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Prediction models and morbidities associated to obstructive sleep apnea: An updated systematic review

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ABSTRACT

Objective: We aim to present a systematic review using a literature update on the performance of clinical questionnaires in predicting the diagnosis of obstructive sleep apnea syndrome compared with polysomnography considered as the reference test to confirm obstructive sleep apnea syndrome.

Source of evidence: Medline, the Cochrane Database of Systematic Reviews, Scopus, and ScienceDirect.

Methods: The article selection stage implemented the PRISMA diagram.

Results: The selected studies state that the Berlin questionnaire, the Epworth sleepiness scale, the STOP questionnaire, the STOP-BANG questionnaire, the ASA checklist, and the No-SAS score are the best performing screening tools to predict obstructive sleep apnea syndrome, as their performance was evaluated for different thresholds of apnea hypopnea index obtained using polysomnography.

Conclusion: The DES-OSA 50 and the No-SAS score are simples, effectives, and easy-to-implement scores to identify individuals at risk of sleep-disordered breathing; it can help clinicians decide which patients should be referred for polysomnography.

Keywords: obstructive sleep apnea syndrome, screening scores, performance of clinical questionnaires, apnea-hypopnea index, polysomnography

INTRODUCTION

Sleep is considered us a complex state of behavior that occupies one-third of the human lifespan [1]. It is the phase of recurrent loss of consciousness that allows the organism to obtain the rest necessary to restore energy while the nervous system remains constantly active [2].

The obstructive sleep apnea syndrome (OSA) corresponds to the occurrence during sleep of complete or partial obstruction of the upper airways, responsible for apnea or hypopnea, which causes fragmentation of sleep that, becomes non-restorative [3]. OSA represents the main sleep-related respiratory disorder, whose repercussions and impact on the quality of life of patients as well as the comorbidities it causes make it a major public health problem [4].

OSA is the most common sleep-related respiratory disorder, characterized on the one hand by the association of diurnal symptomatology, dominated by sleepiness, and on the other hand by its important morbidity by increasing the risk of hypertension, glucose intolerance, cardiovascular, cerebrovascular, social, and professional disorders [5]. In addition, untreated OSA can alter the quality of life of affected subjects by evolving from daytime sleepiness to cognitive dysfunction and an increased risk of road accidents [5].

For this reason, different clinical models are developed to identify patients at high risk for OSA [6]. The screening questionnaires are effective, simple and inexpensive tools which can be used to categorize patients who are eligible for polysomnographie (PSG) [6].

METHODS

Identification of Relevant Articles

Selection criteria

The selection of systematic reviews and scientific articles was based on well-defined criteria:

1. **Type of studies:** Systematic reviews and scientific articles that address the ability of clinical scores to predict OSAS are included.
2. **Language:** Reviews and articles written in English and French were included.
3. **Location:** Reviews and articles that consider studies conducted internationally.

4. **Year of publication:** Publications published between 2008 and 2021.
5. **Field of intervention:** All included articles and reviews that address the ability of clinical scores to predict and diagnose OSA compared with polysomnography.

Data sources

The bibliographic search is done using the bibliographic databases like PubMed, Cochrane, Springer Link, Scopus, and ScienceDirect.

Search strategy

To benefit from a more exhaustive panel of search results, the search equation consists of using keywords including: *OSA*, *clinical questionnaires*, OSA *prediction scores*, and *performance of OSA screening scores*. These are crossed with other keywords targeting searches concerning OSA severity assessment scores including: *Berlin questionnaire*, *Epworth scale*, as well as with keywords targeting associated factors like *risk factors related to OSA and associated comorbidities*.

Assessment of the Quality of Data Extraction and Synthesis

Selection of studies

The selection of studies is done in two stages: The titles and abstracts are read to judge the eligibility of the selected documents according to the pre-established criteria. Then, the texts are read in their entirety. At the end of this selection process, a diagram is drawn up in the form of a PRISMA diagram, indicating the number of articles retained and excluded at each stage.

Criteria for evaluating the quality of reviews and articles

The selection of systematic reviews and scientific articles is based on the selection criteria mentioned above. In order to refine the selection of documents previously retained in the first stage of bibliographic research and to select only those of good quality and limit potential biases when synthesizing the results, the evaluation of the quality of the publications is carried out by verifying if:

1. The goals and objectives of the research are clearly stated.
2. The research methodology is clearly specified and adapted to the goals and objectives of the research.
3. The researchers provide a clear account of the process by which their results were produced.
4. The researchers display sufficient data to support their interpretations and conclusions.
5. The method of analysis is appropriate and sufficiently explained.

Data extraction

The data extraction step aims to collect the data, in other words, gather the results of the included studies, using a data extraction form specifying all essential data (**Appendix A**).

Data extraction in our review is aimed at highlighting any reliable and relevant data that meet our objective. This implies extracting data related to clinical questionnaires that predict OSA, to OSA severity assessment scores, and in particular to the performance of these screening tools in confirming OSA in the at-risk population compared to polysomnography, which has traditionally been considered the reference test.

Data extraction in this review is aimed at bringing to light any reliable and relevant data that meet our objective. This involves extracting data related to clinical questionnaires that predict OSA, to OSA severity assessment scores, and in particular to the performance of these screening tools in confirming OSA in the at-risk population compared to polysomnography, which has always been considered as the reference test.

Data synthesis

Depending on the studies included in this review, the extracted data are analyzed using a descriptive synthesis. This step corresponds to a structured presentation of the essential characteristics of the studies. It started with a descriptive analysis of each study included, regarding the methodology adopted, the objective of the study, and the results found.

Then the studies are associated in precise categories, this will help guide the conclusions of the systematic reviews and scientific articles: A reunification of the results according to the clinical questionnaires of prediction of OSA, a grouping according to the performance of these screening tools compared to polysomnography. The synthesis of the results makes it possible to construct a summary of the results, taking into account the differences between the selected studies.

Bibliographic references

For the management of the bibliographic references, we used the software Zotero, which is a tool that helps to manage bibliographic data and research documents. The software Zotero is primarily used to capture bibliographic information on many sites, and to classify this information in a virtual library: the goal is to be able to generate our bibliography cleanly, without typos, using the different styles available.

RESULTS

Diagram of Selected, Excluded and Analyzed Studies

We performed a systematic search to identify clinical questionnaires and screening scores for OSA. Also, to evaluate their performance in predicting OSA in comparison with the reference test polysomnography.

A comprehensive literature review using the different search strategies was performed in the following databases: CINAHL, Cochrane, PubMed, and ScienceDirect.

The elaboration of the research equation was according to a list of key concepts: “Sleep apnea syndrome”, “Sleep apnea”, “Obstructive sleep apnea syndrome”, “Apnea-Hypopnea Index”, “Screening scores”, “Clinical questionnaires of evaluation of OSA”, and “Polysomnography”.

In addition, we established some limitations during the research, notably, the type of articles selected, which were limited to systematic reviews and scientific articles also the date of the publication since only articles published between 2008 and 2021 were included, linguistic limitations were also faced.

The electronic search provided 77 references. The articles that were considered worthy of a full-text review after examining their titles and abstracts numbered 15. Next, we proceeded to full-text screening to verify compliance with all selection criteria, of which 14 articles were retained that validated all of the predetermined criteria. Consequently, we

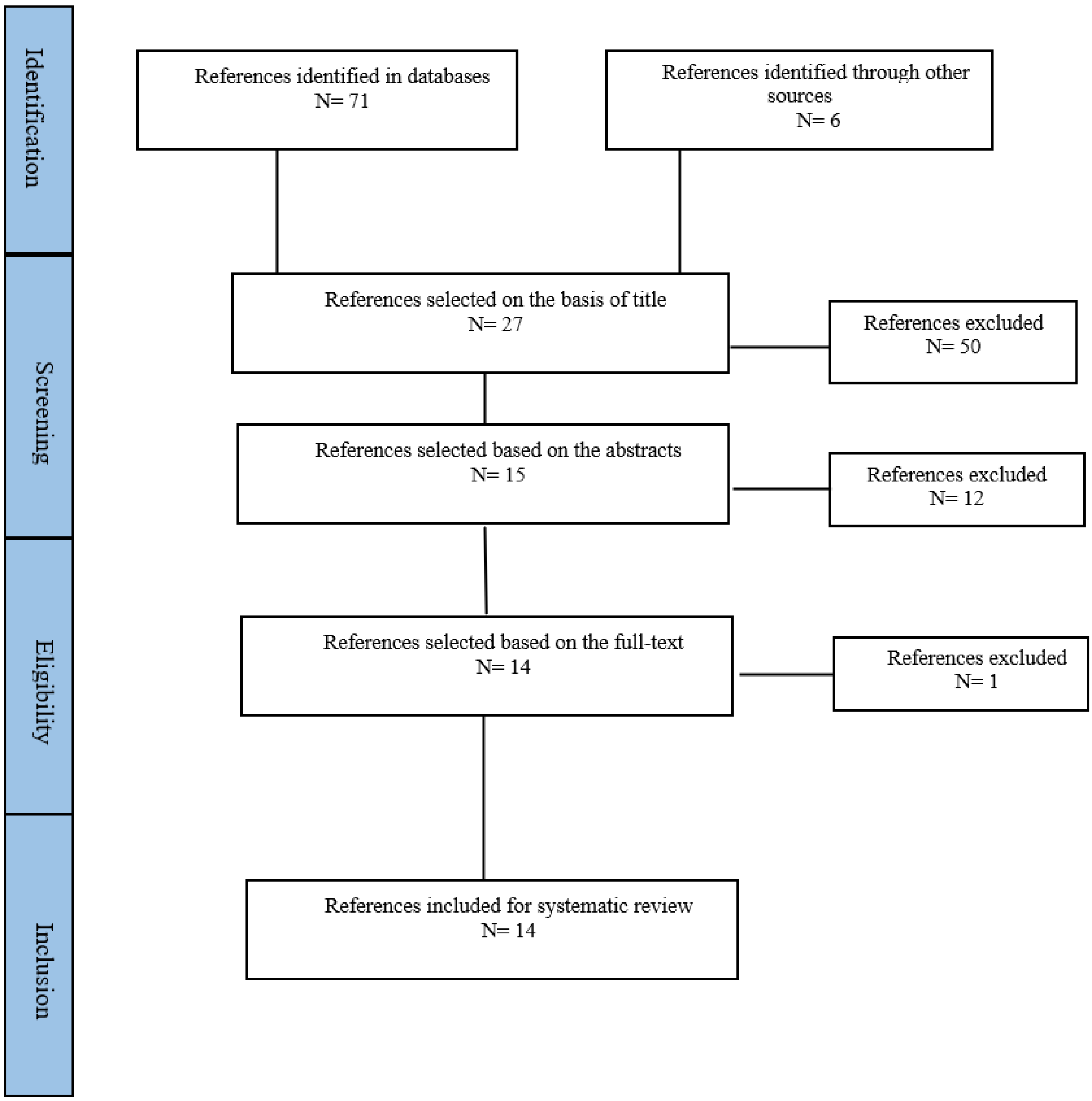

Figure 1. Flow diagram of study selection

excluded 63 articles that did not validate the inclusion criteria (**Figure 1**). In total, 14 publications were identified that successfully approve the inclusion criteria.

The Characteristics of the Included Studies

All studies included in this review used clinical scores for screening for OSAS and laboratory or home PSG to confirm the diagnosis (**Table 1**).

Table 1. The characteristics of the included studies

Author, year, country	Sample	Age (years)	Gender (%) male/female	BMI (kg/m2)	Conclusion
Deflandre et al. (2015) [7] Belgium	733 general surgical population	55.8±14.0	68/32	31.79±12.07	DES-OSA is the only morphological score to outperform the other scores in predicting severe OSA.
Deflandre et al. (2016) [8] Belgium	149 general surgical population	51.37±12.38	68.35/31.65	28.95±5.28	DES-OSA is an effective, simple, morphologically based score for detecting patients with OSA.
Senaratna et al. (2019) [9] Australia	772 general population	52.9(0.9)	152(53%)	29.3(5.3)	The use of STOP-BANG in combination with ESS can improve the sensitivity and specificity of this tool.
Laharnar et al. (2021) [10] Germany	150 sleep center patients	57.5±12.3	90(60%)	30.2±7.2	The OSA prediction score allows a simple & effective detection on only anthropometric measurements & upper airway visibility.
Ahlin et al. (2019) [11] Italy	161 obese patients	46.48±9.68	49.7% men vs. 50.3% women	47.14±8.16	The OSA risk score is one of the best predictive models of moderate to severe OSA.

Table 1 (continued). The characteristics of the included studies

Author, year, country	Sample	Age (years)	Gender (%) male/female	BMI (kg/m2)	Conclusion
Deflandre et al. (2019) [12] Belgium	293 general surgical population	50.5±15.4	-	31.2±10.08	DES-OSA had the best specificity and the OSA-50 score had good sensitivity compared to STOP-BANG & P-SAS
Berger et al. (2016) [13] France	115 general population	62±07.0	-	28.8±5.06	STOP-BANG should be used in clinical screening instead of the Berlin questionnaire.
Ramachandran et al. (2010) [14] USA	43,576 general population	50.9±16.9	17,752(44)	28.2±6.5	P-SAP score is an excellent screening tool for OSA especially for moderate to severe OSA.
Deflandre et al. (2018) [15] Belgium	159 general surgical population	55.8±14.0	68/32	31.79±12.07	DES-OSA score is more effective in identifying patients with OSAS and severe hypoxemia.
Fida et al. (2020) [16] Tunisia	378 hypertensive patients	58.4±10.1	-	37±6.07	STOP-BANG is more sensitive 93.45% than the Epworth 76.19%, but less specific 16.67% vs 42.11%.
Pataka et al. (2014) [17] Greece	1,853 general population	52±14	74.4% men	32.8±7.0	STOP-BANG has the best sensitivity & the 4-V screening tool has the best specificity.
Takegami et al. (2009) [18] Japan	132 general surgical population	56±13.06	-	30.5±5.2	4-variable tool has better sensitivity 93% & good specificity 66% for predicting moderate to severe OSA.
Qing et al. (2018) [19] China	444 general surgical population	60.4±10.02	328 men & 116 women	31±7.5	NoSAS & STOP-BANG scores are the most effective in screening for OSA
Hwang et al. (2021) [20] Canada	1,894 general population	58±13	64% men	30±60.01	STOP-BANG is an effective tool to screen for mild to moderate OSA.

DISCUSSION

Physiopathogenesis of OSA

First of all, the air passes through ducts of different caliber and rigidity to reach the lungs in order to supply them with oxygen [21]. The contraction of the inspiratory muscles, mainly the diaphragm, causes the creation of a negative pressure, which is lower than the atmospheric pressure, within the airways, and thanks to this phenomenon the air is drawn into the thorax [21]. This sealing is guaranteed on the one hand by the negativity of the pleural pressure and on the other hand by the elasticity of the lung which are two essential elements that exert an important force that pulls the edges of the lung towards the outside to open the air ducts located in intrathoracic [4]. However, the upper airways, located outside the thorax, in particular, the pharynx which is a soft, muscular, and membranous tube, is susceptible to collapse during inspiratory movements as the negative pressure created at the time of inspiration sucks the walls inwards [4].

In order to prevent the closure of the pharynx, the organism sets up a protective mechanism even before the beginning of inspiration, notably the contraction of the dilator muscles of the pharynx (genioglossus, geniohyoid, styloglossus, masseter, pterygdoid, and tensor of the soft palate) [4]. This contraction guarantees the opening of the pharynx so that the air can circulate freely both during inspiration and expiration in a duct of regular dimensions [4]. During normal sleep, these protective mechanisms are less, this leads to a physiological decrease at the level of the pharyngeal caliber giving consequently a decrease of the ventilation especially that the phase of sleep is known by a reduction of the needs for oxygen thus these modifications of caliber do not seem to have a deleterious effect [5].

Research about living subjects with obstructive sleep apnea shows that the activity of the pharyngeal dilator muscles increases during wakefulness in patients compared to normal subjects and the pharyngeal muscles are hypertrophied [14]. This hypertrophy is considered to be a compensation mechanism for the narrowness of the pharynx associated with an increase in anaerobic metabolism enzymes [14]. These muscular modifications are responsible for the lesions of fibrosis and inflammation of the soft parts of the pharynx generating an alteration of the pharyngeal stability [22].

However, these complex mechanisms lead to micro-awakenings which affect the quality of sleep of these people, especially that the obstructive apnea generates hypoxia, hypercapnia associated with bradycardia accompanied by an increase in the respiratory load with thoracoabdominal and pharyngeal distortion manifested by an augmentation of the ventilatory command and recruitment of the abdominal muscles [22].

Comorbidities Associated with OSA

OSA affects approximately 4% of men and 2% of women in the general population, with a maximum between the ages of 50 and 60 [5]. OSA considerably increases mortality, especially in severe forms [5].

Then, OSA is not only a mechanical problem, it is also a risk factor for the development of cardiovascular pathologies (hypertension, coronary artery disease, etc.), neurological pathologies (stroke, vigilance disorders, etc.), metabolic pathologies (insulin resistance, type 2 diabetes, etc.), and disturbance of lipid metabolism [5].

In addition, patients with OSA not only have a higher cardiovascular risk but also an increased prevalence of depression, because people with OSA tend to become depressed due to chronic fatigue from non-restorative sleep, which is compounded by the limited effectiveness of antidepressants, as OSA is considered a potential cause of resistance to antidepressant treatments [5].

Furthermore, OSA causes important consequences for society, such as reduced productivity, absenteeism, work-related accidents, and joblessness [7].

Assessment of the Performance of OSA Screening Tools

Obstructive sleep apnea is an under-diagnosed disorder despite its relatively high prevalence, with nearly three out of four people reportedly not being screened or treated [2]. This

Table 2. Specificity and sensitivity of obstructive sleep apnea screening questionnaires only and after the addition of ESS [9]

OSA screening questionnaire	Sensitivity (CI 95%)	Specificity (CI 95%)
Berlin≥2	65% (56-73%)	59% (50-67%)
STOP-BANG≥3	81% (73-87%)	36% (28-44%)
OSA-50≥5	86% (80-92%)	21% (15-29%)
	Questionnaire+ESS	
Berlin≥2+ESS	36% (28-45%)	95% (90-98%)
STOP-BANG ≥3+ESS	50% (41-59%)	92% (86-96%)
OSA-50≥5+ESS	51% (43-60%)	92% (86-96%)

is mainly due to the fact that the reference test is polysomnography which is expensive to perform, as it requires highly trained personnel, sophisticated equipment, and an entire night of recording, especially since most sleep centers usually have long waiting lists for polysomnography and patients are obliged to wait to get their exact diagnosis before starting their treatment increasing risk of worsening OSA [23].

These long waiting lists and limited resources have sparked interest in clinical research to "predict" OSA based on reliable clinical scores [2]. The evaluation of the performance of STOP-BANG was the subject of a variety of studies such as that of Berger and colleagues who set the objective of comparing the predictive ability of the STOP-BANG questionnaire with that of the Berlin questionnaire with regard to the prediction of OSA [13]. The results of this investigation showed that within this study population, 83.6% had moderate to severe OSA, the researchers stated that the STOP-BANG had a high sensitivity of 94.4% compared to the Berlin 71.4% however its specificity for detecting an AHI ≥15 was low 17.6% whereas the Berlin had a slightly increased specificity 31.1% [13].

The same finding was found in a study conducted to evaluate the predictive performance of five of the most commonly used questionnaires for screening for OSA, namely: STOP, STOP-BANG, Berlin questionnaire, Epworth sleepiness scale (ESS) and the 4-V screening tool (4-V), as well as to determine the best possible associations between these instruments, the results of which showed that STOP-BANG had the best sensitivity (97.6%), in spite of its low specificity (12.7%) [17]. However, the Berlin performs well in terms of specificity compared to the STOP-BANG and Stop questionnaires 12.7% and 13%, respectively [17].

In another study conducted in the hypertensive population to compare the predictive ability of STOP-BANG and ESS in predicting OSA showed that STOP-BANG was more sensitive 93.45% but low specificity 16.67%; however, ESS had low sensitivity 76.19% but good specificity 42.11% [16]. Nevertheless, the researchers stated that despite the combination of the two tools the sensitivity (72.62%), was not much improved but the specificity is increased (52.78%) [16].

In addition, a population-based cohort study in Australia aimed at screening for OSA in primary care based on the use of apnea screening questionnaires including STOP-BANG, OSA-50 and the Berlin questionnaire, alone and after the addition of the ESS [9]. The results showed that only the STOP-BANG and the OSA-50 correctly identified the majority of participants who actually presented with OSA, due to their relatively high sensitivities, 81% and 86%, respectively, although their specificities were low 36% and 21%, respectively [9].

This finding was validated by the results of a meta-analysis conducted to evaluate the performance of the STOP-BANG questionnaire which showed that indeed STOP-BANG has a good sensitivity of 89.1% to predict mild OSA, and 90.7% to 93.9% to detect moderate to severe OSA, however its specificity to diagnose OSA was low at 32.3%, 22.5%, and 18.3%, respectively [20]. Nevertheless, the Berlin questionnaire was distinguished from the other questionnaires by its specificity and sensitivity of 59% and 65%, respectively, both of which were low for detecting subjects with suspected OSA (**Table 2**) [9].

Furthermore, the investigators stated that despite combining the OSA screening questionnaires with the ESS including an ESS threshold ≥8, the sensitivity of each questionnaire became low (36-51%), while the specificity was high (94-96%) (**Table 2**) [9].

However, the investigators mentioned that for people likely to initiate an OSA assessment especially in primary care, the use of the STOP-BANG associated with an ESS score of eight or more may produce a flexible balance between sensitivity and specificity of this tool, in order to help clinicians to adjudicate people with suspected OSA [9]. Nonetheless, researchers in another study stated that despite the combination of the different clinical scores, their predictive values were not improved [17].

In a German sleep center, a study conducted in patients to develop a predictive score for severe OSA, in order to allow an early, simple and efficient screening based only on anthropometric measurements and upper airway visibility, showed that this score allows to screen subjects with moderate to severe OSA and also to exclude OSA in a suspicious person, a characteristic rarely met in a screening tool, whereas it is a crucial notion to ensure a better differential diagnosis and a better therapeutic management [10]. The researchers noted that the morphology score does not contain subjective questions, which may reduce the bias associated with subjective assessment measures (**Table 3**) [10].

In this context, another means of predicting OSA has been developed by Ramachandran's team who have designed a retrospective observational study that aims to identify clinical predictors essential for the diagnosis of OSA in a general population, as well as to develop a perioperative sleep apnea prediction score (P-SAP) based on all of these variables and validate it against polysomnography [14]. The results indicated that a diagnostic threshold score P-SAP ≥2 shows a good sensitivity 93.3%; however, a low specificity 32.3% while for a threshold score P-SAP ≥6, the sensitivity is low 23.9% with a better specificity 9.11% (**Table 3**) [14].

Moreover, the investigators compared the STOP-BANG known by its predictive power of OSA with their P-SAP score which validates six of the eight items of the STOP-BANG model and which also integrates elements allowing the exploration of the upper airways including: the high modified Mallampati class and the reduced thyromental distance, these items have been validated in a set of studies as indicators of diagnosis and severity of OSA [14].

Table 3. Predictive parameters of OSA screening questionnaires

Screening questionnaire	Sensibility (CI 95%)	Specificity (CI 95%)	PPV (CI 95%)	NPV (CI 95%)
OSA prediction score [10]				
Score≤5 & IAH<5	72% (55%-85%)	83% (75%-89%)	60% (48%-70%)	89% (83%-93%)
5<Score<8 & IAH<15	49% (38%-61%)	78% (67%-87%)	70% (59%-79%)	59% (59%-65%)
Score≥8 & IAH≥30	82% (65%-93%)	82%(74%-88%)	57% (47%-67%)	59% (53%-65%)
P-SAP score [14]				
Score≥2 & 5<IAH<15	98.2% (93.6%-99.8%)	12.7% (9.6-6.4%)	23.6% (22.6%-23.9%)	96.2% (87.7%-96%)
Score≥6 & IAH≥30	32.4% (23.9%-42%)	85.3% (81.4%-88.6%)	37.9% (29.8%-46.3%)	82% (80.2%-83.9%)

Note. PPV: Positive predictive value; NPV: Negative predictive value; IAH: Apnea-hypopnea index

In fact, the inclusion of type 2 diabetes as a component of the P-SAP score is important because diabetes is not only associated with the diagnosis of OSA, but also with the severity of the disease; these additional components have reduced the false negative rate for the P-SAP score compared to the STOP-BANG score, which is why the researchers foresee the use of the P-SAP score as a useful alternative to other screening tests for OSA [14].

In order to compare the clinical scoring systems of the four STOP-BANG scores, the P-SAP, the OSA50 score, and the DES-OSA score in terms of their ability to predict severe OSA via the recruitment of 293 subjects from the pre-anesthetic consultation, the scores of the four screening questionnaires were collected for each patient who subsequently underwent a confirmatory nocturnal polysomnography [15].

The results of this comparative study of the four prediction scores showed that for specificity the DES-OSA had the best specificity (0.77, 95% CI, 0.70-0.83) among the other questionnaires. Whereas, for sensitivity the OSA50 score had the best sensitivity, compared to the STOP-BANG and the DES-OSA score [15].

This study also evaluated the performance of the original version of the STOP-BANG questionnaire compared to its updated version in terms of its ability to predict severe OSA. The investigators concluded that the new version of the STOP-BANG did not provide too much improvement in terms of sensitivity, which was 85% to 90%, but the specificity of the test was decreased from 49% to 32%, and these statistical results led the investigators to recommend the use of the original version of the STOP-BANG and not the new approach [15].

Some researchers in the field of sleep medicine conducted a study to develop an applicable screening tool based on only four variables: gender, blood pressure level, BMI, and self-reported snoring, which showed a better sensitivity of 93% and a good specificity of 66% with a threshold score of 11 [18]. Although this screening tool for OSA is quickly verifiable as the four variables are often checked in clinical settings during consultations, except that its diagnostic performance was found to be no different from other screening questionnaires [18].

In addition, the performance of screening tools such as the ASA checklist and the No-SAS score was checked in 177 and 221 patients, respectively who also received polysomnography in order to verify the degree of relevance of these tools used in the prediction of OSA, whose sensitivity was found to be 72.1%-87.2% and 86.7%-88.9%, respectively [23].

In a study comparing the ability of the STOP-BANG questionnaire, STOP questionnaire, and ASA checklist to identify patients with OSA, the statistical results did not show a significant difference in their ability to predict OSA [24]. In other a study considered as the first to evaluate the performance of the ASA checklist in predicting OSAS in any group of patients, the results showed that the ASA checklist demonstrated a similar level of sensitivity and specificity as the Berlin and STOP-BANG questionnaires [2,23].

However, other studies have claimed that the Berlin questionnaire and the STOP-BANG questionnaire strongly predicted OSA compared to the ESS and the No-SAS score. This shows that they are reliable tools for screening for OSA in patients at risk [6,22]. Furthermore, the No-SAS score can identify individuals at clinically significant risk for sleep-disordered breathing, and it showed even better performance than the STOP-BANG and Berlin questionnaires, which are the most widely used in predicting OSA [6,25].

Structural Characteristics of Screening Tools

The structural characteristics of screening tools (**Table 4**) have a crucial role in terms of feasibility and speed [26]. **Table 5** shows the common items used in the different questionnaires.

CONCLUSION

In conclusion, the OSA constitutes a serious health problem with severe complications that are mainly due to a delayed diagnosis because access to specialized sleep medicine centers

Table 4. The structural characteristics of the screening tools

Questionnaire	Number of criteria	Number of categories	Format of questions	Predictive threshold score of OSA (AHI≥5)
Q. Berlin	11	3	Multiple choices	2 or more categories scored as positive
ASA check-list	12	3	Check-list	2 or more categories scored as positive
STOP	4	1	Yes/No	Score≥5
STOP-BANG	4	1	Yes/No	Score≥5
No-SAS	5	1	Yes/No	Score≥8
ESS	8	1	Multiple choices	ESS≥10
OSA-50	4	1	Yes/No	Score≥5
DES-OSA 50	5	1	Yes/No	Score≥7
4-Variables scale	4	2	Yes/No	Score≥9
P-SAP	9	1	Yes/No	Score≥4

Note. 12 criteria for adults and 14 criteria for children; ASA: American Society of Anesthesiologists

Table 5. Common items used in the different questionnaires

Items vs. Questionnaires	Q. Berlin	Q. STOP	QSB	ASA-C	QNo-SAS	ESS	Q-OSA-50	QD-OSA-50	4-VS	Q. P-SAP
Age			X		X		X			X
BMI			X	X	X		X	X	X	X
Male gender			X		X			X	X	X
Hypertension	X	X	X							X
Neck circumference			X	X	X			X	X	X
Noisy daily snoring	X	X	X	X	X		X			X
Apnea obseved during sleep	X	X	X	X			X			
Hypersomnolence	X	X		X		X				
Daily fatigue	X	X	X	X						
Upper airway anomalies				X				X		X

Note. QSB: Q. STOP-BANG; ASA-C: ASA checklist; QNo-SAS: Q. No-SAS; QD-OSA-50: Q. DES-OSA-50; 4-VS: 4-Variables scale

to have reference polysomnography is limited for different reasons, from which the need for sensitive and inexpensive screening tools to improve the quality and speed of diagnosis to avoid complications and improve the quality of life of patients living with OSA [22]. For these reasons, the DES-OSA 50 and No-SAS are simple, effective, and easy-to-implement scores for identifying individuals at risk for sleep apnea; they can help clinicians decide which patients should be further screened with nocturnal recording [25].

Author contributions: FEK: witing; **FEK & AB:** conceptualization; **EMEH:** validation; **MA & AB:** methodology; **FEK & MA:** formal analysis; **AB & EMEH:** data curation; **FEK, AB, & MA:** writing-reviewing and editing; **AB & MA:** supervision, administration of the project. All authors have agreed with the results and conclusions.

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APPENDIX A

Data Extraction Sheet

Author...

Title..

Year of publication...

Type of publication: Book ☐ Chapter ☐ Article ☐ Other ☐

Category: Systematic review ☐ Meta-analysis ☐

Key concepts...

Citation to be taken: Yes ☐ No ☐

Research question..

Research method..

Target population...

Main results..

Axis 1: Clinical prediction questionnaires for OSA

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Axis 2: OSA symptomatology

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Axis 3: Comorbidities associated with OSA

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Strengths of the study..

Limitations of the study..