

**Transport Safety Public Symposium in Tokyo**  
**Sleep-Disordered Breathing and Transport Safety**

# **Preventing Accidents in North American Commercial Drivers with Obstructive Sleep Apnea**

**-Summary of Remarks-**

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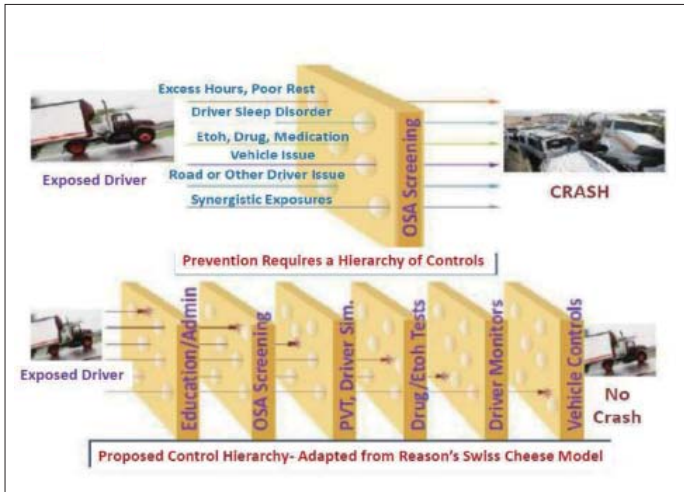
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## Introduction

There are many risks faced by drivers on the road today. Factors that heighten the risk of a driver becoming involved in an accident include: the number of hours a driver has slept or rested, the time of day, whether they have taken drugs or medication, whether they have been drinking alcohol, and adverse conditions on the road. Before any discussion of obstructive sleep apnea (OSA) and road accidents, it is important to note that there are many inter-related issues to consider, and that a single line of defense for just one of these factors will not be enough to prevent a tragedy. We must have a strategy that employs a wide range of preventative measures.

Figure 1



The Reason Model, or “Swiss Cheese model,” developed by James T. Reason is one such strategy.<sup>1</sup> This model proposes the establishment of many different measures—deployed simultaneously or in series—in order to prevent accidents. In 2003, this model was put to the test in Japan when a *shinkansen* train (bullet train) driver fell asleep at the controls.<sup>2</sup> Thanks to this strategic model, no one was injured. Even though the driver fell asleep, there were other measures in place to prevent a serious accident. Control systems installed in the train and the railway system worked together to stop the train automatically before it crashed. This is just one case that supports the effectiveness of the Reason model. It

is not surprising then, that the automobile industry, including companies like Audi, Lamborghini, Volkswagen, and SEAT, is working to create technologies that can detect when a driver is drowsy and take automated measures to avoid an accident, even if the driver is incapacitated. This is especially important for drivers with OSA.

Figure 2

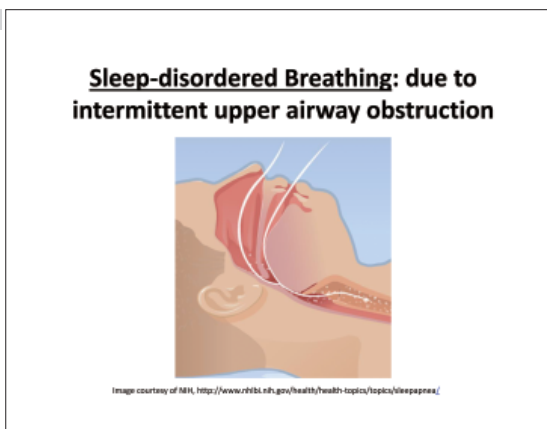


Figure 3

**Obstructive Sleep Apnea**

**Sleep-disordered Breathing: due to intermittent upper airway obstruction**

**Nocturnal symptoms of OSA: disrupted sleep due sleep-disordered breathing**

**Diurnal symptoms: excessive daytime sleepiness, psychomotor deficits, impaired vigilance, sleep attacks**

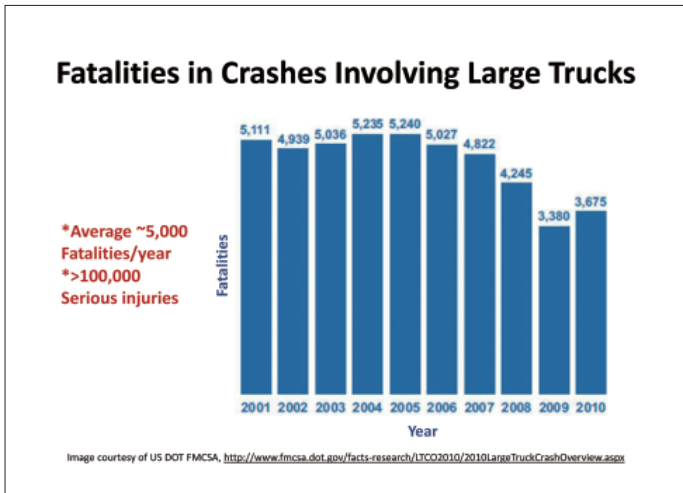
OSA is the clinically significant form of sleep-disordered breathing. It is the most common sleep disorder in the adult population worldwide and the leading medical cause of excessive daytime sleepiness. It is also the most important sleep disorder within the transportation industry.<sup>3</sup> It is caused by the periodic closure of the upper airway, leading to a decrease or cessation of respiration periodically

throughout sleep. The consequences of this are several fold, including intermittent disturbances in breathing because of upper airway obstruction, disrupted sleep, poor sleep, excessive daytime sleepiness, a deterioration of the ability to think, deficits in hand-eye coordination and reaction time, impaired vigilance, and on occasion, sleep attacks that can cause a patient to fall asleep suddenly without warning. These symptoms may or may not be recognized by the patient. Those with OSA often gradually become accustomed to their disorder over many years, and may not realize how poorly or tired they feel. In fact, it is often only after a month of treatment that a patient will tell their physician that they did not realize just how much they suffered for so many years.

### Background: OSA in US-North American Drivers

Different estimates exist regarding the proportion of accidents that involve or are attributable to sleepy drivers, but most scientists agree that it is somewhere between 10% and 30% of all accidents.<sup>4-6</sup> This makes sleepy drivers a very important group. There is the potential for a very large reduction in accidents if we can reduce the risk this group of drivers poses.

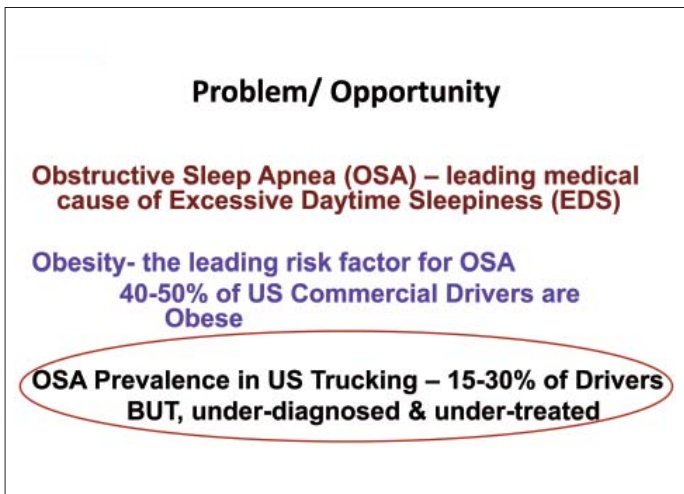
Figure 4



There are over 5,000 fatalities and over 100,000 serious injuries every year due to large bus and truck crashes in the United States.<sup>7</sup> Assuming 20% are due to

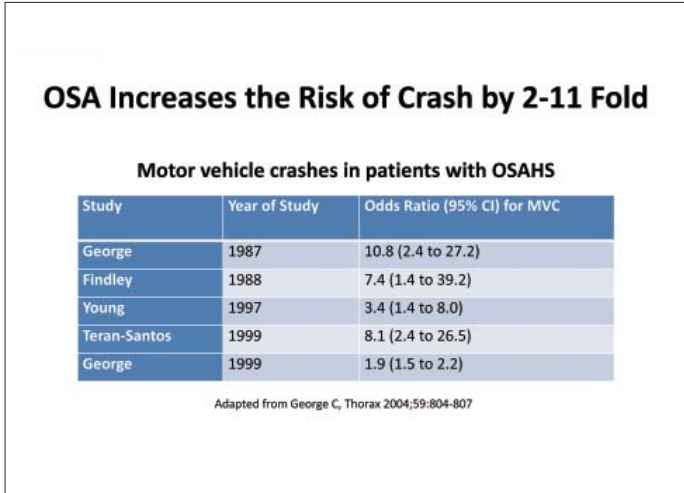
sleepiness, over 1,000 deaths and over 20,000 serious injuries are due to driver fatigue every year. While there are many factors contributing to driver fatigue that can only be controlled by the driver or their employer, such as: when a driver goes to bed, when they wake up, what they do during off hours, how much they drink, what they eat, their shift, the number of hours they work, and the route they drive; there are also many issues that can be mitigated by occupational medicine physicians to alleviate the risk that drowsiness poses. During a medical exam, occupational medicine physicians can screen for certain conditions like the presence of drugs and alcohol, as well as the presence of sleep disorders, in particular OSA.<sup>8</sup>

Figure 5



The presence of obesity increases the risk for OSA. Right now, 40-50% of the commercial drivers in the United States are obese based on their body mass index (BMI).<sup>3</sup> The relationship between obesity and OSA in middle-aged men is tightly correlated. If we take a man in the United States or Europe with a BMI of 32 or higher, even without knowing any other statistic, we can say that this person has approximately a 75% chance of having OSA. The vast majority of these cases will not be recognized. They will not be diagnosed, and they will not be receiving treatment. Thus, these drivers are operating vehicles at risk to themselves, their companies, and the general public.

Figure 6



Studies that compare patients with sleep apnea to normal drivers show that those with sleep apnea are basically two times to 11 times more likely to have an accident. Conservatively, this means that passenger car drivers who have been diagnosed in a clinic with sleep apnea have a motor vehicle accident risk 3-4 times that of the average person in the general population.<sup>9</sup>

There is a solution to this problem. In clinical studies, drivers with OSA who receive continuous positive airway pressure (CPAP) treatment see their rate of accidents reduced to a level in line with control subjects who do not have OSA. In other words, this treatment can be effective in almost completely removing the driving risk of this disorder.

## A Comparison and Contrast of the United States and Asia regarding OSA and Drivers

Figure 7

<b>Compare- Contrast US and Asia for OSA &amp; Drivers</b>	
<b>Similarities</b>	<b>Differences</b>
<b>OSA Under-recognized</b>	<b>Japan- most drivers with OSA are non-Obese (BMI &lt; 30 m/kg<sup>2</sup>)</b>
<b>Obesity increases risk</b>	<b>Japan- screening done by Questionnaires and Home Diagnostics (O2 sat, other Portable Monitors)</b>
<b>OSA Prevalence in Commercial Drivers ~25%</b>	<b>US- screening by Questionnaires &amp; Anthropometrics. Portable Monitors used as alternate diagnostic tool.</b>
<b>OSA has been a Causal Factor in Serious Accidents/ Near Misses</b>	

There are both differences and similarities with respect to OSA within the United States compared to Japan and Asia.<sup>10</sup> Among the similarities is that this disorder is under-recognized everywhere. Most people who have OSA do not realize it. Even if people in their family know that they are snoring, they do not necessarily know that this is a medical problem. Many people think that snoring is a benign habit and that those who snore are getting very restful and peaceful sleep. This is clearly a misconception.

In both Japan and the United States, obesity increases the risk of suffering from sleep apnea. Even though the proportion and prevalence of obesity are dramatically different in the two areas, the prevalence of sleep disordered breathing, from mild up all the way to severe, is similar, at as much as 25% among commercial drivers in both countries.<sup>11</sup> Thus, OSA is a causal factor for serious accidents in both societies.

The main difference between the United States and Japan is that most of the drivers with OSA in Japan are not obese.<sup>10-12</sup> Some have suggested that this

may be due to differences in facial structure or differences in the distribution and the amount of body fat per body weight; however, the exact reason why the Japanese population experiences medical co-morbidities related to obesity at a lower BMI is not yet known. Regardless of which factor is considered, be it hypertension, increased blood sugar, increases in blood cholesterol and triglycerides, Type II diabetes mellitus, or OSA, the Japanese population on average develops these problems at a lower BMI than western populations.<sup>13</sup>

For this reason, unlike in the United States, where BMI information or questionnaires are used to identify patients with a high-risk of OSA for further screening, in Japan, pulse oximetry or air flow monitoring is usually necessary to screen and identify OSA patients.<sup>2,11</sup>

## **Overview of Strategies in North America**

Strategies used in North America to identify drivers with sleep apnea include the use of an official (federal) driver's license medical examination form and various questionnaires in which drivers are asked to report their own symptoms. Drivers do not always offer accurate answers on these questionnaires,<sup>3</sup> but physicians can often convince drivers to divulge information that they would not normally report on a form during interviews within the occupational medicine examination. The way in which a question is posed is important. While a driver is less likely to admit to snoring if asked about it on a questionnaire, during a medical examination, a physician might convince a driver to admit to snoring by joking about whether or not their significant other complains about the noise. A skilled physician can often obtain information that a questionnaire cannot.





an apnea-hypopnea index of 10 or more, which is considered definitive sleep apnea.<sup>15</sup> The Somni-Sage questionnaire is considered generally effective, and can be made even more effective by combining it with objective tests to ensure that even the high-risk drivers who provide inaccurate or deceptive answers about their height and weight and symptoms are identified as well.

It is clear that drivers talk to each other about these tests and change their behavior to avoid a sleep apnea diagnosis. They do this because they do not necessarily want to accept treatment. Even though it may make them feel better, they do not want to have the restriction of extra medical testing and extra monitoring. In 2006, the very first year that Schneider National started using this questionnaire, 29% of drivers admitted that they had excessive daytime sleepiness in some form or another. The proportion of drivers willing to admit this went down every year after that, finally reaching 6% in 2010.<sup>15</sup> The population of drivers is basically the same, so it is thought that the actual reason behind this drop was that drivers talked to each other, learned that the company was trying to identify sleepy drivers, and changed their answers to avoid being diagnosed with a sleep disorder. Nevertheless, the Somni-Sage questionnaire and program maintained a predictive value of roughly 70% every single year, meaning that the prevalence of sleep apnea remained at 20%. Thus, the questionnaire was still effective even after drivers changed their behavior.

According to data collected by the University of Pennsylvania, 50% of commercial drivers in North America have a BMI of 30 or greater.<sup>16</sup> The point where there is the strongest correlation between BMI and OSA is at a BMI greater than or equal to 33 among North American drivers. In particular, using a screening cutoff of a BMI of 33, OSA can be predicted with 77% sensitivity and 71% specificity in the North American driver population.<sup>16</sup>

A similar correlation can be found in certain places elsewhere throughout the world, such as in Israel, which has a largely European population. It was decided there that all drivers with a BMI of 32 or greater would be tested for sleep apnea. The predictive value of that test was very similar. It was found that there is a roughly 75% chance that a male with a BMI of 32 or greater will have OSA.<sup>17</sup> This was confirmed in a sleep laboratory, where 78% in fact tested

positive for OSA. Notably, in this case in Israel, the drivers denied symptoms of sleep apnea and daytime sleepiness. Yet when asked to take a Multiple Sleep Latency Test, which is a napping test administered during the day, 50% of these drivers produced abnormal results consistent with objectively measured excessive daytime sleepiness.

Figure 9

**Joint Task Force OSA Guidelines  
(JOEM & CHEST 2006)**

Includes 2 or more of the following objective measures:

- a. BMI  $\geq$  35 kg/m<sup>2</sup>
- b. NC > 17 inches in men, 16 inches in women
- c. Hypertension (new, uncontrolled, or unable to control with < 2 medications)

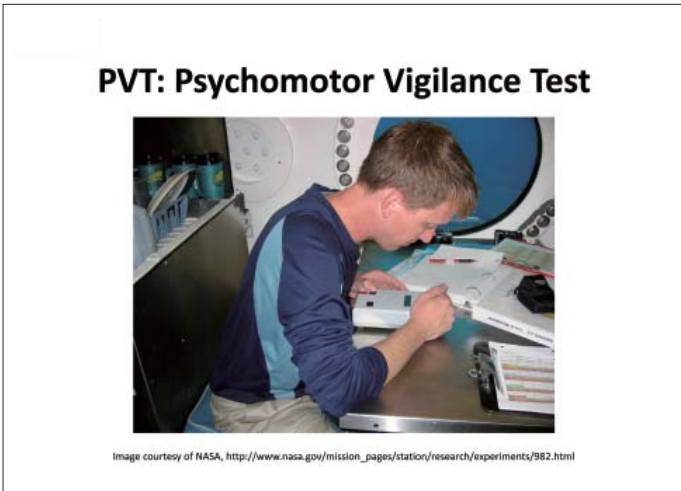
**Talmage et al. JOEM 2008: 13% Prevalence, 95% PPV**  
**Parks et al. JOEM 2009: 12% Prevalence, 100% PPV**  
**Xie et al. JOEM 2011: 79% PPV**

Returning to North America, another strategy being employed to detect OSA is the development of guidelines that can help occupational medicine physicians screen whether or not a driver has this disorder. The most commonly used guidelines for detecting sleep apnea right now in the United States are the Joint Task Force Guidelines or Joint Task Force Consensus Criteria. These guidelines were published in two medical journals in 2006, the *Journal of Occupational and Environmental Medicine and Chest*.<sup>18, 19</sup> They were developed by three medical societies, the American College of Occupational and Environmental Medicine, the American College of Chest Physicians, and the National Sleep Foundation.

The guidelines set the criteria for determining sleep apnea based on objective factors, such as a BMI of 35 or greater and neck circumference. In the United States, a neck circumference greater than 17 inches for men is considered to be a risk factor for sleep apnea. Because body sizes tend to increase somewhat symmetrically, most drivers with a BMI of 35 or greater will have a neck

circumference greater than 17. Over 90% of those who are judged to be high risk by the Joint Task Force Screening Criteria will be found to actually have OSA during sleep laboratory testing. This poses a new problem, which is that when tests are so highly predictive of a disorder, the sensitivity goes down because false positives are no longer being detected. In fact, these tests only estimate the prevalence of sleep apnea to be 12-13%,<sup>14</sup> when it is known that the actual prevalence is closer to 20-25% among driver populations.<sup>3,15</sup> While this suggests they are not the ideal screening criteria, they are generally accepted because they have been published by medical societies and validated in several American occupational medicine clinics.

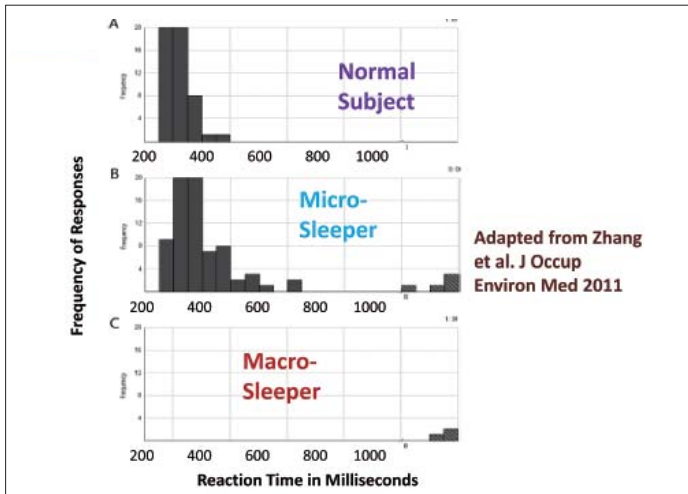
Figure 10



Beyond the guidelines, another potential method being developed to detect OSA is functional testing.<sup>20</sup> One such test is the Psychomotor Vigilance Test, a handheld examination of reaction time. During this test, the subject is asked to look at a screen. At random intervals over ten minutes, a light will appear. As soon as the subject sees the light, they are asked to press a button. When they do so, their reaction time is recorded and the light is briefly stopped. This light stimulus is repeated hundreds of times at random intervals over the ten minute test, making it both a test of reaction time as well as sustained alertness and vigilance.

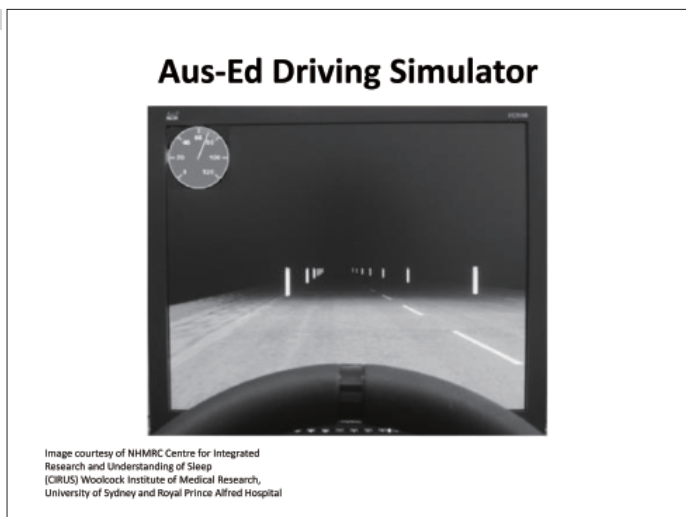
It has been clearly shown through multiple studies using this test that lapses in attention increase dramatically along with sleep deprivation.

Figure 11



It is even possible to discriminate between different individuals using this test. A normal sleeper has a typical reaction time of less than one half of one second. Those with micro sleeps will have reaction times of 500 milliseconds or greater. For these people, most of their reaction times will be normal, but there may be lapses during the ten-minute test. Conversely, “macro sleepers” who fall asleep for the whole test will have almost no reaction time responses.<sup>20</sup>

Figure 12



The Psychomotor Vigilance Test is not the only functional test that can potentially detect OSA. Driving simulators are another type of test that is under investigation. The Aus-Ed Driving Simulator is well known among these.<sup>21, 22</sup> It was created by teams from Australia and Edinburgh, Scotland, hence the name. It can be programmed for right lane or left lane driving, depending on the driver's home country. It simulates night driving on a rural road. In the simulator, trucks periodically appear in front of the driver, and the subjects are asked to break all the way to a complete stop whenever they see one. They also need to maintain their lane as well as they can. The key measure on this test is steering deviation – how closely a driver follows their designated lane of travel as opposed to deviating right and left in the lane. It is possible to crash this test, but that is relatively rare. Crashes tend to indicate even more serious sleepiness.

A study was run using this driving simulator on a group of drivers with OSA and a control group that did not have OSA. The OSA patients had more steering deviation than the control subjects even when the control subjects had a restricted time in bed and the OSA patients were allowed to sleep as normal. Adding sleep restriction to the sleep apnea patients created a remarkable elevation in steering deviation. Even in the presence of alcohol, control subjects drove better than the OSA patients who had not consumed alcohol. As

could be expected, when OSA patients were given alcohol, their performance deteriorated dramatically.<sup>22</sup>

What all of these tests clearly show is that sleep apnea is a serious safety risk. Allowing drivers with sleep apnea to drive without treatment is equivalent to allowing drunk driving to occur without any intervention. The performance of a driver with untreated sleep apnea can be compared to a driver with a blood alcohol concentration of 0.06 to 0.08.

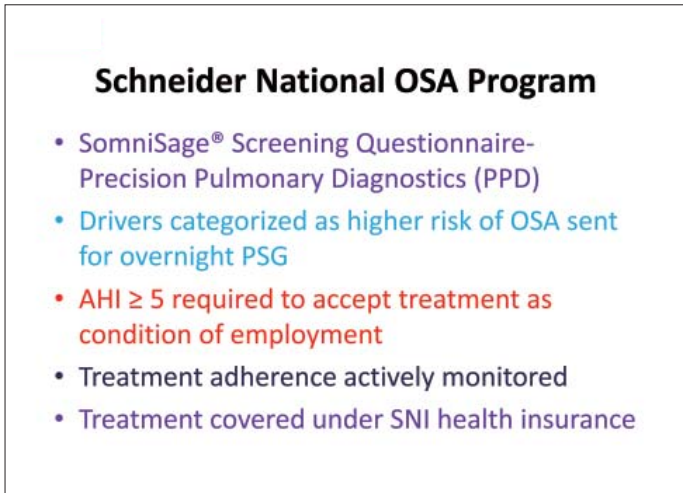
It should be noted that the time of day is an important risk factor. The relative risk of a crash is lowest at 9 or 10 AM in the morning and 7 to 8 PM at night. The highest risk times are midnight, up to 5 o'clock in the morning, and then again in the afternoon at 1 to 2 o'clock. Drivers with OSA can be expected to perform especially poorly at these times.<sup>23</sup>

## **OSA & Accident Risk Commercial Drivers**

Data shows a correlation between accident risk and OSA.<sup>24</sup> Most studies done to date have examined patients from sleep clinics, and these patients may be somewhat different from commercial drivers, who typically do not complain about sleep disorders. However, looking at self-reported body mass indices, new recruit drivers with a BMI of greater than 35 had a 40-50% increased risk of truck accidents compared to non-obese colleagues.<sup>25</sup> In another study taking a random sample of United States transportation operators and asking about accident risk and its connection to sleep complaints in terms of exposure to accidents and near-misses, it was found that there were increased odds for accidents connected to any type of sleep complaint at all.<sup>26</sup> In particular, the study found that excessive daytime sleepiness, excessive use of stimulants, and whether the subject had a history of having been in an accident while commuting to and from work was correlated to an increased risk of a professional crash or near-miss that is 4 to 5 times greater than the baseline risk. Sleep complaints elevated accident risk 2 to 4 fold. Basically, any type of sleep complaint increased the risk of reporting an accident or near-miss.<sup>26</sup>

In the United States, the Federal Motor Carrier Safety Administration, the government agency which is responsible for large trucks and buses, does not require screening for sleep apnea other than the single question on medical examination forms which was mentioned earlier. This is not effective. Some in the transportation industry realize that, and they are working to enhance the detection of OSA among drivers. Because there are so many lawsuits filed after commercial drivers crash, and because many companies want to do the right thing, companies like Schneider National have decided that it is better for their drivers, customers, and the company's bottom line to implement unique sleep apnea screening programs.

Figure 13



**Schneider National OSA Program**

- SomniSage® Screening Questionnaire- Precision Pulmonary Diagnostics (PPD)
- Drivers categorized as higher risk of OSA sent for overnight PSG
- $AHI \geq 5$  required to accept treatment as condition of employment
- Treatment adherence actively monitored
- Treatment covered under SNI health insurance

Schneider National started its program in 2006.<sup>15</sup> The OSA Program primarily uses the Somni-Sage Questionnaire. Any drivers found to be high risk are sent for a sleep study, and if they show an increased amount of sleep disordered breathing, with an apnea-hypopnea index of 5 or greater, they are required to use a CPAP device at home and in their truck in order to maintain their employment with the company. For drivers who wish to take naps or sleep overnight in a truck stop, the device can be plugged into their truck. The company monitors treatment compliance via a wireless device. Monitoring is done every day for the first 30 days, and depending on compliance, it is continued over regular intervals after that. Treatment expenses are covered by



the company's health insurance. Studies of the program's effect on accident risk are ongoing.

## **OSA Treatment and Accident/Medical Costs**

Data continues to be analyzed on the effect of OSA in terms of treatment, accidents, and medical costs. Accident risks are not eliminated for people treated with CPAP, but they are reduced significantly,<sup>27</sup> and thus, we expect that accident costs would fall. OSA is associated with a higher risk of hypertension, incident diabetes mellitus, incident stroke, heart attack, and sudden death; therefore, we also expect that CPAP treatment ultimately decreases medical costs.<sup>28</sup> CPAP treatment for drivers with OSA is essentially a forward-looking investment, because it is rare that a person can lose enough weight to eliminate their sleep apnea. Furthermore, patients actually lose weight more efficiently when they are treated with CPAP, as poor sleep tends to cause people to gain weight due to important hormonal changes that occur during sleep.

## **Conclusions**

There are many different screening strategies for OSA. Some are somewhat effective by themselves, others are not. It is important to combine strategies together into a coherent overall method for screening and the prevention of accidents. The combined strategies should be considered as a serial pathway. If a driver comes out as high risk at any point in the pathway, whether that is based on their BMI, the results of a questionnaire, a reaction time test, or the outcome of a driving simulation test, that driver should undergo a sleep test in order to rule out the possibility that he or she might have a sleep disorder. Only drivers that are consistently low risk throughout the entire process should be exempt from this type of diagnostic procedure. In countries like Japan, where there is a different distribution of BMI and different relationship of BMI to sleep apnea, it may be more difficult to determine who is at high risk for having OSA, and it may be advisable to have the majority of drivers screened using portable or home diagnostic medical devices.

Screening for OSA can produce a high yield. If the entire population of commercial drivers were screened worldwide, it would likely be found that at least 10% and as many as 25% have OSA. It is rare for any form of occupational medicine screening to produce such a high proportion of subjects diagnosed with the condition being examined. Usually, positive results are uncommon. But OSA is different. It is very common, and it is an overlooked issue. The medical community should be more aggressive about screening and diagnosing this problem.

When conducting screening, the best practice is to combine various types of subjective and objective measures. The treatment of OSA does decrease accidents. Accidents are multi-factorial, and so like with screening, multiple layers of controls are required to ensure safety.

In addition to OSA screening, companies should intervene to make sure drivers do not work an excessive numbers of hours and that they have appropriate rest periods. Drivers that have medical or sleep disorders should be investigated by occupational health departments and if found to have OSA only be allowed to drive during the day time provided that they are compliant with CPAP treatment.

There are many potential technological advances that can be used to enhance safety. For example, a camera may be placed inside the cab of a truck or a bus that can monitor the driver's pupil size or the rate at which the driver is closing their eye or blinking, as well as the different types of eye movements that the driver is making. These factors are correlated with sleepiness. Such a camera could be hooked up so that there is a threshold at which the technology gives the driver an alarm, a signal, or even a vibration in their seat to wake them up.

Similarly, there are controls intrinsic to the vehicle or the road itself that may be used to reduce the risk of accident. Rumble strips are used in the roads of both the United States and Japan. These are not always effective. While they may initially wake up the driver, often they give the driver the false sense of security that they will be woken up if they fall asleep. There may be a complementary design change to a vehicle that could be used, by which at some

point, the vehicle itself would sense that the driver is repeatedly on a rumble strip and forcibly slow down, stop, or shut off the vehicle. Likewise, automobile manufacturers are working on mechanisms that can detect how much a vehicle is swaying in its lane or whether there are excessive deviations in the speed or braking. These behaviors may also act as a warning, and through these systems may set off an alarm, and if the driver continues to drive erratically, may cause the vehicle to shut down.

While technology is the future of automotive safety, it is currently limited. Drivers with OSA have a high risk of causing accidents, and for the time being, it is important to continue careful medical monitoring of driver populations in order to detect these drivers and prevent accidents before they happen. Even when better technologies do become available, OSA screening, other medical tests and administrative controls to minimize driver fatigue will remain important as part of a multi-pronged Reason strategy.

## References

1. Reason, JT. Human error: models and management. *BMJ*. 2000 March 18; 320(7237): 768–770.
2. Tanigawa T, Horie S, Sakurai S, Iso H. Screening for sleep-disordered breathing at workplaces. *Ind Health*. 2005 Jan;43(1):53-7.
3. Zhang C, Berger M, Malhotra A, Kales SN. Portable diagnostic devices for identifying obstructive sleep apnea among commercial motor vehicle drivers: considerations and unanswered questions. *Sleep*. 2012 Nov 1;35(11):1481-9.
4. Philip P. Sleepiness of occupational drivers. *Ind Health*. 2005 Jan;43(1):30-3.
5. Radun I, Summala H. Sleep-related fatal vehicle accidents: characteristics of decisions made by multidisciplinary investigation teams. *Sleep*. 2004 Mar 15;27(2):224-7.
6. Akerstedt T. Consensus statement: fatigue and accidents in transport operations. *J Sleep Res*. 2000 Dec;9(4):395.
7. *National Summary of Large Truck and Passenger Carriers Crashes*: US Department of Transportation; 2010.
8. *Certification Process for Drivers with Serious Medical Conditions*: United States Government Accountability Office: 2008.
9. George CF, Sleep. 5: Driving and automobile crashes in patients with obstructive sleep apnoea/hypopnoea syndrome. *Thorax*. 2004 Sep;59(9):804-7.
10. Yamagishi K, Ohira T, Nakano H, Bielinski SJ, Sakurai S, Imano H, Kiyama M, Kitamura A, Sato S, Konishi M, Shahar E, Folsom AR, Iso H, Tanigawa T. Cross-cultural comparison of the sleep-disordered breathing prevalence among Americans and Japanese. *Eur Respir J*. 2010 Aug;36(2):379-84.
11. Sakurai S, Cui R, Tanigawa T, Yamagishi K, Iso H. Alcohol consumption before sleep is associated with severity of sleep-disordered breathing among professional Japanese truck drivers. *Alcohol Clin Exp Res*. 2007 Dec;31(12):2053-8.
12. Villaneuva AT, Buchanan PR, Yee BJ, Grunstein RR. Ethnicity and obstructive sleep apnoea. *Sleep Med Rev*. 2005 Dec;9(6):419-36.
13. Pan WH, Yeh WT, Weng LC. Epidemiology of metabolic syndrome in Asia. *Asia Pac J Clin Nutr*. 2008;17 Suppl 1:37-42.
14. Parks P, Durand G, Tsismenakis AJ, Vela-Bueno A, Kales S. Screening for obstructive sleep apnea during commercial driver medical examinations. *J Occup Environ Med*. 2009 Mar;51(3):275-82.
15. Berger M, Varvirigou V, Rielly A, Czeisler CA, Malhotra A, Kales SN. Employer-mandated sleep apnea screening and diagnosis in commercial drivers. *J Occup Environ Med*. 2012 Aug;54(8):1017-25.
16. Gurubhagavatula I, Maislin G, Nkwuo JE, Pack AI. Occupational screening for obstructive sleep apnea in commercial drivers. *Am J Respir Crit Care Med*. 2004 Aug 15;170(4):371-6.
17. Dagan Y, Doljansky JT, Green A, Weiner A. Body Mass Index (BMI) as a first-line screening criterion for detection of excessive daytime sleepiness among professional drivers. *Traffic Inj Prev*. 2006 Mar;7(1):44-8.
18. Hartenbaum N, Collop N, Rosen IM, Phillips B, George CF, Rowley JA, Freedman N, Weaver TE, Gurubhagavatula I, Strohl K, Leaman HM, Moffitt GL, Rosekind MR. Sleep apnea and commercial motor vehicle operators: statement from the joint Task Force of the American College of Chest Physicians, American College of Occupational and Environmental Medicine, and the National Sleep Foundation. *J Occup Environ Med*. 2006 Sep;48(9 Suppl):S4-37.
19. Hartenbaum N, Collop N, Rosen IM, Phillips B, George CF, Rowley JA, Freedman N, Weaver TE, Gurubhagavatula I, Strohl K, Leaman HM, Moffitt GL; American College of Chest Physicians; American College of Occupational and Environmental Medicine; National Sleep Foundation. Sleep apnea and commercial motor vehicle operators: Statement from the joint task force of the American College of Chest Physicians, the American College of Occupational and Environmental Medicine, and the National Sleep Foundation. *Chest*. 2006 Sep;130(3):902-5.
20. Zhang C, Varvirigou V, Parks PD, Gautam S, Bueno AV, Malhotra A, Kales SN. Psychomotor vigilance testing of professional drivers in the occupational health clinic: a potential objective screen for daytime sleepiness. *J Occup Environ Med*. 2012 Mar;54(3):296-302.
21. Vakulin A, Baulk SD, Catcheside PG, Antic NA, van den Heuvel CJ, Dorrian J, McEvoy RD. Driving simulator performance remains impaired in patients with severe OSA after CPAP treatment. *J Clin Sleep Med*. 2011 Jun 15;7(3):246-53.
22. Vakulin A, Baulk SD, Catcheside PG, Antic NA, van den Heuvel CJ, Dorrian J, McEvoy RD. Effects of alcohol and sleep restriction on simulated driving performance in untreated patients with obstructive sleep apnea. *Ann Intern Med*. 2009 Oct 6;151(7):447-55.
23. Garbarino S, Nobili L, Beelke M, De Carli F, Ferrillo F. The contributing role of sleepiness in highway vehicle accidents. *Sleep*. 2001 Mar 15;24(2):203-6.
24. Tregear S, Reston J, Schoelles K, Phillips B. Obstructive Sleep Apnea and Risk of Motor Vehicle Crash: Systematic Review and Meta-Analysis. *J Clin Sleep Med* 2009;5(6):573-581.
25. Anderson JE, Govada M, Steffen TK, Thorne CP, Varvirigou V, Kales SN, Burks SV. Obesity is associated with the future risk of heavy truck crashes among newly recruited commercial drivers. *Accid Anal Prev*. 2012 Nov;49:378-84.
26. Johnson K, Patel SR, Baur DM, Edens EN, Sherry P, Malhotra A, Kales SN. Association of Sleep Habits with Accidents and Near Misses in United States Transportation Operators. [In Preparation].
27. George CF. Reduction in motor vehicle collisions following treatment of sleep apnoea with nasal CPAP. *Thorax*. 2001 Jul;56(7):508-12.
28. Hoffman B, Wingenbach DD, Kagey AN, Schaneman JL, Kasper D. The Long-Term Health Plan and Disability Cost Benefit of Obstructive Sleep Apnea Treatment in a Commercial Motor Vehicle Driver Population. *J Occup Environ Med*. 2010;52(5):473-7.