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Key points

- Obstructive sleep apnoea (OSA) is often undiagnosed and undertreated in professional drivers.
- Professional drivers often under-report and are reluctant to report OSA symptoms.
- Barriers to OSA diagnosis include appropriate screening and sleep study referrals.
- Screening tools including both subjective and objective data may assist in early identification of possible OSA among professional drivers.

Educational aims

- To evaluate screening instruments currently used to identify OSA risk in professional drivers.
- To provide guidance for developing an assessment strategy for OSA by professional driver medical examiners.

Review

Screening for obstructive sleep apnoea in professional drivers

Professional drivers show a higher prevalence of obstructive sleep apnoea (OSA) compared with the general population. Furthermore, there is concern about the association between OSA and car crash risk given that drivers with OSA show an increased risk for car accidents. Despite this risk, OSA is often underdiagnosed and undertreated in this population, mainly due to lack of appropriate screening and sleep study referrals. Polysomnography (PSG), the gold standard test, is inappropriate for systematic screening because of its high expense, complexity and relative inaccessibility in this population. Therefore, there is a strong demand for good screening tools, including both subjective and objective data that may assist in early identification of possible OSA among professional drivers and, thus, aid in PSG examination referral and OSA management in an accredited sleep centre. However, there is considerable disagreement over screening methods and criteria for triggering a sleep study referral in different countries. There is also a strong need for further research in the area of OSA screening of commercial drivers in order to improve the diagnostic accuracy of screening tools and ensure that patients with OSA are accurately identified.

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Professional drivers are an understudied and medically underserved population, with high rates of obesity and related comorbidities [1]. Research has shown that drivers with multiple comorbidities, such as cardiovascular disease, cerebrovascular diseases, psychiatric conditions, diabetes, medication use, uncorrected visual defects and obesity seem to be at increased risk of being involved in a crash [2]. Disorders associated with sleep disturbance and sleepiness, such as obstructive sleep apnoea (OSA) are also recognised to be associated with increased accident risk [3], exceeding the risk associated with many other medical disorders [4].

Given the impact of OSA on sleep quality, daytime sleepiness, psychomotor vigilance and driving

simulator performance, it is not surprising that untreated OSA increases the risk of crashes by two- to three-fold in comparison with subjects without OSA [5]. The most common symptom of patients with OSA associated with increased crash risk and fatal accidents is subjective daytime sleepiness, [6, 7]. However, the increased crash risk can be seen in patients even without daytime sleepiness and is aggravated by concurrent use of alcohol or sedatives [8]. Nevertheless, effective treatment of OSA seems to normalise the risk for accidents [9]. Therefore, identifying professional drivers with OSA and treating them effectively should decrease crash-related injuries and fatalities and improve drivers' health.

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OSA is usually undiagnosed and undertreated in professional drivers. Barriers to OSA diagnosis are lack of appropriate screening and sleep study referrals. Screening tools, including both subjective and objective data, may assist in early identification. <http://bit.ly/31nD4A9>



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Professional drivers show a higher prevalence of OSA, between 28% and 78%, compared with the general population [10], probably because they tend to be obese, male and middle-aged, the three most common risk factors for OSA [11]. Despite this risk, OSA is often undiagnosed and undertreated in this population, mainly due to lack of appropriate screening and sleep study referrals [12–14]. In an effort to address the high prevalence of untreated OSA in this population, a new directive 2014/85/EU [15] from the European Union has been adopted regulating, for the first time, requirements for issuing a driver's license for amateur and commercial drivers. Based on this directive, all drivers should be subjected to tighter control of their overall health status, including OSA screening and drivers with diagnosed OSA must receive regular treatment and follow-up [15]. Furthermore, a joint Task Force of the European Respiratory Society and the European Sleep Research Society is currently on production to develop practical recommendations to cope with the problems raised by the new EU directive on issuing driving licences and to suggest a research agenda to improve safety on the road in Europe [16]. Additionally, the American Academy of Sleep Medicine has issued a comprehensive and detailed document on screening, and diagnostic and therapeutic approaches for commercial drivers [10]. However, still there is no consensus in the OSA screening approach and there is a lack of a clear standardised model applicable in different countries.

The purpose of this review is to evaluate screening instruments currently used to identify risk of OSA in professional drivers and provide guidance for developing an assessment strategy for OSA by professional driver medical examiners.

Diagnostic evaluation of OSA

The diagnosis of OSA requires either signs/symptoms or an associated medical or psychiatric disorder coupled with five or more predominantly obstructive respiratory events per hour of sleep during polysomnography (PSG). Alternatively, a frequency of obstructive respiratory events ≥ 15 events·h⁻¹ satisfies the criteria, even in the absence of associated symptoms or disorders [17]. This definition indicates that there are also subjects who are diagnosed with OSA but without symptoms.

The gold standard for the diagnosis of OSA is attended overnight PSG [18], which is performed in accredited sleep units. However, it is inappropriate for systematic screening because it is expensive, labour-intensive, not feasible in all subjects and probably time consuming for professional drivers who are regularly on the road. Therefore, simple and inexpensive selection of patients with the potentially highest risk of OSA is needed.

The process of diagnosing and treating OSA in professional drivers should begin with effective and consistent screening. Historically, in order to

screen drivers for OSA, healthcare providers asked questions about loud snoring, witnessed apnoea or daytime sleepiness. However, the professional driver population presents unique and specific challenges to the successful identification of those with OSA. Several studies have indicated that professional drivers usually under report OSA symptoms or show resistance to OSA assessment, in order to avoid potential consequences on medical certification and employment, economic implications of additional testing and occupational consequences of lost work time [13, 14, 19].

For this reason, there is a strong demand for good screening tools, including both subjective and objective data that may assist in the early identification of possible OSA among professional drivers and thus aid in referring them for PSG examination and OSA management in an accredited sleep centre. Furthermore, even when professional drivers do not complain of OSA symptoms, it is essential to perform periodic clinical screening by a skilled physician, as a way to additionally raise the commercial drivers' awareness of the problem.

Screening tools

Current screening strategy often relies on validated questionnaires to identify subjects at risk for OSA. The ideal diagnostic screening tool would contain a few items and be quick to administer and interpret without the need for complicated calculations or examination techniques. A number of clinical questionnaires have been developed to predict the presence of OSA based on symptoms (*e.g.* excessive daytime sleepiness, periods of stopping breathing during sleep observed by others), anthropometrics (*e.g.* body mass index (BMI), neck circumference), demographics (sex and age) and the presence of comorbidities (*e.g.* hypertension, stroke). However, a high sensitivity with an acceptable specificity is a basic requirement for screening patients for a disease with an important health impact, such as OSA. The sensitivity and specificity of OSA screening tools have demonstrated considerable variability depending on the patient population, and the definition of OSA (different cut-off points of apnoea-hypopnoea index (AHI) for OSA diagnosis). Below we briefly describe some instruments that could be used for OSA screening. Epworth Sleepiness Scale (ESS), Berlin questionnaire, STOP and STOP-BANG are the most commonly known questionnaires and most studied (table 1).

Epworth Sleepiness Scale

The ESS is currently the most used subjective test of daytime sleepiness in clinical practice. It is a simple, self-administered, eight-item questionnaire that measures the risk of falling asleep in eight specific situations that are commonly met. A score of < 10 is considered normal. The higher the score (from 10 to 24) the greater the reported subjective daytime

Table 1 Key features of screening questionnaires for OSA

ESS	
How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired?	
Situation	Chance of dozing (0-3)
Sitting and reading	
Watching TV	
Sitting inactive in a public place (<i>e.g.</i> a theatre or meeting)	
As a passenger in a car for an hour without a break	
Lying down to rest in the afternoon when circumstances permit	
Sitting and talking to someone	
Sitting quietly after a lunch without alcohol	
In a car while stopped for a few minutes in the traffic	
Berlin questionnaire	
Age _____ Gender _____	Weight _____ Height _____
Category 1	Category 2
1. Do you snore?	6. How often do you feel tired or fatigued after your sleep?
2. Your snoring is:	7. During your waking time do you feel tired, fatigued, or not up to par?
a) Slightly louder than breathing	8. Have you ever nodded off or fallen asleep while driving a vehicle? If yes:
b) As loud as talking	9. How often does this occur?
c) Louder than talking	Category 3
3. How often do you snore?	10. Do you have high blood pressure?
4. Has your snoring ever bothered other people?	BMI=
5. Has anyone noticed that you quit breathing during your sleep?	
STOP-BANG questionnaire	
STOP	BANG
Snoring	BMI >35 kg·m ⁻²
Tiredness	Age >50 years
Observed you stop breathing	Neck circumference >40 cm (15.7 inches)
Blood Pressure	Gender M ale

sleepiness [20]. Although it is widely used, the real value for patients with OSA is still not clear, as OSA severity does not always correlate with ESS score and even patients with severe OSA may have relatively mild or no daytime sleepiness [21]. Considering its low sensitivity (53.2%) and specificity (58.8%) for diagnosis of moderate and severe OSA syndrome (AHI ≥ 15 events·h⁻¹), the ESS is not suggested as a screening test for OSA diagnosis amongst candidates for drivers [22]. Furthermore, previous studies have shown that ESS combined with BMI identifies only 12–13% of drivers at high risk of OSA [13, 19], a relatively low percentage compared to the number of commercial drivers estimated to have OSA. Notably,

potential denial or deception [13, 19] of self-reported sleepiness should also question the reliability of using ESS as a stand-alone screening tool for OSA risk or as a criterion for determining whether or not a professional driver with OSA should be qualified to drive.

Berlin questionnaire

The Berlin questionnaire is one of the commonly known questionnaires for OSA, first validated in the primary care setting [23]. It has 10 questions covering three categories including: 1) snoring severity (items 1–5); 2) excessive daytime sleepiness (items 6–9); and 3) history of high blood pressure or

obesity (item 10). The questionnaire also includes information about age, sex, height and weight. The physician or medical staff are required to analyse the responses and the scoring can be complicated. If the individual scores positive in at least two of the three categories, the patient is found to be at high risk for OSA. The Berlin Questionnaire has been used for occupational health screening of commercial drivers demonstrating marked range of sensitivities (45.6–93.1%) and specificities (16.2–84.6%) for an $AHI \geq 15$ events·h⁻¹ [22–25]. Nevertheless, further research of its usefulness as an OSA screening tool is needed in this population.

STOP-BANG questionnaire

The STOP questionnaire was developed by CHUNG *et al.* [26] from patients attending surgical pre-operative assessment clinics. It consists of four yes/no questions about snoring, tiredness, observed apnoeas and blood pressure, and was found to have a sensitivity of 79.5% and a specificity of 48.6% for detecting an AHI of 30 events·h⁻¹. The addition of four additional factors (BMI, age, neck circumference and SEX) to create the STOP-BANG questionnaire led to improvement in sensitivity to 100% at the expense of specificity that decreased to 37% [27]. The questionnaire has the advantage of being very straightforward and can be completed quickly and easily (usually within 1–2 min). A score of any three affirmative responses was used to dichotomise the population into low and high risk for OSA. STOP-BANG has been used with high sensitivities (87–100%) and moderate specificities (40.3–48.7%) and even recommended for screening professional drivers in previous studies [24, 28–32].

NoSAS score

The Lausanne NoSAS (Neck circumference, Obesity, Snoring, Age, Sex) score test is a simple, efficient, and easily employed tool enabling identification of individuals at risk for OSA [33]. The score ranges from 0 to 17 and if the individual has a score ≥ 8 , the patient is found to be at high risk for OSA. Overall, the NoSAS score was able to detect 1666 (98%) out of 1703 participants with severe OSA ($AHI > 30$ events·h⁻¹), with 37 (2%) out of 1703 having a false-negative diagnosis in the HypnoLaus cohort [33]. In a recent validation study in a sleep clinic population, with a NoSAS score ≥ 8 , the sensitivity and specificity (positive-predictive value) for moderate/severe OSA were 89.8% and 27.1%, respectively [34]. Compared with the eight items of STOP-BANG and the three separate calculations required for the Berlin Questionnaire, NoSAS score is easier to use as it only includes five items and helps clinicians decide with a higher accuracy than other questionnaires which individuals should be referred for further testing, thereby reducing the number of missed OSA diagnoses and unnecessary PSGs [33].

Nevertheless, more studies are needed to evaluate the efficacy of this score in drivers' population.

OSA evaluation worksheet

The OSA evaluation worksheet is a company-developed OSA screening tool, composed of various markers of OSA risk. Nine questions are completed by the driver, three of which relate to symptoms of OSA such as loud snoring, fatigue and observed apnoea. Additional information measured by a healthcare provider includes BMI, neck circumference, age, comorbidities and Mallampati class. Although it is not a validated tool, one recent study found the OSA evaluation worksheet along with STOP-Bang Questionnaire to be useful tools for OSA screening of professional drivers [32]. However, in this study a low percentage of those screened positive were referred for sleep testing. The authors concluded that screening drivers is useful only when drivers at high risk are referred for sleep testing and actually schedule sleep tests.

Somni-Sage

A carefully constructed on-line screening instrument with an on-line questionnaire (Somni-Sage), including demographics, comorbidities and symptoms, was found to have a high positive-predictive value leading to a large number of OSA diagnoses [19]. Nonetheless, a significant limitation of this study was that 64% of higher risk drivers had not received diagnostic confirmatory testing by the end of the study. Therefore, given the high loss to follow-up the results from such analyses should be treated with considerable caution.

The limited studies available in professional drivers with objective data (PSG/polygraphy) for validation show a huge range of sensitivities and specificities. Taking this into account, results regarding the predictive value of the above screening instruments should be taken into consideration. Furthermore, the majority of studies show a poor specificity, resulting in many false-positive results, which is associated with more frequent referrals for PSG, queues in sleep apnoea laboratories and high costs of unjustified diagnostic procedures. However, all these instruments are not perfect tools, but only a guide to supplement a careful history. Future studies should focus on more validation testing of the OSA screening questionnaires, as well as identification of subjective and objective tools for reliable excessive daytime sleepiness detection and fitness to drive assessment, before a conclusion can be made regarding which tool has the best OSA predictability in the professional drivers population.

Principles of OSA evaluation in professional drivers

Commercial drivers should require a higher standard for assessment of medical fitness to drive and a

lower threshold of diagnostic testing for OSA compared with non-commercial car drivers. The U.S. Preventive Services Task Force (USPSTF) neither supports nor rejects screening of asymptomatic adults for OSA in the general population [35]. However, the USPSTF recommendations do not address individuals performing safety sensitive jobs, such as professional drivers.

Many countries have medical standards for commercial driving licensure that include specific questions about OSA and other sleep disorders, as well as guidelines for treatment and re-evaluation of OSA [16, 36–38]. The European Respiratory Society and the European Sleep Research Society are currently working to develop practical recommendations and address the following questions [16]:

- How should the suspicion of moderate or severe OSA be justified?
- Are there simple and readily available tools to assess OSA and sleepiness in the population?
- What is the consensus on a minimal medical expert standard to establish good compliance to, and effectiveness of, treatment?
- Which tests or investigations should be used to certify continued good vigilance?

Furthermore, Ghosh *et al.* [39] suggested that driving regulatory authorities should take into account specific parameters to assess the risk of road traffic accidents in patients suspected of having OSA, as outlined below.

Driving-related parameters

- Taking a break every hour during long journeys
- Likelihood of feeling sleepy while driving
- Nodded off whilst driving in the past year
- Any accidents in the past 3 years related to sleepiness

Clinical parameters

- ESS and history of tiredness and sleepiness
- Objective testing: AHI, apnoeas and hypopnoeas/ time in bed, oxygen desaturation index

In the USA, a Joint Task Force of the American College of Chest Physicians, American College of Occupational and Environmental Health and the National Sleep Foundation has recommended that OSA testing be performed in commercial truck drivers with a BMI $\geq 35 \text{ kg}\cdot\text{m}^{-2}$ [36], while other groups have endorsed BMI thresholds ranging from $\geq 30 \text{ kg}\cdot\text{m}^{-2}$ to $\geq 40 \text{ kg}\cdot\text{m}^{-2}$ [10, 40]. The American Academy of Sleep Medicine recommends that commercial drivers be referred to a sleep medicine specialist for clinical sleep evaluation and diagnostic testing if they meet any of the following criteria [10].

- BMI $\geq 40 \text{ kg}\cdot\text{m}^{-2}$
- Fatigue or sleepiness during the duty period or involvement in a sleepiness-related crash or accident. Factors suggesting a sleepiness-related crash or accident include single vehicle crash, off-road deviation and rear-ending another vehicle
- BMI $\geq 33 \text{ kg}\cdot\text{m}^{-2}$ and either type 2 diabetes or hypertension requiring two or more medications

Although these criteria intend to classify drivers as high risk for OSA, individuals with lower BMI will likely be missed. Adding subjective criteria based on other symptoms and risk factors are also suggested, but the examiners should be thoroughly trained in the presentation of OSA, in eliciting relevant symptoms and appropriately screening for it. Therefore, medical examiners should undergo minimum training and certification in order to reduce the number of missed cases of OSA.

Despite the several recommendations regarding OSA screening, there is some difficulty providing concrete guidance given the variability between different recommendations and working groups. A recent study assessing the screening practices for OSA among occupational/environmental physicians in the US state of Michigan during driver medical examinations showed that 97% of physicians reported doing some type of screening [41].

Clinical assessment in professional drivers

Required driver medical examinations are commonly performed by occupational/environmental practitioners and screening for OSA should be a common consideration as part of the examination. We propose that clinical evaluation of OSA and its symptoms should begin with early recognition, mainly based on patient report or physician questions about symptoms, risk factors and associated comorbidities. Information given by the patient should, when possible, be supplemented by a bed partner, family member or roommate who may have a different insight into the patient's sleep behaviour or daytime mood and cognitive functioning. Typical symptoms associated with the condition include snoring, witnessed apnoeas, gasping or choking for air at night, excessive daytime sleepiness, impaired cognition and mood changes (table 2). Nocturnal symptoms are generally reported by the bed partner. Snoring is the cardinal one and may be so disruptive that the bed partner can be driven to sleep in another room. An absence of snoring does not exclude OSA diagnosis, but virtually all patients snore. A bed partner may also report a witnessed apnoea that is followed by loud snoring or gasping at the end of the apnoeic episode and this usually serves as the trigger for seeking medical attention.

Unfortunately, patients are unlikely to present with a clear complaint consistent with OSA symptoms.

Table 2 Common symptoms of OSA

Daytime symptoms	Night-time symptoms
Excessive daytime sleepiness	Snoring, gasping or choking in sleep
Fatigue	Witnessed apnoea in sleep
Non-restorative sleep	Insomnia
Cognitive impairment	Restless sleep
Mood disorders	Night-time awakenings, dry mouth
Morning headaches	Nocturia
Impotence, erectile dysfunction	Nocturnal gastro-oesophageal reflux

Self-evaluation questions

1. A 46-year-old obese truck driver with a BMI of 38 kg·m⁻² is referred to the sleep disorders center by the occupational practitioner who wishes to test him for OSA. The patient states that he has a history of snoring but has never been observed to be apneic. Besides obesity, his only medical problem is high blood pressure, which is well controlled by two medications. He does not wish to have an overnight sleep study because he states that she has no symptoms of daytime sleepiness. What is the appropriate next step?
 - a) Given his lack of symptoms, it is unlikely that he has sleep apnoea and a sleep test is unnecessary
 - b) Given his BMI, he has a high probability of having OSA
 - c) The patient should be started on a diet and, if that fails, a sleep study should be considered
 - d) Reassure the patient that the problem is minor and no further testing is necessary
2. Which statement about OSA in professional drivers is not correct?
 - a) The increased crash risk can be seen in OSA patients even without daytime sleepiness
 - b) The prevalence of OSA in professional drivers is very low compared with the general population
 - c) Barriers to professional drivers sleep testing are cost and lack of health insurance
 - d) The simplest questionnaire for sleepiness, the ESS, is not able to discriminate drivers at risk for sleep apnoea
3. Which of the following options is not seen as a barrier to OSA screening in professional drivers?
 - a) Professional drivers voluntarily under report or deny OSA related symptoms on Commercial Driver Medical Examination
 - b) Cost of in-laboratory studies
 - c) Drivers and their employers may seek out clinics that conduct less rigorous examinations without OSA screening
 - d) The ability of drivers and some physicians to appreciate OSA as a serious condition that threatens safe driving
4. In evaluating daytime sleepiness, which of the following is true about the ESS?
 - a) This scale uses a seven-part questionnaire
 - b) It correlates strongly with OSA severity
 - c) It is suggested as a screening test for OSA diagnosis amongst candidates for drivers licences
 - d) ESS has a low sensitivity for OSA detection in professional drivers

Questioning the patient on the key symptoms of OSA, such as snoring and daytime sleepiness, is not so simple as patients often describe sleepiness as “fatigue”, “tiredness” or “lack of energy”. The most common daytime symptom associated with OSA is excessive sleepiness, which in more severe manifestations can result in sleepiness at the wheel while driving. The ESS can be used to help assess the level of daytime sleepiness. However, a number of non-medical and medical conditions, such as a shortage of sleep/sleep restriction due to social or family reasons, shift working or daytime non-shift working, neurological disorders, insomnia, depression and hypothyroidism, should be taken into account when evaluating daytime sleepiness [42]. Physicians also need to be aware that many OSA patients may have minimal or no symptoms. Driving simulators have also been used to identify individual “at-risk” drivers [43]. However, they were found to be insufficiently sensitive, not in widespread clinical use and could not fully replicate real driving [5]. Therefore, a diagnostic strategy is needed including a sleep-oriented history and physical examination. Given the need for stratification to determine patients who urgently require evaluation from a sleep specialist, it would clearly be beneficial to use screening questionnaires, such as the STOP-BANG questionnaire to identify patients who are likely to have OSA. Additionally, adoption of screening tools into the electronic health record as well as training of other medical staff, such as nurses, to help administer screening questionnaires may also help facilitate OSA screening. A clinical care pathway of OSA diagnosis is illustrated in figure 1.

However, screening drivers is useful only when drivers found to be at high risk are referred for sleep testing and drivers actually schedule sleep tests. Barriers to referrals of high-risk drivers include concerns of angering drivers, lack of physical driver characteristics typically noted in OSA and losing business from drivers who seek out examiners who provide less rigorous commercial driver medical examinations (doctor shopping). Recommendations to remove these barriers should include clear screening and referral guidelines, employer-facilitated and employer-funded sleep testing, as well as OSA awareness campaigns directed toward drivers, employers and medical examiners.

The role of home sleep studies

Apart from the increasing interest in the use of screening questionnaires there has been a growing interest in ambulatory models of care, such as home sleep monitoring with portable monitors. In-home unattended, portable recording may be used to help in the detection of OSA in specific patient population, such as medically uncomplicated individuals with high pre-test suspicion for moderate-to-severe OSA [44].

Suggested answers

1. b
2. b
3. d
4. d

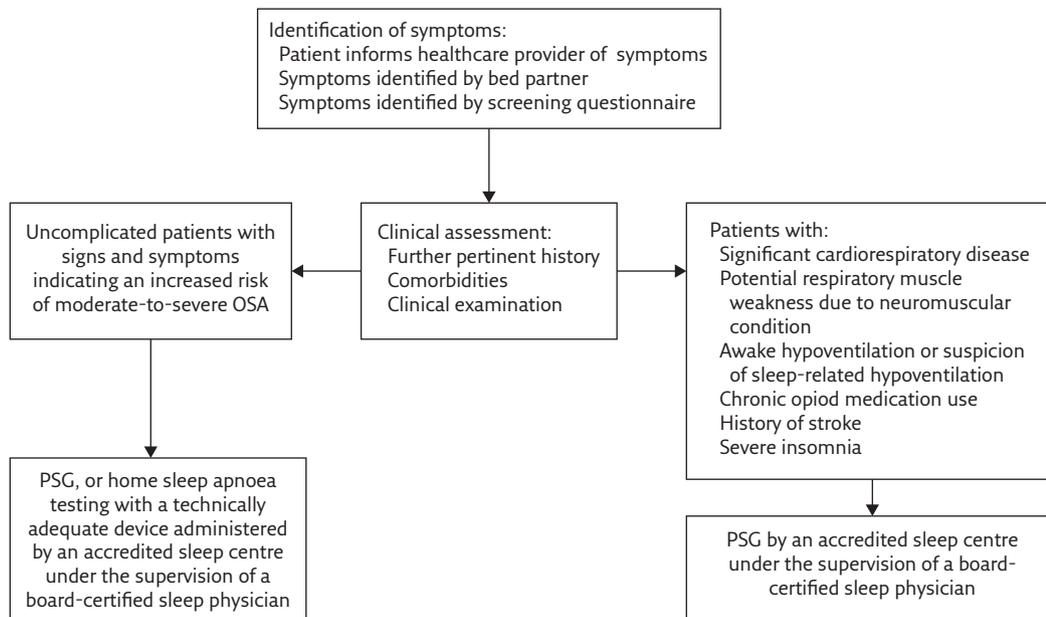


Figure 1 A proposed clinical care pathway of OSA diagnosis in professional drivers.

Although portable monitors have been proposed as a cheaper and more accessible technology, an important proportion of professional drivers tested will likely require a follow-up with in-laboratory PSG due to invalid results, the relatively low sensitivity and specificity of this method, or potential barriers from human factors [45]. Recently, Lyons *et al.* [46] described a promising approach in identifying commercial motor vehicle operators likely to be at risk for a sleepiness-related crash due to OSA, by using the spectral qualities of electrocardiography with portable diagnostic ability and without requiring overnight in-laboratory PSG. Nevertheless, portable monitors remain a challenge for large-scale screening and diagnosis of OSA among professional drivers. Further prospective randomised studies conducted in collaboration with sleep centres are needed to determine the

utility of portable monitors, comparing various portable monitors and type I PSGs.

Conclusion

Reasonable estimates of crash risk attributable to OSA support the use of screening strategies in commercial drivers. However, while most experts agree to OSA screening of drivers, especially professional drivers, the best screening strategy is not clearly defined; however, this is difficult given the current lack of definitive conclusions from research in the area. Furthermore, another challenge is to eliminate the overall inconsistency of provider referrals and sleep testing of professional drivers. Therefore, there is a strong need for further research in the area of OSA screening of commercial drivers in order to alleviate the burden of traffic accidents worldwide.

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Conflict of interest

S.E. Schiza has nothing to disclose. I. Bouloukaki has nothing to disclose.

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