreased TST, extended REM-sleep latency, decreased SWS and reduced sleep efficiency when compared to non-smokers (Zhang et al., 2006). Smoking and excessive alcohol consumption can also increase the risk of sleep apnea (Krishnan, Dixon-Williams & Thorton, 2014). Collectively, hazardous alcohol and drug use as well as smoking result in worst sleep profiles of workers in the mining industry, which can potentially hinder focus and attention and impact the health and safety of workers.

Our results indicate that 86.2% of workers reported meeting the CSEP guidelines of 150 minutes of moderate-to-vigorous exercise per week, which is a much greater level than what is reported in Canada for adults. The most recent available data indicates that only 16% of adults between the ages of 18 and 79 meet that CSEP guideline (Clarke, Jannssen, Tremblay, 2019). It is unclear whether workers distinguished between leisurely physical activity and the physical activity that is completed from performing tasks at work. Our data suggest there is no difference in sleep quality between mine workers that meet the physical activity guideline versus those that do not. However, this does not go against the notion that regular physical activity is regarded as being beneficial for good sleep. Accordingly, the promotion of regular physical activity within this workforce is highly recommended given its widespread positive impact on overall wellbeing including sleep quality.

Workers with unhealthy body composition reported worst sleep quality in our study. These two variables have a bidirectional relationship meaning that poor sleepers may be at greater risk of developing unhealthy body composition and those with poor body composition (i.e. obese) tend to have worst sleep quality (Westerterp-Plantenga, 2016). In a longitudinal study, Taheri and colleagues (2004) found a significant U shape relationship between the amount of total time slept and individuals' average BMI's. Individuals that slept 6 hours or less or more than 9 hrs had higher BMI's than individuals that slept on average 7.7 hours per night, which is well within the recommended 7 to 8 hours per night from the National Sleep Foundation (Hirshkowitz et al, 2015). Ultimately, this is explained by the circadian rhythm that is synchronized on 7-8 hours of sleep (Taheri et al., 2004).

Participants taking medication for mental and physical health concerns were found to have lower sleep quality than those not taking medication. It is possible that poor sleep is a side effect of the medication or could be related to the condition for which medication has been prescribed. We did observe that participants diagnosed with a chronic health concern such as diabetes and high blood pressure or diagnosed with mental health concerns such as depression, anxiety, PTSD and stress reported worst sleep quality than participants who did not meet criteria for such diagnoses. There is a well-established relationship between all of the mental health concerns listed above and poor sleep quality (Buysse, Reynolds, Mond, Berman & Kupfer, 1989; Thase, 2006; Babson, Blonigen Boden, Drescher & Bonn-Miller, 2012; Pires Tufik & Andersen, 2015). Poor sleep quality may be a symptom of these mental health concerns but could also trigger or worsen these mental health problems. For example, prolonged stress increases cortisol secretion, which in turn hinders the secretion of important neurotransmitters such as serotonin, melatonin and histamine, that play a crucial role in sleep onset and maintenance but that are also implicated in mental illness (Van Reeth et al., 2000; Fortunato & Harsh, 2006; Lin, Liao, Chen & Fan, 2014).

We hypothesized that participants who reported poor sleep quality would be more likely to report higher levels of stress as well as screen positively for personal, work and colleague-related burnout (discussed below). The results do in fact support our hypothesis. Participants with higher perceived stress levels reported poorer sleep quality than those with lower levels of perceived stress, which conforms with existing literature. For instance, female police officers who perceived high levels of stress were 4 times more likely to report poor sleep quality (*OR* = 3.72; 95% *CI* = 1.14 – 12.13) compared to other female police officers with lower stress levels (Charles et al., 2011). Furthermore, male counterparts with high levels of perceived stress were 6 times more likely to experience poor sleep quality (*OR* = 5.94 ; 95% *CI* = 2.50 – 14.13) compared to those with lower stress levels (Charles et al., 2011). In the context of the mining industry, there are a variety of potential sources of stress. For example, a study by Green, Jones, Sun & Neitzel (2015) suggests that elevated noise in the mining industry is associated with increased cortisol levels, a marker of stress. Stress can also result from work-family imbalance, job insecurity, the physical environment, or the overall safety of the work environment (McPheran & De Leo, 2014; Smit, Beer & Pienarr, 2016; Dennie, Larivière, Kerekes, Eger, Tiszberger, Dignard, Nowrouzi-Kia, Smith, Schutt, Lessel, Larivière, 2018).

Poor sleep quality in mine workers was significantly associated with high levels of burnout for all three subcategories (personal, work and colleague), which follows the trends observed in the literature. The relationship between disturbed sleep and occupational burnout in one study by Ekstedt et al., (2006) demonstrates that participants who experienced high levels of burnout had greater sleep arousal, sleep fragmentation, longer wake times and stage-1 sleep, lower sleep efficiency, less SWS and REM and lower density in their sleep waves. Comparatively, a study by Gao, Ma, Wang, Gao, Lei & Wang (2019) indicates that good sleep quality was associated with lower risk of burnout in coal miners. Collectively, these results suggest that burnout not only affects the perception of sleep quality but also the physiological structure of sleep.

Work-related factors such as shiftwork and effort-reward imbalance were found to impact sleep quality. We hypothesized that participants working shifts other than dayshift would be more likely to self-report poor sleep quality and quantity. Our results indicate that dayshift workers do in fact perceive their sleep quality and quantity to be better than the workers working other shifts. The results are in line with trends reported in the literature. Shift workers from a variety of occupations such as nurses (Zhang et al., 2016), police officers (Charles et al., 2007), and factory workers (Vetter, Juda & Roenneberg, 2012) experience worst sleep quality when compared to those working strictly dayshifts. Shift work disrupts the circadian rhythm, which then deregulates the secretion of hormones and neurotransmitters that are important for sleep (James, Honn, Gaddameedhi & Van Dongen, 2017). Shiftwork is highly prevalent in the mining industry and may have many adverse effects on health, sleep, alertness, life satisfaction and job performance (Omidi, Zare, Rad, Meshkani & Kalantary, 2017).

Our finding that shiftwork and workplace burnout are related to worst sleep quality is supported by studies in other occupations. For instance, Peterson and colleagues (2019) found a similar relationship between poor sleep quality and burnout in a sample of 3140 police officers. This study also reported that long shifts, mandatory overtime, short sleep and fatigue were factors that were associated with an increase in overall burnout rates in the police force (Peterson et al., 2019). Similar outcomes were also reported in a sample of nurses (Witkoski Stimpfel, Sloane & Aiken, 2012; Dall'Ora, Griffiths, Ball, Simon & Aiken, 2015). A significant association between insufficient sleep and the development of clinical burnout has also been reported (Åkerstedt, Soderstrom, Jeding, Ekstedt, Perski & Åkerstedt, 2012). As for the relationship between effort-reward imbalance and sleep quality, a study by Kudielka and colleagues (2004) suggests that workers reporting over commitment at work were also reporting worst sleep quality. Some of the underlying mechanisms may be related to lower levels of awakening cortisol, which tend to occur in situations where high effort and lower reward result in workplace stress (Bellingrath, Weigl & Kudielka, 2008, Maina, Palmas, Bovenzi & Larese, 2008; Eller, Nielson, Blond, Nielsen, Hanson & Netterstrom, 2012). These physiological changes may disrupt an individual's circadian rhythm and negatively impact sleep quality.

We had hypothesized that underground workers with high physical demands would have worst sleep quality than those working above ground. In fact, our data paint a more complex picture regarding sleep quality of underground versus above ground workers in the mining industry. At low levels of physical demands, above ground workers have better sleep quality than underground workers whereas for moderate and high levels of demands, above ground workers reported worse sleep quality than underground employees. An alternative explanation of the findings could be that those working above ground could have been working outside during the summer months during the data collection phase of the study resulting in perceived higher physical demands compared to those working underground in a more "controlled" environment. It is important to keep in mind that to measure the physical demands in the workplace, we used a subscale of the NIOSH Generic Job Stress Questionnaire. This questionnaire collects information on a true or false scale to assess noise, lighting, temperature, humidity, air circulation, air quality, exposure to dangerous substances, the overall physical environment, and crowded work environments. Therefore, this approximates the physical work environment and whether it reflects the real physical demand level remains an open question. Finally, the comparison of underground workers and above ground workers did not take in consideration the specific occupation. Therefore, the analysis takes in consideration the comparision between those who work in an office setting of the mining industry and were further compared to underground workers. Perhaps a physical demand analyses conducted by an objective third party would yield a different outcome for this research question and hypothesis.

To develop effective intervention strategies to improve sleep in workers from the mining industry, we conducted analyses aimed at determining the variables that are best able to predict sleep quality within this population of workers. In order to determine which health behavior, personal factor or work-related factor influenced sleep quality the most, a stepwise regression was performed. Our analyses revealed that depression, personal burnout, fatigue, PTSD, shiftwork, a diagnosis of a chronic disease and hazardous drug use collectively explained 37.1% of the variance in sleep quality. Depression was the variable that explained the most variance in the model. As previously mentioned, there is a well-established relationship between mental health concerns such as depression and poor sleep quality and therefore this result was entirely expected (Buysse, Reynolds, Mond, Berman & Kupfer, 1989; Thase, 2006; Babson, Blonigen Boden, Drescher & Bonn-Miller, 2012; Pires Tufik & Andersen, 2015).

We also performed a separate stepwise regression analysis using only the work-related factors, which may be modifiable and targeted for interventions. Personal burnout, work-related burnout, low job satisfaction, long commute to work, shiftwork and colleague-related burnout collectively explained 26.7% of the total variance in sleep quality. It is not surprising that all three of the burnout variables (personal, work-related and colleagues) emerged as significant predictors of poor measures of sleep quality as this is supported by other studies linking burnout to disrupted sleep architecture (Ekstedt et al., 2006). It is of concern yet unsurprising that the commute to work is a predictor of sleep quality. Considering that the locations of most of the mines in this specific study are in the periphery of the city, dayshift workers are required to wake up early to commute to their worksites sometimes for well over one hour one-way. Furthermore, although the shifts start around 6am, workers must arrive ahead of time in order to have the safety meetings and change in their protective equipment before starting their workday. In a study of nurses, Dorrian et al. (2008) found that participants travelled on average 19.3 ± 11.8 minutes to and from work. Over a 28-day period, 70 occasions of extreme drowsiness when driving were reported along with seven near accidents (Dorrian et al., 2008). Nearly half of these incidents were reported between the hours of 0700 and 0900, meaning the nurses had just completed their nightshift (Dorrian et al., 2008). However, 40% of the cases of drowsiness were reported to happen between 1400 and 1900 (Dorrian et al., 2008). Commuting home can be a form of stress for some individuals, especially after working long hours in hostile environments and may contribute to worker burnout. The work environment including mismatches between job demands and job control, shiftwork, supervisors, colleagues or the physical working environment can lead to low satisfaction in the workplace (Framke, Sorensen, Pedersen & Rugulies, 2016). Because low job satisfaction emerged as a significant predictor of poor sleep quality, future studies are warranted to further examine what factors have the greatest impact on job satisfaction in the mining industry.

This project can be nested in the WHO Healthy Workplace Model with the two core principles of the framework: management commitment and workers' involvement. That being said, both the employer and the employee have a responsibility to maintain a safe work environment. Workers who are sleep deprived should not meet the requirements of a "healthy worker" and management should be able to recognize the signs of a fatigued worker. This can then be addressed through the Risk Assessment and Management Cycle of the model, that should help workers of the mining industry manage their sleep.

4.1. Possible Interventions

The outcomes of the current study can be used to further develop targeted and tailored interventions aimed at improving the sleep profile and general wellbeing of mine workers that may be at greater risk of poor sleep. Possible interventions to improve overall sleep quality and quantity in the mining industry could incorporate a standard and generic sleep hygiene educational workshop delivered through work or during periodic safety meetings focused on how to achieve better sleep quality.

Alternatively, individualized support plans for workers who screen positive for depression, burnout, PTSD, who engage in hazardous drug use and who work shifts may be warranted.

Other interventions could focus on the relationship between the mind and the body, making individuals aware of their surroundings through forms of meditation, movement, massage and acupuncture (Neuendorf, Wahbeh, Chamine, Tu, Hutchison & Oken, 2015). Meditation has been shown to improve the total wake time and overall sleep quality (Gong, Ni, Liu, Zhang, Su, Lian, Peng & Jiang, 2016). Theoretically, the practice of mindfulness allows the body to improve the self-regulation of the psychological, behavioral, and physiological reactions (Glomb, Duffy, Bono & Yang, 2011). Practicing mindfulness allows one to unwind and step back from the demands of work (Glomb et al., 2011). This then allows the body to recover in terms of psychological detachment, sleep quality, and sleep duration (Glomb et al., 2011).

Other suggested interventions that derive from the findings of this specific study, include the use of taxis or charter buses to transport employees to their vehicles that are parked at a location closer to their home. Drowsy driving is a major issue and often happens in night-shift workers (Lee, Howard, Horrey, Liang, Anderson, Shreeve, O'Brian & Czeisler, 2016). By having chartered buses or taxis for employees after their long shifts, this would help reduce vehicle collisions related to drowsiness. By removing the stress of the commute to and from work this could help alleviate some stress, which could improve overall sleep quality and wellbeing.

The development of an insentive program to encourage workers to stay active and healthy during their time off work could be implemented. The industry could provide a financial support for the purchase of an activity tracker (Fitbit), which would allow workers to be accountable of their own healthy habits. From there, workers could report their level of activity each week and could be rewarded with objects such as t-shirts, jackets or pins or even with extra days off. The industry could consult the FORCE program developed by the Canadian Armed Forces (Canadian Forces Morale & Welfare Services, 2020) and develop their own program.

Establishing a fatigue risk management system could also be beneficial. Workers that would screen as being too fatigued to be at work should be asked to rest a certain number of hours before starting the job. This intervention could work hand in hand with providing educational programs on sleep hygiene. For those working in an office setting of the mining industry, better lighting and promotion of physical activity throughout the day (i.e. taking a 10 minute walk every hour) would help promote healthy sleep behaviors. It is important to remember that this study took into consideration workers from various occupations throughout the mining industry. Therefore, health promotion/educational programs should be tailored to various occupations and needs of specific workers in the mining industry.

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CHAPTER 5: CONCLUSION AND LIMITATIONS

This current large-scale study of workers in the mining industry provides important data on the current state of sleep quality and quantity of workers in this occupational sector. Our results indicate that the majority of these workers self-report poor sleep quality and that most sleep less than the recommended 7 to 8 hours of sleep. A number of specific health behaviors as well as personal and work-related factors have emerged as being linked to sleep quality. More importantly, a set of factors such as depression, personal burnout, fatigue, PTSD, shiftwork, diagnosis of a chronic disease, hazardous drug use, commute to work, and low job satisfaction were found to predict poor sleep quality. This information can assist the mining industry in developing and optimizing evidence-informed strategies and interventions aimed at improving sleep quality and the overall wellbeing of workers. Research aimed to improve the health and wellbeing of mining workers can lead to widespread benefits in an industry with an undeniable economic impact nationally and globally.

There are some limitations to the study that should be considered. First, because some questions in the 45-page questionnaire were found to be redundant, some questionnaires were modified in order to eliminate the repetitious questions. This was the outcome of a pilot study, which involved an extensive consultation with the industry and with a subset of workers. For example, the second question on the original PSQI that asks, “How long (in minutes) has it taken you to fall asleep each night?” was removed. It was removed because of the redundancy of questions in the questionnaire. It was also removed because it would be hard to track the sleep quantity of workers on rotating and nightshift. Therefore, we were not able to calculate sleep efficiency, which is a variable often used to determine sleep quality. Second, the data was collected during the summer months; therefore, the results do not take in consideration the effects of seasonal depression during the winter months. Third, the sample size for some answers was low and therefore some categories were amalgamated to create new manipulated variables. For example, the variable that measured the frequency of smoking asked, "Would you consider yourself to be: a) A daily smoker, b) An occasional smoker, c) A former daily or occasional smoker, d) a never smoker". The variable was manipulated and both a) and b) were categorized together to form the smoker variable, and c) and d) were clustered together to make the non-smoker variable. This may have impacted our ability to flesh out the data in greater detail. Furthermore, despite our extensive consultation with many stakeholders of the mining industry and although every effort was made to create a comprehensive questionnaire to collect data on as many variables of potential relevance to the current set of research questions, it is possible that some variables may have been inadvertently omitted from the questionnaire and subsequent data collection and analyses. Finally, even with this comprehensive research, the interpretation of the results is relevant specifically to this cohort of mine workers and may not be generalizable to other cohorts of mine workers.

The most important future study should be to determine the effectiveness of intervention strategies as described above on the sleep quality of workers. Also, it would be beneficial to conduct more detailed sub-analyses of the various workers according to their specific occupations within the mining industry to further define the factors that impact sleep quality and to optimize interventions. Industries must take into consideration the health and wellness of their employees, and this often starts with a good night sleep.

Bibliography 5.1

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Appendices

Appendix A. *Independent sample t-test analyses for sleep quality relative to health behaviors.*

Variables	*M* and *SD*	*t*-test results
Smoker	M = 6.60, SD = 3.13	t (2105) = -1.48, $p = 0.140$
Non-Smoker	M = 6.37, SD = 3.04	
Meets CSEP Guidelines	M = 6.45, SD = 3.07	t (1852) = 0.028, $p = 0.978$
Does not Meet CSEP Guidelines	M = 6.43, SD = 3.12	
Hazardous Alcohol Behavior	M = 6.94, SD = 3.09	t (1955) = -4.75, $p \leq 0.001$*
Non-Hazardous Alcohol Behavior	M = 6.19, SD = 3.00	
Hazardous Drug Behavior	M = 8.57, SD = 3.02	t(1825) = -4.92, $p \leq 0.001$*
Non-Hazardous Drug Behavior	M = 6.43, SD = 3.07	

*Indicates significant difference between the group variables

Appendix B. *Independent sample t-test analyses for sleep quality relative to personal factors.*

Variables	*M* and *SD*	*t*-test results
Males	M = 6.39, SD = 3.04	t (2120) = 1.455, p = 0.223
Females	M = 6.70, SD = 3.23	
Less than high school – College	M = 6.46, SD = 3.06	t (2121) = -0.910, p = 0.363
Some university – Doctoral	M = 6.32, SD = 3.07	
Marital Status – Single	M = 6.66, SD = 3.06	t (2111) = -1.475, p = 0.140
Marital Status – In a Relationship	M = 6.39, SD = 3.06	
BMI Underweight	M = 6.33, SD = 4.92, p = 0.464	[F(5) = 5.762, $p \leq 0.001$]*
BMI Normal Weight	M = 6.06, SD = *3.01*	
BMI Overweight	M = 6.06, SD = 2.86, p = 0.988	
BMI Obese Type I*	M = 6.68, SD = 3.09, p = 0.040	
BMI Obese Type II*	M = 6.97, SD = 3.15, p = 0.028	
BMI Obese Type III*	M = 7.40, SD = *3.42*, p = 0.013	
Presence of Chronic Disease	M = 7.15, SD = 3.37	t (613.9) = -9.392, $p \leq 0.001$*
No Chronic Disease	M = 6.03, SD = 2.80	
Mental Health Diagnosis	M = 7.74, SD = 3.40	t (613.9) = -9.392, $p \leq 0.001$*
No Mental Health Diagnosis	M = 6.08, SD = 2.88	
Medication for Mental Health	M = 8.25, SD = 3.80	t (618.86) = -9.408, $p \leq 0.001$*
No Medication for Mental Health Issue	M = 6.27, SD = 2.94	
Medication for Physical Health	M = 7.29, SD = 3.28	t (769.5) = -6.854, $p \leq 0.001$*

No Medication for Physical Health	$M = 6.17$, $SD = 2.95$	
Income – $80,000 or Less	$M = 6.39$, $SD = 2.98$	$t\ (1394.4) = 1.089$, $p = 0.289$
Income - $80,000 and Above	$M = 6.54$, $SD = 3.24$	
Difficulty Paying Bills	$M = 7.33$, $SD = 3.18$	$t\ (1137.8) = -9.062$, $p \leq 0.001$*
No Difficulty Paying Bills	$M = 6.04$, $SD = 2.94$	
PTSD Checklist – Additional Screening	$M = 10.05$, $SD = 2.93$	$t\ (2059) = -20.309$, $p \leq 0.001$*
PTSD Checklist – No Concern	$M = 6.00$, $SD = 2.78$	
Beck Depression Inventory – Additional Screening	$M = 9.25$, $SD = 2.84$	$t\ (642.1) = -25.074$, $p \leq 0.001$*
Beck Depression Inventory – No Concern	$M = 5.62$, $SD = 2.62$	
Beck Anxiety Inventory - Additional Screening	$M = 10.32$, $SD = 3.04$	$t\ (2057) = -15.036$, $p \leq 0.001$*
Beck Anxiety Inventory – No Concern	$M = 6.15$, $SD = 2.88$	
Fatigue Severity Scale – Hazardous Fatigue Levels	$M = 6.91$, $SD = 3.03$	$t\ (758.8) = -15.529$, $p \leq 0.001$*
Fatigue Severity Scale – Normal Fatigue Levels	$M = 4.41$, $SD = 2.34$	
Perceived Stress Scale – Above Average Scores	$M = 7.60$, $SD = 3.15$	$t\ (1934.8) = -17.406$, $p \leq 0.001$*

Perceived Stress – Below Average Scores	*M* = 5.39, *SD* = 2.59

*Indicates significant difference between the group variables

Appendix C. *Independent sample t-test analyses for sleep quality relative to work-related factors*

Variables	*M* and *SD*	*t*-test results
Worksite – Mine	$M = 6.45$, $SD = 3.06$	t (2100) = -0.299, p = 0.765
Worksite – Other	$M = 6.41$, $SD = 3.04$	
Occupation– Salary	$M = 6.38$, $SD = 3.00$	t (2102) = -0.672, p = 0.502
Occupation – Non-Salary	$M = 6.48$, $SD = 3.01$	
Work Underground	$M = 6.48$, $SD = 3.08$	t (2121) = -0.792, p = 0.428
Work Above Ground	$M = 6.37$, $SD = 3.05$	
Shift Type – Dayshift	$M = 6.18$, $SD = 3.11$	t (2115) = 4.043, $p \leq 0.001$*
Shift Type - Other	$M = 6.73$, $SD = 3.00$	
Burnout Personal – No Concern	$M = 8.70$, $SD = 2.97$	t (984.1) = -22.821, $p \leq 0.001$*
Burnout Personal - Concern	$M = 5.53$, $SD = 2.62$	
Burnout Work – No Concern	$M = 7.95$, $SD = 3.07$	t (1418.8) = -17.897, $p \leq 0.001$*
Burnout Work - Concern	$M = 5.55$, $SD = 2.71$	
Burnout Colleague – No Concern	$M = 7.73$, $SD = 3.10$	t (2095) = -10.025, $p \leq 0.001$*
Burnout Colleague – Concern	$M = 6.10$, $SD = 2.97$	
ERI – More Rewards	$M = 5.70$, $SD = 2.86$	t (1716.1) = -12.863, $p \leq 0.001$*
ERI – More Effort	$M = 7.44$, $SD = 3.06$	
People Report	$M = 6.40$, $SD = 2.99$	t (2117) = 0.190, p = 0.849
No Report	$M = 6.44$, $SD = 3.09$	
Work Overtime	$M = 6.48$, $SD = 3.05$	t (2119) = -1.019, p = 0.308
No Overtime Work	$M = 6.33$, $SD = 3.12$	

*Indicates significant difference between the group variables

Appendix D. *Independent sample t-test analyses for sleep quantity (hr:min) relative to health behaviors.*

Variables	*M* and *SD*	*t*-test results
Smoker	$M = 5{:}56$, $SD = 1{:}04$	$t\ (2190) = 3.387$, $p \leq 0.001$*
Non-Smoker	$M = 6{:}07$, $SD = 1{:}02$	
Meets CSEP Guidelines	$M = 6{:}05$, $SD = 1{:}02$	$t\ (1914) = -1.299$, $p = 0.194$
Does not Meet CSEP Guidelines	$M = 6{:}11$, $SD = 1{:}05$	
Hazardous Alcohol Behavior	$M = 5{:}58$, $SD = 1{:}04$	$t\ (2019) = 3.066$, $p = 0.002$*
Non-Hazardous Alcohol Behavior	$M = 6{:}08$, $SD = 1{:}02$	
Hazardous Drug Behavior	$M = 5{:}36$, $SD = 1{:}03$	$t\ (1884) = 3.425$, $p \leq 0.001$*
Non-Hazardous Drug Behavior	$M = 6{:}06$, $SD = 1{:}03$	

*Indicates significant difference between the group variables

Appendix E. *Independent sample t-test analyses for sleep quantity (hr:min) relative to personal factors.*

Variables	*M* and *SD*	*t*-test results
Males	*M* = 6:03, *SD* = 1:02	*t* (286.6) = 2.838, *p* = 0.005*
Females	*M* = 6:17, *SD* = 1:12	
Less than high school – College	*M* = 6:02, *SD* = 1:03	*t* (2207) = 4.293, *p* ≤ 0.001*
Some university – Doctoral	*M* = 6:15, *SD* = 1:03	
Marital Status – Single	M = 6:06, *SD* = 1:05	*t* (450.5) = -0.065, *p* = 0.948
Marital Status – In a Relationship	*M* = 6:06, *SD* = 1:02	
BMI Underweight	*M* = 5:10, *SD*=1:02 *p*= 0.149	*F* (5, 2159) = 4.977, *p* ≤ 0.001*
BMI Normal Weight	*M* = 6:13, *SD* =1:04	
BMI Overweight	*M* = 6:09, *SD* = 1:00 *p* = 0.939	
BMI Obese Type I	*M* = 5: 57, *SD* = 1:01 *p* = 0.006*	
BMI Obese Type II	*M* = 6:02, *SD* = 1:11 *p* = 0.566	
BMI Obese Type III	*M* = 5:54, *SD* = 1:10 *p* = 0.185	
Presence of Chronic Disease	*M* = 6:08, *SD* = 1:00	*t* (1435.3) = -2.710, *p* = 0.007*
No Chronic Disease	*M* = 6:00, *SD* = 1:08	
Mental Health Diagnosis	*M* = 6:00, *SD* = 1:06	*t* (2199) = 2.052, *p* = 0.040*
No Mental Health Diagnosis	*M* = 6:06, *SD* = 1:02	
Medication for Mental Health	*M* = 6:06, *SD* = 1:12	*t* (203.58) = -0.263, *p* = 0.793
No Medication for Mental Health Issue	*M* = 6:05, *SD* = 1:02	
Medication for Physical Health	*M* = 5:57, *SD* = 1:05	*t* (2199) = 2.940, *p* = 0.003*
No Medication for Physical Health	*M* = 6:06, *SD* = 1:02	
Income – $80,000 or Less	*M* = 6:04, *SD* = 1:01	*t* (1471) = 0.465, *p* = 0.642
Income - $80,000 and Above	*M* = 6:06, *SD* = 1:06	
Difficulty Paying Bills	*M* = 5:52, *SD* = 1:04	*t* (2193) = 6.357, *p* ≤ 0.001*
No Difficulty Paying Bills	*M* = 6:11, *SD* = 1:02	
PTSD Checklist – Additional Screening	*M* = 5:32, *SD* = 1:04	*t* (2123) = 8.432, *p* ≤ 0.001*
PTSD Checklist – No Concern	*M* = 6:09, *SD* = 1:01	
Beck Depression Inventory – Additional Screening	*M* = 5:39, *SD* = 1:04	*t* (643.2) = 9.310, *p* ≤ 0.001*
Beck Depression Inventory – No Concern	*M* = 6:12, *SD* = 1:01	

Beck Anxiety Inventory -Additional Screening	*M* = 5:36, *SD* = 1:08	*t* (2129) = 5.118, $p \leq 0.001$*
Beck Anxiety Inventory – No Concern	*M* = 6:07, *SD* = 1:00	
Fatigue Severity Scale – Hazardous Fatigue Levels	*M* = 6:01, *SD* = 1:02	*t* (2171) = 5.552, $p \leq 0.001$*
Fatigue Severity Scale – Normal Fatigue Levels	*M* = 6:20, *SD* = 1:03	
Perceived Stress Scale – Above Average Scores	*M* = 5:54, *SD* = 1:04	*t* (2137) = 7.513, $p \leq 0.001$*
Perceived Stress – Below Average Scores	M = 6:14, SD = 1:00	

*Indicates significant difference between the group variables

Appendix F. *Independent sample t-test analyses for sleep quantity (hr:min) relative to work-related factors.*

Variables	*M* and *SD*	*t*-test results
Worksite – Mine	$M = 6{:}02$, $SD = 1{:}00$	$t\ (2132.2) = 2.764$, $p = 0.006$
Worksite – Other	$M = 6{:}09$, $SD = 1{:}05$	
Occupation– Salary	$M = 6{:}12$, $SD = 1{:}03$	$t\ (2188) = 4.143$, $p \leq 0.001$*
Occupation – Non-Salary	$M = 6{:}00$, $SD = 1{:}02$	
Work Underground	$M = 6{:}02$, $SD = 1{:}02$	$t\ (2163.2) = 2.605$, $p = 0.009$
Work Above Ground	$M = 6{:}08$, $SD = 1{:}04$	
Shift Type – Dayshift	$M = 6{:}14$, $SD = 1{:}03$	$t\ (2200) = -7.963$, $p \leq 0.001$*
Shift Type - Other	$M = 5{:}52$, $SD = 1{:}01$	
Burnout Personal – No Concern	$M = 5{:}44$, $SD = 1{:}03$	$t\ (2184) = 10.036$, $p \leq 0.001$*
Burnout Personal - Concern	$M = 6{:}13$, $SD = 1{:}01$	
Burnout Work – No Concern	$M = 5{:}48$, $SD = 1{:}03$	$t\ (2150) = 9.598$, $p \leq 0.001$*
Burnout Work - Concern	$M = 6{:}14$, $SD = 1{:}00$	
Burnout Colleague – No Concern	$M = 5{:}54$, $SD = 1{:}07$	$t\ (651.5) = 3.790$, $p \leq 0.001$*
Burnout Colleague – Concern	$M = 6{:}08$, $SD = 1{:}02$	
ERI – More Rewards	$M = 6{:}13$, $SD = 1{:}02$	$t\ (2098) = 6.945$, $p \leq 0.001$*
ERI – More Effort	$M = 5{:}54$, $SD = 1{:}03$	
People Report	$M = 6{:}03$, $SD = 1{:}00$	$t\ (2202) = 0.997$, $p = 0.319$
No Report	$M = 6{:}06$, $SD = 1{:}04$	
Work Overtime	$M = 6{:}02$, $SD = 1{:}02$	$t\ (2203) = 3.171$, $p = 0.002$*
No Overtime Work	$M = 6{:}11$, $SD = 1{:}05$	

*Indicates significant difference between the group variables