Can Subjective Sleep Problems Detect Latent Sleep Disorders Among Commercial Drivers?

By: Michael K. Lemke, Yorghos Apostolopoulos, **Adam Hege**, Sharon Newnam, and Sevil Sonmez

Abstract

Long-haul truck drivers experience poor sleep health and heightened accident rates, and undiagnosed sleep disorders contribute to these negative outcomes. Subjective sleep disorder screening tools may aid in detecting drivers' sleep disorders. This study sought to evaluate the value of subjective screening methods for detecting latent sleep disorders and identifying truck drivers at-risk for poor sleep health and safety-relevant performance. Using cross-sectional data from 260 long-haul truck drivers, we: 1) used factor analysis to identify possible latent sleep disorders; 2) explored the construct validity of extracted sleep disorder factors by determining their associations with established sleep disorder risk factors and symptoms; and 3) explored the predictive validity of resulting sleep disorder factors by determining their associations with sleep health and safety-relevant performance. Five latent sleep disorder factors were extracted: 1) circadian rhythm sleep disorders; 2) sleep-related breathing disorders; 3) parasomnias; 4) insomnias; 5) and sleep-related movement disorders. Patterns of associations between these factors generally corresponded with known risk factors and symptoms. One or more of the extracted latent sleep disorder factors were significantly associated with all the sleep health and safety outcomes. Using subjective sleep problems to detect latent sleep disorders among long-haul truck drivers may be a timely and effective way to screen this highly mobile occupational segment. This approach should constitute one component of comprehensive efforts to diagnose and treat sleep disorders among commercial transport operators.

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Can subjective sleep problems detect latent sleep disorders among commercial drivers?

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A B S T R A C T

Introduction: Long-haul truck drivers experience poor sleep health and heightened accident rates, and undiagnosed sleep disorders contribute to these negative outcomes. Subjective sleep disorder screening tools may aid in detecting drivers' sleep disorders. This study sought to evaluate the value of subjective screening methods for detecting latent sleep disorders and identifying truck drivers at-risk for poor sleep health and safety-relevant performance.

Materials and Methods: Using cross-sectional data from 260 long-haul truck drivers, we: 1) used factor analysis to identify possible latent sleep disorders; 2) explored the construct validity of extracted sleep disorder factors by determining their associations with established sleep disorder risk factors and symptoms; and 3) explored the predictive validity of resulting sleep disorder factors by determining their associations with sleep health and safety-relevant performance.

Results: Five latent sleep disorder factors were extracted: 1) circadian rhythm sleep disorders; 2) sleep-related breathing disorders; 3) parasomnias; 4) insomnias; 5) and sleep-related movement disorders. Patterns of associations between these factors generally corresponded with known risk factors and symptoms. One or more of the extracted latent sleep disorder factors were significantly associated with all the sleep health and safety outcomes.

Discussion: Using subjective sleep problems to detect latent sleep disorders among long-haul truck drivers may be a timely and effective way to screen this highly mobile occupational segment. This approach should constitute one component of comprehensive efforts to diagnose and treat sleep disorders among commercial transport operators.

1. Introduction

In the United States there are nearly 2,000,000 heavy and tractor-trailer truck drivers (Bureau of Labor Statistics, 2015c). Most of these drivers are considered long-haul truck drivers, whose work requires them to remain on the road for prolonged periods of time (Apostolopoulos et al., 2014; Bureau of Labor Statistics, 2015c). During these periods, nearly all on- and off-duty time – including sleep periods – is spent at worksites, which have been labeled 'healthy living deserts' and are not conducive of sleep health or other safety-related health behaviors (Apostolopoulos et al., 2016b; Apostolopoulos et al., 2011; Lemke et al., 2016b).

Accident rates among long-haul truck drivers are indicative of poor sleep health. The broader transportation and warehousing sector had the highest reported rate of injuries and illnesses among private industries in 2014 and accounted for the largest share of fatal injuries of any occupation group (Bureau of Labor Statistics, 2015a, 2015b). Within this sector, drivers/sales workers and truck drivers accounted for two-thirds of all fatal injuries, with long-haul truck drivers in particular having fatal injury rates that are seven times higher than the overall average across all occupations (Smith, 2015). This emerging public health problem is not isolated to the United States; for example,

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road transport has been identified as a national priority under *The Australian Work Health and Safety Strategy 2012*–2022 (Safe Work Australia, 2012).

Numerous characteristics of the long-haul trucking profession impact sleep health. As a whole, long-haul truck drivers endure numerous hazards, many of which are related to the physical and psychological strains associated with the profession (Apostolopoulos et al., 2014). Principal among these strains are long work hours, shift work, job stress, and unhealthy work environments (Hege et al., 2015; Lemke et al., 2015). These strains reduce sleep quality and sleep duration and increase fatigue and sleepiness, which ultimately impact long-haul truck drivers' health and safety outcomes (Ebrahimi et al., 2015; Hege et al., 2015; Howard et al., 2004; Lemke et al., 2015; McCartt et al., 2000; Pack et al., 2006; Parks et al., 2009; Philip, 2005; Philip and Åkerstedt, 2006). These strains also induce sleep disorders, and the presence of sleep disorders, especially those that are undiagnosed, represent substantial threats to the health and well-being of long-haul truck drivers and the general motoring public.

Undiagnosed – or "*latent*" – sleep disorders continue to plague commercial driving, as the mobility of the population makes it pragmatically difficult to receive objective clinical sleep disorder diagnoses. For example, the most common sleep disorder for long-haul truck drivers is obstructive sleep apnea (OSA) (Sharwood et al., 2012; Xie et al., 2011), yet the sample used in the current study reported only a 11.6% diagnosis rate, compared to national estimates of a 17%–28% prevalence rate (Kales and Straubel, 2014). Other studies have suggested that OSA prevalence is much higher; for example, among 526 male truck drivers in Italy, over 50% were found to be at risk of OSA (Guglielmi et al., 2017). This suggests that the degree of latent OSA may be severe among truck drivers worldwide and warrants urgent attention. Untreated OSA continues to be a significant risk factor in roadway accidents among long-haul truck drivers (Tregear et al., 2009), as do other impactful sleep disorders such as restless legs syndrome (RLS), delayed or advanced sleep phase syndrome, insomnia, and narcolepsy (Krueger et al., 2007a).

The same factors that contribute to other sleep health problems also induce sleep disorders, resulting in heightened prevalence of sleep disorders and leading to fatigue and compromised safety performance (Anderson et al., 2012; Hege et al., 2015; Krueger et al., 2007a; Parks et al., 2009; Smolensky et al., 2011). The third and most recent edition of the American Academy of Sleep Medicine's International Classification of Sleep Disorders (ICSD-3) includes seven major categories of sleep disorders: Insomnia, sleep-related breathing disorders, central disorders of hypersomnolence, circadian rhythm sleep-wake disorders, parasomnias, sleep-related movement disorders, and other sleep disorders (American Academy of Sleep Medicine, 2014; Sateia, 2014). Extant studies indicate that sleep disorders increase subjective sleepiness and degrade alertness and driving task performance, and thus represent major risk factors in injuries and roadway accidents (Braeckman et al., 2011; McCartt et al., 2000; Sanna, 2013). Unsurprisingly, sleep disorders, and especially OSA, have been found to heighten accident risk among truck drivers worldwide, including in the United States, Japan, Portugal, Italy, Brazil, Argentina, and Iran; further, their impacts on workplace safety appear to disproportionately impact truck drivers compared to other professions (Amra et al., 2012; Catarino et al., 2014; Cui et al., 2006; de Pinho et al., 2006; Ebrahimi et al., 2015; Garbarino et al., 2016a,b,c; Garbarino et al., 2017; Guglielmi et al., 2016, 2017; McCartt et al., 2000; Tregear et al., 2009).

Given the severe consequences of sleep disorders for long-haul truck drivers, their families, their employers, and the public, their diagnosis and treatment within this population has become an imperative (Krueger et al., 2007a). A systems approach (Newnam and Goode, 2015; Newnam et al., 2017) to managing sleep disorders has been advocated, with relevant interventions identified at the driver-level, as well as at the company, supply chain, and regulatory/government levels (Ancoli-Israel et al., 2008; Krueger et al., 2007a); however, several barriers have hindered progress. For one, federal regulations, such as those from the U.S. Department of Transportation (DOT) and the Federal Motor Carrier Safety Administration (FMCSA), are generally lacking (Hartenbaum et al., 2006; Kales and Straubel, 2014; Krueger, 2013). This, in turn, has not allowed for regulated enforcement or monitoring of the issue at the trucking company and supply chain levels. The recent decision by the Trump administration to reverse plans to make sleep apnea testing among truck drivers mandatory (Bowden, 2017) suggests further non-involvement at the federal level to address these issues. Another barrier has been the logistics of diagnostic methodologies: Many objective diagnostic techniques (e.g., polysomnography) require drivers to be on-site, which is problematic given the mobility of this population (Kales and Straubel, 2014). A coordinated effort between the U.S. DOT and the FMCSA would likely be required to design designated screening locations to overcome this barrier.

As an alternative to objective screening methods, subjective screening methods, which rely on self-report items (Kales and Straubel, 2014), may be more practical given the nature of long-haul truck driving. Subjective tools have been used for screening for several sleep disorders, such as OSA, shift work disorder, restless leg syndrome, and insomnia, and have been explored across populations such as nurses, preschool children, and older adults (El-Sayed, 2012; Flo et al., 2012; Iwasaki et al., 2010; Luyster et al., 2015; Sadeghniiat-Haghighi et al., 2014). However, the value of such screening methods among long-haul truck drivers, whose unique occupational milieu may induce distinct patterns of sleep disorders and subjective symptomology, have yet to be established (Dagan et al., 2006; Kales and Straubel, 2014). Exploring the value of subjective screening methods in this population appears to be worthwhile and may allow for better identification of undiagnosed sleep disorders in this safety-critical population.

Ultimately, identifying long-haul truck drivers with undiagnosed sleep disorders is a public safety and health priority, and along with the workforce characteristics of long-haul trucking – namely, the combination of long work hours, frequent shift work, poor environmental conditions, unhealthy behaviors, and an aging driver population –developing more efficacious screening methods has never been more important (Kales and Straubel, 2014; Zhang et al., 2012). Because sleep disorders are diagnosable, treatable, and manageable among long-haul truck drivers (Hoffman et al., 2010; Krueger et al., 2007a), enhanced screening guidance can provide practical benefits for long-haul truck drivers and other relevant stakeholders. Therefore, we explored the potential feasibility of using subjective screening methods by evaluating whether self-reported subjective sleep problems constituted psychometrically sound measures for detecting latent sleep disorders among a sample of long-haul truck drivers.

2. Materials and methods

2.1. Study design and participants

A detailed description of the study procedures and cohort characteristics has been described in previous manuscripts that used this same dataset (Apostolopoulos et al., 2016a; Hege et al., 2016, 2015; Lemke et al., 2016a; Lemke et al., 2017a,b,c; Lemke et al., 2015; Wideman et al., 2016). A non-experimental, cross-sectional design was employed to collect survey and anthropometric data from 262 U.S. long-haul truck drivers at a large truck stop located where two major interstates merge (I-40 and I-85) in North Carolina. Due to the consistent and high level of trucking activity, geographic location, and transient nature of the long-haul trucking profession, this specific location constituted a representative national truck stop – one that is part of the chain of truck stops recognized as the largest full-service travel center company in the U.S. – offering numerous truck maintenance services. The recruitment of participants involved researchers using intercept techniques by approaching drivers at the truck stop to invite them to participate in the study, and following up with screening questions to assure that drivers were long-haulers who were staying overnight at the truck stop to assure serological samples could be collected early the following morning. The participating truck drivers and members of the research team did not know each other. For this study, the sample was filtered by eliminating the use of missing data (there were missing anthropometric data for two drivers), ultimately yielding a final sample size of 260. This study was approved by the Institutional Review Board at the University of North Carolina at Greensboro.

3. Survey data

Self-reported demographic, behavioral, health outcome, work organization, and sleep data were collected using the Trucker Sleep Disorders Survey (TSLDS). The TSLDS was developed by the research team using insights gained from other validated instruments, relevant literature, and our previous work with U.S. long-haul truck drivers (National Sleep Foundation, 2012; Netzer et al., 1999; Philip and Åkerstedt, 2006). More specifically, the subjective sleep problem questions were drawn from validated instruments, such as the Berlin Questionnaire and National Sleep Foundation questionnaires (National Sleep Foundation, 2012; Netzer et al., 1999). The TSLDS survey as a whole was pilot tested with a small sample of long-haul truck drivers prior to the start of the study and was reviewed by other public and occupational health researchers to assess for validity of the measures. Key variables used in this study included demographics (age, years of driving, race/ethnicity); perceived stress level; substance (alcohol, caffeine, tobacco) use; health outcomes (cardiovascular health problems, diabetes diagnosis, headaches); work organization (daily work hours, schedule regularity, shift work, pace of work); reports of experiencing driving hazards; workday sleep and nap duration; workday sleep quality; subjective sleep problems; sleep disorder diagnosis; prescribed medication use for sleep/sleep disorders; and use of a Continuous Positive Airway Pressure (CPAP) machine. In addition to these self-reported survey data, anthropometric data relevant to sleep problems and sleep disorders were collected; key variables included body mass index (BMI), waist circumference (WC), sagittal abdominal diameter (SAD), systolic blood pressure (SBP), and diastolic blood pressure (DBP). Each anthropometric measure was taken two times and their average was recorded.

3.1. Health behaviors and outcomes

Drivers were asked about their perceived overall stress level, which could include both work-related and non-work-related stressors, in an ordinal fashion, and their responses were coded as follows: No stress = 0; mild stress = 1; moderate stress = 2; high stress = 3; extreme stress = 4; and chronic stress = 5. Overall stress was measured because both work and non-work stress may be significant; for example, drivers may have job-specific stress (e.g., pressure by employers for on-time deliveries), as well as family or financial pressures. To gauge drivers' use of alcohol, interviewers asked, "*How many alcoholic drinks to you consume daily?*" Alcohol use responses were coded as follows: None = 0, 1 drink = 1; 2–3 drinks = 2; 4–5 drinks = 3; and 6 or more drinks = 4. The use of caffeine was measured in ounces per day and drivers responded in a continuous manner, while tobacco use was measured by the number of packs of cigarettes the driver smoked on a daily basis. Regarding health complications, drivers were asked whether they were diagnosed with cardiovascular health problems or diabetes, or whether they experienced frequent or severe headaches, and responded either 'yes' or 'no'.

3.2. Work organization

Drivers were asked the average number of hours they worked on a daily basis, and the response selections were coded as follows: Less than six hours = 1; between six and seven hours = 2; between seven and eight hours = 3; between eight and nine hours = 4; between nine and 10 h = 5; between 10 and 11 h = 6; between 11 and 12 h = 7; between 12 and 13 h = 8; between 13 and 14 h = 9; and 14 h or more = 10. Shift work was measured using three variables: Daily schedule irregularity; daily number of hours irregularity; and weekly schedule irregularity. For these three shift work questions, drivers had response selections of either "same" or "different." Drivers were also asked about how frequently they experienced a work pace that they considered fast, with response coded as follows: Never = 0; rarely = 1; sometimes = 2; often times = 3; and always = 4.

3.3. Sleep quantity and quality

Drivers were asked about both their sleep quantity and sleep quality. For sleep quantity, drivers were asked in a continuous fashion, "*How long are your naps on workdays?*" and "*How much sleep do you obtain on your workdays/nights?*" Sleep quality was measured using the following question: "How often would you consider you get a good night's sleep on your workdays/nights?" Responses for sleep quality were coded as follows: Never = 0; rarely = 1; almost every night = 2; and every night = 3. Drivers were also asked a series of questions to gauge their scores on the Epworth Sleepiness Scale (ESS) (Talk About Sleep), which queried how often they felt they might doze off during the following activities: Sitting and reading; watching TV; sitting inactive in a public place; as a passenger in a car without a break; lying down to rest when circumstances permit; sitting and talking to someone; sitting quietly after lunch; in their truck/car while sitting idle for a few minutes in traffic. Responses were coded as follows: No chance of dozing = 0; slight chance of dozing = 1; moderate chance of dozing = 2; and high chance of dozing = 3. When adding these together, a driver could accumulate a score of up to 24, which would be indicative of an excessively sleepy driver in need of medical attention.

3.4. Sleep problems and disorders

To measure drivers' experiences with sleep problems, they were asked a series of questions about whether they had experienced the following conditions in the past two weeks: Sleeping soundly; difficulty falling asleep; waking up from sleep; waking up early and being unable to return to sleep; waking up and feeling tired; sleeping through an alarm; hitting the snooze button; waking up from bad dreams; walking in their sleep; talking in their sleep; kicking their legs during sleep; grinding their teeth during sleep; gasping/choking during sleep; stopping breathing during sleep; having frightening dreams during sleep; having leg cramps during sleep; and snoring loudly during sleep. Their responses were coded as follows: Never = 0; rarely = 1; sometimes = 2; frequently = 3; and always = 4. However, to enhance clarity during analyses, the "sleeping soundly" variable was re-coded as follows: always = 0; frequently = 1; sometimes = 2; rarely = 3; and never = 4. Each driver was also asked whether they had been clinically diagnosed with any of the following sleep disorders: Sleep apnea; shiftwork sleep disorder; insomnia; sleep hyponea; and restless leg syndrome. Finally, drivers were asked if they had been prescribed a medication for sleep or sleep disorder and whether they were using a CPAP machine.

3.5. Reports of driving hazards due to sleep

To assess the impact of sleep on work-related safety performance, drivers were asked in a 'yes or no' manner whether they had experienced the following during the prior month: Driving their truck sleepy; due to sleepiness, making a serious error while on the job; due to sleepiness, causing an accident while on the job; and, due to sleepiness, having a "near miss" while driving. A variable, titled "Total Number of Driving Hazards," was then created, which was a count of the total number of these four driving hazards drivers had experienced (ranging from 0–4).

4. Statistical analysis

All statistical analyses were conducted using SPSS 23.0 (IBM Corp, 2015), and several of the descriptive statistics for the TSLDS have been reported in various forms in previous manuscripts (Hege et al., 2016, 2015; Lemke et al., 2016a, 2017a,b, 2015; Wideman et al., 2016). Descriptive and frequency statistics for the demographic variables, behavioral and health outcome measures, work organization characteristics, and sleep duration and quality were first conducted. Means and standard deviations were examined for continuous variables, and the number (N) and percentage (%) were examined for categorical variables. Next, descriptive statistics for subjective sleep problems, experiences with sleep disorders, and treatment for sleep disorders were explored. Means and standard deviations were found for each of the subjective sleep problems. The variables related to drivers' reports of work-related safety performance were then evaluated using descriptive statistics.

4.1. Factor structure and scale validation

To assess the factor structure, an Exploratory Factor Analysis (EFA) was conducted. Principal axis factoring using an oblique (promax) rotation was performed to assess the factor structure. Orthogonal rotation assumes independence of factors (Preacher and MacCallum, 2003), which is unlikely given comorbidities in sleep problems and disorders; thus, an oblique rotation was expected to generate the best factor solution.

Following the EFA, a series of *latent sleep disorder factors* were extracted and labeled, which was then followed by a series of Pearson correlation analyses conducted to determine construct and predictive validity for the extracted latent sleep disorder factors. To assess construct validity, the relationship between the latent sleep disorder factors with known risk factors and symptoms for sleep disorders, across health behavior measures (stress, alcohol consumption, caffeine consumption, and tobacco consumption), reported health outcomes (BMI, WC, SAD, SBP, cardiovascular health problems, diabetes, and headaches), and work organization characteristics (daily work hours, shift work (daily schedule irregularity, daily number of work hours irregularity, weekly schedule irregularity), and fast pace of work) were explored. To explore predictive validity, the relationship between the latent sleep disorder factors and sleep health (sleep duration, sleep quality, and ESS) and work-related safety performance measures ("*drove truck while sleepy during the past month*"; "*due to sleep, made a serious error while on the job*"; "*due to sleep, caused an accident while on the job*"; "*due to sleep, had a "near miss" while driving*"; and "*total number of driving hazards*") were explored.

5. Results

5.1. Description of the sample

The average age of our sample was about 46 years old, and the average years of experience was nearly 15. Table 1 provides the full descriptive results of the demographic, health, work organization, and sleep characteristics of our sample; Table 2 provides the full profile of drivers' subjective sleep problems, sleep disorders, and sleep disorder treatment; and Table 3 provides the full profile of drivers' reports of experiencing driving hazards. These tables show that perceived stress was relatively low, alcohol use was sparse, tobacco use was moderate, and caffeine use was high. The means for BMI, waist circumference, and sagittal diameter signaled that our sample had generally unhealthy body compositions. Daily work hours were long and drivers reported experiencing an average of nearly two of the three shift work characteristics. The mean workday sleep duration was about seven hours, and perceived sleep quality appeared to be relatively good. The mean score for the self-reported ESS among the sample was relatively low. The most significant sleep problems included waking up from sleep, snoring loudly in sleep, waking up feeling tired, and waking up early and being unable to fall back asleep. Sleep disorder diagnoses were relatively uncommon. More than half of the drivers interviewed had driven their truck while sleepy in the past month; further, due to sleep, nearly a third had made a serious error, 6.9% had caused an accident, and more than half 'had a near miss' while driving their truck.

Table 1
Profile of Driver Characteristics.

Driver Characteristics	Mean	SD	N	(%)
Demographics				
Age	46.64	10.53		
Years of driving	14.97	11.53		
Race				
White/Caucasian			149	57.3
Non-White			111	42.7
Health				
Perceived Stress level (0–5 scale)	1.83	1.09		
Alcohol use (0–4 scale)	0.10	0.67		
Caffeine use (oz. per day)	51.02	62.18		
Tobacco use (smoking/packs per day)	0.47	0.64		
Health Issues				
BMI	33.14	7.76		
Waist circumference	114.77	16.56		
Sagittal abdominal diameter	44.42	7.52		
Systolic blood pressure	128.87	18.63		
Cardiovascular health problems			13	5.1
Diabetes diagnosis			44	17.2
Frequent or severe headaches			24	9.2
Work Organization				
Daily work hours (0–10 scale)	7.56	1.83		
Shift work (0–3 scale)	1.80	0.90		
Daily schedule irregularity	0.83	0.38		
Daily number of work hours irregularity	0.64	0.48		
Weekly schedule irregularity	0.32	0.47		
Fast pace of work (0–4 scale)	2.26	1.45		
Sleep				
Naps duration on workdays (min.)	74.02	69.26		
Sleep duration on workdays (hrs.)	6.92	1.67		
Sleep quality on workdays (0–3 scale)	0.76	0.84		
Epworth Sleepiness Scale (0–24 scale)	5.53	4.10		
Epworth Sleepiness Scale Distribution				
Unlikely to be abnormally sleep (0–7)			179	70.8
Average amount of daytime sleepiness (8–9)			33	13.0
Excessively sleepy depending upon situation (10–15)			36	14.2
Excessive sleepiness needing medical attention (16–24)			5	2.0

5.2. Exploratory factor analysis

As criteria for the number of factors to extract, we used Horn's parallel analysis (Horn, 1965), eigenvalues, and Cattell's scree test (Cattell, 1978). With the sample size of 260, and the inclusion of 17 variables in the factor analysis, this ratio met established minimum criteria for having over five participants per variable.(Bryant and Yarnold, 1995; Hatcher, 1994) Using the criteria established by Cohen (1988), who designated effect sizes of 0.10 as "small", 0.30 as "medium", and 0.50 as "large"; cutoff points for coefficients were set at 0.50. The Kaiser-Meyer-Olkin, which is a measure of sampling adequacy, was found to be representative of an appropriate sample size for the factor analysis, at 0.73 (Field, 2013).

Based on these criteria, it was determined that a five-factor solution provided the optimal factor solution. Using cutoff points of above 0.50

Table 2
Profile of Sleep Problems and Sleep Disorders.

Sleep Characteristics Sleep Problems/Disorder Symptoms (Range of 0–4)	Mean	SD	N	(%)
Sleeping soundly	1.47	1.29		
Difficulty falling asleep	1.00	1.11		
Waking up from sleep	2.17	1.36		
Waking up early and unable to fall back asleep	1.59	1.29		
Waking up and feeling tired	1.71	1.30		
Sleeping through alarm	0.68	1.15		
Hitting snooze button	1.29	1.59		
Waking up from bad dreams	0.72	0.98		
Walking in sleep	0.06	0.59		
Talking in sleep	1.05	1.33		
Kicking legs in sleep	0.89	1.20		
Grinding teeth in sleep	0.71	1.27		
Gasping/choking in sleep	0.69	1.18		
Stop breathing in sleep	0.62	1.18		
Frightening dreams in sleep	0.72	1.00		
Leg cramps in sleep	0.82	1.11		
Snore loudly in sleep	2.33	1.59		
Sleep Disorder Diagnosis				
Sleep apnea			30	11.6
Shiftwork sleep disorder			3	1.1
Insomnia			6	2.3
Sleep hypopnea			6	2.3
Restless legs syndrome			6	2.3
Prescribed medication use for sleep/sleep disorders			19	7.8
Use of CPAP machine			26	14.3

Table 3
Reports of Driving Hazards.

Driving Hazards	N	(%)
Drove Truck While Sleepy During the Past Month		
None	115	44.4
At least once	144	55.6
Due to Sleep, Made a Serious Error While on the Job		
No	176	68.0
Yes	83	32.0
Due to Sleep, Caused an Accident While on the Job		
No	242	93.1
Yes	18	6.9
Due to Sleep, Had a "Near Miss" While Driving		
No	124	47.9
Yes	135	52.1
Total Number of Driving Hazards		
None	64	24.9
One	75	29.2
Two	59	23.0
Three	50	19.5
Four	9	3.5

or above to navigate sleep problem cross-loadings between factors, five factors were identified and labeled as follows: Circadian rhythm sleep disorders (sleeping soundly, difficulty falling asleep, waking up early and unable to fall back asleep, and waking up feeling tired); sleep-related breathing disorders (gasping/choking in sleep and stop breathing in sleep); parasomnias (waking up from bad dreams and frightening dreams in sleep); insomnias (sleeping through an alarm and hitting the snooze button); and sleep-related movement disorders (kicking legs in sleep and leg cramps in sleep). Latent sleep disorder factor labels were chosen based on the closest approximation of clusters of subjective sleep problem loadings of 0.50 and above to existing sleep disorder categories in the ICSD-3 (American Academy of Sleep Medicine, 2014; Sateia, 2014). The factor analysis pattern and structure matrices are presented in Tables 4 and 5, respectively. Table 6 provides the correlation matrix among the five sleep disorder factors. None of these associations were statistically significant.

Factor eigenvalues, which represent the relative importance of the factor to the analysis model, ranged from 1.02 (sleep-related movement disorders) to 4.17 (circadian rhythm sleep disorders), with the "circadian rhythm sleep disorders" factor explaining 24.51% of the variance. Cronbach's Alpha, measuring correlation among the variables, ranged from 0.49 (sleep-related movement disorders) to 0.84 (sleep-related breathing disorders), which indicates an acceptable reliability only for sleep-related breathing disorders (0.84) and parasomnias (0.76).

5.3. Validity

The results of the Pearson correlation analyses between the five latent sleep disorder factors and known sleep disorder risk factors and symptoms are presented in Table 7. When examining correlations between the newly created five sleep disorder variables and health, work organization, and other sleep variables, we found that perceived stress was significantly associated across all five sleep disorder factors. Additionally, fast pace of work was significantly associated with circadian rhythm sleep disorders, sleep-related breathing disorders, and parasomnias. Finally, frequent and severe headaches were significantly associated with circadian rhythm sleep disorders, sleep-related breathing disorders, parasomnias, and insomnias. These results provide support for construct validity of the scale.

Finally, the results of the Pearson correlation analyses between the five latent sleep disorder factors and sleep health and safety outcomes are presented in Table 8. The five latent sleep disorder factors were strongly associated with the three sleep health outcome measures, especially sleep duration and sleep quality. Among the safety outcomes, all five sleep disorder factors were significantly associated with both driving a truck while sleepy during the past month and with the total number of driving hazards. All of the sleep health and safety outcome measures were significantly associated with at least one of the latent sleep disorder factors. These results provide support for the predictive validity of the scale.

6. Discussion

Given the safety-critical nature of long-haul truck driving, and the safety performance deficits that result from inadequate sleep, the detection and treatment of sleep disorders in this occupational segment is of vital importance. Unfortunately, such efforts are rebuffed by several pragmatic difficulties, including difficulties in both objective (e.g., practical difficulties in providing polysomnography testing) and subjective (e.g., inherent shortcomings in self-report measures) screening techniques, and sleep disorders among long-haul truck drivers continue to go undiagnosed and untreated. In response to this, the aim of this study was to explore the feasibility of using subjective screening methods by investigating whether the series of self-reported subjective sleep problem questions in the TSLDS was a psychometrically sound measure for diagnosing and monitoring sleep disorders among a sample of long-haul truck drivers. Overall, the results from this study suggest that using subjective sleep problems to screen for latent sleep disorders among long-haul truck drivers may be a valid component of broader initiatives to curb sleep disorders among long-haul truck drivers and transport operators in general.

6.1. Latent sleep disorder factor structure

Overall, our findings highlight the potential value of using subjective sleep problems to detect latent sleep disorders among long-haul truck drivers. The five factors identified in the factor analysis generally correspond with their characteristic symptomology in the ICSD-3 (American Academy of Sleep Medicine, 2014). The relatively low degree of cross-loadings, especially in the pattern matrix, hint at the possibility of a well-developed subjective sleep disorder scale to discriminate between patterns of symptomology which may underlie

Table 4
Factor Analysis Pattern Matrix for Subjective Sleep Problems.

Sleep Problem	Factor[f]				
	1[a]	2[b]	3[c]	4[d]	5[e]
Sleeping soundly	**−0.62**	−0.09	0.08	0.07	−0.11
Difficulty falling asleep	**0.75**	0.10	−0.04	−0.07	−0.17
Waking up from sleep	0.40	−0.07	0.11	−0.02	0.19
Waking and unable to fall back asleep	**0.58**	−0.15	0.11	0.02	0.01
Waking up and feeling tired	**0.50**	0.16	0.00	0.22	0.08
Sleeping through alarm	−0.14	0.15	0.04	**0.72**	−0.07
Hitting snooze button	0.13	−0.07	0.09	**0.58**	0.03
Waking up from bad dreams	0.08	0.01	**0.75**	0.11	−0.16
Walking in sleep	0.04	0.35	0.32	−0.22	−0.11
Talking in sleep	−0.04	0.30	0.33	−0.22	0.24
Kicking legs in sleep	−0.12	0.14	0.05	0.04	**0.57**
Grinding teeth in sleep	0.02	0.01	−0.13	−0.07	0.33
Gasping/choking in sleep	0.01	**0.82**	−0.03	0.02	−0.02
Stop breathing in sleep	0.04	**0.80**	−0.08	0.09	−0.03
Frightening dreams in sleep	−0.04	−0.12	**0.86**	0.08	0.02
Leg cramps in sleep	0.17	−0.16	−0.04	−0.01	**0.55**
Snore loudly in sleep	−0.06	0.28	−0.03	0.12	0.26
Eigenvalues	4.17	1.63	1.55	1.42	1.02
% of Variance	24.51	9.58	9.11	8.36	7.17
Cronbach's Alpha	0.69	0.84	0.76	0.50	0.49
Factor Mean (SD)	6.83 (2.41)	1.25 (2.14)	1.44 (1.79)	1.96 (2.26)	1.71 (1.88)

[a] Factor 1 – Circadian Rhythm Sleep Disorders.
[b] Factor 2 – Sleep-Related Breathing Disorders.
[c] Factor 3 – Parasomnias.
[d] Factor 4 – Insomnias.
[e] Factor 5 – Sleep-Related Movement Disorders.
[f] Bold factors indicate factor loadings ≥ .50.

Table 5
Factor Analysis Structure Matrix for Subjective Sleep Problems.

Sleep Problem	Factor[f]				
	1[a]	2[b]	3[c]	4[d]	5[e]
Sleeping soundly	**−0.67**	−0.35	−0.23	0.01	−0.37
Difficulty falling asleep	**0.70**	0.31	0.19	−0.05	0.18
Waking up from sleep	0.50	0.22	0.31	0.04	0.39
Waking and unable to fall back asleep	**0.56**	0.13	0.26	0.05	0.25
Waking up and feeling tired	**0.62**	0.41	0.29	0.28	0.42
Sleeping through alarm	−0.15	0.12	0.04	**0.71**	0.08
Hitting snooze button	0.18	−0.07	0.14	**0.60**	0.20
Waking up from bad dreams	0.29	0.27	**0.77**	0.11	0.25
Walking in sleep	0.23	0.42	0.41	−0.21	0.17
Talking in sleep	−0.29	0.50	0.54	−0.14	0.47
Kicking legs in sleep	0.20	0.37	0.32	0.14	**0.61**
Grinding teeth in sleep	0.11	0.11	0.04	−0.02	0.27
Gasping/choking in sleep	0.33	**0.81**	0.29	0.07	0.34
Stop breathing in sleep	0.33	**0.78**	0.24	0.14	0.32
Frightening dreams in sleep	0.24	0.22	**0.82**	0.11	0.37
Leg cramps in sleep	0.33	0.14	0.22	0.09	**0.54**
Snore loudly in sleep	0.17	0.37	0.18	0.18	0.36
Eigenvalues	4.17	1.63	1.55	1.42	1.02
% of Variance	24.51	9.58	9.11	8.36	7.17
Cronbach's Alpha	0.69	0.84	0.76	0.50	0.49
Factor Mean (SD)	6.83 (2.41)	1.25 (2.14)	1.44 (1.79)	1.96 (2.26)	1.71 (1.88)

[a] Factor 1– Circadian Rhythm Sleep Disorders.
[b] Factor 2 – Sleep-Related Breathing Disorders.
[c] Factor 3 – Parasomnias.
[d] Factor 4 – Insomnias.
[e] Factor 5 – Sleep-Related Movement Disorders.
[f] Bold factors indicate factor loadings ≥ .50.

extant sleep disorders in drivers. Low Cronbach's alphas for insomnias and sleep-related movement disorders suggest, however, that these factors should be interpreted with caution.

Two of the ICSD-3 categories – central disorders of hypersomnolence, and other sleep disorders – did not strongly emerge from these data. There are two reasons that may explain these findings. First, while many long-haul truck drivers experience daytime sleepiness, central disorders of hypersomnolence are not likely to be prevalent among long-haul truck drivers. This is largely because of the primary disorders within this category – narcolepsy – is a medically disqualifying condition, meaning that individuals with this condition are not allowed to operate a commercial motor vehicle (Federal Motor Carrier Safety

Table 6
Factor Correlation Matrix of Latent Sleep Disorder Factors.

Factor	Circadian Rhythm Sleep Disorders	Sleep-Related Breathing Disorders	Parasomnias	Insomnias	Sleep-Related Movement Disorders
Circadian Rhythm Sleep Disorders	–	0.40	0.36	0.06	0.44
Sleep-Related Breathing Disorders	0.40	–	0.39	0.07	0.44
Parasomnias	0.36	0.39	–	0.04	0.47
Insomnias	0.06	0.07	0.04	–	0.17
Sleep-Related Movement Disorders	0.44	0.44	0.47	0.17	–

Table 7
Associations (Correlations) of Sleep Disorder Factors with Sleep Disorder Risk Factors and Symptoms.

Risk Factors and Symptoms	Sleep Disorder Factors				
	Circadian Rhythm Sleep Disorders	Sleep-Related Breathing Disorders	Parasomnias	Insomnias	Sleep-Related Movement Disorders
BMI	−0.07	0.11	0.02	0.06	−0.07
Waist Circumference	−0.03	0.11	0.01	0.07	−0.03
Sagittal Diameter	−0.01	0.13*	0.03	0.10	−0.01
Systolic BP	−0.08	−0.04	0.06	−0.10	−0.07
Stress	0.24***	0.20***	0.15*	0.16*	0.24***
Alcohol Consumption	0.05	0.07	0.07	0.16*	0.12
Caffeine Consumption	0.15*	0.03	−0.02	0.12	0.11
Tobacco Consumption	0.11	0.00	−0.10	0.03	0.02
Cardiovascular Health Problems	0.07	0.11	0.15*	0.06	0.08
Diabetes	0.10	0.00	−0.02	0.05	0.11
Headaches	0.27***	0.16*	0.19**	0.18***	0.11
Work Hours	0.11	0.10	0.10	0.16*	0.03
Shift Work	0.10	0.00	0.10	0.05	0.12
Schedule Regularity	0.02	−0.06	0.06	0.03	0.09
Hours Regularity	0.14*	−0.04	0.10	0.00	0.05
Weekly Hours Regularity	0.01	0.05	0.05	0.06	0.10
Fast Pace of Work	0.25***	0.14*	0.15*	0.09	0.09

* $p < .05$.
** $p < .01$.
*** $p < .001$.

Administration, 2014). But factor 4, which is presently named "insomnia", was one of the weaker factors (accounting for just over 8% of the variance) and may additionally reflect the presence of other central disorders of hypersomnolence that are not medically disqualifying conditions (e.g., idiopathic hypersomnia). Second, the ICSD-3 category of "other sleep disorders" consists of sleep disorders that do not necessarily share subjective symptomology (American Academy of Sleep Medicine, 2014), making it unlikely that they would strongly emerge from a statistical technique that explores clusters of variables such as factor analysis (Field, 2013).

6.2. Associations between risk factors and symptoms with latent sleep disorder factors

The patterns of associations between potential sleep disorder risk factors and symptoms and the latent sleep disorder factors point to adequate construct validity for the five sleep disorder factors. The unique occupational milieu of long-haul truck drivers is replete with physical and psychosocial stressors (Apostolopoulos et al., 2014), which often induce behavioral risks (Lemke et al., 2016b) and lead to disproportionately poor health outcomes compared to the general U.S. population (Apostolopoulos et al., 2016a). Although there is a paucity in the scientific literature regarding the role of these stressors in

Table 8
Associations (Correlations) of Latent Sleep Disorder Factors with Sleep Health and Safety Outcomes.

Sleep Health and Safety Outcomes	Sleep Disorder Factors				
	Circadian Rhythm Sleep Disorders	Sleep-Related Breathing Disorders	Parasomnias	Insomnias	Sleep-Related Movement Disorders
Sleep Duration	−0.27**	−0.15*	−0.16**	−0.09	−0.19**
Sleep Quality	0.25**	0.25**	0.23**	0.12	0.16*
Epworth Sleepiness Scale	0.15*	0.23**	0.09	0.14*	0.14*
Drove Truck While Sleepy During the Past Month	0.19**	0.22**	0.22**	0.31**	0.15*
Due to Sleep, Made a Serious Error While on the Job	0.10	0.05	0.26**	−0.05	0.09
Due to Sleep, Caused an Accident While on the Job	0.14*	0.06	0.10	0.13*	−0.06
Due to Sleep, Had a "Near Miss" While Driving	0.19**	0.15*	0.29**	0.02	0.10
Total Number of Driving Hazards	0.23**	0.20**	0.35**	0.15**	0.13**

* $p < .05$.
** $p < .01$.

inducing other sleep disorders among long-haul truck drivers, many of these factors and outcomes are associated with sleep disorders in other populations (Merlino and Gigli, 2012; Mysliwiec et al., 2014; Roth, 2012; Sack et al., 2007a,b).

Stress appears to be the most significant risk factor for higher subjective sleep problems among long-haul truck drivers. Stress has also been found to be present among other commercial vehicle drivers, such as Italian truck drivers and U.S. firefighters, with sleep disorders (Barger et al., 2015; Guglielmi et al., 2017). Stress disorders, especially posttraumatic stress disorder, as well as chronic stress, have been associated with parasomnias (Mysliwiec et al., 2014; Spoormaker et al., 2006). The former may be especially important for long-haul truck drivers, a sizeable portion of whom are military veterans and/or have experienced traumatic events (e.g., victims of violent crime; witnessing fatal roadway accidents) (Apostolopoulos et al., 2016c. Thus, reducing psychosocial stress among long-haul truck drivers and improving diagnosis and treatment of stress disorders may improve sleep health. Headaches were significantly associated with four of the five sleep disorder factors. Headaches are a well-known symptom of several sleep disorders, including sleep-related breathing disorders, circadian rhythm sleep disorders, insomnias, and, although not a significant association in these data, sleep-related movement disorders (Epstein et al., 2009; Park et al., 2011; Rains and Poceta, 2006). Other patterns of associations are consistent with the scientific literature, including: Hours regularity and circadian rhythm sleep disorders (Krueger et al., 2007a); sagittal abdominal diameter and sleep-related breathing disorders (Ancoli-Israel et al., 2008; Hartenbaum et al., 2006; Kales and Straubel, 2014; Sharwood et al., 2012; Xie et al., 2011; Yusoff et al., 2010); cardiovascular disease and parasomnias (Barger et al., 2015); alcohol consumption and insomnias (Dahl et al., 2009; Razmpa et al., 2011); and work hours and insomnias (Kanazawa et al., 2006).

Several associations between risk factors and symptoms and the latent sleep disorder factors, especially objective symptoms, were not significant. For example, BMI and cardiovascular health problems are well-established risk factors for sleep-related breathing disorders, especially OSA (Garbarino et al., 2016b; Xie et al., 2011). Similarly, shift work is a known risk factor for circadian rhythm sleep disorders, especially shift work sleep disorder (Drake, 2010; Drake et al., 2004), yet this association was not statistically significant in these analyses. Possible explanations for these non-significant findings are a lack of sensitivity of the survey tool or drivers underreporting their health and sleep problems. An alternate explanation may be low statistical power due to sample size.

6.3. Latent sleep disorder factors, sleep health, and safety-relevant performance

Long-haul truck driver latent sleep disorder factors appear to hold prognostic value for risk of poor sleep health and safety-relevant performance. One or more sleep disorder factors predicted each of the four measures. Sleep duration (Lemke et al., 2016a; Pack et al., 2006; Philip, 2005; Philip and Åkerstedt, 2006), sleep quality (Filiatrault et al., 2002; Lemke et al., 2016a), and sleepiness (McCartt et al., 2000; Pack et al., 2006; Perez-Chada et al., 2005; Philip, 2005; Smolensky et al., 2011; Vennelle et al., 2010) are all known factors that are associated with risk for roadway accidents, while the self-reported driving hazard factors represent actual safety-relevant performance outcomes. Several of these sleep disorders have been speculated to be direct threats to roadway safety (Smolensky et al., 2011).

Circadian rhythm sleep disorder factor scores were associated with all but one of the sleep health and safety outcomes. Given the work-rest orientation typical of many long-haul truck drivers, which frequently constitutes shift work, circadian rhythm sleep disorders are considered to be especially problematic within this occupational segment (Krueger et al., 2007a), and these disorders have been associated with sleep-induced accidents in the general population (Drake et al., 2004). These disorders cause circadian misalignment, which is known to interfere with sleep duration and sleep quality (American Academy of Sleep Medicine, 2014). Especially problematic for long-haul truck drivers is the tendency for resulting sleep debt to accumulate over time (Sack et al., 2007a), as long-haul truck drivers are typically on the road for weeks at a time and may be continually exposed to shift work during this time. Further, social pressures contribute to circadian rhythm sleep disorders (Wright et al., 2013), which may reduce opportunities for long-haul truck drivers to erase sleep debt during non-work days. The resulting sleep duration caused by these disorders frequently causes sleepiness during work shifts (Wright et al., 2013), which may result in roadway accidents.

Sleep-related breathing disorder factor scores were associated with all but two of the sleep health and safety outcomes. The connections between sleep-related breathing disorders, and especially OSA, with poor sleep health are well established. Studies involving long-haul truck drivers and implications for sleep-related breathing disorders have consistently found that these disorders induce sleepiness and are key risk factors for hypersomnolence and sleep-induced accidents, both in North America and internationally (Amra et al., 2012; Cui et al., 2006; Dagan et al., 2006; de Padua Mansur et al., 2015; de Pinho et al., 2006; Ebrahimi et al., 2015; Garbarino et al., 2016a,c; Garbarino et al., 2017; Guglielmi et al., 2016; Howard et al., 2004; Perez-Chada et al., 2005; Tregear et al., 2009). Unsurprisingly, these findings have spurred a number of recommendations for screening, diagnosis, and treatment for these disorders among commercial drivers (Ancoli-Israel et al., 2008; Hartenbaum et al., 2006), although, as mentioned earlier, these continue to be undiagnosed and untreated. These shortcomings indicate the overall inadequacy of efforts to diagnose and treat long-haul truck drivers with sleep-related breathing disorders.

Similarly, parasomnia factor scores were also associated with all but two of the sleep health and safety outcomes. Thus, parasomnias, which include a number of specific sleep disorders, including sleep terrors, nightmare disorder, and REM sleep behavior disorder, appear to be especially important for long-haul truck driver sleep health and safety-relevant performance. Unfortunately, little is known about these disorders in this population. The findings from this study suggest that parasomnias represent potentially critical avenues for improving sleep health and safety-relevant performance among long-haul truck drivers. For example, it has been established in other populations that treatment of parasomnias improves sleep quality (Spoormaker et al., 2006).

Finally, the patterns of associations between latent sleep disorder factors and sleep quality may be especially noteworthy. Sleep quality appears to be an emerging metric of sleep health among long-haul truck drivers. The bulk of research and regulatory action has focused on sleep duration; for example, federal hours-of-service regulations nearly exclusively focus on number of hours dedicated to sleep, rather than when this sleep is occurring (e.g., whether it is during a circadian nadir); however, sleep quality appears to be especially important in long-haul truck driver roadway safety (Filiatrault et al., 2002; Lemke et al., 2016a). Although both sleep quality among long-haul truck drivers and the prevalence and impacts of sleep disorders in this population remain neglected in the scientific literature, sleep-related breathing disorders have been found to be associated with poor quality sleep in this population (Ebrahimi et al., 2015), and poor sleep quality is a known symptom of these disorders (Epstein et al., 2009; Park et al., 2011). Sleep quality was significantly associated with all but one of the latent sleep disorder factors (insomnias), which may indicate the breadth to which these factors influence long-haul truck drivers' sleep health.

6.4. Recommendations

Despite recognition within the transportation safety community of the importance of detecting and treating sleep disorders among long-haul truck drivers, efforts to mitigate the threats that such disorders pose have been generally ineffective. The findings in this study offer a solution to this challenge by advocating for the development of a psychometrically sound screening tool for detecting sleep disorders. The key advantage of a subjective self-report tool is that it allows for pragmatic assessment of broad populations of drivers and could serve as a 'first-line defense' against undetected sleep disorders.

The development of a subjective screening tool for long-haul truck drivers is especially timely. First, trucking companies have increasingly focused on sleep disorders among their drivers in recent years, and several have instituted programs to address these issues (Krueger et al., 2007b; Mabry et al., 2010). A validated and reliable subjective screening tool would reduce the barriers to successfully implementing such programs and may encourage more companies to initiate them. Second, advances in communication technologies, and especially the proliferation of onboard computers and their improved software capabilities, has made it possible for periodic screening of entire trucking fleets. A subjective screening tool could take advantage of such technology; for example, companies could periodically integrate mandatory surveys, which assess subjective sleep problems, as part of the electronic logging process. Third, at the federal regulatory level, a subjective screening tool would be useful as part of the medical certification process to more successfully identify drivers who present a risk to roadway safety due to the presence of undetected sleep disorders. Fourth, such a tool may ultimately help drivers receive treatment for sleep disorders and improve their quality-of-life and extend their careers, which is especially important to the long-term health of the long-haul truck driving industry given the burgeoning driver shortage (Costello and Suarez, 2015). Finally, difficulties in detection and treatment of sleep disorders are present in other safety-critical occupations (e.g., pilots, bus drivers), and the development of a subjective screening tool could be beneficial for detecting latent sleep disorders in these professions as well.

The development and implementation of a subjective screening tool is not a panacea for the problem of undetected sleep disorders among long-haul truck drivers. The array of sleep disorders found within this population point to the variety of physical and psychosocial risks endured by long-haul truck drivers. Ultimately, to improve sleep health among this population, detection and treatment of sleep disorders must be part of comprehensive efforts that address underlying risks such as shift work, job stress, financial pressures, obesogenic work environments, and poor access to healthcare.

6.5. Limitations

There are several limitations of this study. The primary limitation is the lack of concurrent formal diagnoses of sleep disorders in this sample. This study sought to explore the feasibility of using subjective sleep problems to screen for long-haul truck drivers with latent sleep disorders, and it was not intended to advocate for the specific subjective sleep problem questions included here to serve as a formal screening tool. Therefore, our findings should be interpreted as indicating the need for the development of a subjective screening tool to detect latent sleep disorders among long-haul truck drivers, and further that formal development of such a tool will ultimately require concurrent diagnoses to formally establish sensitivity and specificity. Second, the sample size used in this study is relatively small, although, given the novelty of these findings, these data provide useful insights into the value of subjective sleep problems among long-haul truck drivers. Third, several factors inherent to long-haul truck driving and the subjective symptoms of sleep disorders may have reduced the statistical power of the analyses conducted in this study. For example, long-haul truck drivers are continuously exposed to many risk factors for sleep disorders, including shift work (Apostolopoulos et al., 2014), obesogenic workplace environments (Apostolopoulos et al., 2016b), and psychological traumas (Apostolopoulos et al., 2016c. Exposure to these factors may induce multiple diagnosed or undiagnosed sleep disorders simultaneously. Fourth, the tendency of commercial drivers to underreport sleep disorder symptoms has been well-established in the scientific literature, and it is possible that the participants in this study responded to our sleep problem queries in a similar fashion, which may have impacted our findings (Kales and Straubel, 2014; Parks et al., 2009; Talmage et al., 2008). Fifth, some of the variables were not assessed using a validated questionnaire (e.g., stress), which may have reduced the accuracy of these measures. Sixth, data were collected from a single truck stop in North Carolina, which may have compromised the representativeness of these data; however, given the mobility of long-haul truck drivers, biases which would normally accompany single-location data collection methods are less relevant. Finally, the subjective sleep problem questions in the survey did not span the full spectrum of symptomology of sleep disorders, and the symptomology of some sleep disorders (e.g., grinding teeth due to sleep bruxism) are not typically recognized by the individuals themselves (Kato and Lavigne, 2010).

7. Conclusions

The use of subjective sleep problems to screen for undetected sleep disorders among long-haul truck drivers may hold promise for this mobile population. The results of this study point to the potential value of subjective screening tools for identifying drivers with undetected sleep disorders. Further research is warranted pertaining to both the value of subjective sleep problems in detecting latent sleep disorders and the etiology, presence, risk factors, and implications of the array of sleep disorders among long-haul truck drivers in general. Subsequent development of a screening tool which utilizes subjective sleep problems could involve establishing cut-off scores, with individuals scoring above established cut-off scores then being more rigorously screened via telephone interviews with sleep experts. At that point, they could be brought in for more thorough diagnosis and treatment. Before such a tool could be fully utilized, however, it will require concurrent diagnoses to formally establish sensitivity and specificity, and more needs to be known about the implications of its measures, such as how scores should be interpreted to warrant additional action.

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