Obstructive sleep apnea (OSA) is the most common sleep-related breathing disorder and manifests as repeated apneas and hypopneas during sleep. OSA increases the risk of hypertension, glucose intolerance, cardiovascular, and cerebrovascular disorders. Untreated OSA is also associated with daytime sleepiness, cognitive dysfunction, and increased risk of automobile accidents. Polysomnography (PSG) is the gold standard for the diagnosis of OSA, but it is an expensive and time-consuming and requires trained personnel. PSG is a noninvasive technique that involves overnight monitoring of several physiological variables including electroencephalography, eye movements, and muscle tone as well as respiratory effort, airflow, and oxygen saturation. Therefore, different clinical models have been developed to evaluate patients at high risk for OSA. Screening questionnaires are simple, low-cost tools that can be used to prioritize patients eligible for PSG.

OSA screening questionnaires (OSA-SQs) were evaluated in surgical patients in a systematic review by Abrishami et al. In addition to being easy-to-use, the STOP and STOP-Bang questionnaires were found to have a higher methodological quality. Over the past few years, the accuracy of OSA-SQs has been an area of growing research interest and a number of studies have been published on the subject. This systematic review aimed to assess the accuracy of OSA-SQs including the Berlin questionnaire (BQ), STOP-Bang Questionnaire (SBQ), STOP Questionnaire (SQ), and Epworth Sleepiness Scale (ESS), based on an updated search of the literature.

We performed a literature search using Medline, Cochrane Database of Systematic Reviews, and
Scopus for articles published between January 2010 and April 2017 using the following terms: OSA or OSAHS (obstructive sleep apnea hypopnea syndrome), hypopnea or hypopnoea, obstructive sleep apnea or sleep apnea syndrome and sensitivity, specificity, validity, or validation, sleep apnea questionnaires, and screening sleep apnea. The reference list of identified studies was also searched manually to detect eligible studies for inclusion. The flow diagram of study selection process is depicted in Figure 1.

Two authors independently reviewed the titles and abstracts of the search results and disagreements were solved in group discussion. The studies had to meet the following criteria to be included: a) participant age > 18 years; b) the accuracy of the screening questionnaire had been assessed against various apnea-hypopnea indexes (aHI) or respiratory disturbance indexes (RdI) based on PSG as the gold standard; and c) studies were published in English. We also included studies if the validity of screening questionnaires was reported as a secondary outcome. Letters to the editor, review articles, case reports, and commentaries were excluded.

Two independent reviewers extracted the following information from each study that met the inclusion criteria: name of the first author, country and year of publication, study design, number of participants, age, gender, body mass index (BMI), neck circumference, validation tool (various types of PSG included), sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for each aHI or RdI cut-off point including, aHI or RdI of ≥ 5 events/hour (mild OSA), ≥ 15 events/hour (moderate OSA), and ≥ 30 events/hour (severe OSA).

Thirty-nine studies qualified for inclusion in the present review, with sample sizes ranging from 30 to 4770. These studies were carried out in seven different geographic regions including, North America,17,18,20,22,27,38,47,50,52 West Asia,11,16,24,29,30,42,51,53 East Asia,25,26,28,32,36,49,54 Europe,19,31,37,39,43,45,46 South Asia,40,48 North Africa,21,44 and South America.23,33–35 The results of our analysis of the relevant studies are presented below for each of the four OSA-SQs.

**Berlin questionnaire (BQ)**

The BQ was developed in 1999 and includes three sections. The first section is about snoring, the second section is about daytime fatigue and sleepiness, and the last section is about medical history and anthropometric measures such as hypertension and BMI. If two or more categories were positive, the patient is considered high risk for OSA.55 BQ was evaluated in 29 out of the 39 eligible studies with a total 9444 subjects. Table 1 shows the characteristics and demographic information pertaining to these studies. Over half of the studies had < 150 subjects with the mean age ranging from 32 to 69.4 years. Only two studies28,46 assessed the BQ accuracy in the general population, while the subjects in 13 studies were all sleep clinic patients. The remaining 14 studies dealt with a mix of subjects or patient populations. Overnight PSG was used as the validation tool in 23 out of the 29 studies dealing with the BQ. Alternative methods in other studies were type II PSG (full in-home overnight PSG that records all items of standard PSG),17,25 type III PSG22,34,46 that typically measure between four and seven physiologic variables, including two respiratory variables (e.g., respiratory effort and airflow), a cardiac variable (e.g., heart rate or an electrocardiogram), and arterial oxyhemoglobin saturation via pulse oximetry, and daytime PSG.24

Table 2 shows the BQ data for the sensitivity, specificity, PPV, and NPV for one or more aHI cut-off points as reported in the selected studies. The BQ highest sensitivity (97.3%) and NPV (95.4%) for the detection of OSA was found at aHI cutoffs ≥ 30 events/hour. However, the BQ had the highest detection specificity for moderate OSA (91.7%). Our analysis indicates a PPV ranging from 11.5% to 91% at aHI ≥ 5 events/hour.

**STOP-Bang questionnaire (SBQ)**

The SBQ includes four subjective (STOP: Snoring, tiredness, observed apnea, and high blood pressure) and four demographics items (BANG: BMI, Age, Neck circumference, Gender). A score of 5–8 is categorized as high risk for OSA.57
Table 1: Overview of studies included looking at the accuracy of screening questionnaires for obstructive sleep apnea against polysomnography (PSG) as the reference test.

| Study                          | No. of patients | Patient type               | Age, years | Male, % | Body mass index, kg/m² | Validation tool |
|--------------------------------|-----------------|----------------------------|------------|---------|------------------------|-----------------|
| Ong et al. 2010³⁶               | 314             | Sleep clinic patients     | 46.8 ± 15  | 70.5    | 27.9 ± 6               | Lab PSG         |
| Sugaspe et al. 2010³⁷           | 123             | Sleep clinic patients     | 47 ± 13.2  | 67.5    | -                      | Lab PSG         |
| Gantner et al. 2010³⁸           | 143             | Patients with high cardiovascular risk | 62.2 ± 7.6 | 58      | 26.6 ± 3.7             | Level II PSG    |
| Silva et al. 2011³⁹             | 4770            | General population        | 62.4 ± 10.3| 51.5    | -                      | Level II PSG    |
| Saleh et al. 2011⁴⁰             | 100             | Sleep clinic patients     | 45.63 ± 9.67| 51     | 36.34 ± 10.70          | Lab PSG         |
| Srijithesh et al. 2011⁴¹        | 121             | Acute stroke patients     | 36.5       | -       | -                      | Lab PSG         |
| Sforza et al. 2011⁴²             | 643             | General population        | 65.6 ± 0.03| 40.90   | 25.3 ± 0.2             | Level III PSG   |
| Enciso et al. 2011²¹            | 84              | Dental clinic patients    | 54.93 ± 12.63| 77.38  | 26.60 ± 3.74           | Two-night ambulatory somnography |
| Thurtell et al. 2011³⁰          | 30              | Patients with idiopathic intracranial hypertension | 32 ± 6.3 | 20      | 24.4 ± 4.1             | Lab PSG         |
| Martinez et al. 2012²⁴          | 57              | Patients with angina complaints | 54 ± 6.9 | 46      | 23 ± 11                | Level III PSG   |
| Hesselbacher et al. 2012²⁷      | 1897            | Sleep clinic patients     | 53.84 ± 15 | 57.56   | 35.42 ± 5              | Lab PSG         |
| El-Seyd et al. 2012²³           | 234             | Sleep clinic patients     | 50.38 ± 11.29| 58.5  | 37.77 ± 9.54           | Lab PSG         |
| Firat et al. 2012²⁹             | 85              | Bus drivers               | -          | 100     | 29.1 ± 3.8             | Daytime PSG     |
| Amra et al. 2013²¹              | 157             | Sleep clinic patients     | 52.3 ± 13.6| 55.4    | 31.5 ± 6               | Lab PSG         |
| Bouloukaki et al. 2013²⁹       | 189             | Clinic outpatients        | 47 ± 13    | 61.9    | 35.0 ± 25.1            | Lab PSG         |
| Kang et al. 2013²⁹              | 1305            | General population        | 52.78 ± 16.55| 47.7  | 22.81 ± 4.86           | Lab PSG         |
| Best et al. 2013²¹              | 82              | Patients with treatment resistant depression | 47.1 ± 9 | 26.83   | 33.34 ± 8.6            | Level II PSG    |
| Yunus et al. 2013³⁴             | 150             | Clinic outpatients        | 44.7 ± 11.5| 64      | 36.3 ± 11.2            | Lab PSG         |
| Boynton et al. 2013²⁵           | 219             | Sleep clinic patients     | 46.3 ± 13.9| 44.8    | 33.43 ± 8.76           | Lab PSG         |
| Pereira et al. 2013³⁸           | 128             | Sleep clinic patients     | 50 ± 12.3  | 65.62   | 31 ± 6.6               | Lab PSG         |
| Scarlata et al. 2013³⁹          | 254             | Clinic outpatients        | 65.8 ± 12.1| 68.6    | 38.5 ± 7.7             | Lab PSG         |
| Vana et al. 2013³⁵              | 47              | Sleep clinic patients     | 46.4 ± 13.2| 34      | 36.3 ± 9.2             | Lab PSG         |
| Pataka et al. 2014²⁷            | 1853            | Sleep clinic patients     | 52 ± 14    | 74.42   | 32.8 ± 7               | Lab PSG         |
| Karakoc et al. 2014²⁹           | 217             | Surgical population       | 42.5 ± 10.7| 88      | 28.10 ± 4.1            | Lab PSG         |
| Margallo et al. 2014⁴⁰          | 422             | Patients with resistant hypertension | 62.4 ± 9.9| 31      | 31.2 ± 5.7             | Lab PSG         |
| Ha et al. 2014²⁶                | 141             | Sleep clinic patients     | 44.82 ± 12 | 81.6    | 25.33 ± 5              | Lab PSG         |
| Ulasi et al. 2014⁴³             | 1450            | Sleep clinic patients     | 50 ± 9.83  | 62.96   | 31.25 ± 9.09           | Lab PSG         |
| Kim et al. 2015⁵¹               | 592             | Sleep clinic patients     | 47.8 ± 12.7| 83.5    | 24.7 ± 3.5             | Lab PSG         |
| Alhouqani et al. 2015²⁶         | 193             | Sleep clinic patients     | 42.87 ± 11.83| 77.7  | 34.90 ± 8.60           | Lab PSG         |
| Sadeghniiat-Haghighi et al. 2015⁴²| 603          | Sleep clinic patients     | 45.8 ± 12.7| 74.8    | 29.18 ± 5.9            | Lab PSG         |
| Yucege et al. 2015¹¹            | 433             | Sleep clinic patients     | 47.5 ± 10.5| 65.82   | 31.1 ± 5.6             | Lab PSG         |
| Nunes et al. 2015⁵⁵             | 40              | Coronary artery bypass grafting patients | 56 ± 7    | 73      | 30 ± 4                 | Lab PSG         |
| Nunes et al. 2015⁵⁵             | 41              | Abdominal surgery patients | 56 ± 8    | 68      | 29 ± 5                 | Lab PSG         |
| Faria et al. 2015¹¹             | 91              | Patients with chronic obstructive pulmonary disease | 69.4 ± 9.6| 63.7    | 23.6 ± 3.9             | Lab PSG         |
| Popevic et al. 2016³⁸            | 100             | Commercial drivers        | 43.4 ± 10.7| 100     | 29.0 ± 5.7             | Lab PSG         |
| Khaledi-Paveh et al. 2016⁵⁶     | 100             | Sleep clinic patients     | 45.66 ± 11.83| 60     | 29.5 ± 6.1             | Lab PSG         |
| Kiciński et al. 2016³¹          | 123             | Sleep clinic patients     | 54.6 ± 11.1| 66.40   | 33.5 ± 5.2             | Lab PSG         |
| Tan et al. 2016⁴⁰               | 242             | General population        | 48.3 ± 14  | 50.4    | 26.2 ± 5               | Level 3 PSG     |
| Bhut et al. 2016⁴⁰             | 85              | Sleep clinic patients     | 50.5 ± 12.6| 70.6    | 32 ± 1.55              | Lab PSG/Level III PSG |
| Prasad et al. 2017⁴⁰            | 210             | Sleep clinic patients     | 46.5 ± 13.7| 72.9    | 31.9 ± 7.4             | Lab PSG         |
Table 2: Predictive parameters of the screening questionnaires.

| Study                      | AHI ≥ 5 |          |          | AHI ≥ 15 |          |          | AHI ≥ 30 |          |          |
|----------------------------|---------|----------|----------|----------|----------|----------|----------|----------|----------|
|                            | Sensitivity % | Specificity % | PPV % | NPV % | Sensitivity % | Specificity % | PPV % | NPV % | Sensitivity % | Specificity % | PPV % | NPV % |
| Berlin                     | 72      | 73       | 63       | 76       | 61       | 43       | 71       | 53       | 16       |
| Sagaspe et al. 2010<sup>46</sup> | -       | -        | -        | -        | -        | -        | -        | -        | -        |
| Gantner et al. 2010<sup>35</sup> | 97      | 90       | 96       | 93       | -        | -        | -        | -        | -        |
| Saleh et al. 2011<sup>44</sup> | 68.2    | 58.8     | 68.2     | 58.8     | -        | -        | -        | -        | -        |
| Srijithesh et al. 2011<sup>46</sup> | -       | -        | -        | -        | 76.69    | 39.34    | 63.17    | 55.44    | -        |
| Gantner et al. 2010<sup>25</sup> | 25      | -        | -        | -        | -        | -        | -        | -        | -        |
| Thurtell et al. 2011<sup>30</sup> | 83.3    | 58.3     | 75       | 70       | -        | -        | -        | -        | -        |
| Martinez et al. 2012<sup>34</sup> | 69      | 83       | -        | 89       | 63       | -        | -        | -        | -        |
| Kang et al. 2013<sup>24</sup> | 25.0    | 85.4     | 56.5     | 60.0     | 24.5     | 91.7     | 35.5     | 93.3     | -        |
| El-Sayed et al. 2012<sup>21</sup> | 95.07   | 25       | 92.79    | 33.33    | 95.48    | 7.41     | 87.11    | 20       | 97.3     |
| Firan et al. 2012<sup>24</sup> | -       | -        | -        | -        | -        | -        | -        | -        | -        |
| AHA et al. 2013<sup>41</sup> | 84.0    | 61.5     | 96.0     | 25.8     | 87.9     | 36.7     | 75.3     | 58.0     | 87.8     |
| Bouloukaki et al. 2013<sup>19</sup> | 76      | 40       | 94       | 12       | 84       | 61       | 86       | 52       | 79       |
| Kang et al. 2013<sup>24</sup> | 69      | 83       | -        | 89       | 63       | -        | -        | -        | -        |
| Best et al. 2013<sup>37</sup> | 25.0    | 85.4     | 56.5     | 60.0     | 24.5     | 91.7     | 35.5     | 93.3     | -        |
| Yunus et al. 2013<sup>34</sup> | 92      | 17       | 97       | 29       | -        | -        | -        | -        | -        |
| Pereira et al. 2013<sup>38</sup> | 86      | 25       | 91.7     | 15.8     | 91       | 28       | 73.4     | 57.9     | 89       |
| Pataka et al. 2014<sup>37</sup> | 71.8    | 17.2     | 11.5     | 80.2     | 78       | 18       | 16.5     | 80.4     | 90       |
| Karakoc et al. 2014<sup>29</sup> | 83.4    | 22.2     | 76.4     | 30.8     | 89.3     | 22.6     | 42.1     | 76.9     | -        |
| Margallo et al. 2014<sup>35</sup> | 68      | 46       | 85       | 24       | 69       | 40       | 58       | 50       | 76       |
| Ha et al. 2014<sup>26</sup> | 75      | 30.29    | 83.17    | 28.21    | 75       | 32.14    | 62.38    | 46.15    | 80.39    |
| Usladi et al. 2014<sup>41</sup> | 73.1    | 44.5     | -        | -        | 76.4     | 39.5     | -        | -        | 80.3     |
| Kim et al. 2015<sup>35</sup> | 71.5    | 32.0     | 84.3     | 18.0     | 75.5     | 35.4     | 62.1     | 50.6     | -        |
| Yucecege et al. 2015<sup>33</sup> | -       | -        | -        | -        | 84.2     | 31.7     | 48.7     | 63.4     | -        |
| Nunes et al. 2015<sup>59</sup> | -       | -        | -        | -        | 67       | 26       | 50       | 42       | -        |
| Nunes et al. 2015<sup>59</sup> | -       | -        | -        | -        | 82       | 62       | 61       | 83       | -        |
| Faria et al. 2015<sup>13</sup> | 40      | 68.4     | 25       | 81.2     | -        | -        | -        | -        | -        |
| Popevic et al. 2016<sup>20</sup> | 50.9    | 86.0     | 82.9     | 56.9     | 78.3     | 77.9     | 51.4     | 92.3     | 75       |

AHI: apnea-hypopnea index; PPV: positive predictive value; NPV: negative predictive value.

### Table 2: Predictive parameters of the screening questionnaires. (continued)

| Study | AHI ≥ 5 | AHI ≥ 15 | AHI ≥ 30 |
|-------|---------|----------|----------|
|       | Sensitivity | Specificity | PPV | NPV | Sensitivity | Specificity | PPV | NPV | Sensitivity | Specificity | PPV | NPV |
|        | %          |           | % |     | %          |           | % |     | %          |           | % |     |
| Khaledi-Paveh et al. 2016 | 77.3 | 23.1 | 68 | 22 | 58.5 | 45.7 | - | - | 30.8 | 80 | - | - |
| Kicinski et al. 2016 | - | - | - | - | 93.10 | 16.20 | 1.11 | 42 | - | - | - | - |
| Prasad et al. 2017 | 33.5 | 39.1 | 83 | 40 | 87.5 | 37.8 | 72.1 | 62.2 | 89.4 | 32.1 | 56.4 | 75.6 |
| STOP-Bang |  |  |  |  |  |  |  |  |  |  |  |  |
| Ong et al. 2010 | 84.7 | 52.6 | 84.4 | 53.2 | 91.1 | 40.4 | 60.8 | 81.3 | 95.4 | 35.0 | 43.5 | 93.5 |
| Silva et al. 2011 | - | - | - | - | 87 | 43.3 | - | - | 70.4 | 59.5 | - | - |
| El-Sayed et al. 2012 | 97.55 | 26.32 | 93.43 | 50 | 97.74 | 3.7 | 86.93 | 20 | 98.65 | 5.36 | 73.37 | 60 |
| Firat et al. 2012 | - | - | - | - | 87 | 48.7 | 66.6 | 76 | - | - | - | - |
| Boynton et al. 2013 | 82.2 | 48.0 | 84.2 | 44.4 | 93.2 | 40.5 | 58.2 | 87.0 | 96.8 | 33.1 | 36.4 | 96.3 |
| Pereira et al. 2013 | 90 | 42 | 93.7 | 29.4 | 93 | 28 | 73.9 | 64.7 | 96 | 21 | 48.6 | 88.2 |
| Pataka et al. 2014 | 90 | 4.9 | 12.2 | 76.8 | 94 | 5.5 | 17 | 84 | 98.7 | 9.9 | 52.7 | 88.4 |
| Ha et al. 2014 | 81.08 | 57.14 | 88.24 | 43.24 | 85.71 | 45.45 | 70.59 | 67.57 | 86.27 | 34.09 | 43.14 | 81.08 |
| Allhouqani et al. 2015 | 90.24 | 31.03 | 88.10 | 36.00 | 96.75 | 30.00 | 70.83 | 84.00 | 97.70 | 21.70 | 50.60 | 92.00 |
| Kim et al. 2015 | 97.0 | 18.6 | 85.9 | 54.6 | 98.0 | 10.6 | 60.6 | 78.8 | - | - | - | - |
| Sadeghniiat-Haghighi et al. 2015 | 91.6 | 45.2 | 78.2 | 71.6 | 97.1 | 35.2 | 56.9 | 93.3 | 98 | 29.4 | 41.8 | 96.6 |
| Tan et al. 2016 | - | - | - | - | 66.2 | 74.7 | 50.6 | 85.0 | 69.2 | 67.1 | 20.2 | 94.8 |
| Prasad et al. 2017 | 89 | 43.5 | 84.9 | 52.6 | 93.4 | 39.2 | 73.8 | 76.3 | 96.2 | 32.1 | 58.1 | 89.5 |
| STOP |  |  |  |  |  |  |  |  |  |  |  |  |
| Silva et al. 2011 | - | - | - | - | 62 | 56.3 | - | - | 68.8 | 59.5 | - | - |
| El-Sayed et al. 2012 | 91.67 | 25 | 92.57 | 22.73 | 94.35 | 25.93 | 89.3 | 41.18 | 95.95 | 19.64 | 72.55 | 64.71 |
| Firat et al. 2012 | - | - | - | - | 41.3 | 92.3 | 86.4 | 57.1 | - | - | - | - |
| Boynton et al. 2013 | 74.6 | 34.0 | 79.2 | 28.3 | 80.6 | 34.5 | 52.2 | 66.7 | 83.9 | 31.8 | 32.7 | 83.3 |
| Pataka et al. 2014 | 91.7 | 6.4 | 12.8 | 84 | 92.7 | 6.6 | 17.3 | 72 | 97 | 11 | 52.3 | 78.4 |
| Ha et al. 2014 | 74.77 | 50.00 | 85.57 | 33.33 | 76.19 | 40.00 | 65.98 | 52.38 | 80.39 | 36.36 | 42.27 | 76.19 |
| Sadeghniiat-Haghighi et al. 2015 | 86.3 | 46.5 | 81.9 | 54.8 | 91.1 | 37.1 | 61.5 | 79 | 94.1 | 30.7 | 40.2 | 91.1 |
| Nunes et al. 2015 | - | - | - | - | 100 | 5 | 54 | 100 | - | - | - | - |
| Nunes et al. 2015 | - | - | - | - | 88 | 13 | 42 | 60 | - | - | - | - |

AHI: apnea-hypopnea index; PPV: positive predictive value; NPV: negative predictive value.
For the SBQ, we included 13 studies with a total 9584 subjects and sample sizes ranging from 85 to 4770. The studies mostly included sleep clinic patients with an age range of 42.8 to 62.4 years old [Table 1]. Overnight laboratory PSG was used as the validation tool in 10 studies. The highest sensitivity and nPv were reported at aHI thresholds of ≥ 30 events/hour. The PPv value ranged between 12.2% and 93.7% at a HI cutoffs ≥ 5 events/hour. The SBQ showed the highest specificity (74.7%) in detecting moderate OSa [Table 2].

STOP Questionnaire (SQ)
The SQ is a concise and easy-to-use screening tool for OSa with high sensitivity. SQ can classify patients as being at high risk of having OSA if they answer yes to two or more questions. SQ was evaluated in nine studies (8196 subjects) of which six studies were carried out on sleep clinic patients and three on the general, community population, surgical patients, and bus drivers. The number of subjects in the studies varied from 40 to 4770 and the mean age was 44.8–62.4 years. Two studies used type II and daytime PSG for validation, while the others used overnight laboratory PSG. Our review indicates that the SQ had the highest prediction sensitivity (100%), specificity (92.3%), and nPv (100%) in the case of moderate OSA, while in the case of mild OSA the PPv ranged from 12.8% to 92.5% [Table 2].

Epworth Sleepiness Scale (ESS)
The ESS is an eight-item questionnaire to measure daytime sleepiness; it uses a four-point Likert response format (0–3), and the score ranges from 0 to 24. An ESS score ≥ 11 indicates excessive daytime sleepiness and high risk for OSA. Eleven of the 39 studies investigated the accuracy of ESS with a total of 11 014 subjects. The mean age was 46.4–69.4 years. Eight of the 11 studies were conducted on sleep clinic patients, while the remaining three studies were carried out on respiratory patients, the general population.

Table 2: Predictive parameters of the screening questionnaires. (continued)

| Study | AHI ≥ 5 |  |  |  |  |  |  |  |  |  |
|-------|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|       | Sensitivity % | Specificity % | PPV % | NPV % | Sensitivity % | Specificity % | PPV % | NPV % | Sensitivity % | Specificity % | PPV % | NPV % |
| Prasad et al. 2017 | 87.8 | 43.5 | 84.7 | 50 | 91.9 | 39.2 | 73.5 | 72.5 | 95.2 | 33 | 58.2 | 87.5 |

AHI: apnea-hypopnea index; PPV: positive predictive value; NPV: negative predictive value.
The laboratory PSG was used by the majority of the reviewed studies [Table 1]. The highest ESS sensitivity was observed at AH1 ≥ 30 events/hour and ranged between 46.1% and 79.73%. However, the highest values for specificity (75%), NPV (87.5%), and PPV (96.7%) were found in mild OSA with a decreasing trend from mild to severe OSA [Table 2].

**DISCUSSION**

Sleep apnea is a common and potentially serious disorder in which breathing stops and repeatedly restarts during sleep. Hundreds of such breathing interruptions can occur over the course of a single night with each interruption lasting 10 to 20 seconds. Following each of the long apneic periods, the individual is jolted out of the normal sleep phase - the sleep rhythm is disrupted and the individual suffers from fatigue and daytime sleepiness. Other indicative signs of serious sleep apnea include long apneic periods (> 15 seconds), loud snoring, choking or gasping during sleep, irritability, headache, depression, and nightmares. If untreated, sleep apnea can lead to serious disorders including obesity, diabetes, hypertension, and stroke. There are three main types of sleep apnea depending on their cause. The most common variety is OSA, which results from upper airway obstruction because of hypotonia and collapse of the posterior pharyngeal muscles. OSA is characterized by cyclic loud snoring, which is a common problem in obese individuals and patients with endocrine disorders such as hypothyroidism and acromegaly. A common cause of OSA in children is hypertrophy of the tonsils and/or the adenoids. Central sleep apnea results from the reduced central respiratory drive. Complex sleep apnea is a combination of both obstructive and central apneas.59

In light of the profound impact of OSA on the health and quality of life, it is essential that patients are adequately screened to receive the necessary medical care. It is estimated that over 80% of people with moderate to severe OSA remain undiagnosed.60 Thus, a screening tool is necessary to stratify patients based on their clinical symptoms and anthropometric risk factors.

Some easy-to-use questionnaires have been developed as low-cost alternatives to PSG for detecting OSA. In this review, we assessed the accuracy of four self-reported OSA-SQs against PSG as the reference test. The SBQ had the highest sensitivity for the prediction of mild and severe OSA (97.55% and 98.7%, respectively). However, the BQ showed the highest specificity for the detection of mild and severe OSA (90% and 80%, respectively). Compared to other questionnaires, the SQ had the highest sensitivity (100%) and specificity (92.3%) for predicting moderate OSA. The validity of our results for the general population may be questioned based on the fact that most of the subjects in the studies we reviewed were sleep clinic patients where the prevalence of OSA is relatively high. In addition, there is no standard definition of OSA unifying the various validation studies. Features of an appropriate screening questionnaire vary according to the population being surveyed. For example, cultural differences in urban and rural populations require the questionnaire is modified according to those being surveyed. However, it must be noted that it was not our objective of this review.

Diagnosis of true positive OSA patients in a clinical setting using a questionnaire with high sensitivity minimizes negative health consequences and avoids unnecessary and costly diagnostic tests. PSG, the gold standard for OSA diagnosis, is an expensive and time-demanding procedure. Therefore, it is necessary to decrease the number of false-positive subjects in the general population using a screening tool with high specificity. An effective screening tool must also have a high sensitivity to minimize the number of false negatives.

There was no standard definition for OSA in various studies that investigated the validity of OSA screening questionnaires against PSG. A recent meta-analysis indicated that the BQ has a moderate sensitivity and specificity in the general population for detecting hypopnea defined as a 3% oxygen desaturation. However, its sensitivity decreased when the hypopnea definition of 4% oxygen desaturation was applied.59 Based on these observations it is clear that the definition of OSA significantly affects the accuracy of validation studies.

Therefore, it is necessary to test the validity of various OSA-SQs in the general population against the reference standard PSG. Because sleep clinic patients constituted the majority of the subjects in the reviewed studies, it is not possible to extend our conclusions to the general population.
CONCLUSION

SBQ and SQ are appropriate screening tools to determine OSA in sleep clinic patients. Further validation studies designed specifically for the general population are necessary.

Disclosure
The authors declared no conflicts of interest. No funding was received for this study.

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