TABLES

Table 1. Summary of the studies using pattern recognition techniques for classification of suspected OSAS patients using overnight oximetry.

Author (year)	Dataset (n)	Gold standard (cut-off)	Aim	Variables involving oximetry	Classification technique	Se (%)	Sp (%)	Acc (%)
Marcos et al. (2010) [38]	187 adult patients with suspected OSAS	In-lab PSG (AHI ≥10 events/h)	Binary classification	Statistical moments in time and frequency, spectral and nonlinear	MLP ANN with Bayessian training	87.76	82.39	85.58
Almazaydeh et al. (2012) [39]	93 recordings from 32 healthy volunteers and OSAS patients	In-lab PSG (AHI ≥5 events/h)	Binary classification	Delta index, ODI3, CTM	MLP ANN	87.5	100	93.3
Morillo & Gross (2013) [40]	115 patients with suspected OSAS	In-lab PSG (AHI ≥10 events/h)	Binary classification	Time, frequency, stochastic, and nonlinear features	PNN	92.42	95.92	93.91
Álvarez et al. (2013) [41]	320 including healthy and suspected OSAS patients	In-lab PSG (AHI ≥10 events/h)	Binary classification	Statistical moments in time and frequency, spectral and nonlinear	FLD + GAs LR + stepwise SVM + GAs	80.0 95.2 95.2	83.3 86.0 80.0	81.2 88.7 84.5
Hang et al. (2015) [42]	616 patients with suspected OSAS	In-lab PSG (AHI ≥5, 15, 30 events/h)	4-class and binary classification	ODI2 and ODI4	$SVM_{4\text{-CLASS}}$ SVM (AHI ≥15) SVM (AHI ≥30)	- 87.36 87.71	- 93.05 86.56	71.27 90.42 87.33
Huang *et al.* (2015) [43]	124 patients with suspected OSAS	In-lab PSG (AHI ≥5 events/h)	Binary classification	ODI4	DTs MLP ANN LVQ ANFIS	98.67 88.00 80.67 90.67	90.67 93.33 79.33 86.00	94.67 90.67 80.00 88.33

Acc: accuracy; AHI: apnea-hypopnea index; ANFIS: adaptive network-based fuzzy inference systems; ANN: artificial neural network; CTM: central tendency measure; DTs: decision trees; FLD: Fisher's linear discriminant; GAs: genetic algorithms; MLP: Multilayer perceptron; LR: logistic regression; LVQ: learning vector quantization; ODI2: oxygen desaturation index ≥2%; ODI3: oxygen desaturation index ≥3%; ODI4: oxygen desaturation index ≥4%; OSAS: obstructive sleep apnea syndrome; PPN: probabilistic neural network; PSG: polysomnography; Se: sensitivity; Sp: specificity; SVM: support vector machines.

Table 2. Summary of the studies using pattern recognition techniques for regression of the AHI using overnight oximetry.

Author (year)	Dataset (n)	Gold standard (cut-off)	Aim	Variables involving oximetry	Classification technique	Se (%)	Sp (%)	Acc (%)	ICC
Marcos et al. (2012) [45]	240 patients with suspected OSAS	In-lab PSG (AHI ≥5 events/h)	AHI estimation (regression)	Statistical moments in time and frequency, spectral and nonlinear features	$MLP_{REGRESSION}$	-	-	-	0.91
					AHI_{OX} ≥5	91.82	58.82	84.03	-
					AHI_{OX} ≥15	94.87	90.91	93.06	-
Ebben & Krieger (2016) [46]	1467 patients with suspected OSAS	In-lab PSG (AHI ≥5 events/h)	AHI estimation (regression)	ODI4	QR	-	-	-	0.88
					AHI_{OX} ≥5	90	90	91	-
					AHI_{OX} ≥15	82	96	91	-
					AHI_{OX} ≥30	76	98	95	-
Jung et al. (2017) [23]	455 patients with suspected OSAS	In-lab PSG (AHI ≥5 events/h)	AHI estimation (regression)	ODI from morphological-based heuristic rules	Hill regression	-	-	-	0.99
					AHI_{OX} ≥5	98.6	94.4	97.8	-
					AHI_{OX} ≥15	96.4	94.6	95.7	-
					AHI_{OX} ≥30	97.1	96.5	96.7	-

Acc: accuracy; AHI: apnea-hypopnea index; AHI_{OX}: estimated apnea-hypopnea index from oximetry; ANN: artificial neural network; ICC: intra-class correlation coefficient; MLP: Multilayer perceptron; ODI: oxygen desaturation index; ODI4: oxygen desaturation index ≥4%; OSAS: obstructive sleep apnea syndrome; PSG: polysomnography; QR: quadratic regression; Se: sensitivity; Sp: specificity.

Table 3. Summary of the studies using ensemble learning techniques to assist in OSAS diagnosis from overnight oximetry.

Author (year)	Dataset (n)	Gold standard (cut-off)	Aim	Variables involving oximetry	Classification technique	Se (%)	Sp (%)	Acc (%)
Xie & Minn (2012) [50]	25 patients with suspected OSAS	In-lab PSG (AHI ≥5 events/h)	Binary classification	111 ECG-derived and 39 SpO_2-derived features	Bagging.DT (SpO_2)	63.73	92.40	85.43
					Bagging.DT (ECG)	45.49	92.96	81.41
					Boosting.DT (SpO_2)	72.64	87.18	83.64
					Boosting.DT (ECG)	31.59	91.60	77.00
					Bagging.DT (SpO2+ECG)	65.64	93.35	86.60
					Boosting.DT (SpO2+ECG)	71.82	87.59	83.75
Hang et al. (2013) [49]	566 patients with suspected OSAS	In-lab PSG (AHI ≥15, 30 events/h)	Binary classification	Anthropometric and demographic, symptoms, sleep and life quality scores	Ensemble SVMs:			
					- Moderate-to-severe OSAS	89.34	90.15	89.62
					- Severe OSAS	90.11	90.58	90.37
Sánchez-Morillo et al. (2014) [48]	115 patients with suspected OSAS	In-lab PSG (AHI ≥5, 15, 30 events/h)	4-class (no-OSAS, mild, moderate, severe	Statistical, spectral and nonlinear features	Ensemble (DT, SVM, PNN)	-	-	86.0
					- Non-OSAS	91.7	96.7	-
					- Mild	80.0	88.8	-
					- Moderate	73.1	94.4	-
					- Severe	86.7	95.3	-

Acc: accuracy; AHI: apnea-hypopnea index; DT: decision tree; ECG: electrocardiogram; OSAS: obstructive sleep apnea syndrome; PPN: probabilistic neural network; PSG: polysomnography; Se: sensitivity; Sp: specificity; SpO_2: blood oxygen saturation; SVM: support vector machines.

Table 4. Summary of the studies using oximetry to assist in OSAS diagnosis in patients with comorbidities and especial risk groups.

Author (year)	Dataset (n)	Gold standard	Aim	Variables from oximetry	Classification technique	Se (%)	Sp (%)	Acc (%)
Malbois et al. (2010) [54]	68 obese patients before bariatric surgery regardless suspicion of OSAS	At-home RP	Binary classification (AHI ≥10, 30 events/h)	ODI3 and ODI4 from oximetry alone	ODI3, AHI ≥10	97	69	-
					ODI3, AHI ≥30	100	93	-
					ODI4, AHI ≥10	83	93	-
					ODI4, AHI ≥30	91	96	-
Ward et al. (2012) [52]	173 patients with congestive heart failure regardless suspicion of OSAS	Unattended PSG (either in-lab or at-home)	Binary classification (AHI ≥15 events/h)	ODI3 from portable oximetry	ODI3 >7.5 desaturations/h	97	32	-
Aaronson et al. (2012) [51]	56 stroke patients admitted to rehabilitation regardless suspicion of OSAS	In-hospital attended RP	Binary classification (AHI ≥15 events/h)	ODI4 from RP	ODI4 >15 desaturations/h	77	100	-
Chung et al. (2012) [56]	475 patients before surgery regardless suspicion of OSAS	At-home PSG	Binary classification (AHI ≥5, 15, 30 events/h)	ODI3 from portable oximetry alone	ODI3, AHI ≥5	96.3	67.3	87.0
					ODI3, AHI ≥15	70.0	92.5	84.0
					ODI4, AHI ≥30	76.0	97.2	93.7
Scott et al. (2014) [19]	59 COPD admitted for pulmonary rehabilitation regardless suspicion of OSAS	In-hospital PSG	Binary classification (AHI ≥15 events/h)	Visual inspection and ODI4 from in-lab portable oximetry	Manual visual inspection	59	60	-
					Automated ODI4	60	63	-
Mazière et al. (2014) [57]	58 hospitalized elders regardless suspicion of OSAS	In-hospital attended RP	Binary classification (AHI ≥15 events/h)	Variability index ODI3 ODI4 (automated)	Var. ind. >0.51	100	18.8	-
					Var. ind. >0.88	66.7	93.8	-
					ODI3 ≥15	69.1	93.8	-
					ODI4 ≥15	33.3	100	-
Andrés-Blanco et al. (2017) [55]	407 patients suspected of OSAS with and without COPD	In-hospital PSG	Regression of AHI, common cut-offs	Statistical, spectral, and nonlinear	MLP ANN: AHI_{LAB} ≥15			
					- Non-COPD	97.5	58.6	87.3
					- COPD	96.2	56.3	86.8
					AHI_{HOME} ≥15			
					- Non-COPD	97.5	24.1	78.2
					- COPD	86.5	37.5	75.0

Acc: accuracy; AHI: apnea-hypopnea index; AHI_{HOME}: estimated apnea-hypopnea index from at-home oximetry; AHI_{LAB}: apnea-hypopnea index from PSG; ANN: artificial neural network; COPD: chronic obstructive pulmonary disease; MLP: Multilayer perceptron; ODI3: oxygen desaturation index ≥3%; ODI4: oxygen desaturation index ≥4%; OSAS: obstructive sleep apnea syndrome; PSG: polysomnography; RP: respiratory polygraphy; Se: sensitivity; Sp: specificity; Var. ind.: variability index.

Table 5. Summary of the studies assessing oximetry-based test for OSAS in the clinical practice.

Author (year)	Dataset (n)	Gold standard	Aim	Variables from oximetry	Classification technique	Se (%)	Sp (%)	Acc (%)
Antic et al. (2009) [60]	195 patients with high risk of moderate-to-severe OSAS - 100 nurse model - 95 physician model	In-lab PSG (manual scoring of AHI)	Simplified CPAP management at home	ODI2	ODI2 >27 + nurse skilled in CPAP (auto-titrating at home) vs. ODI2 >27 + manual setting by specialist (in-lab)	-	-	-
Chai-Coetzer et al. (2011) [11]	157 selected patients (4:1 high-to-low risk rate according to BQ)	At-home PSG (manual scoring)	Binary classification (AHI ≥30 events/h)	ODI3 from ApneaLink ($ODI3_{AI}$)	OSA50 ≥5 + $ODI3_{AL}$ ≥16	88	82	83
Sharma et al. (2017) [61]	592 OSAS positive from 5062 obese patients admitted to cardiology, internal medicine, family practice services	In-lab PSG (AHI ≥5 events/h)	Binary classification (AHI ≥5 events/h)	ODI4 from portable oximetry at home	ODI4 ≥5 ODI4 ≥10 ODI4 ≥15 ODI4 ≥20	89 74 65 55	48 78 90 94	- - - -

Acc: accuracy; AHI: apnea-hypopnea index; BQ: Berlin questionnaire; CPAP: continuous positive airway pressure; ODI2: oxygen desaturation index ≥2%; ODI3: oxygen desaturation index ≥3%; $ODI3_{AI}$: estimated oxygen desaturaion index ≥3% from ApneaLink; ODI4: oxygen desaturation index ≥4%; OSAS: obstructive sleep apnea syndrome; OSA50: sleep questionnaire; PSG: polysomnography; Se: sensitivity; Sp: specificity.

Table 6. Summary of the studies comparing overnight portable oximetry with additional simplified screening test for OSAS.

Author (year)	Dataset (n)	Gold standard	Aim	Simplified screening test	Classification technique	Se (%)	Sp (%)	Acc (%)	AUC
Rofail et al. (2010) [16]	98 patients with clinical suspicion of OSAS	In-hospital PSG	Binary classification (AHI ≥5, 30 events/h)	At-home oximetry vs. at-home airflow	ODI3 ≥5	77	89	-	-
					RDI_{AF} ≥5	80	87	-	-
					ODI3 ≥30	90	85	-	-
					RDI_{AF} ≥30	90	85	-	-
Ting et al. (2014) [62]	151 male bus drivers regardless suspicion for OSAS	In-hospital PSG	Binary classification (AHI ≥5, 15 events/h)	In-lab oximetry + actigraphy vs. in-lab airflow from ApneaLink vs. in-lab HRV	ODI3 ≥4.6(AHI ≥5)	97	78	-	0.95
					RDI≥8.2(AHI ≥5)	82	63	-	0.79
					PRI7≥18.6(AHI ≥5)	81	63	-	0.76
					ODI3≥15.6(AHI≥15)	91	87	-	0.94
					RDI≥14.8(AHI ≥15)	82	69	-	0.81
					PRI7≥22.0(AHI ≥15)	82	68		0.75
Dawson et al. (2015) [64]	73 patients with clinical suspicion of OSAS	In-hospital PSG	Binary classification (AHI ≥5 events/h)	At-home oximetry alone vs. at-home ApneaLink	$ODI4_{OX}$	-	-	-	0.827
					$ODI4_{AL}$	-	-	-	0.840
					RDI_{AL}	-	-	-	0.849

Acc: accuracy; AHI: apnea-hypopnea index; AUC: area under the receiver operating characteristics curve; HRV: heart rate variability; ODI3: oxygen desaturation index ≥3%; $ODI4_{AL}$: oxygen desaturation index ≥4% from ApneaLink; $ODI4_{OX}$: oxygen desaturation index ≥4% from oximetry alone; OSAS: obstructive sleep apnea syndrome; PRI7: pulse-raising index of increases ≥7%; PSG: polysomnography; RDI: respiratory disturbance index; RDI_{AF}: respiratory disturbance index from airflow; RDI_{AL}: respiratory disturbance index from ApneaLink; Se: sensitivity; Sp: specificity.

Table 7. Summary of the studies analyzing overnight oximetry and additional biomedical recordings together in order to develop improved screening test for OSAS.

Author (year)	Dataset (n)	Gold standard	Aim	Biomedical recordings	Classification technique	Se (%)	Sp (%)	Acc (%)	AUC
Heneghan et al. (2008) [68]	59 patients with clinical suspicion of OSAS	In-hospital PSG	Binary classification (AHI ≥5, 15 events/h)	Portable oximetry + ECG simultaneous to PSG	AHI_{OX-ECG} ≥5 (AHI_{PSG} ≥5)	95.8	100	-	-
					AHI_{OX-ECG} ≥15 (AHI_{PSG} ≥15)	74.2	96.4	-	-
Yadollahi et al (2010) [66]	66 patients with clinical suspicion of OSAS	In-hospital PSG	Binary classification (AHI ≥5, 15 events/h)	Oximetry + tracheal sounds from PSG	AHI_{OX-TS} ≥5 (AHI_{PSG} ≥5)	74.3	82.4	-	0.87
					AHI_{OX-TS} ≥15 (AHI_{PSG} ≥15)	84.6	96.0	-	0.96
Barak-Shinar et al. (2013) [65]	140 patients with clinical suspicion of OSAS	In-hospital PSG	Binary classification (AHI ≥5, 15 events/h)	Oximetry + PPG from PSG	AHI_{OX-PPG} ≥5 (AHI_{PSG} ≥5)	97.03	97.44	-	-
					AHI_{OX-PPG} ≥15 (AHI_{PSG} ≥15)	94.44	96.51	-	-
Li et al. (2017) [67]	49 patients with clinical suspicion of OSAS	In-hospital PSG	Binary classification (AHI ≥5, 15, 30 events/h)	Portable oximetry + PPG simultaneous to PSG	RDI_{OX-PPG} for group:				
					- 5≤AHI_{PSG}<15	95.3	50.0	-	0.849
					- 15≤AHI_{PSG}<30	89.7	90.0	-	0.888
					- AHI_{PSG} ≥30	68.8	97.0	-	0.936
Abedi et al. (2017) [70]	54 patients with clinical suspicion of OSAS	In-hospital PSG	Binary classification - Event-based - Patient-based	Oximetry + thoracic respiratory effort	SVM: - Obs vs. cent - No-OSAS vs. OSAS	92.7 99.5	89.5 90.2	87.8 96.0	- -

Acc: accuracy; AHI: apnea-hypopnea index; AHI_{PSG}:apnea-hypopnea index from PSG; AHI_{OX-ECG}: estimated apnea-hypopnea index from oximetry and ECG; AHI_{OX-PPG}: estimated apnea-hypopnea index from oximetry and photoplethysmography; AHI_{OX-TS}: estimated apnea-hypopnea index from oximetry and tracheal sounds; AUC: area under the receiver operating characteristics curve; Cent: central apneic events; ECG: electrocardiogram; Obs: obstructive apneic events; OSAS: obstructive sleep apnea syndrome; PPG: photoprethysmography; PSG: polysomnography; RDI: respiratory disturbance index; RDI_{OX-PPG}: respiratory disturbance index from oximetry and photoprethysmography; Se: sensitivity; Sp: specificity; SVM: support vector machines.

Table 8. Summary of the studies using visual or semi-automated analysis of overnight oximetry in the detection of pediatric OSAS.

Author (year)	Dataset (n)	Gold standard (cut-off)	Aim / Data	Technique	Classification approach	Se (%)	Sp (%)	Acc (%)
Velasco-Suárez et al. (2013) [74]	167 children with suspected OSAS	In-lab PSG (AHI ≥1 events/h)	Binary classification / In-lab oximetry	Nº of clusters of desaturations >2 + Nº drops below 90% >1	Visual inspection	86.6	98.9	93.4
Tsai et al. (2013) [77]	148 children with suspected OSAS	In-lab PSG (AHI ≥1, 5, 10 events/h)	Binary classification / In-lab oximetry	Manual ODI4	ODI4 >2.05 (AHI ≥1)	77.7	88.9	79.0
					ODI4 >3.50 (AHI ≥5)	83.8	86.5	85.1
					ODI4 >4.15 (AHI ≥10)	89.1	86.0	87.1
Van Eyck et al. (2015) [18]	130 obese children with suspected OSAS	In-lab PSG (AHI ≥2 events/h)	Binary classification / In-lab oximetry	Brouillette criteria Velasco criteria	Manual scoring of desaturations	58 66	88 69	78 68
Villa et al. (2015) [75]	268 children with suspected OSAS	In-lab PSG (AHI ≥1 and 5 events/h)	Binary classification / In-lab oximetry	Clusters of deasturations and clinical history	Semi-automatic			
					- AHI ≥1	91.6	40.6	85.8
					- AHI ≥5	40.6	97.9	69.4

Acc: accuracy; AHI: apnea-hypopnea index; ODI4: oxygen desaturation index ≥4%; OSAS: obstructive sleep apnea syndrome; PSG: polysomnography; Se: sensitivity; Sp: specificity.

Table 9. Summary of the studies using automated analysis of overnight oximetry in the detection of pediatric OSAS.

Author (year)	Dataset (n)	Gold standard (cut-off)	Aim / Data	Technique	Classification approach	Se (%)	Sp (%)	Acc (%)
Chang et al. (2013) [76]	141 children with suspected OSAS	In-lab PSG (AHI ≥5 events/h)	Binary classif. / Questionnaires and oximetry	Presence of mouth breathing, restless sleep, ODI4	LR	60.0	86.0	71.6
Jing-Ru et al. (2017) [78]	32 habitually snoring children	In-lab PSG (AHI ≥1, 5, 10 events/h)	Binary classif. / Portable pulse oximetry watch (attended)	Automated ODI4	ODI4 >1 for cut-off AHI ≥1	59.26	80.00	-
					ODI4 >5 for cut-off AHI ≥5	70.59	66.67	-
					ODI4 >10 for cut-off AHI ≥10	64.29	83.33	-
Garde et al. (2014) [15]	146 children with suspected OSAS	In-lab PSG (AHI ≥5 events/h)	Binary classif. / Portable oximetry (attended)	Time and spectral:	LDA			
				- SpO2		80.0	83.9	78.5
				- SpO2 + PR		88.4	83.6	84.9
Álvarez et al. (2017) [27]	50 children with suspected OSAS	In-lab PSG AHI ≥1, 3, 5 events/h	Binary classif. / Port. oximetry from at-home RP	Statistical, spectral and nonlinear features	LR (AHI ≥1)	89.6	71.5	85.5
					LR (AHI ≥3)	82.9	84.4	83.4
					LR (AHI ≥5)	82.2	83.6	82.8
Gutiérrez-Tobal et al. (2015) [80]	50 children with suspected OSAS	In-lab PSG (AHI ≥3 events/h)	Binary classif. / Airflow + SpO_2 from at-home RP	Spectral features from airflow + ODI3	LR	85.9	87.4	86.3
Crespo et al. (2017) [33]	50 children with suspected OSAS	In-lab PSG (AHI ≥3 events/h)	Binary classif. / Port. oximetry from at-home RP	Nonlinear features and conventional oximetric indices	LR	84.5	83.0	83.5
Vaquerizo-Villar et al. (2017) [81]	298 habitually snoring children	In-lab PSG (AHI ≥1, 5, 10 events/h)	Multiclass classif / In-lab oximetry	Bispectrum, PSD, ODI3, age, sex, BMI	3-class MLP:			
					- AHI ≥5	61.8	97.6	81.3
					- AHI ≥10	60.0	94.5	85.3
Hornero et al. (2017) [82]	4191 habitually snoring children	In-lab PSG (AHI ≥1, 5, 10 events/h)	Estimation AHI / In-lab oximetry	Statistical, spectral, nonlinear features, and ODI3	MLP ANN:			
					- AHI ≥1	84.0	53.2	75.2
					- AHI ≥5	68.2	87.2	81.7
					- AHI ≥10	68.7	94.1	90.2
Cohen & De Chazal (2015) [79]	288 infants (<27 weeks) healthy and suspected OSAS	At-home PSG (event-based classification)	Portable pulse oximetry + ECG (unattended)	T/F feat. ECG	Linear discriminant	39.6	76.4	74.7
				T/F feat. ECG + T feat. Oximetry		58.1	67.0	66.7

Acc: accuracy; AHI: apnea-hypopnea index; ANN: artificial neural network; BMI: body mass index; ECG: electrocardiogram; LDA: linear discriminant analysis; MLP: Multilayer perceptron; LR: logistic regression; ODI3: oxygen desaturation index ≥3%; ODI4: oxygen desaturation index ≥4%; OSAS: obstructive sleep apnea syndrome; PR: pulse rate from oximetry; PSD: power spectral density; PSG: polysomnography; RP: respiratory polygraphy; Se: sensitivity; Sp: specificity; SpO_2: blood oxygen saturation from oximetry; T feat.: time domain features; T/F feat.: features from time and frequency domains.