Factors Associated With Obstructive Sleep Apnea Among Commercial Motor Vehicle Drivers

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Objective: Identify factors associated with obstructive sleep apnea (OSA) risk during commercial driver medical examinations. **Methods:** A case-control study was conducted at an occupational health clinic by reviewing the commercial driver medical examinations medical records performed from January 2007 to December 2008. The magnitude of association with OSA was estimated with logistic regression. **Results:** Among 1890 commercial motor vehicle drivers, 51 were confirmed positive for OSA by polysomnography after initial screening by Joint Task Force guidelines, yielding estimated positive predictive values of 78.5% for the screening criteria. Multivariable logistic regression showed that body mass index $\geq$ 30 (odds ratio: 26.86), hypertension (odds ratio: 2.57), and diabetes (odds ratio: 2.03) were independently associated with OSA. **Conclusion:** Medical examiners' use of objectively measurable risk factors, such as obesity, history of hypertension, and/or diabetes, rather than symptoms, may be more effective in identifying undiagnosed OSA in commercial drivers during the commercial driver medical examinations.

Motor vehicle–related accidents are the leading cause of work-related fatalities in the United States.[1] Workers employed in transportation and material-moving (trucking) occupations experience the third highest fatality rate, with 1246 of 4340 occupational deaths in 2009 being in bus and truck drivers.[2,3] Approximately two-thirds of fatally injured truckers were involved in highway crashes, with 10% to 30% of crashes being sleep related.[4,5] Therefore, identifying truck drivers prone to excessive daytime sleepiness is a major public safety priority.

Obstructive sleep apnea (OSA) is a common disease associated with daytime sleepiness. Obstructive sleep apnea is characterized by repetitive episodes of airflow cessation (apnea) or airflow reduction (hypopnea) that occur during sleep as a consequence of upper airway collapse. These episodes may result in hypoventilation, hypoxemia, recurrent arousals from sleep, and activation of the sympathetic nervous system. In addition to daytime somnolence, untreated OSA can cause cognitive impairment, reduced work productivity,[6] and an increased risk of motor vehicle crashes by twofold to sevenfold.[7–10] Untreated OSA is also associated with the development of hypertension, diabetes, heart disease, and stroke—all of which may independently produce sudden incapacitation, a crash, and death.[11,12]

Operation of a commercial motor vehicle is considered a "safety-sensitive position," requiring a commercial driver's license and certification of medical fitness through a commercial driver medical examination (CDME) at least every 2 years. To detect those drivers at high risk for OSA during a CDME, the Federal Motor Carrier Safety Administration (FMCSA) changed the CDME reporting form in 2000[13] by including a question that asks a driver whether he or she suffers from "sleep disorder, pauses in breathing while asleep, day time sleepiness, or loud snoring." Nevertheless, several studies have reported that most drivers with objectively identified OSA were likely to answer this question negatively.[14,15]

In 2006, the Joint Task Force (JTF) of American College of Chest Physicians, American College of Occupational and Environmental Medicine, and the National Sleep Foundation developed consensus criteria for in-service evaluation of commercial drivers with possible sleep apnea (Table 1).[16] It is recommended that if a driver falls into any one of the five major categories during a CDME, certification must be for 3 months or less with a pending polysomnography (PSG) evaluation for OSA. Reports have shown high (94.8% to 100%)[14,15] positive predictive values (PPV) based on JTF consensus criteria. Nonetheless, a recent electronic survey among 552 American College of Occupational and Environmental Medicine members by Durand and Kales[17] found that only 42% of physicians were actually using JTF guidelines, or another specific protocol, and that 39% were waiting for additional evidence before implementing these consensus guidelines in practice.

Obesity, male gender, and older age are strong risk factors for OSA, and comorbid conditions such as hypertension, coronary disease, and diabetes are also important.[11,16] Several studies have reported that the relative risk of OSA was more than 10 times higher in persons with a body mass index (BMI) > 29 kg/m^2, which is much lower than the JTF-recommended screening BMI criterion (35 kg/m^2).[18,19] In addition, OSA appears to be independently associated with several comorbid conditions, such as hypertension, coronary disease, and diabetes,[11,16] which suggested that commercial driver medical examiners should be highly suspicious of an increased OSA risk for drivers with any of these conditions. Although the Joint Task Force Consensus conference criteria do successfully identify drivers who need to be tested, they consider only some of the identified risk factors, including obesity, neck circumference, and history of hypertension. The purpose of this study is to characterize PSG-confirmed drivers with OSA after initial implementation of JTF guidelines during CDMEs and identify independent factors associated with drivers who are at high risk for OSA.

MATERIALS AND METHODS

Study Setting

Medical records of FMCSA-regulated CDMEs conducted from January 2007 to December 2008 were reviewed at an occupational health clinic in Lebanon, Tennessee. This clinic used the JTF screening criteria for OSA in all CDMEs.

Study Setting and Population

Commercial motor vehicle (CMV) drivers who presented for the CDMEs at an occupational health clinic in Lebanon, Tennessee from January 1, 2007, to December 30, 2008, and who had complete medical examination records were eligible for the study. Clinic policy is to always follow JTF guidelines for OSA referral. Each driver was counted only once, beginning with the first time he or

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TABLE 1. Joint Task Force–Recommended Criteria for OSA Screening Among Commercial Motor Vehicle Drivers

Sleep history suggestive of OSA (snoring, excessive daytime sleepiness, and witnessed apneas)
Two or more of the following:
BMI $\geq$35 kg/m^2
Neck circumference greater than 17 inches in men, 16 inches in women
Hypertension (new, uncontrolled, or unable to control with less than two medications)
ESS > 10
Previously diagnosed sleep disorder; compliance claimed, but no recent medical visits/compliance data available for immediate review (must be reviewed within 3-mo period)
AHI > 5 but <30 in a previous sleep study or polysomnogram and no excessive daytime somnolence (ESS < 11), no motor vehicle accidents, no hypertension requiring 2 or more agents to control

AHI, apnea hypopnea index; ESS, Epworth Sleepiness Scale; OSA, obstructive sleep apnea; BMI, body mass index. Adapted from Hartenbaum N, Collop N, Rosen IM, et al. *J Occup Environ Med*. 2006:48(suppl):S4–S37.[16]

she presented to this clinic during the study period. A total of 1890 eligible participants were identified. The medical record review and secondary data analyses were approved by the institutional review board of Meharry Medical College.

Clinic Procedures and Data Collection

Each driver completed the health history section of the federal CDME form. All histories were reviewed by the examining physician. During the physical examination, each driver's blood pressure, height (inches), and weight (pounds) were measured by nursing staff. The neck circumference (inches) was assessed with a tape measure to the nearest 0.25 in by the examining physician. The examining physician determined whether the driver met the JTF consensus criteria listed in Table 1 for PSG. Drivers with suspected OSA were issued a 3-month medical certification and referred for PSG evaluation in a sleep laboratory with instructions to forward the PSG results to the clinic. The PSG referrals were made to multiple community- and hospital-associated sleep laboratories. The apnea hypopnea index (AHI) or respiratory disturbance index (RDI) and lowest recorded oxygen saturation were extracted from PSG reports to indicate the presence and severity of OSA. The AHI/RDI cut points of 5, 15, and 30 were used to indicate mild, moderate, and severe OSA, respectively. Mild OSA was defined as an AHI/RDI of 5 to 15 events per hour, moderate as 15 < AHI/RDI < 30, and severe as AHI/RDI of 30 and more.

Statistical Analysis

Data extracted from CDME form and PSG reports were manually entered into a computer database. Statistical Program for Social Science (SPSS, version 17.0, IBM, Armonk, NY) software for Windows was applied for all statistical analyses. Analyses of variance or independent *t* tests were used to compare means for continuous variables. Chi-squared tests or Fisher exact tests were performed to compare the proportions for binary or multilevel variables. Independent magnitude of association was determined by logistic regression analysis in a stepwise backward sequence. An α value of $P < 0.05$ was considered statistically significant for all tests.

RESULTS

Over a 24-month period (January 2007 through December 2008), 1890 commercial drivers having CDMEs in the study clinic were enrolled. Of these, 91.6% were men and 8.4% were women. The average age of participants was 43.7 (standard deviation: $\pm$11.52 years). Ages ranged from 18 to 77 years. The average BMI was 30.5 (standard deviation: $\pm$6.6). Overall, 82.7% of participants had BMI of at least 25 and more, and 46.8% were obese (BMI: 30 and more).

Figure 1 illustrates the algorithm of OSA screening used in this study. Among 1890 CMV drivers, 57 drivers had a previous diagnosis of OSA and had already been prescribed continuous positive airway pressure (CPAP) before the examination. Of the 1833 remaining drivers who were screened with JTF criteria, 192 were positive for potential OSA and were instructed to have a PSG performed in a sleep laboratory. Of these, 127 drivers (66%) were lost to follow-up. Of the remaining 65 drivers, 51 (78.5%) were confirmed OSA positive by PSG, while 14 (21.5%) were not, yielding an estimated PPV of 78.5% for the JTF screening criteria.

After combining drivers with an established history of PSG already using CPAP with new cases confirmed by PSG, the confirmed prevalence of OSA among the participants remaining in follow-up is 6.1% (108/1763). Interestingly, only 50 (2.6%) of all drivers reported a sleep history suggestive of OSA (snoring, excessive daytime sleepiness, witnessed apnea) on the CDME form. Of these, 39 (78%) were confirmed positive by PSG, including 8 (16%) that were newly diagnosed, and 31 (62%) that were already being treated for OSA; 10 (20%) were lost to follow-up and only one was negative by PSG.

The prevalence of risk factors and OSA-related diseases among PSG-confirmed OSA-positive CMV drivers are summarized in Table 2. Compared with non-OSA CMV drivers, the drivers with confirmed OSA were older (aged 46.7 years vs 43.7 years) ($P = 0.006$), with the highest percentage (65%) between the ages of 40 to 59 years. The average BMI was 40.72, which was significantly higher than that of non-OSA CMV drivers ($P < 0.001$). Among CMV drivers with OSA, nearly 50% were morbidly obese (BMI $\geq$ 40). There was a significantly higher prevalence of hypertension (48.1%), diabetes (21.3%), and self-reported sleep disorder (36.1%) (all $P < 0.001$) among OSA-positive drivers. Also, of 108 drivers with PSG-confirmed OSA, only 39 (36.1%) reported a sleep history suggestive of OSA. The majority (80%) of drivers who answered the CMDE form question positively had a history of OSA and had already been prescribed CPAP. Further comparison of OSA-positive

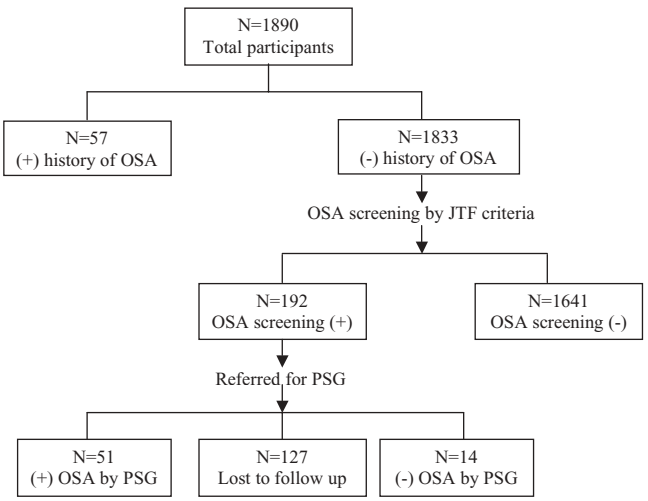

FIGURE 1. Obstructive sleep apnea (OSA)–screening flow chart. JTF, Joint Task Force; PSG, polysomnography.

TABLE 2. Prevalence of BMI, Age, Hypertension, Diabetes, and Heart Disease Among Presumed OSA-Negative Commercial Motor Vehicle Drivers and Confirmed OSA-Positive Commercial Motor Vehicle Drivers

Characteristics	OSA-Negative CMV Drivers ($n = 1655$)	OSA-positive CMV Drivers ($n = 108$)	*P*
Age, mean ± SD, y	43.63 ± 11.68	46.73 ± 9.82	0.002
BMI, mean ± SD, kg/m^2	29.03 ± 5.04	40.72 ± 7.62	<0.001
Hypertension			
No	1,328 (80.2)	56 (51.9)	<0.001
Yes	327 (19.8)	52 (48.1)	
Diabetes			
No	1,556 (94)	85 (78.7)	<0.001
Yes	99 (6.0)	23 (21.3)	
Heart disease			
No	1,588 (96)	102 (94.4)	0.287
Yes	67 (4.0)	6 (5.6)	

BMI, body mass index; OSA, obstructive sleep apnea; SD, standard deviation.

TABLE 3. Comparison of Characteristics of OSA-Positive Drivers by OSA Severity

Characteristics	Mild OSA ($n = 22$), %	Moderate OSA ($n = 20$), %	Severe OSA ($n = 31$), %	*P*
Age	46.73 ± 9.79	49.3 ± 8.67	43.9 ± 10.69	0.078
BMI	37.61 ± 6.58	38.89 ± 6.98	44.16 ± 9.21	0.016
Neck circumference	17.7 ± 0.97	18.19 ± 0.61	19.5 ± 1.72	0.001
Minimal SaO_2	83.87 ± 5.78	80.71 ± 8.00	77.09 ± 11.26	0.021
Hypertension	13 (59.1)	9 (42.9)	14 (42.4)	0.5
<2 medications	9 (69.2)	7 (77.8)	7 (50)	
≥2 medications	4 (30.8)	2 (22.2)	7 (50)	0.45
Diabetes	4 (18.2)	4 (19)	4 (12.1)	0.716
Diet	0 (0)	0 (0)	1 (25)	
Diet and pills	4 (100)	4 (100)	3 (75)	0.487
Heart disease	2 (9.1)	1 (4.8)	1 (3.0)	0.797

OSA, obstructive sleep apnea; BMI, body mass index; SaO_2, oxygen saturation.

TABLE 4. Independent Correlations of Body Mass Index, Hypertension, and Diabetes With Obstructive Sleep Apnea Identified by Logistic Regression

Characteristics	Odds Ratio	95% Confidence Interval
BMI		
<30	1	
≥30	28.86	10.85–66.48
Hypertension		
No	1	
Yes	2.57	1.67–3.96
Diabetes		
No	1	
Yes	2.03	1.16–3.54

BMI, body mass index.

drivers with available AHI/RDI results found that there is significant correlation for higher BMI, higher neck circumference, and lower minimal oxygen saturation with an increasing severity of OSA (Table 3).

Logistic regression analysis (Table 4) identified several independent factors associated with OSA among CMV drivers in this study. Among these factors, drivers who were obese with a BMI ≥ 30 had more than a 25-fold increased risk of OSA. A history of hypertension was another independent factor for OSA. Drivers with a reported history of hypertension were 2.5 times more likely to have OSA as compared with those with a normal blood pressure. The third independent factor identified in this study was a history of diabetes, with an odds ratio of 2.03 (95% confidence interval: 1.51–5.70).

DISCUSSION

These results confirm previously reported high PPVs for the JTF-recommended consensus criteria.[14,15,20] In our study, during 24 months of using the JTF-recommended OSA screening criteria on 1833 CMV drivers with no history of OSA, we found 192 cases (10.5%) that screened positive for OSA. After PSG referral, 51 of 65 (78.5%) of those having a PSG were confirmed positive, yielding a PPV of 78.5%. The relatively lower PPV in this retrospective study as compared with two previous studies (PPV of 94.8% to 100%)[14,15] is possibly because of our study design. The studies conducted by Talmage et al[14] and Parks et al[15] were both prospective studies. Furthermore, with such high percentage of drivers (66%) lost to follow-up in our study, the PPV may be underestimated.

Our study suggests that asking a driver whether he or she suffers from sleep disorder, pauses in breathing while asleep, day time sleepiness, or loud snoring may have limited value. In our study, only 50 drivers (2.6%) reported a positive sleep history on the CDME form. Moreover, of 108 drivers with positive OSA, only 39 (36.1%) reported a sleep history suggestive of OSA, with the majority (80%) of these being drivers who were already being treated for OSA with CPAP. Similar findings were also reported by Talmage et al[14] in 2008, who found that none of the 1443 drivers without confirmed of OSA checked "yes" to the CDME question about sleep disorder, pauses in breathing while asleep, day time sleepiness, or loud snoring. These findings suggest that commercial drivers with undiagnosed OSA may not understand the sleep disorder questions listed on the CDME form and/or that drivers with OSA underreport sleep disorder symptoms. Medical examiners' use of objectively measurable risk factors, rather than symptoms, during the CDMEs may be more effective in identifying CMV drivers with undiagnosed OSA.[14,15]

Obesity is well recognized as one the most important risk factors for OSA.[11] In our study, we found that the average BMI of drivers with OSA was 40.72, which was significantly higher than non-OSA CMV drivers (BMI: 29.03 ± 5.04). The prevalence of OSA significantly and steadily increased in obese drivers with a BMI ≥ 30 and more, and rose to 36% (about 60-fold increase relative to individuals with normal weight) among morbidly obese individuals (BMI of 40 and more). Further comparison of OSA severity based on available AHI/RDI data yielded a significant, positive correlation between higher BMI and increasing severity of OSA, which

is consistent with a previous report.[14] Moreover, logistic regression analysis of the present data revealed a strong association between a BMI ≥30 and the risk of OSA with an odds ratio of 26.86 (95% confidence interval: 10.85–66.48). This BMI threshold is much lower than the present JTF-recommended BMI threshold of 35 and more. Because of the robust relationship between obesity and OSA risk, the medical expert panel and medical review board of FMCSA have recommended a more strict criterion of referring all drivers with a BMI ≥33 kg/m^2, or BMI ≥30 kg/m^2, for PSG testing.[19] Our finding of a strong association between BMI ≥30 and OSA risk support this.

It is well known that OSA is associated with other comorbid conditions, such as hypertension, coronary disease, and diabetes.[11,21–24] In our study, we found a significantly higher OSA prevalence among drivers with hypertension (12.5% vs 3.8%), and diabetes (16.2% vs 4.86%). Conversely, we also found a significant higher prevalence of hypertension (48.1%) and diabetes (21.3%) among OSA-positive drivers. This is consistent with other studies conducted at clinic settings.[24,25] In addition to obesity and hypertension, we also identified a history of diabetes as another factor associated with increasing OSA risk. Because of small sample size, we were unable to determine whether this risk is independent from hypertension and/or obesity, but it does suggest that medical examiners should also be alert to diabetes as a possible risk factor for OSA when conducting CDMEs.

Our study has a number of limitations. First, this is a cross-sectional, retrospective, case-control design based on CDMEs medical record review in a single occupational clinic. This limits our study's generalizability. Nevertheless, because this is the third clinic-based study that validates the JTF criteria, generalizability to the US population seems logical.

In addition, we are unable to assess the relationship between OSA and such factors as neck circumference, race/ethnicity, and smoking history because no documentation of these demographic criteria was a part of the standard CDME physical examination. Inclusion of these factors might be useful in future versions of the FMCSA CDME form.

In addition, we observed a high loss to follow-up rate (66%) among drivers referred for PSG testing. This may have resulted in significant referral bias since the proportion of OSA among those lost may have been higher than among those who were tested and returned for follow-up. Similar findings were also reported by Parks et al.[15] Several factors might have contributed to this observation, including drivers "doctor shopping" for clinics that conduct less rigorous examinations, the high cost of PSG testing, poor health insurance coverage, and long waiting periods for PSG.[15,17] Doctor shopping, in particular, might be a significant public safety risk. Policy makers at FMCSA should therefore consider uniform standards for objective OSA testing in the future. Recently, the FMCSA has proposed to establish and maintain a National Registry of Certified Medical Examination program to improve highway safety and driver health by requiring that medical examiners be trained and certified to determine effectively whether an interstate CMV driver meets FMCSA standards. Also, once every calendar month, the medical examiner listed on the National Registry of Certified Medical Examination would be required to electronically transmit certain information about each CMV driver examined during the previous month.[26] When this new FMCSA examiner registry is implemented, it will be much harder for commercial drivers who are denied certification or requested to have testing in the near future to go to a different examiner, conceal medical information, and receive full certification. Furthermore, concurrent driver, medical examiner, and employer information campaigns to increase awareness and appreciation of the risks of untreated OSA could also be of benefit. In addition, a recent study by Watkins et al[20] comparing the accuracy of a portable RUSleeping (Philips Respironics, Andover, MA) screening device with subsequent PSG in commercial drivers suggests a possible alternative to expensive, time-consuming diagnostic PSG studies. Nevertheless, in that study, some drivers clearly tried to sabotage the screening test. Having drivers tested in a certified sleep laboratory insures that the person being tested is correctly identified and that testing is performed while the driver is actually asleep.

Finally, as with previous studies,[14,15] our data were limited by the lack of PSG information on drivers negative for OSA screening by JTF criteria. This precludes precise estimates of the sensitivity and specificity of JTF consensus guidelines. Federal Motor Carrier Safety Administration or National Institutes of Health might consider funding such a study.

In conclusion, our study confirmed that the JTF-recommended consensus criteria have a high PPV for OSA. Also, results suggest that in addition to obesity with a BMI ≥ 30 and hypertension, medical examiners should be alert to drivers with history of diabetes when conducting OSA screening at CDMEs. Finally, the high loss to follow-up in this series raises concerns about under-diagnosis of OSA using current JTF guidelines in this clinic's population. Efforts to ensure objective OSA testing and/or more efficient alternatives to PSG testing may be warranted.

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