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Research article

Stop-bang questionnaire: Practical approach to diagnosis of obstructive sleep apnea in roncopathic subjects

Running title: Practical approach to diagnosis of obstructive sleep apnea in roncopathic subjects

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Abstract: A correlation was established between snoring and obstructive sleep apnea syndrome (OSAS). Although this association is highly prevalent in the general population, OSAS remains largely undiagnosed. The STOP-BANG Questionnaire (SBQ) consists of simple questions with dichotomous answers (yes/no). It is utilized for the preoperative clinical assessment of anesthesiological risk in patients with suspected OSAS, and positive response to ≥3 questions reinforces the diagnostic suspicion. The SBQ survey during an ENT visit in a patient with a rupture may be a reliable, fast, concise, and easy-to-use screening tool to diagnose OSAS. The present study aimed to evaluate the predictability of SBQ during an ENT visit and compare it with the apnea-hypopnea index (AHI) in patients undergoing nocturnal cardiorespiratory monitoring, a gold standard for the diagnosis of OSAS. A population of roncopathic subjects was evaluated using SBQ, ENT assessment, and night-time cardiorespiratory monitoring. SBQ was administered by the ENT specialist during the first visit in the presence of the bed partner. A total of 98 snoring subjects were evaluated. A significant linear correlation was established between AHI and the number of positive responses to SBQ. The present study demonstrated that SBQ can be employed for the diagnosis of OSAS in roncopathic population.

Also, a linear correlation was found between the SBQ score and the OSAS grade based on the AHI. The SBQ administered by the ENT specialist is a rapid and reliable screening tool, capable of reducing the national health costs through early and targeted diagnosis.

Keywords: OSAS; STOP BANG; roncopathy; sleep apnea screening; snoring; cardiorespiratory monitoring; sleep apnea diagnosis

1. Introduction

Obstructive sleep apnea syndrome (OSAS) is a chronic respiratory disease associated with snoring, characterized by the appearance of repeated episodes of upper airway obstruction (apnea) during sleep. Thus, it is a severe social and economic health problem.

The obstructive apneas are determined by respiratory and cardio circulatory alterations and fragmented physiological duration of sleep, which, in turn, compromises the psychophysical performances causing daytime sleepiness. Failure to diagnose and treat this disease has repercussions on the health and social level, such as increase in morbidity and mortality of affected patients, increase in health costs due to the treatment of associated comorbidities (cardiovascular, metabolic), loss of productivity due to prolonged absence from work with reduced work performances, and high risk of road accidents and accidents at work [1].

OSAS has a high prevalence in the general population i.e. 15–20% of the adult patients in the USA and 2.5–3% in Italy (the number of patients fluctuating between 1,450,000 and 1,740,000) [2]. These values were underestimated due to the lack of information from patients as well as the specialized centers for the treatment of these diseases.

Recent studies have shown that the patient with OSAS is 375% more likely to cause a fatal car accident than a normal patient. Approximately, 22% of the road accidents in Italy are caused by daytime sleepiness while driving, which mainly originates from OSAS; the latter determines the cost of about 1 billion Euros annually (between direct and indirect costs) for the entire community [3,4].

Young et al. reported a prevalence of symptomatic OSAS in 2% women and 4% middle-aged men; however, the prevalence of sleep disorders was estimated in the 30–60 years age group (9% women and 24% men) [5,6]. These data render OSAS as common asthma pathology. The risk of OSAS increases with age; >24% of individuals aged >6 years have OSAS, and >50% individuals in nursing homes for the elderly suffer from clinically significant OSAS. Its prevalence in the adult was between 1.2 and 7.5%, which increases to >15% after the age of 65 years and 25% at the age of 80 years [7].

The diagnostic recognition, classification, and OSAS management require dedicated equipment and skill specific to the field of Sleep Medicine. The diagnosis is based on clinical presentation, physical examination, and objective data obtained from a sleep study. Polysomnography (PSG) represents the gold standard for the diagnosis of OSAS and provides the elements to set the positive airway pressure values required for therapy [3]. In addition, PSG records the parameters that assess the sleep according to the standard criteria that include the staging of the sleep and the evaluation of the events, such as microstructural morphology, respiratory noise, oronasal airflow, thoracoabdominal movements, heart rate, oximetry, and body position.

Apnea is defined as the complete absence of airflow through the nose and mouth for >10 s. The three types of apnea are distinguished as follows:

I. Central apnea sleep in which the interruption of breathing is caused by altered control of ventilation in the central nervous system, which is not associated with respiratory efforts during the event;
II. Obstructive sleep apnea in which the control of ventilation is normal; however, an obstruction occurs, usually in the pharynx or hypopharynx, which interrupts airflow despite strong inspiratory efforts by the patient (with the paradoxical movement of the chest wall). The typical OSAS patient presents ≥20 apnea episodes/h during sleep [8]. These last for >10 s; also, apnea causes a concomitant reduction in oxygen saturation;
III. Mixed type sleep apnea is a combination of two components. Nonetheless, obstructive sleep apnea is the most common pathology.

According to the World Health Organization (WHO), OSAS meets the criteria for defining chronic disease, and to diagnose the disease in adults according to the International Classification of Sleep Disorders 2014, the following criteria must be fulfilled [9]:

a. Apnea-hypopnea index (AHI) of at least five obstructive events/h associated with signs and/or symptoms (excessive daytime sleepiness, chronic fatigue, snoring, sudden awakenings with a lack of "choking" lack of air, subjective nocturnal disturbances, apnea) or clinical characteristics (arterial hypertension, coronary artery disease, stroke, diabetes, cognitive dysfunction, mood disorders).
b. AHI of at least 15 events/h, irrespective of signs and/or symptoms or clinical manifestations.

Based on the AHI, OSAS is defined as mild (5< AHI <14), moderate (15< AHI <29), and severe (AHI >30) [8]. Previous studies showed that scientific evidence ensures the sustainability of the National Health System (NHS) [10].

Therefore, the prevention campaign of OSAS is essential to ensure quality healthcare with sustainable public spending [9]. Furthermore, the primary and secondary prevention should be under intensive focus (through the elimination of risk factors) *via* information and screening to reveal the unrecognized cases [10].

2. Materials and methods

We submitted 130 snoring patients to the STOP BANG questionnaire, of which 98 (84 men and 14 women) were at high risk for OSA by answering at least 3 questions positively.

We studied the 98 snorers who were found to be at high risk in the STOP BANG questionnaire.

The total of adult snoring patients were interviewed from November 2015 to December 2016 at the University Screening Center for Obstructive Respiratory Sleep of University G. d'Annunzio Chieti-Pescara, Department of Medical and Oral Sciences, Chieti, and were positive for the STOP-BANG screening.

All patients were provided information about the study that was conducted according to the Declaration of Helsinki and ICH-GCP, GU 184/2003. Written informed consent was obtained from all patients.

All patients followed the protocol:

I. SBQ;

II. Anamnestic questionnaire (physiological anamnesis (smoking, alcohol), remote and near-pathological anamnesis, potential therapies in progress);
III. Sleep observation (nocturia, nocturnal restlessness, chocking episodes)
IV. Work history (type of work, accidents at work caused by sleep, road accidents caused by sleep, decrease in work and relational efficiency);
V. Evaluation of diurnal drowsiness by Epworth scale;
VI. Anthropometric evaluation (BMI, neck circumference, waist circumference);
VII. Full ENT physical examination with craniofacial evaluation, evaluation of the occlusion class, anterior rhinoscopy, oropharyngoscopy (with the evaluation of Mallampati and tonsillar index), complete fiber optic rhinopharyngoscopy with Müller maneuver,
VIII. Night-time cardiorespiratory monitoring, outpatient.

Of the 98 STOP-BANG-positive patients with values ≥3 on a scale of 8 points, the following parameters were taken into consideration [11]:

(a) age ≥ or ≤50 years,
(b) daytime fatigue or sleepiness according to the Epworth scale (pathological drowsiness if values ≥10),
(c) BMI ≥ or ≤35,
(d) neck circumference ≥ or ≤40 cm,
(e) apnea was reported while monitoring the sleep,
(f) cardiac hypertension,
(g) headache,
(h) choking episodes (sudden awakenings with a feeling of lack of air),
(i) nocturia,
(j) night restlessness,
(k) alcohol consumption (daily consumption: < or >1/2 L/day or >1 L),
(l) smoking (smoker or former smoker),
(m) decreased working and relational efficiency,
(n) workplace accidents caused by sleep,
(o) road accidents caused by sleep.

These parameters were related to the results of polysomnography according to the classification of the AHI grading (apnea/hypopnea index, number of apneas/hypopneas per hour):

AHI <5 is negative for OSAS, i.e., simple snorer;
AHI ≥5 positive for OSAS;
5< AHI <14 OSAS is low grade;
15< AHI <29 OSAS of moderate grade;
AHI ≥30 OSAS indicates high grade.

Considering the single parameters taken into consideration, we aimed to evaluate the predictability of the screening questionnaires through their specificity and sensitivity. In addition, the correlation between the polysomnographic data and the risk factors in the SBQ was established. Also, risk factors, such as smoking and alcohol, headache, decreased work and relational efficiency, sleep-related accidents, and observations during the sleep together with nocturia were considered.

3. Statistical analysis

The statistical analysis was performed using the Pearson index with the chi-square test. The chi-square test (χ^2) is a statistical inference technique that is based on the chi-square statistic.

It can be used with variables at nominal and/or ordinal scale level, generally arranged in the form of contingency tables.

The main purpose of this statistic is to verify the differences between observed and theoretical values (generally called "expected") and to make an inference on the degree of deviation between the two. The specificity of the STOP BANG questionnaire was studied through the ROC curve. The ROC curve (acronym of the English terms Receiver Operating Characteristics) is a statistical technique that measures the accuracy of a diagnostic test all along the range of possible values. Since the ROC curve measures the agreement between the test of interest and the presence/absence of a specific disease (as identified by a golden standard), it represents the method of choice for validating a diagnostic test. The ROC curve also allows to identify the optimal threshold value (the so-called best cut-off), i.e. the test value that maximizes the difference between the true positives (i.e. the proportion of individuals who have an altered test value among all those actually affected by the disease) and false positives (i.e. the proportion of individuals who despite having an altered test value are not affected by the disease of interest). The ROC curve is constructed considering all possible test values and, for each of these, the proportion of true positives (sensitivity) and the proportion of false positives are calculated. By joining the points which relate the proportion of true positives and of false positives (the so-called coordinates) you get a curve called the ROC curve. The area below the ROC curve (AUC, an acronym for the English terms "Area Under the Curve") is a measure of diagnostic accuracy.

4. Results

All the 98 patients (84 males and 14 females), aged 18–76 (average, 51.35) years, were snorers and positive for STOP-BANG survey. Of the screening-positive patients, 38 (38.8%) reported tiredness during the day, 28 (29.6%) reported sleep apnea, 40 (40.8%) reported arterial hypertension in drug treatment, 70 (71.4%) reported motor restlessness during sleep, 91 (92.6%) had a BMI <35 and only 7 (7.1%) had BMI >35, 38 (38.8%) had a neck circumference >40 cm, 47 (48%) reported nocturnal awakenings with choking sensation, 29 (29%) reported headache on awakening and during the day, 2 (2%) reported work-related accidents caused by sleep, 36 (36.7%) reported nocturia waking up and getting out of bed at least once a night to go to the bathroom, 44 (44.9%) reported other associated diseases, and 51 (52%) were on drug therapy (Table 1).

Table 1. Responses to the STOP BANG questionnaire and polygraphic analysis of the 98 subjects.

Tiredness	Subjects with daytime sleepiness (Epworth Sleepiness Scale (EES) >10)
ESS >10	61
ESS <10	37
Total	98

Continued on next page

Tiredness	Subjects with daytime sleepiness (Epworth Sleepiness Scale (EES) >10)
Pressure	Subject with hypertenction
Hypertension	40
No hypertension	58
Total	98
Sleep disturbance	Subjects with reported Choking
with choking	47
without choking	51
Total	98
Neck	Subjects with neck circumference >40 cm
>40 cm	50
<40 cm	48
Total	98
Gender	Snorers (17 y.o.< age <76 y.o.)
Male	84
Female	14
Total	98
Obstructions	Subjects with apneas observed or reported in sleep
with apneas observed	28
without apneas observed	70
Total	98
Body Mass Index	Subjects with BMI ≥35
BMI ≥35	7
BMI <35	91
Total	98
Age	Subject with age ≥50 y.o.
age ≥50	53
age <50	45
Total	98
Apnea Hypopnea Index	Snoring subjects analyzed with polysomnography
AHI ≥30	43
20< AHI <29	20
10< AHI <20	3
5< AHI <10	20
AHI <5	12
Total	98

Analyzing the patients' voluptuous habits, we found that 20 patients (20.4%) were habitual smokers, and 44 (44%) consumed <1/2 L of wine or beer daily.

The analysis of daytime sleepiness revealed that 62.2% of patients responded to the Epworth questionnaire with a score ≥10, demonstrating pathological daytime sleepiness. Fifty (51%) patients reported concentration deficits, 38 patients (38.8%) reported decreased work and relational efficiency, and 8 (8.2%) patients reported traffic accidents caused by sleep.

All the patients in the study were subjected to polysomnographic examination; the results were as follows: 83 (84.7%) patients were positive for OSAS with AHI ≥5, 43 (43.9%) patients exhibited severe OSAS for AHI ≥30, 20 (20.4%) showed moderate OSAS results (20< AHI <29), 3 (3.1%) showed mild-to-moderate grade OSAS (10< AHI <20), 20 (20.4%) displayed mild OSAS (5< AHI <10), and 12 (12.2%) were negative for OSAS (AHI <5), i.e., simple snorers.

Positive results in patients were evaluated based on AHI with grading: 0: AHI <5, 1: 5< AHI <10, 2: 10< AHI <20, 3: 20< AHI <30, 4: AHI >30 through the contingency tables correlating the neck circumference >40 cm = 1, <40 cm = 0; age >50 = 1, <50 = 0; BMI >35 = 1, <35 = 0; drowsiness with ESS <10 (0) = not sleepy, ESS ≥10 (1) = not sleepy; hypertension (1), normotension (0); nocturia present (1), not present (0); headache (1), no headache (0).

A patient with AHI <5 (0) had circumference >40 cm, 5 patients with 5< AHI <10 (1) had a neck circumference >40 cm, a patient with 10< AHI <20 (2) had circumference >40 cm, 5 patients with 20< AHI <30 (3) had neck circumference >40 cm, and 38 patients with AHI >30 (4) had neck circumference >40 cm (Table 2). Numerically significant data with $\chi^2 = 0.002$.

Table 2. Distribution of subjects with STOP BANG score ≥3 in relation to the "AHI".

Apnea/Hypopnea index	Subjects with neck circumference >40 cm	Subjects with age ≥50 years old	Subjects with BMI ≥35	Subjects with daytime sleepiness (ESS >10)
AHI <5	1	2	0	7
5< AHI <10	5	11	0	11
10< AHI <20	1	3	0	2
20< AHI <30	5	14	1	12
AHI >30	38	23	6	29

It was found that 53/98 (51.94%) patients were aged ≥50 years: 2 with AHI <5 (0), 11 with 5< AHI <10 (1), 3 with 10< AHI <20 (2), 14 with 20< AHI <30 (3), and 23 with AHI >30. Numerically significant data with $\chi^2 = 0.023$.

A total of 7 out of 98 (6.86%) patients had BMI >35 (1), a patient with 20< AHI <30 (3) had BMI >35, and 6 patients with AHI >30 had BMI >35. Numerically significant data with $\chi^2 = 0.212$.

It was observed that 61/98 (59.78%) patients were sleepy for ESS ≥10 (1), of which, 7 with AHI <5 (0), 11 with 5< AHI <10 (1), 2 with 10< AHI <20, 12 with 20< AHI <30, and 29 with AHI >30. Numerically significant data with $\chi^2 = 0.896$.

It was found that 43/98 patients had an AHI ≥10 (1) (limit for cardiovascular risk); of these, 21 were hypertensive (1) (Table 3). Numerically significant data with $\chi^2 = 0.153$.

Table 3. Distribution of subjects with STOP BANG score ≥3 in relation to the "AHI".

Apnea/Hypopnea index	Subjects with hypertenction	Subjects with normal blood pressure
AHI ≥10	31	48
AHI <10	2	10

A total of 40 out of 98 (39.2%) patients were hypertensive; of these 2 had an AHI <5 (0), 7 had 5< AHI <10 (1), 2 had 10< AHI <20 (2), 8 had 20< AHI <30 (3), and 21 had AHI >30 (4). Numerically significant data with $\chi^2 = 0.271$.

A total of 62 out of 98 (60.76%) patients reported nocturia. Of these, 7 had AHI <5, 13 had 5< AHI <10, 10 had 20< AHI <30, and 32 had AHI >30. Numerically significant data with $\chi^2 = 0.058$.

A total of 29 out of 98 (28.42%) patients suffered from headache; of these, 1 had AHI <5 (0), 6 had 5< AHI <10 (1), 1 had 10< AHI <20 (2), 8 had 20< AHI <30 (3), and 13 had AHI >30. Numerically significant data with $\chi^2 = 0.452$.

The sum of values from 1–7 with AHI grading 0–4 for SBQ were detected as follows: STOP-BANG value 3 in 43 patients had an AHI >30 (4), in 20 patients had 20< AHI <30 (3), in 3 patients had 10< AHI <20 (2), in 20 patients had 5< AHI <100 (1), and in 13 patients had AHI <5. Numerically significant data with $\chi^2 = 0.096$ (Table 4).

Table 4. Risk for OSAS based on the STOP BANG score compared to the "AHI".

OSAS RISK	AHI <5	5< AHI <10	10< AHI <20	20< AHI <30	AHI >30
STOP BANG = 1	1	0	0	0	0
STOP BANG = 2	2	0	0	1	0
STOP BANG = 3	3	6	0	5	4
STOP BANG = 4	5	7	1	5	9
STOP BANG = 5	1	3	1	4	10
STOP BANG = 6	1	3	1	4	17
STOP BANG = 7	0	1	0	1	3

5. Discussion

Screening tests have been used by both the specialists and general practitioners to identify the patients at risk of OSAS or justify programmed polysomnographic studies or perform ENT interventions.

Next, we searched for "sleepiness" predicted by the Epworth Sleepiness Scale with respect to a great risk of OSAS.

For the prevention of OSAS, specialized assessments are activated in all cases, during which the attending physician, the competent doctor, or the monocratic doctor highlights a possible obstruction of the respiratory tract, such as anthropometric alterations of the facial massif and the first airways in adults and adenotonsillar hypertrophy in the pediatric patient [12].

Hence, the educational role is fundamental, while general practitioners, competent doctors, hygienist doctors, and health assistants are vital for the prevention and early diagnosis of this disease.

Recent statistical surveys have shown that the prevalence of OSAS in surgical intervention candidates is higher than that in the general population and varies according to the type of intervention [13].

In particular, 7out of 10 patients underwent bariatric surgery and were positive for OSAS, most of them owing to high levels of obesity [11].

Furthermore, the Berlin Chung Questionnaire classified 24% of 305 surgical patients as high-risk for OSAS. Also, 13 (4.2%) were confirmed by polysomnography, and 80% of patients with moderate OSAS were not diagnosed.

The subset of the population unaware that it suffers from night apnea syndrome and might never receive the indication to undergo a polysomnographic study poses a challenge for those dealing with sleep and severe problem for cardiologists, neurologists, anesthesiologists, resuscitators, and insurance companies due to the high percentage of sleep-related accidents [11].

Some low-cost and easily reproducible screening tests have been identified over a period for a large number of patients with the risk of OSAS. This procedure would have the natural advantage of directing the current resources towards a selective population, thereby reducing the number of negative examinations [12].

The commonly used tools are the Epworth Scale, the Berlin test, and the SBQ.

The STOP-BANG acronym is derived as follows:

S (Snore = Russians): Russians strong?
T (Tired = tired): Do you often feel tired?
O (Observed = observed): Has anyone noticed the stoppage of your breath at night?
P (Pressure = blood pressure): Do you have high blood pressure?
B (BMI = body mass index): Is your BMI >35?
A (AGE = age): Is your age >50 years?
N (Neck = neck): Is your neck circumference >40 cm?
G (Gender = gender, sex): Are you male?

The technical characteristics of this diagnostic tool are illustrated below. The specific attention of anesthesiologists to the problem is due to several reasons [13]:

I. OSAS is an often undiagnosed disease, and hence, the majority of the sick individuals show up for surgery without knowing that they have sleep apnea [14].
II. Severe OSAS shows a significant increase in anesthesiological risk.
III. Conventional methods for diagnosis (polysomnography, sleep monitoring) are extremely complicated to be used as a routine in all patients who undergo the operation for different diseases [15].

Interestingly, half of the questions in the SBQ describes information about cardiovascular risk (BMI, arterial hypertension, gender, age) [16], while others are directed towards the predisposition and effects of night apnea syndrome (snoring, tiredness, observation of sleep, neck circumference) [17].

The simplicity of this test lies in the yes/no answer, unlike the other tests, wherein gradual progression of the symptom is expressed, or the appearance is recorded.

The ease of administration and reading makes the test a valid candidate for preoperative anesthesia screening, as well as a useful tool for a cost-effective and rapid investigation in the office of a primary care physician or at a screening center.

Therefore, to obtain maximum information with minimum effort, several studies have been carried out to validate the questionnaire [18], i.e., to establish whether the results obtained with these simple eight questions would provide only dichotomous answers (yes/no). This tool is effective in predicting the presence (and severity) of the apnea syndrome [19].

The present results demonstrated that the STOP-BANG predicts the presence of OSAS [20].

The sensitivity of the questionnaire (i.e., the ability to not let the sick patients be missed) is extremely high: mild apnea (AHI 5–15) 83.6%, moderate apnea (AHI 15–30) 92.9%, and severe apnea (AHI >30) 100%.

The few "false negatives" exhibited mild or moderate forms of apnea.

The specificity (Figure 1) (i.e., the ability to not exchange healthy subjects for sick individuals) was low (from 37% to 57% according to the groups). On the other hand, "false positives" were abundant. Further tests would confirm that these subjects were healthy.

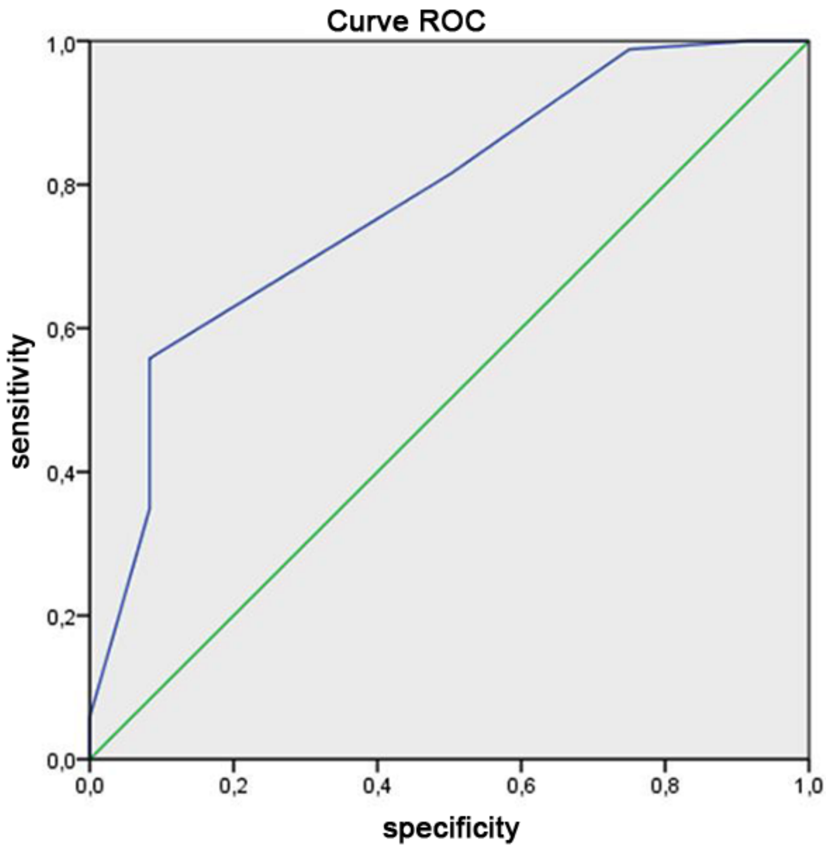

Figure 1. Relation between sensitivity and specificity of the questionnaire.

The questionnaire, with the criteria for evaluating the results, was defined in two stages (starting from the Berlin questionnaire):

I. The questionnaire originally provided only the first part (STOP).
II. The second part (BANG), added later, consists of questions that are not specific to OSAS.

It is used to assess the severity of the risk, which increases with the number of "yes." The interpretation of the answers suggested that ≥3 YES is a high risk of OSAS.

In addition, the questionnaire was validated in subjects other than the original group (sleep lab patients) using PSG as the gold standard. Thus, the fundamental planning tool is the National Prevention Plan, which sets the objectives and prevention tools for a decline at the regional level in the regional implementation plans.

6. Conclusion

OSAS is an emerging health and social issue as its consequences are daytime sleepiness and associated cardiovascular and metabolic comorbidities. In Italy, since 2015, the directives are aimed at reducing the number of road accidents through targeted tests for drivers while renewing or obtaining a driving license [10]. OSAS is a disease that, if left untreated, can be a reason for revoking a license.

Furthermore, a diagnostic-therapeutic assistant pathway has been initiated for the accurate diagnosis, therapy, and follow-up of this disease. However, it requires an articulated and complex multidisciplinary approach.

Nevertheless, comprehensive content, adequate language and timing, and health education and promotion are the key elements for participation. The SBQs and Epworth scale for daytime sleepiness identifies patients with OSAS and daytime sleepiness. The speed with which questionnaires are administered and the simplicity of the answers make it a suitable tool for both screening centers and the General Practitioner's clinic. The 90% sensitivity of the test allows an accurate diagnosis without expensive instrumental tests in the field of General Medicine and Occupational Medicine.

Thus, the productivity of the workers in reducing road accidents by pathological daytime sleepiness would be increased [21–25].

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Conflict of interest

All authors declare no conflicts of interest in this paper.

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