

The goal of the Federal Motor Carrier Safety Administration (FMCSA) is to reduce commercial vehicle related fatalities, as well as the number of persons injured in commercial vehicle related crashes, by 50 percent by the year 2010.

FMCSA's Research and Technology programs encompass a range of issues and disciplines, all related to motor carrier and bus safety and security. FMCSA defines a "research program" as any systematic study directed toward fuller scientific discovery, knowledge, or understanding that will improve safety and security, and reduce the number and severity of commercial motor vehicle crashes. Similarly, a "technology program" includes those that adopt, develop, test and/or deploy innovative driver and/or vehicle best practices, and technologies that will improve safety and security, and reduce the number and severity of commercial motor vehicle crashes.

Currently, FMCSA's Office of Research and Technology conducts programs in the area of *Driver Safety Performance, Commercial Vehicle Safety Performance, Carrier Compliance and Safety, Safety Systems and Technology, Cross-Cutting Safety Initiatives, and Security*. The study described in the following Tech Brief was designed and developed as part of FMCSA's Research and Technology *Driver Safety Performance* Program. The primary goals of this program are to improve the safety behavior of non-commercial drivers in the vicinity of trucks and buses, and ensure that commercial drivers are physically qualified, trained to perform safely, and mentally alert.



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A Study of Prevalence of Sleep Apnea Among Commercial Truck Drivers

Introduction

Staying awake means staying alive. This is a slogan used to describe a research study on sleep apnea sponsored by the Federal Motor Carrier Safety Administration (FMCSA) and the American Transportation Research Institute of the American Trucking Associations (ATA). The research project addressed the prevalence of sleep apnea among commercial truck drivers, potential risk factors, and its impact on driving performance.

This Tech Brief summarizes the project's final report, *A Study of Prevalence of Sleep Apnea Among Commercial Truck Drivers*.

Background

Sleep apnea is a major contributor to daytime drowsiness—a condition that could prove deadly for commercial truck drivers and involved passenger vehicles. It is a condition where, during sleep, a narrowing or closure of the upper airway causes repeated sleep disturbances leading to poor sleep quality and excessive daytime sleepiness. Since excessive sleepiness can be a consequence of sleeping disturbances, drivers with sleep apnea have compromised driving performance leading to increases in the risks of crashes. According to the Divided Attention Driving Task, a research test designed to mimic driving performance, individuals with sleep apnea perform, on average, as poorly as individuals whose levels of blood alcohol concentration exceed the legal limit. The results of this study show that the prevalence rates of sleep apnea among commercial truck drivers are similar to sleep apnea rates found in other general populations. This is in contrast to the extremely high prevalence rates reported previously by the Stoohs study. [Stoohs, *Sleep and Sleep-Disordered Breathing in Commercial Long-Haul Truck Drivers*, 1995]

Purpose

This research study had three objectives:

- To estimate the prevalence of sleep apnea among a sample of commercial truck drivers living within a 50-mile radius of the University of Pennsylvania
- To examine the relationship in commercial truck drivers between severity of sleep apnea and decreased function related to driving performance
- To develop a profile of an overall sample of commercial truck drivers with regard to their sleep apnea-related characteristics and risks

Methodology

To estimate prevalence of sleep apnea in a sample population, researchers had to decide the following: sample population to be studied, higher risk and lower risk categories for likelihood of sleep apnea, placement category for in-laboratory testing, and methods to be used for in-laboratory testing.

Sample Population

The first step in estimating the prevalence of sleep apnea was to decide on a target population or population of interest for the study. Two approaches were considered when evaluating commercial truck drivers, before selecting the most applicable method. The first approach based the sample on drivers of specific commercial driving companies. However, there was concern that the hiring practices of some commercial driving companies may have specific features affecting the nature of their driver population, thereby improperly influencing the sampling pool. The second approach, and the one upon which this study was based, used a target population based on a random sample of commercial driver's license (CDL) holders living within 50 miles of the University of Pennsylvania. This approach had the advantage of a precisely defined sampling frame, which permitted a true random sample of 4,826 commercial truck drivers in a precisely defined population. The Pennsylvania Department of Motor Vehicles provided the random sample of CDL holders. Approximately 31.5 percent, or 1,391 participants, responded.

Higher Risk, Lower Risk and Placement Categories for Likelihood of Sleep Apnea

To determine the placement into higher risk and lower risk categories for the likelihood of sleep apnea, an instrument called a Multivariable Apnea Prediction (MAP) was used to calculate a MAP score based on age, gender, and body mass index (which measures the degree of obesity). Responses to survey questions about symptoms of sleep apnea also were evaluated as part of the calculation of each driver's MAP score. Of the total scores, 778 drivers scored high on the MAP and were placed in the higher risk group, while 551 drivers with low MAP scores made up the lower risk group. All drivers who were placed in the higher risk category were enrolled in in-laboratory testing, while those placed in the lower risk category were enrolled in random order for in-laboratory testing.

Methods for In-Laboratory Testing

All in-laboratory participants were assessed using multiple instruments with regard to their subjective perception of sleepiness and functional impairment, as well as objective measures of sleepiness, lack of attention, and other functional consequences of sleepiness. Various methods of testing were used in analyzing both subjective and objective measures of sleepiness. Methods to analyze subjective measures included self-report questionnaires, which measured drivers' self-perception of sleepiness and functional impairment. Methods to analyze objective measures included assessment of reaction times, performance lapses, and lane tracking ability.

Subjective Measures of Sleepiness:

- **Epworth Sleepiness Scale**

Drivers were asked to complete a simple self-administered questionnaire of eight items measuring their general level of daytime sleepiness, whereby they rated the likelihood of dozing off or falling asleep when in various situations commonly encountered in daily life, such as watching television, or being a passenger in a car.

- **Karolinska Sleepiness Scale**

This highly sensitive measurement scale for sleepiness was conducted on drivers who experienced shortened sleep duration the previous night. Participants, who were sleepy during the test, encountered intrusions of sleep episodes into their normal states of wakefulness. This test measures "sleep intrusions" into states of wakefulness.

- **Stanford Sleepiness Scale (SSS)**

This test is a single seven-item subjective measure scale for sleepiness. It asks the participants to circle the statement that best describes how sleepy they feel at the moment they are answering the question.

- **Functional Outcomes of Sleep Questionnaire (FOSQ)**

This is a self-report measure designed to assess the impact of disorders of excessive sleepiness on multiple activities of everyday living. This test is used to determine how disorders of excessive sleepiness affect participants' ability to conduct normal activities and the extent to which these abilities are improved by effective treatment of excessive daytime sleepiness.

Objective Measures of Sleepiness:

- **Multiple Sleep Latency Test**

This test, which measures the psychological pressure to fall asleep, studied the rate at which drivers fell asleep during daytime naps. Drivers were asked to fall asleep in a dark room at two-hour intervals, where the length of time it took to fall asleep was measured and the average of all nap opportunities was calculated.

- **Psychomotor Vigilance Test (PVT)**

Using a handheld device with a small visual display, this test measured driver reaction time to stimuli over a 10-minute period. Measurements that are sensitive to the effects of sleep loss, such as median reaction time, number of performance lapses, lapse duration, and optimum response time, were recorded.

- **Divided Attention Driving Task**

Designed to mimic driving performance, participants were tested using a driver-like model. They used a steering wheel device to track randomly moving targets, while simultaneously responding to numbers that randomly appeared at the corners of a computer screen. Each driver's average deviation from the desired center point and slope of increase was computed over the time of the test.

- **Digit Symbol Substitution Test (DSST)**

This test assessed cognitive speed and accuracy by subjecting drivers to a 90-second test, whereby the participant viewed nine identified symbols and was asked to identify one symbol at a time by typing its corresponding number. As soon as the driver responded, a new symbol appeared. Excessive sleepiness greatly affected the ability to perform this test.

Findings

A major goal of the study was to determine the prevalence of sleep apnea in commercial truck drivers, based on the results of several tests conducted on a random sample of commercial driver's license (CDL) holders living within a 50-mile radius of the University of Pennsylvania. The results of the study revealed that 17.6 percent of CDL holders had mild sleep apnea, 5.8 percent had moderate sleep apnea, and 4.7 percent had severe sleep apnea.

A significant research finding was that although sleep apnea is common among commercial vehicle drivers, its prevalence is considerably less than the 78 percent reported for mild sleep apnea of CDL holders in the Stoohs study. Instead, the rates of prevalence are more similar to study results in other, more general populations, rather than commercial truck drivers as a group.

The study also revealed that the prevalence of sleep apnea depends on the relationship between two major factors, age and degree of obesity, with prevalence increasing with both. This relationship is important, because it provides the commercial driving industry with predictions that are useful in estimating the prevalence of sleep apnea in any population of drivers.

Another meaningful study finding showed that the prevalence of sleep apnea depends on the average duration of sleep over consecutive nights at home. Short sleep duration, six hours or less per night, results in an increase in the prevalence of sleep apnea. It was revealed that sleep duration is affected by the time at which drivers awake in the morning, and since more than 35 percent of commercial truck drivers terminate their sleep before 6:00 am, they have significantly shorter sleep durations and higher chances of daytime sleepiness. All measures of sleepiness showed that the effects of daytime performance depend, not only on the severity of sleep apnea, but also on the average sleep duration of the driver.

A large number of drivers indicated self-reported sleepiness on the subjective tests; however, it was not a determining factor of the presence and severity of sleep apnea, since no relationship was found between self-report measures and any of the performance ability tests. This lack of relationship is unclear, and indicates that self-reports of sleepiness are not a reliable source in identifying drivers who are likely to have sleep apnea. Conversely, almost all of the objective tests of performance showed a clear relationship between performance ability and the severity of sleep apnea, i.e. the relationship between the measurement of sleepiness, and rate of performance lapses and lane tracking ability.

Researcher

This study was performed by the Trucking Research Institute, American Trucking Associations Foundation, 2200 Mill Road, Alexandria, VA 22314. Contract No. DTFH61-93-R-00088.

Distribution

This Tech Brief is being distributed according to a standard distribution. Direct distribution is being made to the Service Centers and Divisions.

Availability

The study final report FMCSA-RT-02-030 is available from the National Technical Information Service (PB2002-108226).

Key Words

Alertness Performance; Commercial Drivers; Daytime Sleepiness; Driving Tasks; Performance Measures; Prevalence of Sleep Apnea; Sleep Apnea; Sleep Deprivation; Sleep Duration.

Notice

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Since sleep apnea and shortened sleep duration were prevalent in the CDL test group, any effort to deal with impaired driving performance, as a result of excessive sleepiness, needs to consider both issues. These issues are important, since the risk of having sleep apnea is higher in CDL holders who have shorter durations of sleep. Although the prevalence of severe sleep apnea and chronic inadequate sleep among commercial truck drivers gives rise to serious concerns, it can be a reversible condition with effective treatment. However, a major challenge to ensuring driver safety against the adverse effects of sleep apnea is to develop cost-effective ways of identifying at-risk drivers, and ensuring a solution to this treatable and preventable problem.

Recommendations

Based on the results of the sleep apnea research project, researchers offered several recommendations to address the problems with the prevalence of sleep apnea among commercial truck drivers. These suggestions, however, do not necessarily represent the position or policies of the FMCSA. The recommendations include the following:

- Conduct research to assess the role of sleep apnea in crash causation for commercial vehicles
- Conduct research as to the efficacy of different strategies in order to identify commercial truck drivers with severe sleep apnea or chronic sleep deprivation
- Convene a committee of experts from various backgrounds to review and develop public policies on sleep apnea and make appropriate recommendations

References

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