ABSTRACT
Evidence suggests that sleep deprivation can negatively affect behavior, wellbeing, and work performance. Although several researchers debated the relationships between sleep deprivation and work performance, research that clearly determines the relationship between construction workers’ sleep deprivation and safety performance has yet to be performed. To contribute to the analysis of such relationship, the researchers designed and administered a survey at three construction sites in Seattle (WA). The survey collected information about workers’ schedule, and sleeping habits and issues. The study concluded that most of the workers sleep between five to six hours before a working day and, therefore, could become the candidates to experience sleep deprivation related issues. Further, respondents were asked to rank the impact of sleep deprivation on the occurrence of ten types of near misses. Three types of near misses relating to the operation of forklifts, scissor lifts, trucks, or carts; the lack or improper use of personal protective equipment; and, the use of ladders were recognized as most likely to occur because of sleep deprivation. Thus, this study warrants that sleep deprivation might cause safety concerns for particular construction activities and that trade-specific investigation is necessary to clearly understand the relationship between sleep deprivation and safety.

INTRODUCTION
According to the United States (US) Bureau of Labor Statistics, the US construction industry is among the most dangerous industries with an average over 1,000 fatalities each year from 1994 to 2011. In the US, the current approach to construction safety is strongly based on the standards and regulations issued by the
Occupational Safety and Health Administration (OSHA). According to the US Department of Labor (2006), OSHA implements three main strategies such as strong enforcement of rules and regulations; outreach, education, and assistance to employers and employees; and, cooperation with employers in voluntary partnerships and alliances programs. This approach emphasizes the role of management commitment and workers’ training and motivation to prevent unsafe conditions and unsafe behavior (Mitropoulos et al. 2005). In particular, this approach is based on the hypothesis that a greater enforcement action (i.e., prescription, inspection, and punishment) enhances the motivation to comply (Scholz and Gray 1990). Although this approach has played an important role in improving safety on construction sites, it presents limitations (Mitropoulos et al. 2005) and is mostly associated with the lagging indicators of safety performance.

Near Misses as Leading Indicator of Safety Performance

Near misses can be defined as unplanned events in which no accidents and/or injuries occurred but had the potential to do so (Phimister et al. 2004). The collection and analysis of near misses proved to be a useful practice in enhancing safety in many areas (van der Schaaf and Kanse 2004), such as medicine (Kaplan 2005), nuclear and chemical plants (International Atomic Energy Agency 2005; Jones et al. 1999), and construction (Goldenhar et al. 2003; Hinze 2002). One of the main reasons supporting the use of near misses, rather than accidents and injuries, in serving as a leading indicator of safety performance lays in the fact that near misses are more frequent than accidents and injuries (Phimister et al. 2004). In fact, the ratio of near misses to events with harm can be as high as 300:1 (Kaplan 2005). Thus, when possible, researchers should always use near misses data when analyzing safety performance.

Chronic Sleep Deprivation and Human Performance

Chronic sleep deprivation is a frequent and pervasive issue in modern society (Bonnet 2005; Dinges et al. 2005; R. Powell and Copping 2010). Several factors causing chronic sleep deprivation have been identified, such as domestic and social responsibilities, excessive work demands (e.g., extended for hours), shift work, and medical disorders and conditions (e.g., insomnia, pain) (Bonnet and Arand 2003). Chronic sleep deprivation occurs when a person’s basal sleep need cannot be fulfilled (Webb 1969). In other words, chronic sleep deprivation occurs when a person suffers from sleep debt and, therefore, cannot obtain a daily amount of sleep sufficient to avoid the accumulation of waking deficits (Van Dongen, N. L. Rogers, et al. 2003). Basal sleep need changes between subjects and over time due to several factors, such as age, genetic characteristics, environmental conditions, and societal factors (Dinges et al. 2005). Studies analyzing healthy adults statistically determined that the basal sleep need is slightly over eight hours per day (Van Dongen, Maislin, et al. 2003; Wehr et al. 1993). However, it is not uncommon that a large part of the population gets less than eight hours per day of sleep. For instance, recent polls of the National Sleep Foundation (2011, 2012) determined that over 70% of the respondents (US residents, age 25 to 55 years) sleep less than eight hours per day during workdays (Figure 1 and Figure 2).
Although different individuals respond to sleep deprivation in significantly different ways, it is undoubtedly demonstrated that sleep deprivation can strongly impair human functioning in terms of behavior, well-being, and performance (Bell et al. 2002; Costa 1997; Davis et al. 2001; Dinges 1995; Pilcher and Huffcutt 1996). It is recognized that sleep deprivation increases daytime sleep propensity and negatively affects cognitive performance, mood, motivation, and health (Dinges et al. 2005). Numerous studies focused on the cognitive effects of sleep deprivation. Among other cognitive functions, several studies showed a decrease of vigilance and attention, short and long term memory, visuomotor performance, verbal functions, and planning and decision making skills. For instance, Alhola and Polo-Kantola (2007) listed over 50 studies reporting deterioration of performance in cognitive functions due to sleep deprivation. As noted elsewhere (Dinges et al. 2005), it was demonstrated that healthy adults consistently sleeping less than seven hours per night present cognitive
impairments similar to the ones observed in individuals not sleeping for 24 to 48 hours (Van Dongen, Maislin, et al. 2003). Further, several authors showed that the worsening in cognitive performance due to sleep deprivation is comparable to the one occurring after alcohol consumption (Dawson and Reid 1997; Fletcher et al. 2003; Lamond and Dawson 1999; Williamson and Feyer 2000). For instance, Williamson and Feyer (2000) determined that the cognitive performance of individuals not sleeping for 17 to 19 hours was comparable to that at a Blood Alcohol Content (BAC) of 0.05%. This finding is truly significant since the alcohol level at which a person is considered to be legally impaired is equal to 0.05% in most of the western European countries.

Numerous studies have been conducted to explore sleep deprivation consequences for drivers (Horne and Baulk 2004; N. B. Powell et al. 2002; Stutts et al. 2003; Taylor and Bramoweth 2010), and different trades and occupations. Several authors focused their attention on pilots and flight attendants (J. A. Caldwell 2012; J. A. Caldwell et al. 2004; Mallis et al. 2010; Roma et al. 2010); nurses and medical doctors (Bartel et al. 2004; Christian and Ellis 2011; MacDonald et al. 2011; Reznick and Folse 1987; Scott et al. 2006); and, soldiers (Killgore 2010; Miller et al. 2010). However, to the best of authors’ knowledge, only one study performed by Powell and Copping (2010) focused on construction workforce.

AIM OF THE STUDY

Chronic sleep deprivation affects many individuals. Numerous researchers examined the relationship between sleep deprivation and workforce behavior, wellbeing, and performance. However, investigation of the relationship between sleep deprivation and construction workforce safety performance has yet to be accomplished. Thus, the aim of this study is to initiate such investigation by collecting information about construction workers’ sleeping habits and the impact of sleep deprivation on the occurrence of common construction near misses.

METHODOLOGY

The authors designed and administered a paper survey to construction workers and office personnel at three construction sites for mixed-use, and sport and athletic facilities located in Seattle (WA). The paper survey was preferred over the electronic survey because it was easier to access construction workers this way. The survey was anonymous and consisted of four main sections. The first section assessed participants’ background by collecting information on respondents’ age, gender, and experience in the construction industry. The second section assessed respondents’ working schedule, sleeping habits (e.g., “what is the average number of hours per night that you sleep on a night with work the next day?”), and sleeping issues. Ten most common near miss categories in the order of popularity (from high to low) were presented in the third section (Table 1). The participants were provided a Likert scale (from “1 - not at all” to “10 - very much”) and asked to rate each near miss category accordingly to how much the lack of sleep may influence their occurrence. These near miss categories were gathered as a collective effort by the undergraduate students taking the Construction Safety class at the University of Washington. The students sampled 54 industry practitioners at the Seattle area to solicit their input on
the three most commonly-seen near misses on-site. Finally, the concluding section presented general questions about sleep deprivation and job performance (e.g., “do you feel sleep deprivation affects your job performance?”; “have you seen times where sleep deprivation has affected a co-worker’s job performance?”).

SURVEY RESULTS

Twenty-six construction practitioners participated in the survey. The majority of the participants were male (22 respondents). Fifteen participants were between 31 and 40 years of age, four younger than 30 year old; and, seven 41 year old or older. Twenty-two had at least six years of experience in construction and all the respondents were involved in site operations either at the management (7 respondents) or trade level (19 respondents). Further, construction workers were evenly split among thirteen different trades.

Table 1. Near Miss Categories Provided in the Survey

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<th>Near Miss Categories</th>
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<tr>
<td>1. Falling Debris/Objects/Tools (e.g., falling or flying objects)</td>
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<td>2. Forklifts, Scissor lifts, Truck, and Carts (e.g., someone nearly being run over)</td>
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<td>3. Trips/Slipping</td>
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<td>4. Falls/Short Falls</td>
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<td>5. Material Handling (e.g., incorrect rigging of an object to be hoisted)</td>
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<td>6. Tool Failure or Improper Equipment Use</td>
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<td>7. Not Wearing Proper Personal Protective Equipment (PPE)/Improper Use of PPE</td>
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<td>8. Ladders (e.g., standing on the top rung, adding height through unsafe methods)</td>
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<td>9. Electrocution</td>
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<td>10. Confined Work Areas (e.g., ducking and jumping out of the way to avoid being struck or to get out of the way of someone/something else)</td>
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Although more than 80% of the respondents regularly worked daytime shift and did not have sleeping issues, none of the respondents reported to sleep more than eight hours per night and over 60% slept between five and six hours per night before a workday (Figure 3). Respondents stated to sleep more before a non-work day and 80% of the respondents reported to sleep seven hours or more. However, almost 20% of the respondents reported less than six hours of sleep per night.

The number of vote with a rating value of “7” or more for each near miss category is displayed in Figure 4. The three near miss categories recognized as more likely to occur than others because of sleep deprivation are: 1) lack or improper use of PPE (20 votes); 2) operation of forklifts, scissor lifts, trucks, or carts (12 votes); and, 3) use of ladders (11 votes).
Figure 3: Average number of hours slept before a workday and non-workday.

Figure 4: Number of vote with a 7 or more rating value per near miss category.
In final survey section, most of the respondents stated that they do not think sleep deprivation can affect job performance. However, two respondents stated that they witnessed lack of sleep affecting their co-workers.

DISCUSSION

Although the collected data still need to be expanded due to the small sample size, the survey findings provide few valuable insights. The data show that the respondents are not getting the recommended sleep level. According to the literature, healthy adults should usually sleep at least eight hours per day to not suffer from chronic sleep deprivation. All the respondents stated that on average they sleep eight hours or less during workdays, and more than 60% stated that they sleep six hours or less during workdays. Considering that healthy adults constantly sleeping less than seven hours per night have cognitive impairments comparable to the ones observed in individuals remaining awake for one or two days (Van Dongen, Maislin, et al. 2003), it can be concluded that most of the interviewed construction practitioners may suffer from significant cognitive decrements and, therefore, being more prone to causing near misses and accidents, and injuring themselves and/or others.

The collected data present a lower number of hours slept when compared to the national polls (Figure 1 and Figure 2). Further, the study findings are similar to the ones obtained from a sample of construction workers in Vancouver, Canada (R. Powell and Copping 2010). Thus, it can be concluded that construction workforce is more likely at risk of suffering from chronic sleep deprivation than other occupations. However, as indicated by R. Powell and Copping (2010), subjective estimates of number of slept hours may not be correct. Thus, tools and techniques allowing objective measures of sleep should be considered for future studies.

Respondents indicated three specific near miss categories as more disturbing due to lack of sleep. Among the three, the operation of forklifts, scissor lifts, trucks, or carts is a more common near miss event itself and could serve as the next segment for investigation. While this finding is solely based on respondents’ judgment and still needs to be further supported by expanded pool of evidence, it was a reasonable argument considering the numerous evidences on the negative influence of sleep deprivation on cognitive and driving performance. For instance, by analysing risk factors for sleep-related vehicle crashes, Stutts et al. (2003) determined that drivers reporting an average of less than seven hours of sleep per night were more prone to incur in car accidents. Therefore, future studies can focus on the analysis of the relationship between sleep deprivation and on-site driving behaviors.

CONCLUSIONS

Chronic sleep deprivation is a widespread issue and previous studies indicated that chronic sleep deprivation can significantly affect behavior, wellbeing, and work performance. Although the relationships between sleep deprivation and work performance has already been analyzed for different activities, trades, and occupations, only one previous study initiated the analysis of relationship between sleep deprivation and construction workforce performance. The present study contributes to such analysis by collecting information about construction workforce
sleeping habits and issues, and the impact of sleep deprivation on the occurrence of near misses common in construction. The results suggest that construction workers may sleep less than eight hours per night and, therefore, suffer from chronic sleep deprivation. The results also suggest that three near miss categories such as operation of forklifts, scissor lifts, trucks, or carts; lack or improper use of PPE; and, use of ladders may be more likely to occur because of sleep deprivation. Thus, further and comprehensive examination of the chronic sleep deprivation - safety performance relationship should be considered for future studies.

REFERENCES


National Sleep Foundation. (2012). *Bedroom Poll - Summary of Findings*. Crofton, MD, USA.


