the sensitivity and specificity of those features to SAs and SHs have not been probed.
Methods: We studied 804 polysomonography samples from 704 patients with obstructive sleep apnea and 100 controls. The input data were converted into scalograms as 4-channel 2D images to train Xception networks. For training, 77,638 patches were sampled from the original 6-hour sleep data with 30-second time width. A 10% of these patches were segregated as the test-set. With each feature sets, we tested the following classifications: 1) normal vs apnea vs hypopnea; 2) normal vs. apnea+hypopnea; 3) normal vs. apnea; and 4) normal vs. hypopnea.
Results: SpO2 classified normal vs. apnea most accurately (98%), followed by NAF (85%), ECG (77%), and HR (63%). SpO2 also showed the highest accuracy in classifying normal vs. hypopnea (87%), and normal vs. apnea+hypopnea (96%) and three groups (82%). When the combination of four features were used, the classification accuracies were generally improved compared to use of SpO2 only (normal vs. apnea 99%; vs. hypopnea 89%; vs. apnea+hypopnea: 94%; three groups: 86%).
Conclusion: Deep learning with SpO2 or NAF feature most accurately classified apneas from normal sleep events, suggesting these features' characterization of sleep apnea events. Oxygen desaturation, which is a typical pattern of hypopnea, was only the feature showing reliable accuracy in classifying hypopnea vs. normal. Nevertheless, combination of four polysomnography features could improve the identification of sleep apnea and hypopnea. Furthermore, classifying normal vs. apnea+hypopnea was more accurate than separately classifying three groups, suggesting deep learning approaches as the primary screen tool. Since the classification accuracy of using SpO2 was higher than any other features, developing a portable equipment measuring SpO2 and running deep learning algorithms has the potential for inexpensive, accurate diagnostics of obstructive sleep apnea syndrome.
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VALIDATION OF CLAIM BASED ALGORITHMS FOR SLEEP APNEA USING ICD CODES

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Introduction: Obstructive sleep apnea (OSA) is a common condition characterized by repeated episodes of partial or complete obstruction of the respiratory passages during sleep. According to recent studies prevalence of obstructive sleep apnea ranges between 9–38%. OSA is associated with increased all-cause mortality particularly associated with cardiac diseases. In order to provide representation of larger population estimates, administrative data using ICD codes have been utilized. Accurate identification of sleep apnea is important for research related to health care utilization and health outcomes. Our aim is to validate an algorithm for identification of patients with obstructive sleep apnea using ICD 10 codes seen at UTMB.
Methods: Patient medical records were collected from University of Texas Medical Branch EHR system. We included patients who visited from 6/1/2015 to 5/31/2018 in pulmonary or primary care clinics who had any sleep disorder diagnostic codes (ICD-10: G47.30, G47.31, G47.33, G47.34, G47.36, G47.20, G47.10, G47.39, G47.8, G47.9, F51.13, F51.09, R06.89, J96.90, R40.0, F51.9, R06.83, R06.3, G47.63, G47.39, Z86.69). Two algorithms were created. First algorithm included patient with sleep diagnostic codes used at 2 separate office visits. Second algorithm included patients with sleep diagnostic codes and evidence of sleep study. The performance of most used codes was calculated individually.
Results: 1200 patients were identified with ICD codes used during two office visits. According to the first algorithm with only ICD codes 75% of patients had sleep apnea. Upon addition of evidence of sleep apnea with ICD codes the % of patients with sleep apnea increased to 95.44. Among most used ICD codes, G47.30 had 86.47% patients with sleep apnea according to first algorithm and 96.01% with second algorithm. The percentages for G47.33 was 80.86% and 96.4%, for G47.10, 78.05% and 87.67%, for R40.0 78.91% and 90.63% respectively.
Conclusion: In conclusion, claim based algorithms for sleep apnea diagnostic codes showed good test positive percentages overall, but algorithm with ICD 10 codes with sleep study performed better in identifying patients with sleep apnea than ICD-9-CM codes alone. Similarly, the individual performance of most used ICD codes was highly improved when evidence of sleep study was present.
Support (if any):

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DYNAMIC PHENOTYPE LEARNING: A NOVEL MACHINE LEARNING APPROACH TO DEVELOP AND DISCOVER NEW OSA SUB-TYPES

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Introduction: Current approach to processing polysomnography is labor intensive and produces metrics that are poor at identifying obstructive sleep apnea (OSA) phenotypes necessary to enhance personalized care. We describe our approach to utilize Dynamic Phenotype Learning (DPL) as an innovative machine learning technique to identify OSA subtypes that can better predict clinical risk and success with therapies.
Methods: This study is a collaboration between Kaiser Permanente Southern California (KPSC), a large integrated health system, and EnsoData Research, which specializes in applied A.I. analysis of physiologic waveforms. KPSC sleep medicine compiled a database of N=5,368–234,250 subjects that include Types I, II, III, or IV sleep study data, daily PAP data, patient reported data, and comprehensive electronic health record information, with present research applications to study the relationship between OSA and PAP adherence with cardiovascular outcomes, health economic impacts, novel coronavirus (COVID-19) outcomes, and predictive PAP adherence and OSA severity clinical decision tools. DPL is a machine learning method for studying known and new biomarkers and care-pathway indices, including personalized screening, diagnostic, treatment, adherence, and outcomes predictors, that can be rooted in physiologic data. DPL processes waveform signal data without scoring, annotations, or expert synthesis, by applying a novel machine learning mechanism that blurs supervised and unsupervised deep learning paradigms, to find relationships between physiome dynamics expressed in waveforms and phenotypes and endotypes of interest.
Results: We demonstrate DPL method with an illustrative study on known indices, to explain its ability to (1) lift theoretical-empirical predictive accuracy ceilings and (b) reduce several sources of bias and variance. We show DPL exceeds the ROC-AUC and PRC-AUC of equivalent deep learning models in N=30,000 Report-Demographic (ODI, PLMSI, Weight), Scoring (REM, OSA), and Waveform (EEG, PPG) datasets respectively to predict AHI, TST, Brain Age, and OSA-Insomnia. We present our current collaboration advancing DPL to

identify specific phenotypes that better predict: (a) cardiovascular risk; (b) neurocognitive outcomes; (c) response to PAP and alternative therapies.
Conclusion: DPL methods are being applied to large and comprehensive patient dataset to identify phenotypic indices and biomarkers with potential to take us beyond the AHI, and uncover relationships between OSA sub-types, treatments, and health outcomes.
Support (if any):

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SLEEP AND STROKE: IMPROVED OSA TIME TO DIAGNOSIS FOR STROKE PATIENTS USING AN INPATIENT DIAGNOSTIC AND TREATMENT STRATEGY

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Introduction: Obstructive sleep apnea (OSA) is an independent risk for development of stroke. Despite this known relationship there is insufficient screening of sleep apnea in many recognized stroke centers, including Geisinger. In 2016, 68 patients were admitted to Geisinger Wyoming Valley (GWV) with ischemic stroke. Less than 10% had a Sleep Medicine Referral. When referred, average time to CPAP initiation was 9–12 months. An ongoing quality improvement (QI) study implemented inpatient home sleep apnea testing (HSAT) for stroke patients and subsequent autoPAP, if positive. Interim analysis demonstrates high rates of OSA using this screening method, suggesting a viable mechanism for improved time to OSA diagnosis.
Methods: All patients at GWV evaluated by neurology due to acute neurologic change were considered for enrollment (9/1/2019-10/10/2020). Only patients 18 years and older hospitalized with diagnosis of ischemic stroke were included. Patients were consented for participation. The evening of enrollment an Alice NightOne HSAT device was applied by a respiratory technician. If OSA was identified, the patient was placed on APAP the following evening.
Results: A total of 302 patients were screened with 82 patients meeting criteria for enrollment (27%) and 64 consenting for participation and attempting HSAT (21%). 18 of the 82 (22%) eligible patients refused participation. 12 patients (19%) had insufficient HSAT studies to determine OSA diagnosis. Of the patients who successfully completed an adequate HSAT study 85% (44/52) had OSA identified.
Conclusion: OSA is highly prevalent in patients with ischemic stroke and represents a modifiable risk factor for recurrent stroke. At baseline, rate of and time to diagnosis of OSA was poor with less than 10% of stroke patients receiving a sleep referral and time to initiation of CPAP was approximately 1 year. Standard universal in hospital surveillance for OSA using an HSAT in admitted stroke patients appears to allow for an increased rate of capture, but perhaps also a shorter time to diagnosis. This data may also suggest that prevalence of OSA in this stroke population is similar to slightly higher than previously reported. Further analysis of this program is required to evaluate for statistical significance and impact of APAP use.
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REM PREDOMINANCE OF OSA: ASSOCIATED WITH SUPINE POSITION, BUT NOT WITH CPAP ADHERENCE

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Introduction: Obstructive sleep apnea (OSA) is a heterogeneous disease dependent on many factors including the sleep stage and the body position. OSA is often more severe during the rapid eye movement (REM) sleep stage, a phenomenon known as REM predominance. Prior studies suggested associations of higher REM predominance of OSA with younger age, higher obesity, and lower adherence to continuous positive airway pressure (CPAP) therapy, but these studies had small cohort sizes. Here we leverage home-based sleep tests (HST) that estimate REM sleep and measure body position to study REM predominance in a larger cohort of OSA patients.
Methods: We retrospectively reviewed patients who took HST at our clinic using devices based on peripheral arterial tonometry (WatchPAT, Itamar Medical). The HST results included estimated REM sleep periods and measured body positions. Auto-titrating CPAP therapy was prescribed for the majority of OSA patients diagnosed by the HST. Our inclusion criteria were: apnea-hypopnea index (AHI) above 5 / hour, estimated REM sleep time above 30 minutes, oxygen saturation below 90% (T90) for less than 10 minutes, and successful retrieval of CPAP usage data. CPAP adherence was defined as the percentage of nights with CPAP usage above four hours, and REM predominance as the ratio between REM AHI and non-REM AHI. Additionally, the percentage of estimated sleep time in supine position was calculated.
Results: Among 292 consecutive patients whose HST were reviewed, 113 patients met the inclusion criteria. The 25th-75th percentile ranges of age, body mass index (BMI), AHI, REM predominance, CPAP adherence and supine sleep percentage were 36–56 years, 28.1–38.4 kg/m2, 8.9–25.9 /hour, 1.27–2.89, 40%-97% and 28%-72%, respectively. REM predominance was not associated with CPAP adherence ($P > 0.05$), but was significantly associated with lower age, higher BMI, and higher supine sleep percentage (all $P < 0.01$).
Conclusion: We found that REM-predominant OSA is relatively more prevalent not only in young and obese patients, but in patients who sleep relatively more in the supine position. This association of REM predominance with body position is a novel finding to our knowledge. Contrary to prior studies, we did not find association of REM predominance with adherence to CPAP therapy.
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PREVALENCE OF PULMONARY HYPERTENSION IN PATIENTS REFERRED FOR SLEEP APNEA DIAGNOSTICS

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Introduction: The aim to evaluate the prevalence of pulmonary hypertension according to echocardiography in patients referred for sleep apnea diagnostics.
Methods: We included 145 patients referred to Sleep laboratory for sleep apnea diagnostics. Mean age 63,8 ± 10,4 years, BMI 34,0 ± 5,7 kg/m2, AHI 31,3 ± 20,3/h, ODI 3% 28,2 ± 19,5/h, min SpO2 77,4 ± 9,8%, systolic pulmonary artery pressure (systolic PAP) 25,9 ± 16,4 mmHg. All patients underwent cardiorespiratory and respiratory diagnostics for sleep apnea and echocardiography.
Results: From the random sample of patients referred to Sleep laboratory 14,5% (21) had systolic PAP > 40 mmHg (by echocardiography). Patients with higher levels of systolic PAP (Systolic PAP, mmHg 49,9 [43,6; 56,2] vs 20,7 [19,9; 23,5],p=0.000) had more severe OSA (AHI 35,7 [27,1; 44,3] vs 26,6 [22,6; 30,6], p = 0.029, ODI 3%, /h 35,8 [25,1; 46,4] vs 23,8 [19,8; 27,8], p= 0.017) and were more obese (BMI 37,1 [33,8; 40,4] vs 33,4 [32,4; 34,5], p=0.024). Prevalence of AHI > 30 /h was 62% in group with systolic PAP > 40 mmHg vs 23% in the group with systolic PAP < 40 mmHg. We observed differences in echocardiography, in group with systolic PAP > 40 mmHg: left atrium (4.6 ± 0,5