



Understanding the role of sleep quality and sleep duration in commercial driving safety



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ARTICLE INFO

Article history:

Received 23 May 2016

Received in revised form 22 August 2016

Accepted 22 August 2016

Keywords:

Sleep quality

Sleep duration

Commercial drivers

Accidents

ABSTRACT

Introduction: Long-haul truck drivers in the United States suffer disproportionately high injury rates. Sleep is a critical factor in these outcomes, contributing to fatigue and degrading multiple aspects of safety-relevant performance. Both sleep duration and sleep quality are often compromised among truck drivers; however, much of the efforts to combat fatigue focus on sleep duration rather than sleep quality. Thus, the current study has two objectives: (1) to determine the degree to which sleep impacts safety-relevant performance among long-haul truck drivers; and (2) to evaluate workday and non-workday sleep quality and duration as predictors of drivers' safety-relevant performance.

Materials and methods: A non-experimental, descriptive, cross-sectional design was employed to collect survey and biometric data from 260 long-haul truck drivers. The Trucker Sleep Disorders Survey was developed to assess sleep duration and quality, the impact of sleep on job performance and accident risk, and other relevant work organization characteristics. Descriptive statistics assessed work organization variables, sleep duration and quality, and frequency of engaging in safety-relevant performance while sleepy. Linear regression analyses were conducted to evaluate relationships between sleep duration, sleep quality, and work organization variables with safety composite variables.

Results: Drivers reported long work hours, with over 70% of drivers working more than 11 h daily. Drivers also reported a large number of miles driven per week, with an average of 2,812.61 miles per week, and frequent violations of hours-of-service rules, with 43.8% of drivers "sometimes to always" violating the "14-h rule." Sleep duration was longer, and sleep quality was better, on non-workdays compared on workdays. Drivers frequently operated motor vehicles while sleepy, and sleepiness impacted several aspects of safety-relevant performance. Sleep quality was better associated with driving while sleepy and with job performance and concentration than sleep duration. Sleep duration was better associated with accidents and accident risk than sleep quality.

Discussion: Sleep quality appears to be better associated with safety-relevant performance among long-haul truck drivers than sleep duration. Comprehensive and multilevel efforts are needed to meaningfully address sleep quality among drivers.

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1. Introduction

There are nearly 2 million heavy and tractor-trailer truck drivers in the United States, most of whom are considered long-haul truck drivers (Bureau of Labor Statistics, 2015c). Long-haul truck drivers remain on the road for prolonged periods of time and generally haul "truckload" freight, which involves long distance traveling directly from shipper to consignee (Apostolopoulos et al., 2014; Bureau of Labor Statistics, 2015c). Long-haul truck drivers

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endure numerous hazards endemic to their occupation, many of which are related to the physical and psychological strains associated with the profession (Apostolopoulos et al., 2014). These hazards have far-reaching consequences, impacting profitability for transportation companies, health care costs for health insurance companies, and ultimately the safety of the general motoring public (Apostolopoulos et al., 2014).

The array of hazards experienced by long-haul truck drivers induce disproportionately high injury rates. Workers in the transportation and warehousing sector had 95,040 occupational injuries and illnesses in 2014, resulting in an incidence rate of 225.2 per 10,000 full-time workers, which was the highest reported among private industries (Bureau of Labor Statistics, 2015b). Of particular concern are fatal injury rates within this sector, as the transportation and material moving occupations accounted for the largest share (28%) of fatal occupational injuries of any occupation group; further, transportation incidents accounted for 40 percent of fatal workplace injuries in 2014 and rose from 1865 in 2013–1891 in 2014 (Bureau of Labor Statistics, 2015a). In comparison, during that same timeframe, fatal work injuries among farming, fishing, and forestry occupations rose 9%, yet decreased by 15% among protective service occupations (Bureau of Labor Statistics, 2015a). Among occupations within the transportation and material moving occupations, drivers/sales workers and truck drivers accounted for 2 out of every 3 fatal injuries, and heavy and tractor-trailer drivers had their highest fatal injury total since 2008 (Bureau of Labor Statistics, 2015a). Overall, fatal injury rates are seven times higher for truck drivers than the overall average across all occupations (Smith, 2015). Of these fatal injuries, 81% were due to transportation incidents, and more specifically, 70% were due to roadway incidents (Smith, 2015). In addition, there were six occupations in 2014 where the incidence rate per 10,000 full-time workers was greater than 300, and the number of cases with days away from work was greater than 10,000; among these six occupations, heavy and tractor-trailer truck drivers had the highest number of days-away-from-work injuries and illnesses in 2014, with 55,710 cases (Bureau of Labor Statistics, 2015b).

Sleep is a critical factor for long-haul truck drivers' injuries, especially roadway incidents (Howard et al., 2004; Philip, 2005; Philip and Åkerstedt, 2006; Starnes, 2006). However, sleep is often compromised among long-haul truck drivers, which often contributes to fatigue; in turn, fatigue consistently degrades multiple aspects of safety-relevant performance (Ingre et al., 2006; Moller et al., 2006; Otmani et al., 2005; Philip and Åkerstedt, 2006; Philip et al., 1999). Sleep duration in particular has been associated with long-haul truck drivers' accidents and injuries (Belenky et al., 2007; Chen et al., 2016; Dawson, 2005; Hanowski et al., 2007). Reduced sleep duration increases subjective sleepiness and performance lapses, significantly impairing the ability to long-haul truck drivers to safely operate a commercial motor vehicle (Heaton, 2009; McCartt et al., 2000); unfortunately, sleep duration among long-haul truck drivers is usually abbreviated. Work organization factors, including long work hours and schedule unpredictability, are associated with reduced sleep duration (Hege et al., 2015; Philip et al., 2002). Finally, individual factors, including obstructive sleep apnea, as well as cardiometabolic comorbidities such as increased BMI, heightened glucose and cholesterol levels, and hypertension, are associated with reduced sleep duration (Moreno et al., 2006; Pack et al., 2006).

Because of the well-established connections between sleep, fatigue, and safety, several aspects of long-haul truck drivers' work hours are federally regulated to ensure sufficient duration of sleep. Drivers are not legally allowed to driver more than 11 h total without taking a 10-h break (the "11-h rule"), nor are they allowed to drive beyond the 14th consecutive hour since taking their last 10-h break (the "14-h rule") (U.S. Federal Motor Carrier Safety Administration, 2015b). Additional regulations apply as well, such

as required 30-min breaks and a 34-h "restart" provision (U.S. Federal Motor Carrier Safety Administration, 2015b). The use of logbooks is a critical component of such regulation, which not only allow law enforcement to ensure compliance but, due to the transition across the trucking industry to electronic logbooks, also allow trucking companies themselves to actively and accurately monitor drivers' compliance with hours-of-service regulations. Sleep promotion efforts by federal regulatory bodies and trucking companies are oriented towards sleep duration. However, these monitoring systems neglect sleep quality, which is compromised among long-haul truck drivers (McCartt et al., 2000). Due to its subjective and complex nature, a precise definition of sleep quality is elusive (Harvey et al., 2008; Krystal and Edinger, 2008). However, several methods exist for assessing sleep quality, including objective (e.g., polysomnography) and subjective (e.g., the Pittsburgh Sleep Quality Index) measures.

Numerous factors may interrupt long-haul truck drivers' sleep while on the road. For one, long-haul truck drivers obtain the bulk of their sleep in their worksites, usually at truckstops, which feature high levels of air (e.g., diesel exhaust) and noise (e.g., trucks idling engines, blowing air horns, engaging parking brakes) pollution (Doraiswamy et al., 2005). Further, sleep is primarily obtained in the sleeper berths of their truck cabs, which are often uncomfortable (e.g., poor mattress quality, extreme ambient temperatures). Work organization characteristics, such as long work hours (Ebrahimi et al., 2015; Hege et al., 2015) and shift work (Ebrahimi et al., 2015; Hege et al., 2015; Lemke et al., 2015) may additionally compromise sleep quality. Finally, individual characteristics, such as smoking (Ebrahimi et al., 2015), higher body mass index (Chen et al., 2016), and the presence of obstructive sleep apnea (Ebrahimi et al., 2015; Parks et al., 2009) may further reduce sleep quality.

While several studies have examined the link between sleep duration and accident risk among long-haul truck drivers, few have considered the importance of sleep quality in safety-relevant performance (Braeckman et al., 2011; Filiatrault et al., 2002). Consideration of sleep quality among long-haul truck drivers has far-reaching implications for federal, corporate, and individual strategies to reduce fatal and non-fatal injuries for both drivers and the general motoring public, as the bulk of safety enhancement strategies target only sleep duration. Thus, the current study has two objectives: (1) to determine the degree to which sleep impacts safety-relevant performance among long-haul truck drivers; and (2) to evaluate workday and non-workday sleep quality and duration as predictors of safety-relevant performance. Sleep quality is defined here as long-haul truck drivers' perceptions of getting a good night's sleep, and a concise subjective measure of sleep quality is used which bifurcates responses for sleep quality on workdays versus non-workdays.

2. Materials and methods

2.1. Study design and participants

The study was approved by the Institutional Review Board (IRB) of a university in North Carolina. A more complete description of the methodology employed in this study can be found in previous publications (Hege et al., 2016; Hege et al., 2015; Lemke et al., 2015; Wideman et al., 2016). Briefly, a non-experimental, descriptive, cross-sectional design was employed to collect survey and biometric data from 260 male long-haul truck drivers over a period of six months at a large-size truckstop located in North Carolina. For numerous reasons, including its consistent and high level of trucking activity; its geographic location along a major interstate; its presence as a major national chain and its resulting draw of both company and owner-operator drivers; its abundant overnight

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