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# Supporting Information

## Supplementary methods and results

**This appendix was part of the submitted manuscript and has been peer reviewed. It is posted as supplied by the authors.**

Appendix to: Senaratna CV, Perret JL, Lowe A, et al. Detecting sleep apnoea syndrome in primary care with screening questionnaires and the Epworth sleepiness scale. *Med J Aust* 2019; doi: 10.5694/mja2.50145.

**Appendix: Detecting sleep apnoea syndrome in primary care with screening questionnaires and the Epworth sleepiness scale**

**Supplementary methods**

OSA screening questionnaires

Berlin questionnaire (BQ) has information on height and weight and ten questions, arranged under three categories: snoring and cessation of breathing (category 1; five questions); symptoms of fatigue and excessive daytime sleepiness (category 2; four questions); and body mass index (BMI; derived from height and weight measurements) and hypertension (category 3; height, weight information and one question, respectively). Positive scores in at least two categories suggest that the respondent has a high risk of OSA.[1]

STOP-Bang questionnaire has questions on snoring, tiredness, cessation of breathing in sleep, presence of hypertension, age, and gender and information on BMI (using height and weight) and neck circumference. Each question or measurement is scored equally and a score of at least 3 out of the total of 8 suggests that the respondent is at high risk of OSA.[2] The STOP-Bang can be used at different cut-offs, with higher cut-offs generally increasing specificity and reducing sensitivity.[3,4]

OSA-50 questionnaire is a four-item instrument that has three questions, one each on snoring (a score of 3 if positive), cessation of breathing during sleep (a score of 2 if positive), and age (a score of 2 if ≥ 50 years), and a measurement of obesity (a score of 3 if waist circumference is > 102 cm for males and > 88 cm for females). A score of ≥ 5 out of the total of 10 suggests that the respondent is at high risk of OSA.[5]

**Table 1. Questions and responses to define trigger symptoms that are likely to initiate OSA assessment in primary care settings**

| Domain | Question | Trigger response |
|---|---|---|
| Troublesome snoring | | |
| | How often do you snore? | Nearly every day/3–4 times a week |
| | Has your snoring ever bothered other people? | Yes |
| | During the last month, do you or have you been told you snore loudly in sleep? | 3–4 times per week/5–7 times per week |
| Witnessed apnoea | | |
| | Has anyone noticed that you stop breathing during your sleep? | Nearly every day/3–4 times a week/1–2 times a week/1–2 times a month |
| | During the last month, do you or have you been told you snort or gasp in sleep? | 1–2 times per week/3–4 times per week/5–7 times per week |
| | During the last month, do you or have you been told you choke or stop breathing in sleep? | 1–2 times per week/3–4 times per week/5–7 times per week |
| Excessive sleepiness/fatigue/tiredness | | |
| | During your waking time, do you feel tired, fatigued, or not up to par? | Nearly every day/3–4 times a week |
| | How often do you feel tired or fatigued after your sleep? | Nearly every day/3–4 times a week |
| | Have you ever nodded off or fallen asleep while driving a vehicle? | Nearly every day/3–4 times a week/1–2 times a week/1–2 times a month |
| | During the last month, have you had excessive sleepiness during the day? | Yes |

Justification for the use of Epworth sleepiness scale (ESS) in both the reference and index tests

OSA is traditionally defined as AHI≥5/hr but its population prevalence is very high[6] and many with mild OSA are asymptomatic or minimally symptomatic.[7] The US preventative services taskforce recently stated that the proportion of persons with OSA (as defined on sleep study) who are asymptomatic or have unrecognised symptoms is unknown.[8] On the other hand, in the clinical practice, patients can perceive themselves to be asymptomatic, yet notice a benefit when treated, and this is one of the justifications for offering treatment for those with AHI ≥ 15/hr regardless of the symptoms.[9,10] Symptomatic OSA is typically considered as OSA with excessive daytime sleepiness (EDS), which is often defined using ESS.[11] Despite not being a perfect measure of EDS and being affected by conditions other than OSA, ESS is the only low-cost and reproducible measure of sleepiness currently available that also responds to treatment.[12] For these reasons, ESS is conventionally used to define symptomatic OSA that needs treatment-considerations. Therefore, we used ESS to define symptomatic, mild OSA that was a component of the reference test in our study.

Because the diagnostic tests for OSA are costly, reducing the false-positivity among those who are referred for sleep studies by increasing the pre-test probability of OSA is a need in many setting. This is often done using subjective assessments but in other settings, some measure of objectivity is recommended – ESS again has become the most cost-effective and reproducible means of doing this. For example, the Australian Department of Health has proposed to combine OSA-screening-questionnaires with ESS≥8 to allow the primary-care physicians to refer patients directly for sleep studies.[13,14] Other studies that has explored the possibility of managing OSA at primary-care settings have also supported use of ESS to denote high probability of OSA.[15,16] For these reasons, we used ESS also as a part of the index tests to ensure that our study is comparable to other similar studies and make our findings pragmatic and policy-relevant.

## References


1. Netzer NC, Stoohs RA, Netzer CM, et al. Using the Berlin Questionnaire to identify patients at risk for the sleep apnea syndrome. Ann Intern Med 1999; 131:485-491.
2. Chung F, Yegneswaran B, Liao P, et al. STOP questionnaire: a tool to screen patients for obstructive sleep apnea. Anesthesiology 2008; 108: 812-821.
3. Chung F, Abdullah HR, Liao P. STOP-Bang questionnaire: A practical approach to screen for obstructive sleep apnea. Chest 2016; 149: 631-638.

4. Chung F, Subramanyam R, Liao P, et al. High STOP-Bang score indicates a high probability of obstructive sleep apnoea. Br J Anaesth 2012; 108: 768-775.
5. Chai-Coetzer CL, Antic NA, Rowland LS, et al. A simplified model of screening questionnaire and home monitoring for obstructive sleep apnoea in primary care. Thorax 2011; 66: 213-219.
6. Senaratna CV, Perret JL, Lodge C, et al. Prevalence of obstructive sleep apnea in the general population: a systematic review. Sleep Med Rev 2017; 34: 70-81.
7. Arnardottir ES, Bjornsdottir E, Olafsdottir KA, et al. Obstructive sleep apnoea in the general population: highly prevalent but minimal symptoms. Eur Respir J 2016; 47: 194-202.
8. US Preventive Services Task Force. Screening for obstructive sleep apnea in adults: US preventive services task force recommendation statement. JAMA 2017; 317: 407-414.
9. Ramar K, Dort LC, Katz SG, et al. Clinical practice guideline for the treatment of obstructive sleep apnea and snoring with oral appliance therapy: an update for 2015. An American Academy of Sleep Medicine and American Academy of Dental Sleep Medicine clinical practice guideline. J Clin Sleep Med 2015; 11: 773-827.
10. Carter GS. Screening for improvement of health outcomes in asymptomatic obstructive sleep apnea. JAMA Neurol 2017; 74: 394-396.
11. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep 1991; 14: 540-545.
12. Doneh B. Epworth Sleepiness Scale. Occup Med 2015; 65: 508.
13. Medicare Benefits Schedule Review Taskforce. Final report from the Thoracic Medicine Clinical Committee; Canberra: Department of Health, 2016; p. 226. http://www.health.gov.au/internet/main/publishing.nsf/content/C195FC32CB2DBAD6CA25801800175428/$File/MBS%20Thoracic%20Report%20FINAL.pdf (viewed July 2018).
14. Medicare Benefits Schedule Review Taskforce. Thoracic Medicine Clinical Committee report: taskforce findings. Canberra: Department of Health, 2018; p. 3. https://www.health.gov.au/internet/main/publishing.nsf/content/C195FC32CB2DBAD6CA25801800175428/$File/Taskforce%20Summary%20-%20Thoracic.pdf (viewed July 2018).
15. Sánchez-Quiroga MÁ, Corral J, Gómez-de-Terreros FJ, et al; the Spanish Sleep Network and Primary Care Group. Primary care physicians can comprehensively manage sleep apnea patients: a non-inferiority randomized controlled trial. Am J Respir Crit Care Med 2018; 198: 648-656.
16. Antic NA, Buchan C, Esterman A, et al. A randomized controlled trial of nurse-led care for symptomatic moderate–severe obstructive sleep apnea. Am J Respir Crit Care Med 2009; 179: 501-508.

**Supplementary results**

**Table 2. Characteristics of the sample by their participation status in sleep studies and availability of valid sleep study data**

| | Accepted sleep study *v* declined | | Underwent sleep studies *v* not | | Sufficient sleep data *v* not | |
|---|---|---|---|---|---|---|
| **Characteristic** | **Accepted** | **Declined** | **Underwent** | **Did not undergo** | **Sufficient** | **Insufficient or none** |
| | **635** | **137** | **424** | **348** | **351** | **416** |
| Age (years), mean (SD) | 53.0 (0.9) | 53.6 (0.5)* | 53.0 (0.9) | 53.3 (0.7)* | 52.9 (0.9) | 53.3 (0.8)* |
| Sex (men) | 311 (49.3%) | 75 (55%) | 211 (49.8%) | 175 (50.9%) | 182 (51.1%) | 204 (49.5%) |
| BMI ($kg/m^2$), mean (SD) | 28.6 (5.4) | 29.6 (6.6) | 28.8 (5.4) | 28.8 (5.9) | 28.7 (5.3) | 28.9 (5.9) |
| Neck circumference (cm); mean (SD) | 37.4 (4.1) | 37.9 (4.6) | 37.4 (3.9) | 35.5 (4.5) | 37.5 (3.9) | 37.4 (4.5) |
| Hypertension | 117 (18.8%) | 28 (20%) | 81 (19%) | 64 (19%) | 69 (20%) | 76 (19%) |
| BQ ≥ 2 | 55 (40%) | 246 (39.0%) | 124 (36.0%) | 177 (41.8%) | 153 (43.1%) | 148 (35.9%)† |
| STOP-Bang ≥ 3 | 81 (59%) | 370 (58.6%) | 194 (56.4%) | 257 (60.6%) | 221 (62.1%) | 230 (55.8%) |
| STOP-Bang ≥ 4 | 51 (38%) | 223 (35.3%) | 123 (35.8%) | 151 (35.6%) | 131 (36.8%) | 143 (34.7%) |
| OSA-50 ≥ 5 | 95 (69%) | 451 (71.5%) | 239 (69.5%) | 307 (72.4%) | 261 (73.3%) | 285 (69.2%) |
| ESS, mean (SD) | 5.5 (4.0) | 5.3 (4.0) | 5.8 (4.0) | 5.1 (3.8)‡ | 5.9 (4.1) | 5.1 (3.8)§ |
| ESS ≥ 11 | 64 (11%) | 14 (11%) | 52 (13%) | 26 (8.0%)¶ | 46 (13%) | 32 (8.2%)** |
| ESS ≥ 8 | 160 (26.4%) | 37 (28%) | 124 (30.1%) | 73 (22%)‡ | 109 (31.6%) | 88 (22%)†† |

BMI = body-mass index; BQ = Berlin questionnaire; ESS = Epworth sleepiness scale; SD = standard deviation.
* $P < 0.001$; † $P = 0.042$; ‡ $P = 0.020$; § $P = 0.010$; ¶ $P = 0.043$; ** $P = 0.023$; †† $P = 0.005$.

**Table 3. Distribution of high risk for obstructive sleep apnoea (OSA) by Berlin, STOP-Bang and OSA-50 questionnaires, by OSA classification (clinically relevant OSA*)**

| | Berlin questionnaire | | STOP-Bang questionnaire | | OSA-50 questionnaire | |
|---|---|---|---|---|---|---|
| | **High risk for OSA** | **Low risk for OSA** | **High risk for OSA** | **Low risk for OSA** | **High risk for OSA** | **Low risk for OSA** |
| **No clinically relevant OSA** | 58 (41%) | 89 (59%) | 91 (64%) | 50 (36%) | 111 (79%) | 30 (21%) |
| **Clinically relevant OSA** | 91 (65%) | 49 (35%) | 113 (81%) | 27 (19%) | 121 (86%) | 19 (14%) |

* Defined as moderate to severe obstructive sleep apnoea (oxygen desaturation index ≥ 15) or mild obstructive sleep apnoea (oxygen desaturation index, 5–14) with excessive day time sleepiness (Epworth sleepiness scale score ≥ 8).

**Table 4. Diagnostic utility of obstructive sleep apnoea (OSA) screening questionnaires at their standard cut-off scores for moderate to severe OSA (oxygen desaturation index ≥ 15)**

| | Area under the ROC curve (95% CI) | Sensitivity (95% CI) | Specificity (95% CI) | PPV (95% CI) | NPV (95% CI) | Positive LR (95% CI) | Negative LR (95% CI) | DOR (95% CI) |
|---|---|---|---|---|---|---|---|---|
| **OSA screening questionnaires** | | | | | | | | |
| BQ ≥2 | 66% (60–72%) | 75% (64–83%) | 57% (50–64%) | 47% (37–53%) | 83% (75–89%) | 1.8 (1.4–2.1) | 0.4 (0.3–0.6) | 4.0 (2.3–6.8) |
| Stop-Bang ≥3 | 58% (53–64%) | 84% (74–90%) | 33% (27–40%) | 37% (30–44%) | 81% (71–89%) | 1.2 (1.1–1.4) | 0.5 (0.3–0.8) | 2.5 (1.4–4.7) |
| OSA-50 ≥5 | 57% (53–61%) | 92% (85–97%) | 22% (16–28%) | 36% (30–42%) | 86% (73–94%) | 1.2 (1.1–1.3) | 0.3 (0.2–0.7) | 3.4 (1.5–7.7) |
| **OSA screening questionnaires and ESS ≥ 8** | | | | | | | | |
| Berlin plus ESS ≥8 | 57% (52–63%) | 30% (21–41%) | 84% (78–89%) | 47% (34–61%) | 72% (66–78%) | 1.9 (1.2–3.1) | 0.8 (0.7–1.0) | 2.4 (1.3–4.2) |
| STOP-Bang plus ESS ≥8 | 56% (50–61%) | 36% (26–47%) | 75% (68–81%) | 40% (29–52%) | 78% (65–78%) | 1.4 (1.0–2.1) | 0.8 (0.7–0.1) | 1.7 (1.1–2.9) |
| OSA-50 plus ESS ≥8 | 56% (50–62%) | 38% (28–49%) | 75% (68–81%) | 42% (31–53%) | 72% (65–78%) | 1.5 (1.0–2.0) | 0.8 (0.7–0.1) | 1.8 (1.1–3.1) |

CI = confidence interval; ROC = receiver operator characteristic; PPV = positive predictive value; NPV = negative predictive value; LR = likelihood ratio; DOR = diagnostic odds ratio.

**Table 5. Diagnostic utility of STOP-Bang at various cut-offs for clinically relevant obstructive sleep apnoea (OSA)***

| Screening criteria | Sensitivity (95% CI) | Specificity (95% CI) | PPV (95% CI) | NPV (95% CI) | Positive LR (95% CI) | Negative LR (95% CI) | DOR (95% CI) |
|---|---|---|---|---|---|---|---|
| STOP-Bang ≥ 2 | 98% (94–100%) | 4% (2–9%) | 50% (44–56%) | 67% (30–92%) | 1.0 (1.0–1.1) | 0.5 (0.1–2.0) | 2.0 (0.5–7.6) |
| STOP-Bang ≥ 3 | 81% (73–87%) | 36% (28–44%) | 55% (48–62%) | 65% (53–76%) | 1.2 (1.1–1.4) | 0.5 (0.4–0.8) | 2.3 (1.3–4.0) |
| STOP-Bang ≥ 4 | 52% (44–61%) | 62% (54–70%) | 58% (49–67%) | 57% (49–65%) | 1.4 (1.1–1.8) | 0.8 (0.6–1.0) | 1.8 (1.1–2.9) |
| STOP-Bang ≥ 5 | 31% (24–40%) | 88% (81–93%) | 72% (59–83%) | 56% (50–63%) | 2.6 (1.6–4.3) | 0.8 (0.7–0.9) | 3.3 (1.8–6.2) |
| STOP-Bang ≥ 6 | 14% (8–20%) | 97% (93–99%) | 83% (61–95%) | 53% (46–59%) | 4.8 (1.7–13.7) | 0.9 (0.8–1.0) | 5.4 (1.9–16) |
| STOP-Bang ≥ 7 | 3% (1–7%) | 100% (97–100%) | 100% (40–100%) | 51% (45–57%) | 9.1 (0.5–170) | 1.0 (0.9–1.0) | 9.3 (0.5–180) |

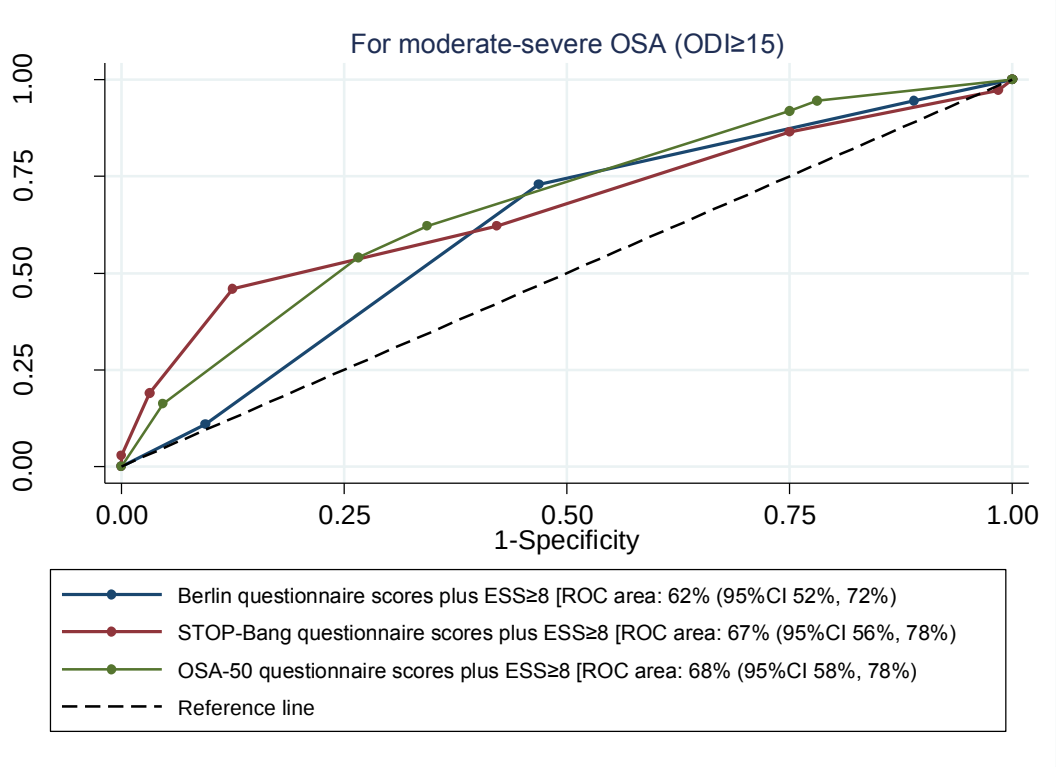
CI = confidence interval; ROC = receiver operator characteristic; PPV = positive predictive value; NPV = negative predictive value; LR = likelihood ratio; DOR = diagnostic odds ratio. * Defined as moderate to severe obstructive sleep apnoea (oxygen desaturation index ≥ 15) or mild obstructive sleep apnoea (oxygen desaturation index, 5–14) with excessive day time sleepiness (Epworth sleepiness scale score ≥ 8).

**Table 6. Diagnostic utility of STOP-Bang at various cut-offs (with ESS ≥ 8) for clinically relevant obstructive sleep apnoea (OSA)***

| Screening criteria | Sensitivity (95% CI) | Specificity (95% CI) | PPV (95% CI) | NPV (95% CI) | Positive LR (95% CI) | Negative LR (95% CI) | DOR (95% CI) |
|---|---|---|---|---|---|---|---|
| STOP-Bang ≥ 2/ESS ≥ 8 | 61% (52–69%) | 89% (83–94%) | 85% (76–91%) | 70% (62–76%) | 5.7 (3.5–9.3) | 0.4 (0.4–0.5) | 13.0 (6.9–24.3) |
| STOP-Bang ≥ 3/ESS ≥ 8 | 50% (41–59%) | 92% (86–96%) | 86% (77–93%) | 65% (58–72%) | 6.4 (3.5–11.5) | 0.5 (0.5–0.6) | 11.7 (5.9–23.4) |
| STOP-Bang ≥ 4/ESS ≥ 8 | 30% (22–38%) | 94% (88–98%) | 82% (69–91%) | 58% (51–64%) | 4.6 (2.3–9.1) | 0.8 (0.7–0.8) | 6.2 (2.9–13.1) |
| STOP-Bang ≥ 5/ESS ≥ 8 | 16% (11–24%) | 99% (95–100%) | 92% (74–99%) | 54% (48–61%) | 9.5 (2.6–34.4) | 0.8 (0.8–0.9) | 11.3 (3.0–42.4) |
| STOP-Bang ≥ 6/ESS ≥ 8 | 6% (3–12%) | 100% (97–100%) | 100% (66–100%) | 52% (46–58%) | 19.3 (1.1–328) | 0.9 (0.9–1.0) | 20.6 (1.2–357) |
| STOP-Bang ≥ 7/ESS ≥ 8 | 1% (1–4%) | 100% (97–100%) | 100% (2–100%) | 50% (44–56%) | 3.0 (0.1–73.5) | 1.0 (1.0–1.0) | 3.0 (0.1–75.3) |

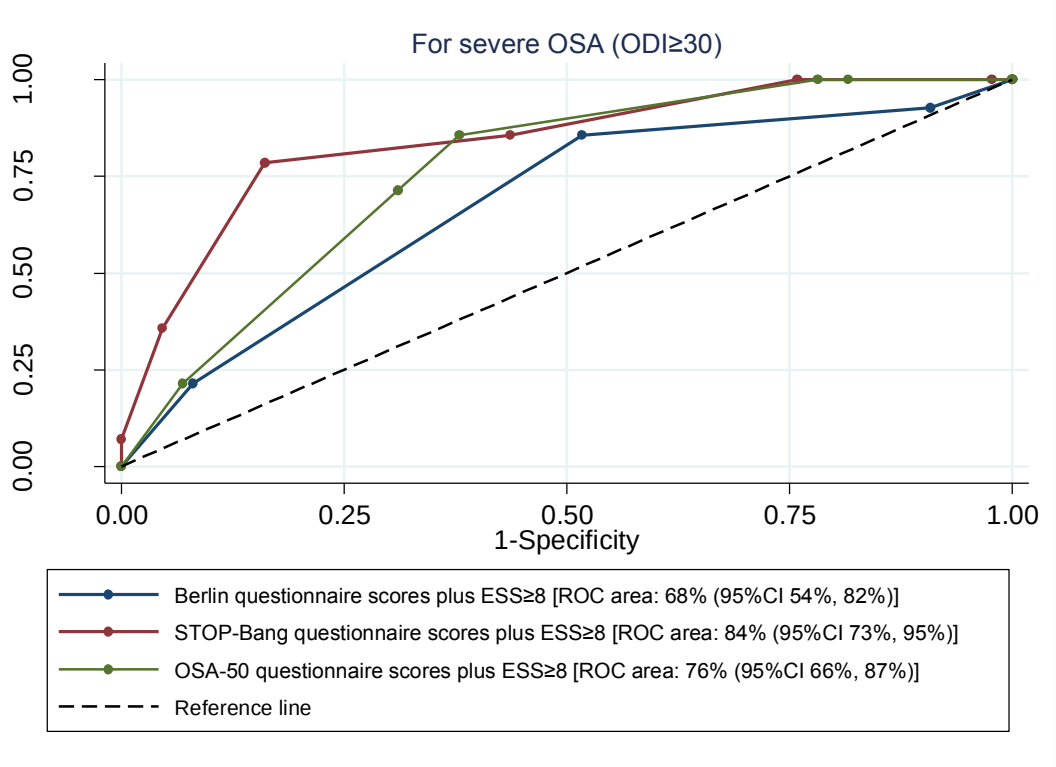
ESS = Epworth sleepiness scale; CI = confidence interval; ROC = receiver operator characteristic; PPV = positive predictive value; NPV = negative predictive value; LR = likelihood ratio; DOR = diagnostic odds ratio. * Defined as moderate to severe obstructive sleep apnoea (oxygen desaturation index ≥ 15) or mild obstructive sleep apnoea (oxygen desaturation index, 5–14) with excessive day time sleepiness (Epworth sleepiness scale score ≥ 8).

**Figure 1. Receiver operator characteristic (ROC) curves for obstructive sleep apnoea (OSA) screening questionnaire scores/ESS ≥ 8 for detecting moderate to severe OSA**




ESS = Epworth sleepiness scale.

**Figure 2. Receiver operator characteristic (ROC) curves for obstructive sleep apnoea (OSA) screening questionnaire scores/ESS ≥ 8 for detecting moderate to severe OSA**




ESS = Epworth sleepiness scale.