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Title: Diagnostic Accuracy of a Modified STOP-BANG Questionnaire with National Anthropometric Obesity Indexes

Running head: Diagnostic Accuracy of a Modified STOP-BANG Questionnaire

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Abstract

OBJECTIVES: Obstructive sleep apnea (OSA) is a very common sleep-related disorder and has many medical complications. Although the STOP-BANG questionnaire is an attractive screening tool because of high sensitivity, it lacks power in specificity. The aim of the present study was to evaluate and compare the diagnostic accuracy of standard STOP-BANG and a modified STOP-BANG questionnaire, using national cut-off values for neck circumference that determined OSA, in a sleep center population.

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MATERIALS AND METHODS: One hundred eighty-five participants who were referred to the sleep-disordered breathing clinic were consecutively enrolled. We used 40 cm and 36 cm as the cut-off values for neck circumference, thus scoring patients accordingly and creating a modified STOP-BANG score with national anthropometric obesity indexes.

RESULTS: The median neck circumferences were 41 (39-44) cm, 40 (37-42) cm, and 43 (40-45) cm for total population, female gender, and male gender, respectively. The mean STOP-BANG score was 4.5 ± 1.5 , and the mean modified STOP-BANG score was 4.9 ± 1.5 . Discrimination of OSA measured by area under the curve for both questionnaires is comparable ($p > 0.05$). Sensitivity to define OSA (apnea-hypopnea index (AHI) ≥ 5) was 92.2% and 93.8% for original and modified STOP-BANG questionnaire, respectively. Sensitivity for moderate (AHI ≥ 15) and severe OSA (AHI ≥ 30) was identical for both questionnaires.

CONCLUSION: The STOP-BANG questionnaire has an excellent sensitivity, but modest specificity and adding national obesity indexes for neck circumference achieved similar results in terms of sensitivity and specificity with the original questionnaire.

KEYWORDS: STOP-BANG, OSA, national anthropometric index

INTRODUCTION

Obstructive sleep apnea (OSA) is a very common sleep-related disorder and has many medical complications, such as hypertension, cardiovascular diseases, neurovascular diseases, and metabolic syndrome [1]. The aim of a sleep questionnaire is to help sleep clinicians to prioritize their patients and to efficiently allocate limited resources for polysomnography (PSG). Sleep questionnaires help patients receive treatment in time and avoid associated complications.

The STOP-BANG questionnaire was developed by Chung et al. [2] in 2008 and has since been validated in many languages, such as Danish, Portuguese, Chinese, and Turkish [3-6]. It is a validated screening tool for OSA in different populations [7].

Although the STOP-BANG questionnaire is an attractive screening tool because of high sensitivity, it lacks power in specificity. Several studies aimed to improve validity specially to decrease false-positive cases by increasing specificity [8]. Alternative scoring models [9-11] adding serum bicarbonate levels [12] and body type [13] to calculations are evaluated for this purpose. However, the validity and effect of cut-off values for neck circumference in the STOP-BANG questionnaire in different nationalities remain unknown.

Several studies investigated the association between anthropometric measurements and OSA severity. Neck circumference was found to be better associated with OSA than body mass index (BMI) and waist circumference [14-17]. Soylu et al. [14] evaluated the relationship between anthropometric obesity indexes and OSA in a Turkish population and described neck circumferences 40 and 36 cm as a risk factor for OSA in male and female patients, respectively. In a Colombian population, a neck circumference of 36.9 cm for female and 41.2 cm for male gender is found to be associated with OSA symptoms [18]. However, in a study from Australia, male patients with OSA

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have 44, and female patients with OSA have 38 cm neck circumference [19]. These findings highlight the differences of OSA-associated neck circumference across populations.

We aimed to evaluate and compare the diagnostic accuracy of standard STOP-BANG and a modified STOP-BANG questionnaire, using national cut-off values for neck circumference that determined OSA, in a sleep center population.

MATERIALS AND METHODS

Study Design and Patient Selection

Patients who were evaluated in a tertiary care hospital pulmonary outpatient clinic and referred to the sleep-disordered breathing clinic were consecutively enrolled between September 1, 2013 and March 31, 2014. Exclusion criteria were age <18 years, previously diagnosed and treated for OSA, and incomplete questionnaire.

As part of the study, a sleep physician evaluated the patient's medical history, sleep-related complaints, and brief physical examination. Demographic and anthropometric measurements, such as weight, height, and neck circumference were recorded. Measurements were made with the same equipment for all patients. Neck circumference was measured in the upright position at the level of the cricothyroid membrane.

The local ethics committee approved the study. Written informed consent was obtained from all of the patients.

Polysomnography

Overnight PSG was performed to all patients using the Compumedics E-series Sleep System (Compumedics Sleep, Melbourne, Australia) device. Manual sleep staging and associated respiratory events were scored according to the American Academy of Sleep Medicine guideline [1].

A diagnosis of OSA was made if the apnea-hypopnea index (AHI) was $\geq 5/h$ and the presence of clinical symptoms or $AHI \geq 15/h$. OSA severity was classified as mild (AHI 5-14/h), moderate (AHI 15-29/h), and severe ($AHI \geq 30/h$). Participants with $AHI < 5$ were defined as the control group.

Questionnaires

The STOP-BANG questionnaire is an 8-item questionnaire, each item scored as 1. Patients with higher scores have higher probability of OSA [20]. The STOP-BANG questionnaire is validated in Turkish [6].

It has been shown that with a stepwise increase of the STOP-BANG score, the probability of OSA increases [7]. The STOP-BANG questionnaire with a score ≥ 3 consistently demonstrated high sensitivity to detect OSA in different populations [7]. In accordance with previous studies, we used a cut-off value of 3.

The cut-off values for neck circumferences in the original STOP-BANG questionnaire are 43 cm and 41 cm for male and female gender, respectively. We used 40 cm and 36 cm as the cut-off values for

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neck circumference, thus scoring patients accordingly and creating a modified STOP-BANG score with national anthropometric obesity indexes.

Daytime sleepiness was measured by the Epworth Sleepiness Scale (ESS). ESS is a self-administered, simple and reliable questionnaire that consists of eight questions. Each item is scored 0-3 points, and having high scores indicates having worse daytime sleepiness. ESS is validated in Turkish [21].

Statistical Analysis

Data were analyzed using the IBM Statistical Package for the Social Sciences (IBM SPSS Statistics Corp.; Armonk, NY, USA) version 22. Variables were analyzed for normal distribution by using visual (histograms and probability plots) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk's test). Means and standard deviations were reported for normally distributed continuous data, and medians and interquartile ranges for non-normally distributed continuous data. Correlation between normally distributed and non-normally distributed data was calculated by Pearson test and Spearman test, respectively. Comparison of two groups with normally and non-normally distributed data was analyzed by Student's t-test and Mann-Whitney U test, respectively. For the assessment of the performance of the STOP-BANG and modified STOP-BANG scores, multiple 2x2 contingency tables were used to calculate sensitivity, specificity, positive predictive value, negative predictive value (NPV), and likelihood ratio for each cut-off value of AHI. Receiver operating characteristic (ROC) curve analysis was used to calculate the area under the curve (AUC) for each cut-off value of AHI. MedCalc was used for comparison of AUC values. A p value <0.05 was considered statistically significant.

RESULTS

The study population consisted of 185 participants who were 48.2±10.9 years old. Of the patients, 65.4% were male. The median neck circumferences were 41 (39-44) cm, 40 (37-42) cm, and 43 (40-45) cm for total population, female gender, and male gender, respectively. One hundred fifty-two (82.7%) had OSA (AHI≥5), 115 (62.2%) had moderate or severe OSA (AHI≥15), and 73 (39.1%) had severe OSA (AHI≥30). The mean STOP-BANG score was 4.5±1.5, and the mean modified STOP-BANG score was 4.9±1.5. Table 1 shows the population characteristics.

Correlation analysis showed that both original and modified STOP-BANG scores are statistically significantly correlated with age, BMI, daytime sleepiness, AHI, oxygen desaturation index, and oxygen desaturation (Table 2).

Discrimination of OSA measured by AUC is poor for both questionnaires, and results are comparable (p>0.05). Figure 1 shows the ROC curve of the original and modified STOP-BANG questionnaires at different OSA severity. Sensitivity to define OSA (AHI≥5) was 92.2% and 93.8% for original and modified STOP-BANG questionnaire, respectively. Sensitivity for moderate (AHI≥15) and severe OSA (AHI≥30) was identical for both questionnaires. However, specificity remained low for both questionnaires. Table 3 shows the predictive values of the questionnaires for scores ≥3.

DISCUSSION

In our study, the STOP-BANG scores modified with national neck circumference values showed similar diagnostic accuracy with the original STOP-BANG scores (STOP-BANG AUC=0.661 vs. modified

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STOP-BANG AUC=0.635, $p>0.05$). Sensitivity for all OSA (AHI \geq 5), moderate (AHI \geq 15), and severe OSA (AHI \geq 30) was 93.8%, 95.74%, and 98.38% and 92.25%, 95.74%, and 98.38% for modified and original STOP-BANG scores, respectively. Changing the original neck circumference cut-off values with national indexes did not improve specificity. The specificity of STOP-BANG score \geq 3 for OSA (AHI \geq 5), moderate (AHI \geq 15), and severe OSA (AHI \geq 30) was 25.9%, 20.9%, and 17%, respectively. When national neck circumference cut-off values were added to the STOP-BANG score \geq 3, the specificity changed into 14.8%, 12.9%, and 11.7% for all OSA (AHI \geq 5), moderate (AHI \geq 15), and severe OSA (AHI \geq 30), respectively. Our findings are in accordance with previous studies, proving that the STOP-BANG questionnaire is a useful tool as a screening questionnaire with a good sensitivity and NPV.

The sensitivity results of our study are in accordance with a large meta-analysis of 9206 patients. Whereas in specificity, our results for both original and modified STOP-BANG are lower. Among the sleep clinic population, the sensitivity to detect any OSA (AHI $>$ 5), moderate to severe OSA (AHI $>$ 15), and severe OSA (AHI $>$ 30) was 90%, 94%, and 96%, respectively [7]. The specificity was 49%, 34%, and 25% for all OSA (AHI $>$ 5), moderate to severe OSA (AHI $>$ 15), and severe OSA (AHI $>$ 30), respectively [7].

Our sensitivity and specificity results are both better than those reported by Acar et al. [6]. In a Turkish validation study, STOP-BANG had 93.2%, 92.3%, and 96.9% sensitivity, in addition to 2.8%, 3.4%, and 6.4% specificity for all OSA, moderate, and severe OSA, respectively [6].

Ong et al. [22] used lower BMI cut-off and different cut-offs for neck circumference to improve the sensitivity. Changing neck circumference did not significantly affect sensitivity or predictive accuracy of the questionnaire. Although using lower BMI cut-off resulted in better sensitivity, it led to a significant decrease in specificity.

Neck circumference is found to be the best single clinical measurement for predicting OSA [23,24]. It is found to be associated with disease severity in both genders, especially in men [19]. The neck circumference-to-height ratio is shown to be associated with AHI, independent from visceral fat level especially in non-obese patients [25]. Hip circumference and neck circumference normalized by height are significant predictors of OSA in female patients [26]. Results about neck circumference suggest that fat distribution in the upper airway can be an important risk factor in OSA development.

The strength of our study is that all patients completed diagnostic overnight PSG, which is the gold standard of diagnosis of OSA [1]. Using pre-screened subjects referred to the sleep laboratory is the limitation of our study because it decreases generalizability.

The STOP-BANG questionnaire has an excellent sensitivity, but modest specificity and adding national obesity indexes for neck circumference achieved similar results in terms of sensitivity and specificity with the original questionnaire.

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Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of local ethics committee.

Informed Consent: Written informed consent was obtained from all of the patients.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – N.A.A.Ö., A.G.D., E.D.Ç., A.U, M.K.; Design – N.A.A.Ö., A.G.D., E.D.Ç.; Supervision – A.G.D., A.U., M.K.; Resources – N.A.A.Ö., A.G.D., A.U., M.K.; Materials – A.U., M.K.; Data Collection and/or Processing – N.A.A.Ö., A.G.D., E.D.Ç., A.U., M.K.; Analysis and/or Interpretation – N.A.A.Ö., A.G.D., E.D.Ç., A.U., M.K.; Literature Search – N.A.A.Ö., A.G.D.; Writing Manuscript – N.A.A.Ö., A.G.D., E.D.Ç., A.U., M.K.; Critical Review – N.A.A.Ö., A.G.D., E.D.Ç., A.U., M.K.

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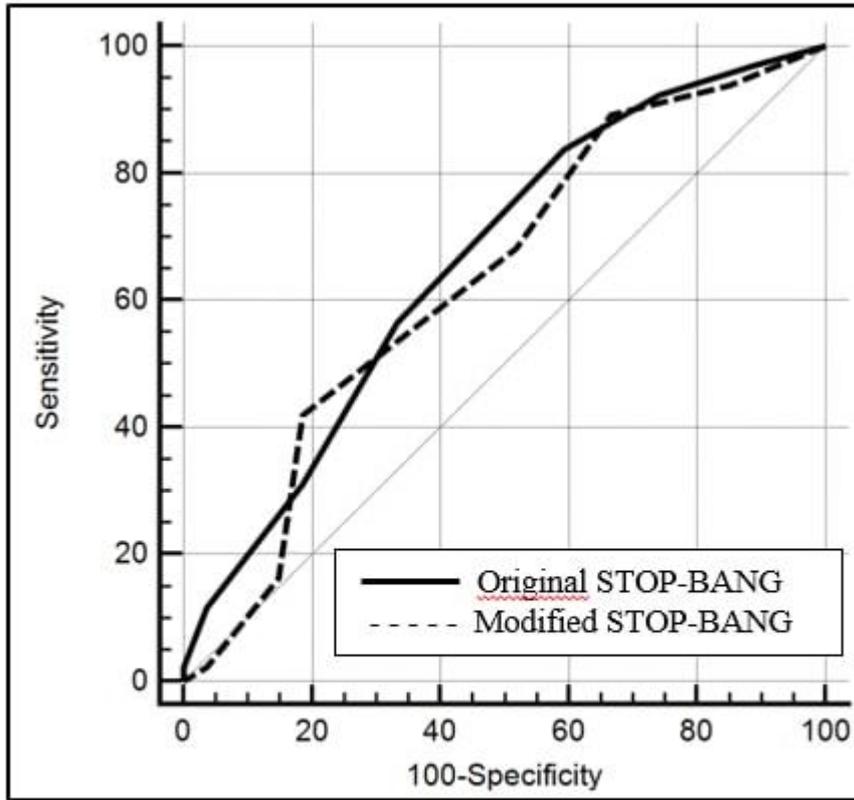
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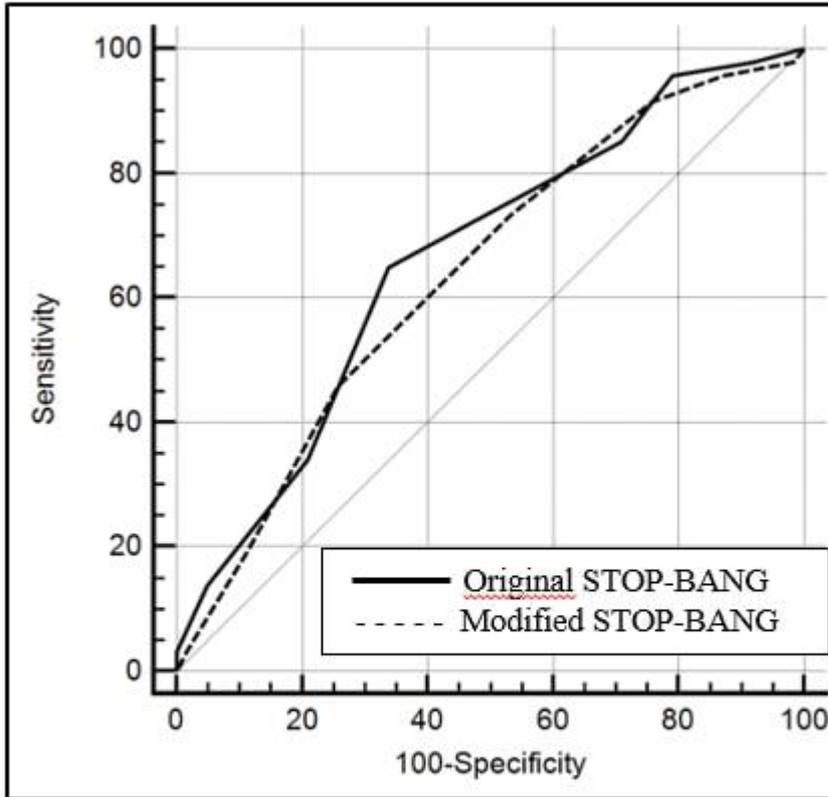
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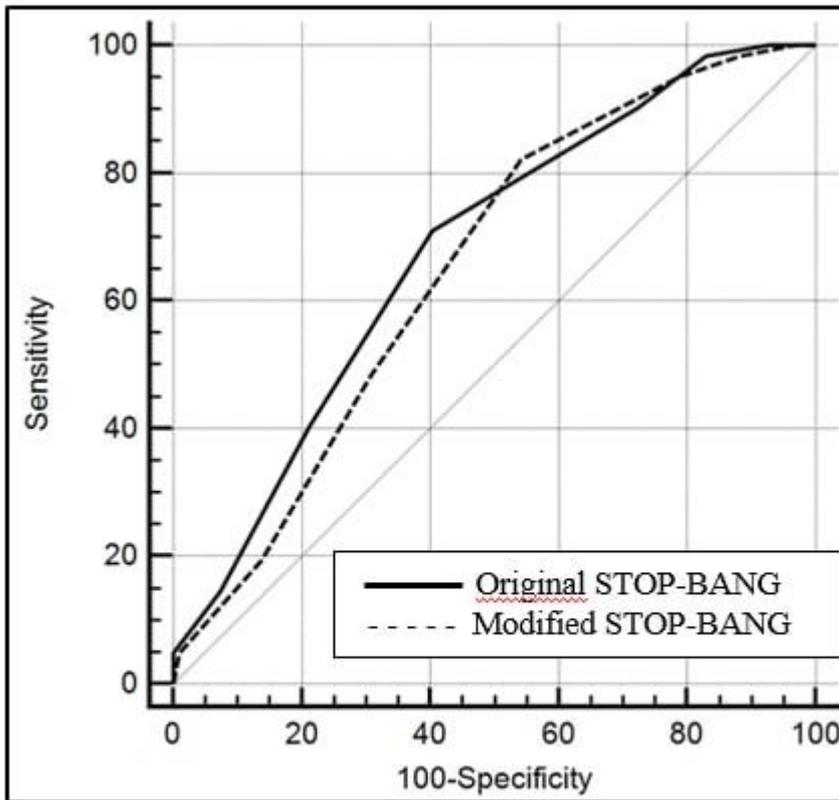
a. ROC curves for original and modified STOP-BANG scores for AHI ≥ 5

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b. ROC curves for original and modified STOP-BANG scores for AHI ≥ 15

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c. ROC curves for original and modified STOP-BANG scores for AHI ≥ 30

Figure 1. a-c. ROC curves for original and modified STOP-BANG questionnaires. (a) ROC curves for original and modified STOP-BANG scores for AHI ≥ 5 (AUC: 0.661, 95% CI [0.581-0.735]; AUC: 0.635, 95% CI [0.554 - 0.710], respectively); (b) ROC curves for original and modified STOP-BANG scores for AHI ≥ 15 (AUC: 0.662, 95% CI: [0.582 - 0.736]; AUC: 0.639, 95% CI [0.558 - 0.714], respectively); (c) ROC curves for original and modified STOP-BANG scores for AHI ≥ 30 (AUC: 0.679, 95% CI: [0.600 - 0.751]; AUC: 0.652, 95% CI [0.572 - 0.727], respectively). Solid lines represent the ROC curves for the original STOP-BANG scores, and dashed lines represent the modified STOP-BANG scores

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Table 1. Population characteristics

Age (year)	48.2±10.9
Gender (male)	121 (65.4%)
BMI (kg/m ²)	35.5±11
Neck circumference	41 (39-44)
Epworth Sleepiness Scale	9 (0-24)
STOP-BANG score	4.5±1.5
Modified STOP-BANG score	4.9±1.5
AHI (event/h)	21.9 (0-130.2)
ODI 3% (event/h)	17.6 (0-116)
Mean oxygen desaturation	5 (0-23)
Time with O ₂ sats <90% (%)	5 (0-100)
Apnea-hypopnea duration (min)	50.2 (0-325.6)
All OSA, n (%)	153 (82.7)
Severe OSA, n (%)	73 (39.1)

BMI: body mass index; AHI: apnea-hypopnea index; ODI: oxygen desaturation index; OSA: obstructive sleep apnea

Table 2. Correlation of the original and modified STOP-BANG questionnaire with clinical characteristics

	STOP-BANG score		Modified STOP-BANG score	
	r	p	r	p
Age (year)	0.325	<0.001	0.336	<0.001
BMI (kg/m ²)	0.246	0.002	0.244	0.002
Epworth Sleepiness Scale	0.324	<0.001	0.314	<0.001
AHI (event/h)	0.378	<0.001	0.338	<0.001

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Apnea-hypopnea duration (min)	0.378	<0.001	0.326	<0.001
ODI 3% (event/h)	0.460	<0.001	0.420	<0.001
Mean oxygen desaturation	-0.391	<0.001	0.369	<0.001
Time with O ₂ sats <90% (%)	0.465	<0.001	0.439	<0.001
Lowest O ₂ sats	-0.486	<0.001	0.379	<0.001

BMI: body mass index; AHI: apnea-hypopnea index; ODI: oxygen desaturation index

Table 3. Predictive value of questionnaires

		STOP-BANG score ≥ 3	Modified STOP-BANG score ≥ 3
AHI ≥ 5			
	AUC	0.661	0.635
	Sensitivity (%)	92.25 (86.21-96.22)	93.80 (88.15-97.2)
	Specificity (%)	25.93 (11.11-46.28)	14.81 (4.19-33.73)
	PPV (%)	85.61 (82.56-88.21)	84.03 (81.7-86.1)
	NPV (%)	41.18 (22.64-62.61)	33.3 (13.95-60.66)
	Likelihood ratio	1.25 (0.99-1.57)	1.1 (0.94-1.3)
AHI ≥ 15			
	AUC	0.662	0.639
	Sensitivity (%)	95.74 (89.46-98.83)	95.74 (89.46-98.83)
	Specificity (%)	20.97 (11.66-33.18)	12.90 (5.74-23.85)
	PPV (%)	64.75 (66.61-67.77)	62.50 (60-64.92)
	NPV (%)	76.49 (52.62-90.46)	66.67 (38.62-86.41)
	Likelihood ratio	1.21 (1.06-1.39)	1.10 (0.99-1.22)

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AHI≥30			
	AUC	0.679	0.652
	Sensitivity (%)	98.39 (91.34-99.96)	98.39 (91.34-99.96)
	Specificity (%)	17.02 (10.05-26.16)	11.70 (5.99-19.97)
	PPV (%)	43.88 (41.51-46.28)	42.36 (40.42-44.33)
	NPV (%)	94.12 (68.52-99.16)	91.67 (59.29-98.81)
	Likelihood ratio	1.19 (1.08-1.31)	1.11 (1.03-1.21)

AUC: area under the curve; PPV: positive predictive value; NPV: negative predictive value

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