Implications of OSA on Work and Work Disability Including Drivers

Ann Y. Teng, DO[a,*], Christine Won, MD, MS[b]

KEYWORDS

• OSA • Disability • Drivers • Sleep • Apnea • Impairment • Snoring • SDB

KEY POINTS

- This article illustrates the impact of obstructive sleep apnea (OSA) on the work force.
- Specifics of OSA impact on individuals are discussed with regard to veterans, first responders, farmers, and pilots, with a special concentration on commercial vehicle drivers.
- The pathophysiology of the disease as well as the consequence of impairment and disability due to OSA on work capacity is introduced.
- Federal guidelines for occupational specific recommendations are presented. Importance is placed on the health care provider's role in identifying and incorporating effective screening and treatment strategies for workers with sleep apnea.

Obstructive sleep apnea (OSA) is a common and debilitating disease characterized by repetitive upper airway obstruction associated with sleep disruption, oxygen desaturation, and exaggerated sympathetic tone. OSA is associated with significant medical diseases such as increased cardiovascular morbidity and cognitive and psychological limitations. With respect to the workplace, there is increasing recognition that untreated and ineffectively treated OSA has adverse effects on individual performance as well as the overall safety for workers and, in certain circumstances, the general public **Fig. 1**.

The prevalence of OSA (defined by an apnea–hypopnea index [AHI] $\geq$5) in the middle-aged adult population has been estimated to be up to 24% in men and 9% in women.[1] The National Commission on Sleep Disorders Research estimates that OSA affects 7 million to 18 million people in the United States and that OSA remains undiagnosed in approximately 92% of affected women and 80% of affected men.[2] Given such a high prevalence, untreated OSA becomes a significant burden on the entire workforce. At the individual level, treatment of OSA and its associated comorbities can contribute to increasing health care costs for employers, increased absenteeism, and alterations in job performance. The consequence of OSA poses a danger to public safety not only for workers but also for those whom they serve.

Several risk factors for OSA such as male gender, obesity, and increasing age influence the growing impact and presentation of OSA in the workplace. The current obesity epidemic in the general population could lead to the increasing presence of OSA in the workplace. More than half of morbidly obese

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[a] Occupational Environmental Medicine, Yale School of Medicine, 135 College Street, 3rd Floor, New Haven, CT 06515, USA; [b] Pulmonary and Critical Care Medicine, Yale School of Medicine, 300 Cedar Street, New Haven, CT 06520-8057, USA
* Corresponding author.
E-mail address: ann.teng@yale.edu

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Screening Recommendation for CMV Drivers With Possible or Probable Sleep Apnea

Medically Qualified To Drive Commercial Vehicles if Driver Meets Either of the Following:	In-Service Evaluation Recommended if Driver Falls Into Any One of the Following Five Major Categories (3-mo Maximum Certification):	Out-of-Service Immediate Evaluation Recommended if Driver Meets Any One of the Following Factors:
1. No positive findings or any of the numbered in-service evaluation factors	1. Sleep history suggestive of OSA (snoring, excessive daytime sleepiness, witnessed apneas)	1. Observed unexplained excessive daytime sleepiness (sleeping in examination or waiting room) or confessed excessive sleepiness
2. Diagnosis of OSA with continuous positive airway pressure compliance documented	2. Two or more of the following (1) body mass index > 35 kg/m^2; (2) neck circumference > 17 inches in men and 16 inches in women; (3) hypertension (new, uncontrolled, or unable to control with fewer than two medications)	2. Motor vehicle accident (run off road, at fault, rear-end collision) likely related to sleep disturbance unless evaluated for sleep disorder in the interim.
	3. Epworth sleepiness scale score > 10	3. Epworth sleepiness scale score ≥ 16 or functional outcomes of sleep questionnaire score < 18
	4. Previously diagnosed sleep disorder; compliance claimed, but no recent medical visits/compliance data available for immediate review (must be reviewed within 3-month period); if found not to be compliant, should be removed from service (includes surgical treatment)	4. Previously diagnosed sleep disorder (1) noncompliant (continuous positive airway pressure treatment not tolerated); (2) no recent follow-up (within recommended time frame); (3) any surgical approach with no objective follow-up
	5. Apnea-hypopnea index > 5 but < 30 in a prior sleep study or polysomnography and no excessive daytime somnolence (Epworth sleepiness scale score < 11); no motor vehicle accidents; no hypertension requiring two or more agents to control	5. Apnea hypopnea index > 30.

Fig. 1. Screening recommendations for CMV drivers with possible or probable sleep apnea. (*From* Hartenbaum N, Callop N, Rosen IM, et al. Sleep apnea and commercial motor vehicle operators. Chest 2006;130(3):902; with permission.)

Recommendation Regarding the Evaluation for Fitness for Duty for Commercial Drivers With Possible or Probable Sleep Apnea

Categories	Recommendations
Diagnosis	1. Diagnosis should be determined by a physician and confirmed by polysomnography, preferably in an accredited sleep laboratory or by a certified sleep specialist. 2. A full-night study should be done unless a split-night study is indicated (severe OSA identified after at least 2 h of sleep).
Treatment	1. First-line treatment for CMV drivers with OSA should be delivered via positive airway pressure (continuous positive airway pressure, bilevel positive airway pressure). 2. All CMV drivers receiving positive airway pressure must use a machine that is able to measure time on pressure. 3. A minimum acceptable average use of continuous positive airway pressure is 4 h within a 24-h period, but drivers should be advised that longer treatment would be more beneficial. 4. Treatment should be started as soon as possible, but within 2 wk of the sleep study. 5. Follow-up by a sleep specialist should be done after 2 to 4 wk of treatment.
Return to work after treatment (treatment with positive airway pressure)	1. After approximately 1 wk of treatment there contact between the patient and personnel from either the durable medical equipment supplier, treating provider, or sleep specialist. 2. An apnea-hypopnea index < 5 is documented with continuous positive airway pressure at initial titration (full night or split night) or after surgery or with use of oral appliance; apnea hypopnea index is ≤ 10 depending on clinical findings. 3. Query the driver about mask fit and compliance, and remind him/her to bring card (if used) or machine to next session. 4. At a minimum of 2 wk after initiating therapy, but within 4 wk, the driver should be re-evaluated by the sleep specialist, and compliance and BP assessed. 5. If the driver is compliant and BP is improving (must meet FMCSA criteria), the driver can return to work but should be certified for no longer than 3 mo.
Return to work after treatment (treatment with oral appliances)	1. Oral appliances should only be used as a primary therapy if the apnea-hypopnea index is < 30. 2. Prior to returning to service, the driver must have a follow-up sleep study demonstrating an apnea-hypopnea index < 5, but ≤ 10 while wearing an oral appliance. 3. All reported symptoms of sleepiness must be resolved, and BP must be controlled or improving (must meet FMCSA criteria).
Return to work after treatment (treatment with surgery or weight loss)	The driver should have a follow-up sleep study; the apnea-hypopnea index is ideally < 5, but ≤ 10 required to document efficacy.

Fig. 1. (*continued*)

persons are reported to have OSA, and it is 50% more prevalent in persons with cardiac or metabolic disorders.[2] There is evidence that obese employees have "presenteeism" and are less productive while on the job.[3] OSA itself contributes to increased fatigue and cognitive decline. Based on trends observed from NHANES studies from 1976 to 2004 it is projected that, by the year 2030, 86.3% of all American adults will be overweight or obese and 51.1% of them will be obese.[4] Therefore, the direct and indirect financial cost of obesity in the US workforce would be astronomical if this current trend continues.

With the aging of the workforce, the prevalence of OSA in the older population prompts an additional concern for the workforce. It has been projected that the American workforce is aging and that between the years of 2006 and 2016, the number of workers 55 to –64 years of age will increase by 36.5%, whereas the number of workers older than 65 years will increase by 80%.[3] It is anticipated that in 2015, 1 in 5 workers will be 55 years of age or older.[5] Studies have shown that absence of chronic illness and good mental health are the factors that have been scientifically observed to be associated with low occupational injury rates.[5] An older working population complicated by additional chronic illnesses could incur more workplace injuries and impairment.

This article explores the impact of OSA on the workplace. The neurocognitive limitations and comorbidities such as increased cardiovascular morbidity associated with OSA are reviewed. The presentation of OSA among specific working populations including commercial vehicle drivers, first responders, and veterans is discussed. The regulations, recommendations, and policies set forth by specific agencies for the screening, management, and treatment of OSA and the definitions of impairment and disability with regard to OSA are described.

IMPACT OF OSA ON NEUROCOGNITION

Multiple studies suggest neurocognitive defects that contribute to the decrements in workplace performance seen in workers with OSA. The exact pathophysiological mechanisms that cause neurocognitive defects in patients with OSA are not completely clear. Some studies have observed that OSA is related to changes in cognition, including impaired memory, attention, vigilance, executive function, and psychomotor deficits.[6,7] A meta-analysis of the neuropsychological effects of OSA revealed a decline in vigilance, executive functioning, and coordination, but not in intelligence, verbal functioning, or visual perception.[6] In a small cohort study by Nagele and colleagues,[7] it was found that patients with OSA had a significantly decreased ability to initiate new mental processes and to inhibit automatic ones. Frontal lobe dysfunction was found to be correlated most significantly with the severity of hypoxemia, whereas memory deficits were correlated with the number of apneic episodes per hour of sleep.[7] In a cross-sectional study of the cohorts from the Apnea Positive Pressure Long-term Efficacy Study (APPLES), no association was found between AHI and neurocognitive performance. The severity of oxygen desaturation was only found to be weakly associated with worse neurocognitive performance.[8]

Although there is variability in study results regarding OSA's impact on neurocognition, it is consistently demonstrated that OSA causes chronic sleepiness and affects a patient's quality of life. OSA has been found to significantly affect a patient's moods, specifically including increased irritability, fatigue, depression, and anxiety.[6,7] One study incorporated the Short Form (36) questionnaire to test the impact of sleep disruption on patients. It found that patients with OSA scored lower on all 8 dimensions thought to reflect the psychological well-being and performance status of individuals.[9] When the same questionnaire was implemented in another study, quality of life in the mental domain was significantly affected, revealing that depression was highly correlated with OSA.[10] It was observed that patients who had neurocognitive deficits, assessed by a psychomotor vigilance test, had greater impairments in the physical domain (physical functioning, general health perceptions, bodily pain, role limitations because of physical health) in assessment of quality of life.[10]

The influences of comorbidities associated with OSA are quite pertinent. Patients with hypertension, diabetes, and stroke have been found to have cognitive impairments from neurovascular changes.[11] Studies of neuroimaging done on patients with OSA have reflected vasculature changes and unique cerebral alterations.[10,12] Neuroimaging techniques using structural magnetic resonance imaging and proton magnetic resonance spectroscopy have exhibited changes to brain structure and metabolism. Neuronal cell damage was seen in both gray and white matter, resulting in reduced prefrontal activation during working memory task in patients with OSA.[12]

Patients with OSA often experience performance deficits in the workplace with regard to productivity and reaction time. In a small crossover study, subjects with OSA were less aware of their impairment caused by sleep deprivation. After a sleep deprivation experiment was imposed,

those with OSA showed a longer reaction time than those without it.[13] In addition, for blue-collar workers, significant differences have been observed between patients with mild OSA (AHI 5–15/h) and those with severe OSA (AHI >30/h) on a validated work limitation questionnaire.[14] It seems that blue-collar workers with severe OSA were approximately 2 times more likely to report limitations at work stemming from time management and mental interpersonal demands.[14] These differences were not observed in white-collar workers. In general, subjects without excessive daytime sleepiness (EDS) were not found to have significant changes in work productivity, whereas those with OSA who reported EDS indicated decreased level of productivity.[15]

IMPACT OF OSA ON DRIVING

The impact of OSA on driving has been thoroughly studied. The contribution of sleep disorders such as OSA to fatal motor vehicle accidents has been increasingly recognized in the past few decades, given the threat posed by commercial vehicle drivers with OSA.[16] It has been observed that driving performance consistently worsens in sleep loss states, resulting in more crashes. Sleep loss states affect a driver's maintenance of lane positions, reaction time, and steering in simulation.[17] A retrospective study found that after adjustment for potential confounders, such as alcohol consumption, visual refraction disorders, body mass index (BMI), years of driving, age, history with respects to traffic accidents, use of medications causing drowsiness, and sleep schedule, subjects with sleep apnea had traffic accident rates that were 2 to 15 times higher than that of the general population.[18] A sleep apneic patient with an AHI of 10 or more was found to have 6.3 (95% confidence interval [CI] 2.4–16.2) times the risk of having a traffic accident than the general public.[18]

Simulation studies have shown that patients with OSA demonstrate slower reaction times, incur increased steering errors, have an increased time to target acquisition, and have more off-road incidents.[17] According to a study on alcohol use and sleep restrictions, patients with OSA demonstrated an increased steering deviation of 50.5 cm (95% CI 46.1–54.9 cm) as compared with 38.4 cm (95% CI 32.4–44.4 cm) for controls.[19] The deviation was 40% greater with sleep restriction and alcohol compared with the controls with the same interventions.[19] In the simulation, patients with OSA experienced a greater number of microsleeps and prolonged eye closures than the controls, thereby crashing more frequently (odds ratio [OR] = 25.4).[19] Sleep restriction and alcohol have been demonstrated to have a profound impact on patients with OSA. In a study of truck drivers, sleep latency was related to severity of OSA: those with moderate or severe OSA had a mean sleep latency of 4.36 minutes as opposed to 7.9 minutes in drivers without OSA.[11]

IMPACT OF OSA IN SPECIFIC WORKFORCES

Commercial Motor Vehicle Drivers

The prevalence of OSA on commercial motor vehicle (CMV) operators contributes to significant safety and health risks. CMV operators are also likely to be subject to sleep-related issues from shift work and sleep deprivation. Studies have suggested that CMV operators have a higher prevalence of OSA than the general population.[20] In a study of Belgian truck drivers, 26% of commercial drivers were at high risk for OSA, based on the Berlin questionnaire, compared with 21% of the general population.[21] It has been hypothesized that truck drivers often exhibit more risk factors for developing OSA because of poor dietary habits, lack of exercise, and prevalent obesity. A higher prevalence of smoking within this population also constitutes an additional risk factor for OSA.[22]

Acknowledging the implications of health and safety risk, the US Department of Transportation's Task Force on Pulmonary Disorders and Commercial Drivers has determined that untreated OSA is an important and preventable cause of motor vehicle accidents, and new regulations are potentially forthcoming.[23]

Pilots

OSA in pilots is of great concern to the Federal Aviation Administration (FAA) and the National Transportation Safety Board (NTSB). In 2 isolated incidents in 2008 and 2009, aircraft overflew destination points in Minnesota and Hawaii. These incidents prompted investigation into pilot fatigue and led to increased awareness of the impact of OSA. Information obtained by the FAA noted that people with mild-to-moderate OSA can show performance degradation equivalent to 0.06% to 0.08% blood alcohol level, a level greater than that of legal intoxication in many states.[24] The NTSB cites that OSA is responsible for a 6-fold increased risk of aviation crashes.[25]

Inconsistent sleep times and sleep/wake cycles, time zone changes, and long flights are problematic and exacerbate the symptoms of OSA. The insufficient supply of pilots coupled with longer flight hours prompted by the automation of cockpit technology further contributed to pilot fatigue.[26] Studies of airline pilots show an increased risk of crashes or near misses because of sleep deprivation.[27]

Police Officers and First Responders

There have been limited studies to address sleep apnea in police officers. A cross-sectional and prospective cohort study done on North American police officers indicated that sleep disorders led to increased risk of errors, unintended injuries, motor vehicle crashes, administrative errors, and even uncontrolled anger toward subjects.[28] Within one cohort of 4957 police officers, 40.4% screened positive for a sleep disorder and 33.6% were positive for OSA.[28] A synopsis of the results is shown in **Table 1** and demonstrates the increased risk of certain tasks performed by police officers with OSA over that of controls.[28]

The frequency of extended shifts, shift work, and long work hours accompanying the occupation enhances the effects of OSA. Circadian rhythm disruptions of sleep deprivation, deficits, and fragmentation are all important consequences of the altered work schedules.[29] Accordingly, although the line-of-duty deaths rates in police have decreased significantly since the 1970s, the proportion of deaths due to unintentional injuries have shown little change, and in 2003, it even exceeded that of felonious death.[28] One-third of line-of-duty deaths were related to motor vehicle accidents, and because OSA contributes significantly to increased sleepiness and vehicle accidents, it has been speculated that several accidents that were prevented were related to OSA appropriately diagnosed and treated.[28]

OSA has been additionally identified as a potential consequence of responders at the World Trade Center (WTC) worksite. A study by Sunderram and colleagues[30] found that there was a high prevalence of OSA in WTC responders that did not match the general population. In the responder sample, the lack of association between BMI or weight and AHI is suggestive of mechanisms other than obesity that contribute to the development of OSA. The authors postulated new-onset upper airway inflammation as a factor in the pathogenesis of OSA in these individuals. It was also found that 36.5% of 11,701 male WTC first responders scored "high risk" for OSA on the modified Berlin questionnaire. The incidence of converting to "high risk" for OSA among the 4576 WTC first responders who did not initially score "high risk" was 16.9% over an average duration of 1.4 years. It should be noted that although the Berlin questionnaire is a validated tool for identifying those at risk for OSA, an overnight polysomnogram is required to confirm a diagnosis of sleep apnea.[31]

Table 1
Odds ratios of specific tasks in police officers with OSA

Odds Ratio	Task
1.43	Administrative error
1.51	Falling asleep while driving
1.63	Error or safety violation related to fatigue
1.25	Adverse work-related outcome (includes uncontrolled anger toward subjects)
1.23	Absenteeism
1.95	Falling asleep during meetings

Farmers

More than half of the nation's principal farm operators hold concurrent off-farm jobs.[32] The demands of the concurrent job combined with the high-demand seasonality of production increases the risk of injury to workers.[32] Inadequate amounts of sleep, erratic sleep patterns, and the use of sleep medications and stimulants are believed to contribute to injury rates. A greater number of injuries and fatalities on the farm in older farmers has been linked to snoring and sleep disorders, although not specifically to OSA.[33] In 1994, the National Institute for Occupational Safety and Health funded a project of Farm Family Health and Hazard Surveillance. A telephone interview examining 3 separate signs of sleep apnea in male farmers (snoring, gasping/snorting, and stopping breathing) demonstrated that in the previous year farmers with these signs were 2 times as likely to report injuries as those who did not have them.[32]

Veterans

A recent study has shown that US veterans are 4 times as likely as other Americans to have sleep apnea.[34] With more than 63,000 veterans receiving benefits for sleep apnea, the benefits now cost tax payers more than $500 million per year.[34] Along with increased screening, the prevalence can be associated with exposures to dust, sand, and grit from deployment that may contribute to airway inflammation.

In addition, some research has shown that post-traumatic stress disorder may be associated with increased OSA.[35] Data show that psychosis is significantly more common in veterans diagnosed with sleep apnea than those not diagnosed with sleep apnea and that these psychotic symptoms may be improved with the treatment of the sleep apnea.[35] OSA accompanied by comorbid conditions of stress and hypertension has been shown

to affect cognitive impairment, including deficits in auditory and verbal memory as well as executive function.[36]

TREATING OSA AND PERFORMANCE OUTCOME

It is often acknowledged that the economic cost of screening and testing underlying sleep disorders is reasonable.[22] Studies have indicated that appropriate treatment of OSA, such as nasal positive airway pressure, can reduce the risk of traffic accidents.[37] Simulated driving measures improved after 3 months of continuous positive airway pressure (CPAP) treatment in patients with severe OSA, whereas cognitive performance continued to be impaired when compared with controls.[38] Despite this fact, it is estimated that 38,800 accidents involving drivers with sleep apnea could be prevented annually if these drivers were treated.[38]

Some neurobehavorial deficits found in patients with sleep apnea may not fully recover after CPAP treatment.[19] One study showed that after 15 days of CPAP treatment, attention, visuospatial learning, and motor performances returned to normal, whereas complex executive functions, semantic memorization, and visuoconstructive abilities remained impaired.[39,40] The long-term effects of regular CPAP use on neurocognitive function are not well studied. Although some impairments resulting from chronic untreated OSA may not be fully reversible with OSA treatment, the impact of CPAP therapy may be appreciable through its ability to prevent further degradation of neurocognitive performance in the workplace.

LAWS AND POLICIES

The Federal Motor Carrier Safety Administration (FMSCA)

As previously noted, the prevalence of OSA is greater in the commercial vehicle operators than the general population.[20] The Federal Motor Carrier Safety Administration (FMCSA) is the government agency entrusted with setting regulations for the physical fitness of truck and bus drivers. FMCSA projects that as many 28% of commercial driver license holders have sleep apnea.[41] With an estimated 14 million commercial drivers' license holders in the United States, this estimate means that there are up to 3.9 million professional drivers with OSA.[42] According to 49 CFR 391.41 of the federal safety regulations, a driver must have "no established medical history or clinical diagnosis of a respiratory dysfunction likely to interfere with his/her ability to control and drive a commercial motor vehicle safely."[43] With the growing recognition of the impact of OSA on driving performance, recent revisions to the regulation cite sleep apnea as an example of respiratory dysfunction that may interfere with a driver's ability to safely control and drive commercial vehicles.

Although mentioned in the regulations, management and qualification standards for sleep apnea are not specifically provided. Federal medical examiners are responsible for determining the fitness of duty of drivers with sleep apnea, but the regulations are open ended and variable. Moderate-to-severe sleep apnea interferes with safe driving and is considered a disqualifying condition, but no definition of moderate-to-severe sleep apnea is given.[41] Because medical certification is generally for 2 years, if a driver develops new conditions or impairment that may be disqualifying before the next medical examination, it is the legal responsibility of the driver to obtain recertification from a qualified medical examiner before resuming operations as a CMV driver.[44] In addition, each state may have its own medical standards for driving a CMV in intrastate commerce.[41] This, coupled with the fact that many states have adopted a medical regulation indicating that sleep apnea is a disqualifying condition, forces medical examiners to consult with local departments of motor vehicles.[45]

Commercial drivers follow the so-called Hours of Services (HOS) regulations while driving a CMV. This federal regulation is meant to reduce driver fatigue and decrease the likelihood of an accident. Although changes may still be made, at present, the new HOS "final rule" (effective February 27, 2012, implemented by July 1, 2013) limits a driver's workweek to 70 hours (decreased from 82 hours). For every 8 hours of work, drivers must take a minimum of 30 minutes of break. If a driver works the maximum 70 hours in a week, the driver must rest from 1:00 AM to 5:00 AM at least twice that week and must take a minimum of 34 hours off duty before beginning the next workweek. In addition, this "final rule" maintains the prior daily driving maximum of 11 hours until the FMCSA is able to conduct further research examining the benefits of a lesser limit.[46]

In a clerical error, the FMCSA had accidentally published proposed recommendations on sleep apnea on April 20, 2012 in the Federal Register, only to have it withdrawn on April 27, 2012. The premise of these recommendations provided insights on FMCSA's purpose to adopt a more concrete guideline to the management of OSA in CMV drivers. The released recommendations included standards that require drivers with BMI greater than 35 kg/m to have a mandatory sleep study within 60 days of conditional certification. If OSA is diagnosed and the driver is compliant with

treatment, the conditional certification can be extended for another 90 days. Minimally acceptable compliance is defined here as CPAP treatment greater than 4 hours nightly for more than 70% of days and is based on the current standard of practice. The extension cannot be for more than 1 year without verification of continual compliance with treatment. Drivers with sleep apnea who fall asleep at the wheel, or are found not to be compliant with treatment, will have their certification disqualified.[47] It could be requested of the driver to produce data printed from CPAP machines to verify compliance before certification renewal.

The Federal Aviation Administration (FAA)

To educate pilots about fatigue, the Congress mandated a Fatigue Risk Management Plan (FRMP) for all airlines in 2010. In December 2011, new rules were incorporated by the FAA to set standards for fatigue management.[48] The new rules set requirements for pilot flight time, duty period, and rest; the rules include limitations on the number of flight segments and flight zone crossings.[48] With these rules, the FAA limits daily flight time to 9 hours and requires a 10-hour minimum rest period before the next flight duty period.[49] Pilots must have the opportunity for at least 8 hours of uninterrupted sleep during their 10-h rest period and on a weekly basis must have at least 30 consecutive hours free from duty.[49] In addition, the FAA has prescribed a fitness-for-duty expectation that pilots and airlines report fatigue and take a joint responsibility to be relieved of duty.[49]

Pilots with sleep apnea are not immediately disqualified from flying. The Assisted Special Issuance (AASI) now provides FAA physicians the ability to reissue an airman medical certificate under the provisions of an authorization for 14 CFR 67.401.[48] An FAA physician not only provides the initial certification decision but also grants the authorization. According to the FAA, a first-time issuance of such an authorization for sleep apnea requires that all requisite medical information be submitted and deferred to either the Aerospace Medical Certification Division (AMCD) or Regional Flight Surgeon (RFS).[48]

Examiners may reissue an airman medical certificate if the applicant provides evidence of previous authorization granted by the FAA and an optimal or no concerns report (within last 90 days) regarding the status of the treatment, compliance of the treatment, and whether the treatment is efficacious.[50] Specifically, a comment on daytime sleepiness that references the current treatment modality is required.[50] Examiners must defer to AMCD or RFS if there is a question regarding treatment adequacy, noncompliance, or other associated illnesses (eg, heart failure) or if the maintenance of wakefulness test (MWT) demonstrates sleep deficiency.[50]

An MWT will be requested for most pilots after treatment of sleep apnea. The MWT requires that patients be monitored in 40-minute intervals for their ability to stay awake sitting comfortably in bed.[51] Although many sleep specialists agree that the MWT may not adequately demonstrate sleep apnea control, as of yet no other objective testing has been validated for this purpose, or has been shown superior to the MWT.[50] As a result, it continues to be used as a certifying test for issuance of authorization.[52]

SCREENING AND DIAGNOSIS

The FMCSA does not require any standard protocol for OSA screening. Their guidelines do suggest that individuals scoring high risk on the Berlin questionnaire, or with specific findings and comorbities ascertained by history and physical examination such as snoring, sleepiness, witnessed apneas, advanced age, obesity, small upper airway, family history of OSA, or comorbid hypertension, diabetes type 2, or untreated hypothyroidism, should be considered high risk for OSA. Unfortunately, many of these measures are self-reported and there is strong incentive for drivers to deny a history or symptoms of a sleep disorder. Parks and colleagues[53] found that drivers who were subsequently found to have OSA on polysomnograph (PSG) denied related symptoms on their Commercial Driver Medical Examination. The Epworth Sleepiness Scale (ESS) is a common tool among sleep specialists to assess subjective daytime sleepiness. Unfortunately, ESS has not been shown to reliably predict OSA or automobile crashes.[54] In fact, Talmage and colleagues[51] found that subjective sleepiness as measured by the ESS was inversely related to the severity of sleep apnea as defined by the AHI on PSG in truck drivers undergoing required Department of Transportation (DOT) physicals. However, drivers were more willing to divulge symptoms related to sleep apnea when reporting anonymously. Smith and Phillips[55] found that among 595 truck drivers completing an anonymous online survey, an alarming 56% were positive on the Berlin questionnaire and 21% reported falling asleep at stoplights. Therefore, health care providers must maintain a high level of awareness for risk of OSA in commercial drivers and screen vigilantly regardless of self-reported symptoms.

The role of portable monitoring in screening and diagnosis of OSA in drivers remains undefined.

Portable monitoring when used as a screening tool for OSA in unselected commercial drivers has shown to have a positive predictive value of 64% and a negative predictive value of 87% for moderate-to-severe OSA in comparison to the in-laboratory PSG.[56] Therefore, portable monitoring for screening may be most useful in those highly suspected for OSA based on symptoms or clinical findings, and those who despite high clinical suspicion screen negative for OSA by portable monitoring should have a follow-up in-laboratory sleep test to confirm the negative findings. Despite limited data, portable monitoring remains an attractive screening mechanism for drivers because of its objectivity. As mentioned before, there is powerful incentive for many drivers to deny symptoms of sleep apnea. Sharwood and colleagues[57] found in a study of 517 drivers that at-home diagnostic testing found 41% of drivers to be positive for OSA, whereas only 4.4% of them reported a previous diagnosis of sleep apnea and only 12% of drivers reported daytime sleepiness (ESS score >10). Furthermore, a multivariable apnea prediction index based on numerous self-report measures showed poor agreement with the portable monitoring results. There is also a real concern for data manipulation of unattended sleep studies for similar reasons leading to inaccuracy of self-reported measures. However, portable monitoring will likely play a significant role in screening and diagnosing OSA in commercial drivers because of its primary advantage over in-laboratory PSGs of convenience and greater accessibility and potential for wider dissemination. As of now, the FMCSA recommends portable devices for screening only when they include all 3 measurements, namely, oxygen saturation, nasal pressure, and sleep/wake time.

TREATMENT

CPAP is the first-line treatment of OSA. A meta-analysis of 9 observational studies found a large risk reduction across all studies in crash risk of drivers with moderate-to-severe OSA (AHI $\geq$15) before and after CPAP treatment.[58] While the data was determined to be limited by study design, the consistent findings across all studies makes the conclusion that CPAP reduces crash risk a real likelihood. In another meta-analysis by Antonopoulos and colleagues,[59] CPAP treatment was associated with nearly 55% reduction in real crashes and near-miss crashes. Based on their analysis, treating 5 patients with OSA with CPAP is expected to prevent 1 real crash and treating 2 patients with OSA with CPAP is expected to prevent 1 near-miss crash.

Although oral appliances and surgery are considered second-line therapy for OSA in those who fail CPAP, there are no studies addressing these treatment options in drivers. Furthermore, unlike with current CPAP devices, there is no objective means of monitoring adherence with an oral appliance. The FMCSA currently recommends that these alternative therapies achieve an AHI less than or equal to 10 and result in improvement in daytime sleepiness in order for the driver to return to driving.

Some driving companies may request objective evidence of improvement in sleepiness with a Multiple Sleep Latency Test (MSLT) or MWT. In one study by Pizza and colleagues,[60] sleep latencies on the MSLT and more so on the MWT did in fact correlate with driving performance during a simulated driving test. However, whether the MSLT or MWT predict reduced crash risk in patients with OSA who have been treated have not been assessed. Despite limited evidence, however, the FAA, as mentioned earlier, requires MWT studies on most pilots with OSA on CPAP. Currently, an MLST or MWT is not recommended by the Joint Task Force for drivers diagnosed and treated for OSA to return to driving.[20]

The FMCSA Medical Expert Panel currently recommends immediate removal from active duty those with AHI greater than 20 who are not currently receiving treatment or are noncompliant with treatment or those who experience sleepiness with driving or have had a crash because of falling asleep while driving. However, more data are required to understand driving risks with abnormal sleep study findings and to make further recommendations for removing a driver from active duty.

IMPAIRMENT AND DISABILITY

The definition of disability varies based on the context of reference. The WHO international classification of functioning, disability, and health (IFC) defines an umbrella term disabilities that covers impairments, activity limitations, and participation restrictions. Although impairment is associated with disability, the 2 are not identical. Impairment is defined as loss or deviation in physiologic function, psychological function, or anatomic structure of the body.[61] Unlike disability, impairment does not incorporate a person's interaction with the environment. In addition, depending on the treatment or severity, impairment may be permanent, change over time, or completely resolve. Disability is recognized as a complex phenomenon, reflecting an interaction between features of an impaired body function and structure and the society in

which affected people live.[62] It has also often been described as any restriction or lack of ability to perform an activity in the manner or within the range considered normal for a human being.[61]

Specifically, OSA has been found to contribute to work disability. It often arises as the interplay between disease, work, and personal factors. For example, based on the expectation of occupation, a bus driver who falls asleep or has trouble staying awake while driving would have a higher claim to disability than a clerical worker who dozes off at the desk. From the case of the clerical worker, he or she may have impairments from sleep apnea, but not be disabled. In actuality, receiving disability benefits for OSA would require implication that no gainful work could be obtained. Significant documentation of treatment course, impairments, and justification under the preface of documented cor pulmonale or mental cognitive decline would need to be obtained for consideration for disability.[63] Even with this documentation, there is no absolute threshold of function or specific cause that marks whether a person is disabled or not.[64]

OSA can contribute to increased sick days and absenteeism.[6] It has been shown that even before obtaining a diagnosis of sleep apnea this affected population demonstrated excessive lost work days, calculated for females to be 1.8 times that of the control subjects and for males to be 1.6 times that of controls.[65] Even after adjusting for comorbid conditions, a large case-control study in Finland (n = 4785) revealed a statistically significant increased risk of absenteeism in those diagnosed with OSA as compared with controls.[65] EDS was found to be more strongly correlated to sick leave and disability than to snoring or breathing cessations.[66] The impact of OSA may not be apparent for years: excess risk of lost workdays was seen up to 5 years before diagnosis for women and up to 1 year before diagnosis for men.[65]

Consequently, self-reported symptoms of sleep apnea syndrome have been found to be independent risk factors for permanent disability.[15] Accordingly, patients with the combination of OSA and EDS (also referred to as OSAS), were at higher risk of both recent work disability (OR 13.7; 95% CI, 3.9–48) and longer term work duty modification (OR, 3.6; CI, 1.1–12).[67] In a Finnish study, both men and women with OSAS were found to have an approximately 2.5-fold increase in the risk of disability pensions 6 years after diagnosis of sleep apnea compared with their controls.[65] Employees diagnosed with OSAS had an increased risk of work disability in all diagnostic categories (mental and behavioral, musculoskeletal and connective tissue, circulatory system, injury, poisoning, and other external causes) and were at particularly high risk for work disability caused by injuries and mental disorders.[66]

Finally, since consequences of sleep apnea may include physiologic conditions such as cognitive deficits, psychomotor coordination, fatigue, and cardiovascular comorbidities, it is not uncommon for patients with sleep apnea to have multiple comorbidities contributing to absenteeism.[6]

ECONOMIC IMPACT

In an effort to decrease the risk of crashes, focus has been directed at minimizing factors such as fatigue and sleepiness as well as their interplay with OSA.[68] Data provided by the National Highway Traffic Administration estimate that at least 1 million police-reported crashes were caused by driver fatigue each year, resulting in 1550 deaths, 71,000 injuries, and $12.5 billion in losses.[69] The combined direct and indirect costs of CMV crashes were estimated at US $7.2 million for a fatal crash and $331,000 for a nonfatal crash resulting in injury.[68] It has been projected that that if all US drivers having OSAS were treated with CPAP at a cost of $3.18 billion, every year $11.1 billion dollars in collision costs would be avoided and 980 lives would be saved.[18]

Patients with OSA also use more health care dollars and have more medical visits than the general population. Because OSA often coexists or interferes with other chronic diseases, data have suggested that undiagnosed sleep apnea may cost up to $3.4 billion in medical costs in the United States.[6] OSA is estimated to directly contribute $11 million because of hospitalization alone.[6] While the indirect costs of disability, absenteeism, decreased productivity, and modified work duties were not explicitly calculated, these certainly also have a large economic impact.[67]

COMORBID SLEEP DISORDERS

Patients with OSA not infrequently have other comorbid sleep disorders, all of which should be addressed in the assessment of job performance and safety. For this reason, a thorough evaluation by a sleep specialist is helpful to decipher the contribution of OSA compared with other sleep disorders on patients' sleepiness and daytime function. Most often, patients are treated aggressively for their OSA whether it be borderline/mild or severe. A minority of patients do not derive symptomatic improvements despite effective CPAP therapy. These patients are candidates for wake-promoting medications. Alternatively, their comorbid sleep disorders will require addressing and therapy as well.

Shift Work

Shift work is an essential component of the industrialized US economy. An estimated 21 million workers (17.7% of the American workforce) work alternate shifts that fall at least partially outside the range of daytime shifts.[70] According to a poll from 2010, 25% of working individuals claim that their current work schedule does not permit sufficient sleep.[71] This sort of long-term shift work increases the risk of obesity and hypertension, and it has also demonstrated changes in heart rate, hormone secretion, and metabolism.[72] Because obesity is frequently observed among patients with OSA, it has been postulated that shift workers are at a heightened vulnerability to development of OSA.[37]

Studies of shift work in patients with OSA show an increase in AHI per hour and greater oxygen desaturation on diurnal PSG after shift work compared with nocturnal PSG.[25] It has also been observed that AHI is greater during diurnal sleep after nighttime shifts. This result may suggest that there is a risk of underdiagnosing the severity of the disease in nocturnal PSG in shift workers.[25] Health care providers must consider the possibility that shift workers presenting with the typical history of somnolence and negative nighttime PSG may still have elevated AHI during diurnal PSG after a nighttime shift. In addition, CPAP titrated during nighttime sleep may be suboptimal for daytime sleep.[25]

COMORBID MEDICAL CONDITIONS

Cardiovascular Outcomes

OSA has been implicated in various worsening cardiovascular conditions. Chronic hypoxemia in patients with OSA is associated with neural, humoral, thrombotic, metabolic, and inflammatory disease mechanisms, each of which has also been implicated in the pathophysiology of cardiac and vascular disease.[72] The hypoxia found in OSA also contributes to lung diseases such as pulmonary hypertension and cor pulmonale, further compromising the cardiopulmonary system.[73] Compared with controls, patients with OSA have been found to have increased heart rates, decreased heart rate variability, and increased blood pressure variability.[74]

With respect to cardiovascular risk, studies have shown that decreased heart rate variability may lead to an increased risk of hypertension and increased mortality in patients with heart failure. Increased blood pressure variability has been correlated with an increased risk for target organ damage, and surges in blood pressure may result in myocardial ischemia.[72] Furthermore, vasoactive and trophic substances (eg, endothelin), coupled with the activation of inflammatory and procoagulative mechanisms, are thought to contribute to progression of coronary artery disease.[74]

Diabetes

OSA and insulin resistance often occur concomitantly, a correlation noted in both obese and nonobese individuals.[75] Recent studies suggest that OSA itself is an independent risk factor for insulin resistance and diabetes mellitus.[75] Population studies suggest that up to 40% of patients with OSA will also have diabetes.[75] There is strong evidence to indicate an association between OSA and the risk for type 2 diabetes, but whether a causal relationship exists is yet to be determined.[76] Some evidence suggests that cortisol may trigger mechanisms that cause accumulation of abdominal fat and ultimately lead to insulin resistance.[75]

Stroke

Determining which is the cause and which the effect with respect to OSA and stroke has proved to be a challenge. Numerous studies use snoring as an indicator of OSA, but this does not directly support OSA as a causal agent.[77] In correlation studies dealing with stroke and OSA, many subjects had a prior history of strokes, which confounds any possible conclusions of causality.[77] Despite this fact, many studies have supported the association between OSA and stroke. Various mechanisms have been postulated, including abnormal cerebral hemodynamics, increased platelet aggregation, increased fibrinogen concentration, increased blood viscosity, and abnormal vascular endothelial function.[77] Furthermore, it has been shown that the presence of sleep apnea in patients undergoing rehabilitation after stroke is associated with a more profound functional impairment and a longer period of hospitalization and rehabilitation.[75]

Obesity

Weight changes have been shown to be significantly correlated with OSA. One study by the Wisconsin Sleep Cohort found that a 10% weight increase was associated with a 32% increase in AHI and a 10% weight decrease was associated with 26% decrease in AHI.[78] Additionally, a 10% weight increase has been linked to a 6-fold increase in the odds of developing moderate-to-severe OSA.[78] Studies have suggested that comorbid conditions related to obesity may be better managed if patients are evaluated and treated for previously undiagnosed OSA.[79] Weight loss has

a large positive impact on OSA and CPAP requirements. Weight itself may be a risk factor for workplace injuries.

SUMMARY/RECOMMENDATIONS

Given the effectiveness of available treatments, early intervention should be implemented to minimize the decline of health and cognition associated with untreated OSA. Consequences of OSA such as sleepiness and fatigue have major impacts on both economics and public health. For example, commercial vehicle drivers having OSA-related sleepiness clearly affects the safety of the roads; even police relations with the public may be strained by OSA. OSA contributes to workplace disability and is also associated with other chronic medical conditions that themselves lead to disability. Furthermore, the association with cardiovascular diseases, diabetes, stroke, and obesity should prompt physicians to suspect, evaluate, and treat OSA in an efficient manner. Treating the effects of OSA reduces absenteeism, length of modified work days, reaction time, and production. Ultimately, effective treatment of OSA results in improved quality of life for workers and financial savings for employers. Although recommendations for OSA screening and treatment exist for several specific work populations, a large population of patients with OSA unfortunately remain undiagnosed. Continued collaborative effort between people with OSA, their employers, and their physicians must exist to ensure that provisions for educating, screening, evaluating, and treating OSA in the workplace are established.

REFERENCES

1. Young T, Palta M, Dempsey J, et al. The occurrence of sleep-disordered breathing among middle-aged adults. N Engl J Med 1993;328(17):1230.
2. Lurie A. Obstructive sleep apnea in adults: epidemiology, clinical presentation, and treatment options. Adv Cardiol 2011;46:1–42.
3. Finkelstein EA, DiBonaventura MC, Burgess SM, et al. The costs of obesity in the workplace. J Occup Environ Med 2010;52(10):971.
4. Wang Y, Beydoun MA, Liang L, et al. Will all Americans become overweight or obese? Estimating the progression and cost of the US obesity epidemic. Obesity (Silver Spring) 2008;16(10):2323.
5. Hymel PA, Loeppke R, Baase C, et al. Workplace health protection and promotion: a new pathway for a Healthier—and Safer—Workforce. J Occup Environ Med 2011;53(6):695.
6. Leger D, Bayon V, Laaban J, et al. Impact of sleep apnea on economics. Sleep Med Rev 2012;16(5):455–62.
7. Naëgelé B, Thouvard V, Pepin JL, et al. Deficits of cognitive executive functions in patients with sleep apnea syndrome. Sleep 1995;18(1):43–52.
8. Quan SF, Wright R, Baldwin CM, et al. Obstructive sleep apnea-hypopnea and neurocognitive functioning in the sleep heart health study. Sleep Med 2006;7(6):498.
9. Smith IE, Shneerson JM. Is the SF 36 sensitive to sleep disruption? A study in subjects with sleep apnoea. J Sleep Res 1995;4(3):183.
10. Lee IS, Bardwell W, Ancoli-Israel S, et al. The relationship between psychomotor vigilance performance and quality of life in obstructive sleep apnea. J Clin Sleep Med 2011;7(3):254–60.
11. Jackson M, Howard M, Barnes M. Cognition and daytime functioning in sleep-related breathing disorders. Prog Brain Res 2011;190:53–68.
12. Ayalon L, Peterson S. Functional central nervous system imaging in the investigation of obstructive sleep apnea. Curr Opin Pulm Med 2007;13(6):479.
13. Desai A, Marks G, Jankelson D, et al. Do sleep deprivation and time of day interact with mild obstructive sleep apnea to worsen performance and neurobehavioral function? J Clin Sleep Med 2006;2(1):63–70.
14. Mulgrew AT, Ryan CF, Fleetham JA, et al. The impact of obstructive sleep apnea and daytime sleepiness on work limitation. Sleep Med 2007;9(1):42–53.
15. Nena E, Steiropoulos P, Constantinidis T, et al. Work productivity in obstructive sleep apnea patients. J Occup Environ Med 2010;52(6):622–5.
16. Viegas CA, de Oliveira H. Prevalence of risk factors for obstructive sleep apnea syndrome in interstate bus drivers. J Bras Pneumol 2006;32(2):144–9 [in English, Portuguese].
17. Heaton K, Rayens M. Feedback actigraphy and sleep among long-haul truck drivers. AAOHN J 2010;58(4):137–45.
18. Philip P. Sleepiness of occupational drivers. Ind Health 2005;43(1):30–3.
19. Vakulin A, Balk SD, Catcheside PG, et al. Effects of alcohol and sleep restriction on simulated driving performance in untreated patients with obstructive sleep apnea. Ann Intern Med 2009;151(7):447.
20. Hartenbaum N, Callop N, Rosen IM, et al. Sleep apnea and commercial motor vehicle operators. Chest 2006;130(3):902.
21. Moreno CR, Carvelho FA, Lorenzi C, et al. High risk for obstructive sleep apnea in truck drivers estimated by the Berlin questionnaire: prevalence and associated factors. Chronobiol Int 2004;21(6):871.
22. Braeckman L, Verpraet R, Van Risseghem M, et al. Prevalence and correlates of poor sleep quality and daytime sleepiness in Belgian truck drivers. Chronobiol Int 2011;28(2):126–34.

23. Hoffman B, Wingenbach DD, Kagey AN, et al. 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.
24. Brown JR. Obstructive sleep apnea. In: federal aviation administration. 2012. Available at: www.faa.gov/pilots/safety/pilotsafetybrochures/media/Sleep_Apnea.pdf. Accessed April 2, 2012.
25. Rosekind MR. Sleep: a critical factor to enhance transportation safety in national transportation safety board. 2011. Available at: http://www.ntsb.gov/doclib/speeches/rosekind/Rosekind_031811.pdf. Accessed April 2, 2012.
26. Evans D. Pilot fatigue: unresponsive federal aviation. J Air Law Commerce 2000;65(3):567–604.
27. Price WJ, Holley DC. Shiftwork and safety in aviation. Occup Med 1990;5(2):343–77.
28. Rajaratnam SM, Barger L, Lockley S, et al. Sleep disorders, health, and safety in police officers. JAMA 2011;306(23):2567–78.
29. Klawe JJ, Laudencka A, Miskowiec I, et al. Occurrence of obstructive sleep apnea in a group of shift worked police officers. J Physiol Pharmacol 2005;56:115.
30. Sunderram J, Udasin I, Kelly-McNeil K, et al. Unique features of obstructive sleep apnea in World Trade Center responders with aerodigestive disorders. J Occup Environ Med 2011;53(9):975.
31. Webber MP, Lee R, Soo J, et al. Prevalence and incidence of high risk for obstructive sleep apnea in World Trade Center-exposed rescue/recovery workers. Sleep Breath 2011;15(3):283–94.
32. Spengler S, Browning S, Reed D. Sleep deprivation and injuries in part-time Kentucky farmers: impact of self reported sleep habits and sleep problems on injury risk. AAOHN J 2004;52(9):373–82.
33. Heaton K, Azuero A, Reed D. Obstructive sleep apnea indicators and injury in older farmers. J Agromedicine 2010;15(2):148.
34. Young A. VA sees sharp rise in apnea cases. In: USA Today. 2010. Available at: http://www.usatoday.com/news/health/2010-06-07-apnea_N.htm. Accessed March 29, 2012.
35. Sharafkhaneh A, Giray N, Richardson P, et al. Association of psychiatric disorders and sleep apnea in a large cohort. Sleep 2005;28(11):1405.
36. Yesavage JA, Kinoshita LM, Kimball T, et al. Sleep-disordered breathing in Vietnam veterans with posttraumatic stress disorder. Am J Geriatr Psychiatry 2012;20(3):199.
37. Asaoka S, Namba K, Tsuiki S, et al. Excessive daytime sleepiness among Japanese public transportation drivers engaged in shiftwork. J Occup Environ Med 2010;52(8):813–8.
38. Findley LJ, Smith C, Hooper J, et al. Automobile accidents involving patients with obstructive sleep apnea. Am J Respir Crit Care Med 1988;138(2):337.
39. Ferini Strambi L, Baietto C, Di Gioia MR, et al. Cognitive dysfunction in patients with obstructive sleep apnea (OSA): partial reversibility after continuous positive airway pressure (CPAP). Brain Res Bull 2003;61(1):87.
40. Lau EY, Eskes GA, Morrison DL, et al. Executive function in patients with obstructive sleep apnea treated with continuous positive airway pressure. J Int Neuropsychol Soc 2010;16(6):1077.
41. National Sleep Foundation. Sleep apnea and commercial drivers. In: National Transportation Safety Board. Available at: http://www.fmcsa.dot.gov/safety-security/sleepapnea/industry/commercial-drivers.aspx. Accessed March 27, 2012.
42. US GAO. Commercial drivers certification process for drivers with serious medical condition. 2008. Available at: http://www.gao.gov/new.items/d08826.pdf. Accessed April 4, 2012.
43. Federal Motor Carrier Safety Association. Physical qualifications for drivers. In: US Department of Transportation. 2011. Available at: http://www.fmcsa.dot.gov/rules-regulations/administration/fmcsr/fmcsrruletext.aspx?reg=391.41. Accessed April 4, 2012.
44. Federal Motor Carrier Safety Association. Frequently asked questions, medical. In: US Department of Transportation. 2011. Available at: http://www.fmcsa.dot.gov/rules-regulations/topics/medical/faqs.aspx#question61. Accessed July 6, 2012.
45. Federal Motor Carrier Safety Association. Summary of hours-of-services (HOS) regulation. In: US Department of Transportation. 2011. Available at: http://www.fmcsa.dot.gov/rules-regulations/topics/hos/index.htm. Accessed April 4, 2012.
46. Federal Motor Carrier Safety Association. News release, U.S. Department of Transportation takes action to ensure truck driver rest time and improve safety behind the wheel. In: US Department of Transportation. 2011. Available at: http://www.fmcsa.dot.gov/rules-regulations/topics/hos/statement.aspx. Accessed April 4, 2012.
47. Federal Motor Carrier Safety Administration. Proposed recommendations on sleep apnea. In: Federal Register. 2012. Available at: https://www.federalregister.gov/articles/search?conditions[term]=sleep+apnea+fmcsa&commit=Go. Accessed April 4, 2012.
48. Federal Aviation Administration. Flight crew member duty and rest requirements. In: US Department of Transportation. 2011. Available at: http://www.faa.gov/regulations_policies/rulemaking/recently_published/media/2120-AJ58-FinalRule.pdf. Accessed March 28, 2012.
49. Federal Aviation Administration. New rule seeks to prevent pilot fatigue. In: US Department of Transportation. 2011. Available at: http://fastlane.dot.gov/2011/12/flight-time-duty-time.html. Accessed April 3, 1012.

50. Federal Aviation Administration. Guide for aviation medical examiners. In: US Department of Transportation. 2011. Available at: http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/aam/ame/guide/special_iss/all_classes/sleep_apnea/. Accessed March 28, 2012.
51. Talmage JB, Hudson TB, Hegmann KT, et al. Consensus criteria for screening commercial drivers for obstructive sleep apnea: evidence of efficacy. J Occup Environ Med 2008;50(3):324.
52. Crump G. FAA position on sleep apnea. In: Aircraft Owners and Pilots Association. 2011. Available at: http://www.aopa.org/membership/articles/2011/201101sleep.html. Accessed March 28, 2012.
53. Parks P, Durand G, Tsismenakis AJ, et al. Screening for obstructive sleep apnea during commercial driver medical examinations. J Occup Environ Med 2009;51(3):275.
54. Drake C, Nickel C, Burduvali E, et al. The 10-year risk of verified motor vehicle crashes in relation to physiologic sleepiness. Sleep 2010;33(6):745.
55. Smith B, Phillips B. Truckers drive their own assessment for obstructive sleep apnea: a collaborative approach to online self-assessment for obstructive sleep apnea. J Clin Sleep Med 2011;7(3):241–5.
56. Watkins MR, Talmage JB, Thiese MS, et al. Correlation between screening for obstructive sleep apnea using a portable device versus polysomnography testing in a commercial driving population. J Occup Environ Med 2009;51(10):1145.
57. Sharwood L, Elkington J, Stevenson M, et al. Assessing sleepiness and sleep disorders in Australian long-distance commercial vehicle drivers: self-report versus an "at home" monitoring device. Sleep 2012;35(4):469–75.
58. Tregear S, Reston J, Schoelles K, et al. Continuous positive airway pressure reduces risk of motor vehicle crash among drivers with obstructive sleep apnea: systematic review and meta-analysis. Sleep 2010;33(10):1373.
59. Antonopoulos CN, Sergentanis TS. Nasal continuous positive airway pressure (nCPAP) treatment for obstructive sleep apnea, road traffic accidents and driving simulator performance: a meta-analysis. Sleep Med Rev 2010;15(5):301–10.
60. Pizza F, Contardi S, Mondini S, et al. Daytime sleepiness and driving performance in patients with obstructive sleep apnea: comparison of the MSLT, the MWT, and a simulated driving task. Sleep 2009;32(3):382.
61. Taiwo O, Cantley L. Impairment and disability evaluation: the role of the family physician. Am Fam Physician 2008;77(12):1689–94.
62. WHO. Disability and health. In: World Health Organization. 2011. Available at: http://www.who.int/topics/disabilities/en/. Accessed April 1, 2012.
63. Social Security Online. Disability evaluation under social security (Blue Book- September 2008). In: social security disability programs medical/professional relations 2008. Available at: http://www.ssa.gov/disability/professionals/bluebook/3.00-Respiratory-Adult.htm. Accessed July 6, 2012.
64. Leonardi M, Bickebbach J, Ustun TB, et al. The definition of disability: what is in a name? Lancet 2006;368(9543):1219.
65. Sjsten N, Vahtera J, Salo P, et al. Increased risk of lost workdays prior to the diagnosis of sleep apnea. Chest 2009;136(1):130–6.
66. Sivertsen B, Overland S, Glozier N, et al. The effect of OSAS on sick leave and work disability. Eur Respir J 2008;32(6):1497–503.
67. Omachi T, Claman D, Blanc P, et al. Obstructive sleep apnea: a risk factor for work disability. Sleep 2009;32(6):791–8.
68. Hiestand D, Phillips B. Obstructive sleep apnea syndrome: assessing and managing risk in the motor vehicle operator. Curr Opin Pulm Med 2011;17(6):1.
69. NCSDR/NHTSA Expert Panel on Driver Fatigue and Sleepiness. Drowsy driving and automobile crashes. DOT HS 808 707. Washington, DC: USA Author; 1998.
70. McMenamin TM. Time to work: recent trends in shift work and flexible schedules. Mon Labor Rev 2007;130:3.
71. Drexel C, Merlo K. Shift work and sleep optimizing health, safety, and performance. J Occup Environ Med 2011;53:S1.
72. Shamsuzzaman AS, Bernard JG, Virend KS, et al. Obstructive sleep apnea. JAMA 2003;290(14):1906.
73. Fletcher EC, Schaaf JW, Miller J, et al. Long-term cardiopulmonary sequelae in patients with sleep apnea and chronic lung disease. Am Rev Respir Dis 1987;135(3):525–33.
74. Ip MS, Lam B, Matthew M, et al. Obstructive sleep apnea is independently associated with insulin resistance. Am J Respir Crit Care Med 2002;165(5):670.
75. Shaw JE, Punjabi NM, Wilding JP, et al. Sleep-disordered breathing and type 2 diabetes: a report from the international diabetes federation taskforce on epidemiology and prevention. Diabetes Res Clin Pract 2008;81(1):2.
76. Tasali E, Mokhlesi B, Van Cauter E. Obstructive sleep apnea and type 2 diabetes. Chest 2008;133(2):496.
77. Gibson GJ. Sleep disordered breathing and the outcome of stroke. Thorax 2004;59(5):361.
78. Punjabi NM. The epidemiology of adult obstructive sleep apnea. Proc Am Thorac Soc 2008;5(2):136.
79. Gami AS, Capples SM, Somers VK, et al. Obesity and obstructive sleep apnea. Endocrinol Metab Clin North Am 2003;32(4):869.