# Hits and Misses

## *Screening Commercial Drivers for Obstructive Sleep Apnea Using Guidelines Recommended by a Joint Task Force*

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**Objective:** To evaluate joint task force criteria-based screening for severe obstructive sleep apnea (s-OSA) in commercial drivers. **Methods:** Among a community-based cohort of licensed commercial vehicle drivers, we assessed utility of the joint task force criteria. We conducted full, 14-channel overnight polysomnography in all drivers, defining s-OSA as an apnea–hypopnea index of 30 or more per hour. **Results:** One hundred of 104 drivers with successful polysomnography studies were predominantly obese (median body mass index = 32.8 kg/m$^2$; interquartile range = 26.8 to 37.4) and had a median apnea–hypopnea index of 20.6 per hour (interquartile range = 10.0 to 34.2). Examination-based criteria were more effective (sensitivity = 80%; negative posttest probability [nPTP] = 17%) than symptom-based criteria (sensitivity = 63%; nPTP = 23%). Examination and symptom-based criteria combined had high sensitivity (97%) and low nPTP (7%), but poor specificity (19%). **Conclusions:** Examination-based criteria missed 20% of s-OSA cases. Combining examination with confidentially reported symptoms improved sensitivity but required confirmatory polysomnography in 86%, supporting universal screening of all drivers.

Large truck accidents are a major public health concern, and resulted in 3675 fatalities and 80,000 injuries in 2010.[1] Lapses in vigilance and outright sleepiness during driving caused by undiagnosed or untreated obstructive sleep apnea (OSA) have been identified as significant contributors to vehicular accidents.[2–6] The use of continuous positive pressure to treat OSA can reduce the risk of motor vehicle accidents.[7] In an effort to address the high prevalence of untreated OSA among commercial motor vehicle (CMV) operators,[8] a joint task force (JTF) in 2006 published guidelines to screen for OSA in this group (see Table 1).[9]

In clinical settings, investigators studying the efficacy of the JTF guidelines reported a high positive predictive value of 79% to 100%, meaning that those whose screen "positive" have a high likelihood of being diagnosed with OSA on subsequent confirmatory polysomnography (PSG).[10–12] However, this figure may be inaccurate for two reasons. First, up to 71% of those who screened positive did not return for the recommended PSG confirmation, which may underestimate the prevalence of OSA in those who screened positive.[12] Second, in previous studies of JTF screening and other novel screening approaches for sleep apnea in the commercial vehicle operator population, few drivers with a "negative" screening test had subsequent confirmatory testing to exclude the presence of OSA. This is a serious limitation because of the well-documented underreporting of symptoms of sleep apnea by CMV operators.[10–13] Therefore, we do not have accurate estimates of the negative posttest probability (nPTP), defined as the likelihood that a subject who screens "negative" for OSA may still prove to have the condition on subsequent confirmatory testing. If JTF screening criteria were found to have a high nPTP, then an undue number of CMV operators with OSA would not be identified by these criteria.

In this community-based study of CMV operators, we assessed how well the JTF guidelines capture previously unidentified cases of OSA. We conducted confirmatory PSG in those who screened positive as well as negative by JTF criteria. We also evaluated the effect of varying body mass index (BMI) thresholds and definitions of severity criteria for OSA on the efficacy of these guidelines. Finally, we assessed the utility of subjective variables, such as self-reported history of fall-asleep accidents or daytime sleepiness, to screen for OSA in a confidential research setting.

## METHODS

The Institutional Review Board of the University of Pennsylvania Medical Center approved the conduct of the study. All subjects provided signed informed consent.

### Subject Selection

From 2009 to 2011, we recruited holders of active commercial driver's licenses through Internet advertisements and word of mouth. We verified that eligible participants held a current, valid commercial driver's license, resided within 40 miles of the Penn Sleep Center, and were between 18 and 65 years old. We excluded those who reported the current use of continuous positive pressure, bi-level positive airway pressure (PAP), or supplemental oxygen; nocturnal hypoxia because of another medical illness; somatic or psychiatric complaints that precluded ability to complete study procedures (Fig. 1).

### Demographics, Apnea Symptoms, Physical Examination

Using an electronic, handheld data capture system (Point-of-View System, Denver, CO), subjects reported demographics, apnea symptoms, tobacco and alcohol use, and the Epworth Sleepiness Scale (ESS).[14] For all subjects, we simulated a preemployment physical examination to determine fitness for duty, using the United States Department of Transportation's Medical Examination Report for Commercial Driver Fitness Determination. The study physician measured and recorded the driver's BMI, blood pressure, and neck circumference.

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**TABLE 1.** Joint Task Force Screening Recommendation for Commercial Motor Vehicle Drivers With Possible or Probable Sleep[9]

| 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 on 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 the 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 in men >17 in and in women 16 in; (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-mo 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/h |

OSA, obstructive sleep apnea.

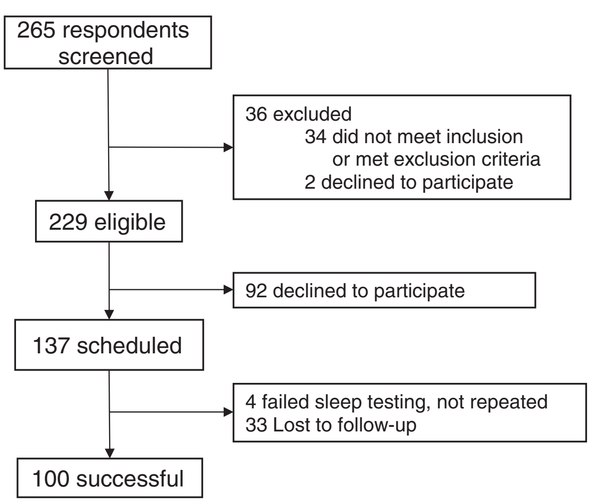


**FIGURE 1.** Enrollment diagram.

## Polysomnography

On the night of the examination, two registered PSG technologists who were blind to questionnaire data went to subjects' homes to set up a 14-channel PSG using the Titanium (Natus® Systems Inc, Broomfield, CO). The technologists left after assembly and returned the following morning to retrieve the equipment. The recordings included electroencephalograms (C3, C4, Oz), eye, chin and pretibial muscle activity, electrocardiography, finger oximetry, chest and abdominal respiratory effort, and airflow by the nasal cannula and oral thermistor. Because of long distance from the Sleep Center, three participants opted to have PSG done in our laboratory rather than at home; these were assembled and similarly unattended by the technologists.

## Scoring of Sleep Studies

Registered PSG technologists scored PSGs[15,16] and computed the apnea–hypopnea index (AHI) as the number of apneas plus hypopneas divided by hours of sleep time. We defined an apnea as 90% or more reduction in airflow for 10 seconds or more. A hypopnea was scored if airflow decreased by 50% or more from baseline, with either 3% or more fall in oxyhemoglobin saturation or an arousal from sleep. We considered cases of severe OSA (s-OSA) in our primary analyses, defined as AHI of 30 or more per hour. We considered an alternate threshold of 20 or more per hour in secondary analyses.

## Protection of Confidentiality

The National Institutes of Health provided us with a Certificate of Confidentiality to give us the authority to resist a court-ordered subpoena to release protected health information. We communicated this information to all participants before obtaining informed consent.

## Statistical Methods

For examination-derived (objective) data alone or in combination with subjective components of the JTF criteria, we computed sensitivity, specificity, positive and negative posttest probability, along with their exact 95% confidence limits. We performed all analyses using SAS Version 9.2 (Cary, NC).

# RESULTS

## Demographics

We enrolled 137 operators, of whom 33 did not follow up; we then obtained successful in-home PSG data in 100 of 104 (96%) subjects (Fig. 1). Nonparticipant data were available for 34 of 37 subjects who enrolled but did not complete testing, and showed that, compared with the 100 subjects who completed testing, there were no significant differences in BMI, age, sex, or frequency of self-reported loud snoring, snorting/choking, or breathing stops during sleep.

The 100-subject cohort with complete data (Table 2) was predominantly male (94%), middle-aged (mean = 44.0 years; standard deviation = 8.6 years) and obese, with 71% having a BMI of 30 kg/m$^2$ or more and a median BMI of 32.8 kg/m$^2$ (interquartile range [IQR] = 26.8 to 37.4). A total of 13% had excessive daytime sleepiness, using the traditional cut point of more than 10 on the ESS score, although 8% reported an ESS score of 16 or more. The latter would require an immediate out-of-service evaluation according to JTF screening criteria (Table 3).[9] PSG demonstrated a median AHI of 20.6 per hour (IQR 10.0 to 34.2). Ninety of the 100 subjects who competed testing met criteria for a diagnosis of any OSA (AHI ≥5 per hour). The cohort had equal proportions of mild (30%), moderate (30%), and severe (30%) OSA. Using an alternate AHI threshold proposed by a medical expert panel of the Federal Motor Carrier Safety Administration for mandatory PAP treatment of OSA in commercial vehicle operators,[17] more than one half (53%) of subjects demonstrated an AHI of 20 or more per hour.

### Report of Symptoms/History by JTF Criteria

Using the JTF's subjective screening criteria (symptoms of sleepiness or medical/driving history risk factors), only 11 of the 100 subjects were screened positive, requiring confirmatory polysomnogram testing for OSA. Among those 11 subjects, 7 were screened positive by the ESS score of 16 or more, 3 by high-risk motor vehicle accident (fall-asleep or single-vehicle), and 1 by reporting both an ESS score of 16 or more and a history of a high-risk motor vehicle accident. Only 7 of 30 (23%) who were diagnosed with s-OSA would have triggered an out-of-service evaluation when screened with the symptoms/history portion of the JTF criteria. All seven had an ESS score of 16 or more.

**TABLE 2.** Baseline Characteristics and Severity of Obstructive Sleep Apnea of the Subject Cohort ($n$ = 100)

| Variable | Mean | SD (Range) |
|---|---|---|
| Age, y | 44.0 | 8.6 (24–64) |
| Race | | |
| White, % | 54 | |
| Black, % | 41 | |
| Other, % | 5 | |
| Married, % | 40 | |
| Bed partner present, % | 54 | |
| Current smoker, % | 30 | |
| Weight, lb | 239.1 | 58.1 (130–439) |
| Height, in | 70.0 | 3.3 (61.0–79.5) |
| BMI measured, kg/m$^2$ | 34.3 | 8.0 (21.6–68.8) |
| Normal (20.0–24.9), % | 9 | |
| Overweight (25–29.9), % | 20 | |
| Obese (30.0–34.9), % | 32 | |
| Morbid I (35–39.9), % | 22 | |
| Morbid II (≥40), % | 17 | |
| Sex (male), % | 94 | |
| Systolic blood pressure, mm Hg | 132.7 | 11.4 (113–170) |
| Diastolic blood pressure, mm Hg | 78.5 | 14.3 (50–122) |
| Neck circumference measured, cm | 43.2 | 4.0 (34.2–54.5) |
| ESS | 6.6 | 4.8 (0–22) |
| ESS >10, % | 13 | |
| ESS ≥16, % | 8 | |
| AHI events/h | 26.6 | 22.6 (1.6–96.8) |
| Mild (AHI = 5–14), % | 30 | |
| Moderate (AHI = 15–29), % | 30 | |
| Severe (AHI = ≥30), % | 30 | |

AHI, apnea–hypopnea index; BMI, body mass index; ESS, Epworth Sleepiness Scale score; SD, standard deviation; y, years.

### Efficacy of JTF Screening Criteria in Finding Cases of Severe OSA

Using AHI of 30 or more per hour (ie, severe OSA) to define a case, the complete JTF criteria (subjective and objective criteria together) captured 29 of 30 (97%) subjects with severe OSA (sensitivity = 97%; 95% confidence interval [CI] = 83 to 100; nPTP = 7%; CI = 0 to 34). Specificity using these criteria was low at 19% (CI = 10 to 30).

Because of the potential inaccuracy of subjective reports,[18,19] we also evaluated how lowering the BMI threshold would impact the utility of objective screening criteria. When used alone, BMI of 35 kg/m$^2$ or more captured 19/30 (63%) subjects with s-OSA (sensitivity = 63%, CI = 44 to 80; nPTP = 18%, CI = 9 to 30). Adding neck circumference of 15.5 in or more in women and 17 in or more in men and blood pressure elevation on examination to BMI 35 kg/m$^2$ or more increased the sensitivity to 80% subjects with s-OSA (sensitivity = 80%, CI = 61 to 92; nPTP = 17%, CI = 7 to 34). Using a lower threshold of BMI 30 kg/m$^2$ or more alone on screening would capture 90% of subjects with severe OSA (sensitivity = 90%, CI 74 to 98; nPTP = 10%, CI = 2 to 27), albeit at a cost of a lower specificity of 37% (CI = 26 to 50) and positive posttest probability of only 38% (CI = 27 to 50).

### Sensitivity Analysis: Using AHI of 20 Events or More per Hour Threshold

More than half (53%) had AHI of 20 or more per hour. Applying the full JTF criteria (subjective and objective components together) using a BMI threshold of 35 kg/m$^2$ or more resulted in sensitivity 93% (CI = 82 to 98), a low specificity 21% (CI = 11 to 36), and nPTP 29% (CI = 8 to 58). At this AHI threshold, however, limiting the JTF criteria to BMI 35 kg/m$^2$ or more alone (without subjective or other objective criteria) captured only 27 of 53 subjects (sensitivity = 51%, CI = 37 to 65; nPTP = 43%, CI = 30 to 56) (Table 4). Adding remaining examination findings of enlarged neck circumference and high blood pressure measurement to the BMI 35 kg/m$^2$ or more criterion resulted in capturing 37 of 53 subjects (sensitivity = 70%, CI = 56 to 82; nPTP = 46%, CI = 29 to 63). Screening with BMI of 30 kg/m$^2$ or more alone improved sensitivity to 81% (CI = 68 to 91) and nPTP 34% (CI = 18 to 54), although requiring PSG testing for 71% of subjects.

## DISCUSSION

This report, on the basis of a community-drawn cohort of commercial vehicle operators, demonstrates three main findings. First, we found a high prevalence of OSA among CMV operators who are currently employed or pursuing work (90% had AHI ≥5 per hour). Nearly one third had severe OSA (AHI ≥30 per hour) and more than 50% had AHI of 20 or more per hour, the threshold at which PAP treatment was recommended by expert consensus.[17] High prevalence rates of OSA have been reported in other cohorts who received confirmatory polysomnograms.[5,20] A similarly high prevalence of OSA was suggested in a large cohort evaluated by Berger and colleagues[13] in a single, large trucking company, which used an online screening instrument for OSA. That study found that in the slightly more than one third of "high-risk" drivers who

 

**TABLE 3.** Joint Task Force Screening Criteria: Analysis of Testing Characteristics for Screening for Severe Obstructive Sleep Apnea, Apnea–Hypopnea Index 30 Events or More per Hour, Using Various BMI Thresholds

| | Sensitivity % (95% CI) | Specificity % (95% CI) | Positive Posttest Probability % (95% CI) | Negative Posttest Probability % (95% CI) |
|---|---|---|---|---|
| BMI alone | | | | |
| BMI ≥35 kg/m$^2$ | 63 (44–80) | 71 (59–83) | 49 (32–65) | 18 (9–30) |
| BMI ≥33 kg/m$^2$ | 70 (51–85) | 59 (46–70) | 42 (28–57) | 18 (9–31) |
| BMI ≥30 kg/m$^2$ | 90 (74–98) | 37 (25–50) | 38 (27–50) | 10 (2–27) |
| Neck circumference* | 67 (47–83) | 59 (46–70) | 41 (27–56) | 20 (10–33) |
| Any examination finding† | | | | |
| BMI ≥35 kg/m$^2$ | 80 (61–92) | 41 (30–54) | 37 (25–50) | 17 (7–34) |
| BMI ≥33 kg/m$^2$ | 80 (61–92) | 37 (26–50) | 35 (24–48) | 19 (7–36) |
| BMI ≥30 kg/m$^2$ | 90 (74–99) | 24 (15–36) | 34 (24–35) | 15 (3–38) |
| Any symptoms/history‡ | 63 (44–80) | 53 (41–65) | 37 (24–51) | 23 (12–37) |
| Any symptom/history or examination finding§ | | | | |
| BMI ≥35 kg/m$^2$ | 97 (83–100) | 19 (10–30) | 34 (24–45) | 7 (0–34) |

*Neck circumference in men more than 17 in and in women 16 in.
†Any examination finding defined as one or more of the following: BMI elevation greater than or equal to the threshold listed; neck circumference in men more than 17 in and in women 16 in; elevated systolic blood pressure of 140 mm Hg or more or diastolic pressure of more than 85 mm Hg on examination.
‡Any symptom/history defined as follows: observed unexplained excessive daytime sleepiness (sleeping in the waiting room) or confessed excessive sleepiness; motor vehicle accident (run-off road, at fault, rear-end collision) likely related to sleep disturbance unless evaluated for sleep disorder in the interim; Epworth Sleepiness Scale score of 16 or more; previous, physician-diagnosed sleep apnea.
§Any examination finding or symptom/history finding as listed above.
BMI, body mass index (kg/m$^2$); CI, confidence interval.

**TABLE 4.** Joint Task Force Screening Criteria: Analysis of Testing Characteristics for Screening for Obstructive Sleep Apnea, Apnea–Hypopnea Index 20 Events or More per Hour, Using Various BMI Thresholds

| | Sensitivity % (95% CI) | Specificity % (95% CI) | Positive Posttest Probability % (95% CI) | Negative Posttest Probability % (95% CI) |
|---|---|---|---|---|
| BMI Alone | | | | |
| BMI ≥35 kg/m$^2$ | 51 (37–65) | 74 (60–86) | 69 (52–83) | 43 (30–56) |
| BMI ≥33 kg/m$^2$ | 60 (46–74) | 62 (46–76) | 64 (49–77) | 42 (28–57) |
| BMI ≥30 kg/m$^2$ | 81 (68–91) | 40 (26–56) | 61 (48–72) | 34 (18–54) |
| Neck circumference* | 55 (40–68) | 57 (42–72) | 59 (44–73) | 47 (33–62) |
| Any examination finding† | | | | |
| BMI ≥35 kg/m$^2$ | 70 (56–82) | 40 (26–56) | 57 (44–69) | 46 (29–63) |
| BMI ≥33 kg/m$^2$ | 72 (58–83) | 36 (23–52) | 56 (43–68) | 47 (29–65) |
| BMI ≥30 kg/m$^2$ | 85 (72–93) | 26 (14–40) | 56 (45–67) | 40 (19–64) |
| Any symptoms/history‡ | 68 (54–80) | 66 (51–79) | 69 (55–81) | 35 (22–51) |
| Any symptom/history or examination finding§ | | | | |
| BMI ≥35 kg/m$^2$ | 92 (82–98) | 21 (11–36) | 57 (46–68) | 29 (8–58) |

*Neck circumference in men more than 17 in and in women 16 in.
†Any examination finding defined as one or more of the following: BMI elevation greater than or equal to the threshold listed; neck circumference in men more than 17 in and in women 16 in; elevated systolic blood pressure of 140 mm Hg or more or diastolic pressure more than 85 mm Hg on examination.
‡Any symptom/history defined as follows: observed unexplained excessive daytime sleepiness (sleeping in the waiting room) or confessed excessive sleepiness; motor vehicle accident (run-off road, at fault, rear-end collision) likely related to sleep disturbance unless evaluated for sleep disorder in the interim; Epworth Sleepiness Scale score of 16 or more; previous, physician-diagnosed sleep apnea.
§Any examination finding or symptom/history finding as listed above.
BMI, body mass index (kg/m$^2$); CI, confidence interval.

subsequently underwent confirmatory PSG testing, 80% had an AHI of 5 or more per hour, with a mean AHI 29 per hour; however, among "low-risk" drivers, 2% of whom underwent confirmatory PSG testing, 60% had an AHI of 5 or more per hour, with the mean AHI of 17 per hour. Our observations in this cohort reinforce the finding that OSA is not only highly prevalent among CMV operators but is also commonly found among those drivers classified as being at "low" risk by various BMI or symptom-related screening criteria.

Second, with regard to specific threshold values of BMI for screening drivers, this study demonstrates that a BMI threshold of 35 kg/m$^2$ or more alone would capture less than two thirds of subjects with severe OSA (AHI $\geq$30 per hour). Adding examination findings of high blood pressure measured during the commercial driver medical evaluation and enlarged neck circumference (in men $\geq$17 in and in women $\geq$15.5 in) improved sensitivity to 80%. Using an alternate disease definition (AHI $\geq$20 per hour) resulted in a lower sensitivity (51% [CI = 37 to –65]) for BMI of 35 kg/m$^2$ or more alone, and frequent missed cases of OSA (nPTP 43% [CI = 30 to –56]).

Our third main finding is that in a nonpunitive environment where confidentiality was assured and no economic penalty existed for accurate reporting of symptoms, the addition of subjective criteria to examination criteria improved the sensitivity and negative predictive value of the JTF screening criteria. For example, for the severe OSA threshold, adding subjective criteria to examination criteria improved sensitivity from 80% (CI = 61 to 92) to 97% (CI = 83 to 100), albeit at a cost of a "positive" screening test for 86% of subjects who completed PSG testing. Similarly, for the alternate disease threshold (AHI $\geq$20 per hour), the addition of symptoms and history to examination data improved the sensitivity from 70% (CI = 56 to 82) to 93% (CI = 82 to 98) but resulted in an attendant drop in specificity to 21% (CI = 11 to 36) and a modest drop in nPTP to 29% (CI = 8% to 58%). Screening by these criteria for AHI of 20 or more per hour similarly resulted in a "positive" screen in 86% of drivers.

The added value of subjective criteria suggests that examiners should be thoroughly trained in the presentation of OSA and in ways to screen for it. The establishment of a national registry of medical examiners who have undergone minimum training and certification could reduce the number of missed cases through appropriate efforts to elicit symptoms.

The need to conduct confirmatory polysomnograms in more than eight in ten subjects raises the question of whether, in a high-risk, obese population with a high prevalence of OSA, a universal sleep study testing algorithm should be implemented. An online universal screening program has been initiated previously and is being considered by some carriers.[13] Indeed, prior data suggest that such a program may ultimately offer cost savings because of reduction in rates of disability, employee turnover, and health care utilization.[21,22] Barriers to universal sleep study screening for OSA include the expense of in-laboratory studies, the waiting time, associated scheduling studies, and reliance on a local laboratory. In light of those limitations, out-of-laboratory, limited-channel sleep studies may be preferable. An ambulatory pathway using limited-channel studies has been proven to be effective in producing similar rates of adherence to PAP treatment, and similar improvements in functional outcomes in a cohort of veterans, who like CMV operators, are predominantly male and have a high prevalence of obesity.[23] However, for CMV operators, a chain of custody solution should be in place, to ensure that the person who wore the device is the one for whom the study was prescribed. In addition, in this high-prevalence cohort, a negative unattended, limited-channel study may still require in-laboratory confirmatory PSG, as limited-channel studies may underestimate the AHI.[23]

Some CMV operators may feel compelled to underreport symptoms because of economic concerns stemming from a potential delay in employment while awaiting diagnosis and treatment,[18,19] or because of a lack of awareness of their symptoms. Inaccuracies in reporting may lead to underestimates of the prevalence of OSA and lower the nPTP of screening. These missed cases of impaired drivers with OSA may result in ongoing exposure to crash risk for the individual, the employer, and the public at large. Online screening tools, rather than in-person assessments by medical personnel, may encourage reporting[13,19] by offering privacy and anonymity.

## STRENGTHS AND LIMITATIONS

The strengths of this study are several: (1) we used a prospective design, in which full PSGs were conducted after collection of screening data; (2) scorers were blind to screening information; (3) to increase generalizability, we recruited our subjects from the community among drivers who had active CDLs and were employed or seeking employment, rather than from a single trucking company; (4) all subjects underwent "gold standard," 14-channel PSGs, which allowed us to assess the discriminatory power of the screening criteria accurately. One limitation is the relatively small size of the cohort, which results in less precision in our estimates of predictive power. Second, the possibility of volunteer bias exists because subjects were self-referred, which may have led to more severe cases being enrolled and raising the prevalence. In fact, the prevalence of obesity in this study (median BMI = 32.8 kg/m$^2$; IQR = 26.8 to 37.4) is higher than values of 28.4 to 30.9 kg/m$^2$ reported in selected cohorts of CMV operators,[5,8,13,24] but quite similar to a recent study by Smith and colleagues[19] in which 70% of CMV operators surveyed had a BMI of 30 kg/m$^2$ or more. Indeed, our data may also reflect the rising prevalence of obesity in the general population, particularly among men.[25] On the other hand, of 265 drivers who responded to our advertisements, 127 (48%) either declined to participate or were lost to follow-up. Drivers with more severe disease may have declined to respond or participate in the study because of concerns about employment repercussions related to being diagnosed with OSA, thereby underestimating the prevalence of severe sleep apnea. Thus, even the high prevalence we found may be an underestimate of the true prevalence of the disorder in workplace settings. A compulsory testing program of CMV operators across a wide range of trucking companies may yield more accurate prevalence estimates.

## SUMMARY AND FUTURE DIRECTIONS

Our findings indicate that one third to one fifth of cases of severe OSA may be missed by existing JTF guidelines, which are based on a threshold BMI of 35 kg/m$^2$ or more. These data support the need to consider a lower BMI threshold for screening. In addition, we have found that subjective data, when provided in a confidential and nonpunitive environment, add discriminatory value to BMI data. This suggests that medical examiners should be well versed in the clinical presentation of OSA and make efforts to obtain this information rather than relying solely on BMI estimates to determine who should receive confirmatory sleep study testing. Given the high frequency of disease, however, our findings also support the consideration of universal testing to reduce the risk of missed cases and resultant sleepiness-related accidents. Future analyses should evaluate the cost-effectiveness of broader in-laboratory and ambulatory screening.

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