

Maryland Sleep Society Annual Conference 2026

Residual Sleep Apnea and Hypoxemia Despite Low PAP- Reported AHI: Literature Review

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Beyond device downloads: residual sleep apnea and hypoxemia missed by Flow-Based CPAP Monitoring

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Malhotra SR, Do QT, Gunn S, Chopra S, Lloyd KK, Thomas RJ. Beyond Device Downloads: Residual Sleep Apnea and Hypoxemia Missed by Flow-Based CPAP Monitoring. Sleep. 2026 Jul. PMID: 42436640.

Conflict of Interest Disclosures for Speakers

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Learning Objectives

- Awareness of clinical scenarios where a low PAP-reported AHI may not reflect complete treatment response and discordance between PAP-derived AHI and other measures of testing.
- Understand the potential value of additional physiologic monitoring and cardiopulmonary coupling based methods for evaluation of sleep apnea.
- Discuss the clinical implications of residual disease, particularly in patients with pulmonary or other relevant comorbidities.

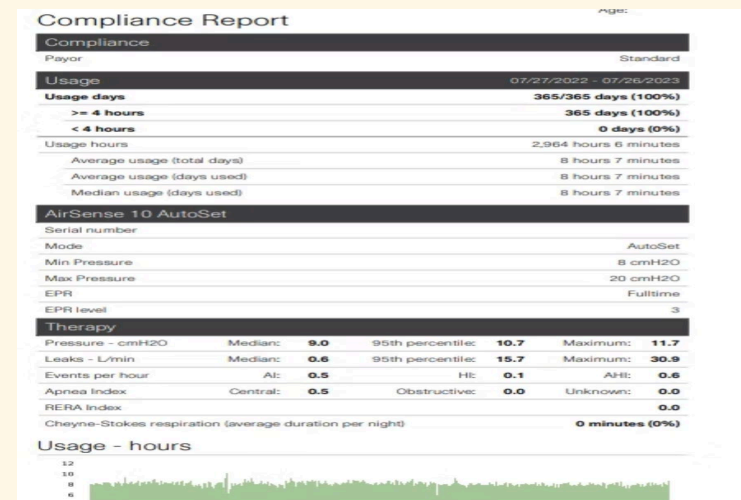
WHY THIS PAPER?

The clinical problem

- PAP downloads are excellent for usage and leak, but residual AHI is generated by proprietary flow-based algorithms
- The authors ask whether complementary physiologic monitoring detects residual disease that AHI FLOW misses
- Adherence $\neq$ treatment efficacy. When should a 'good' PAP download not be enough?

Background

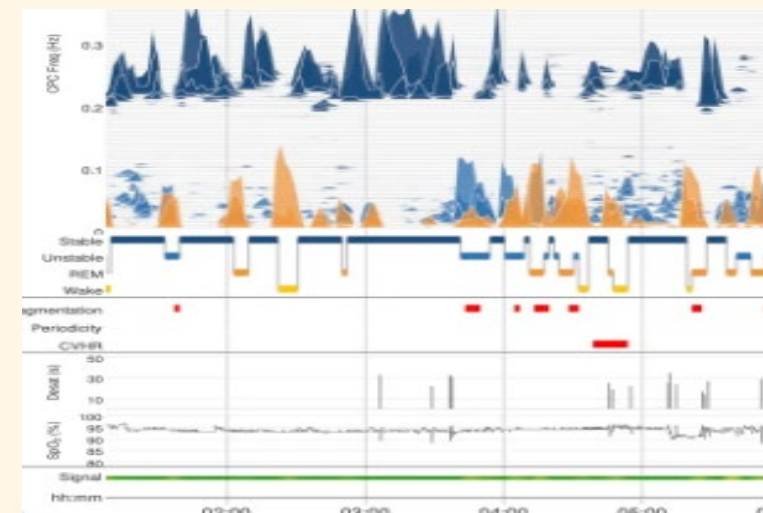
- Early PAP devices were primarily designed to **deliver therapeutic pressure**; treatment effectiveness was assessed clinically and, when necessary, with repeat polysomnography
- **Flow sensors** were added and algorithms were developed to identify **apneas and hypopneas** from changes in the airflow signal



- Cardiopulmonary coupling: computed from signals such as the electrocardiogram (ECG) or photoplethysmogram (PPG). Oximetry can be added

- Home sleep apnea test routinely use ECG/PPG and arterial tonometry techniques for evaluation of OSA

- Data algorithms and software is used to compile CPC data into AHI



AHI FLOW versus AHI CPC

PAP AHI FLOW

- Flow-based event detection from PAP device signals
- Manufacturer-specific proprietary algorithm
- No EEG or direct oximetry

SleepImage AHI CPC

- ECG/PPG-derived respiration analyzed by Manufacturer-specific proprietary algorithm
- Oximetry data included
- FDA-cleared and previously validated

Study Objectives

- Compare PAP device–derived residual AHI (**AHI FLOW**) with cardiopulmonary coupling (CPC)–derived AHI (**AHI CPC**) to determine whether PAP downloads may miss residual sleep-disordered breathing
- **Methods:** Retrospective analysis of patients in a telemedicine sleep program using **ResMed PAP data** and concurrent **SleepImage CPC home sleep testing**
- **Study population:** **465 patients**, contributing **24,939 nights** of matched PAP and CPC data

Study design

465

unique patients

mean age 57.1 y

24,939

concurrent nights

median 22 nights/patient

≥4 h

required use

both PAP and CPC

2023–25

registry period

telemedicine clinic

- Retrospective observational analysis of de-identified Empower Sleep Registry data
- All PAP devices were ResMed and longitudinal home testing used SleepImage cardiopulmonary coupling (CPC) software
- Statistics: descriptive analyses, Wilcoxon/t-tests, Spearman correlation, Bland–Altman; patient-level sensitivity analysis addressed unequal night contributions

Who was studied?

57.1 y

Mean age

30.5%

Female

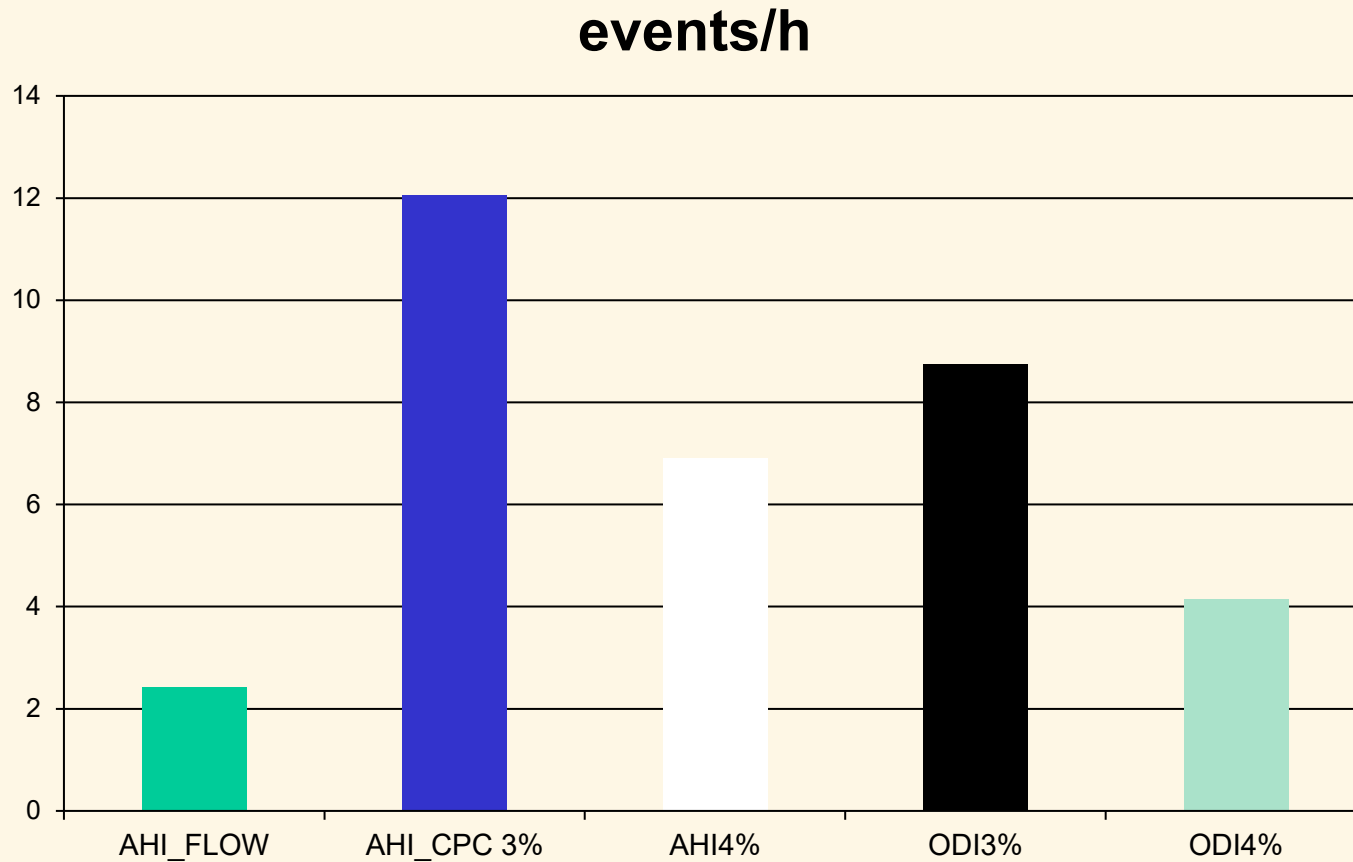
28.8

Mean BMI

kg/m²

- Co-morbidities : Hypertension 40.4%, Insomnia 43.4%; anxiety 31.8%; diabetes 11.4%; AF/flutter/SVT 8.2%; CAD 5.8%; heart failure 2.8%; COPD 1.1%
- Mean ESS 5.9
- This was a selected telemedicine population accustomed to repeated longitudinal testing—not a random sample of all PAP users

Results



2.42 / h

Mean AHI FLOW

median 1.50

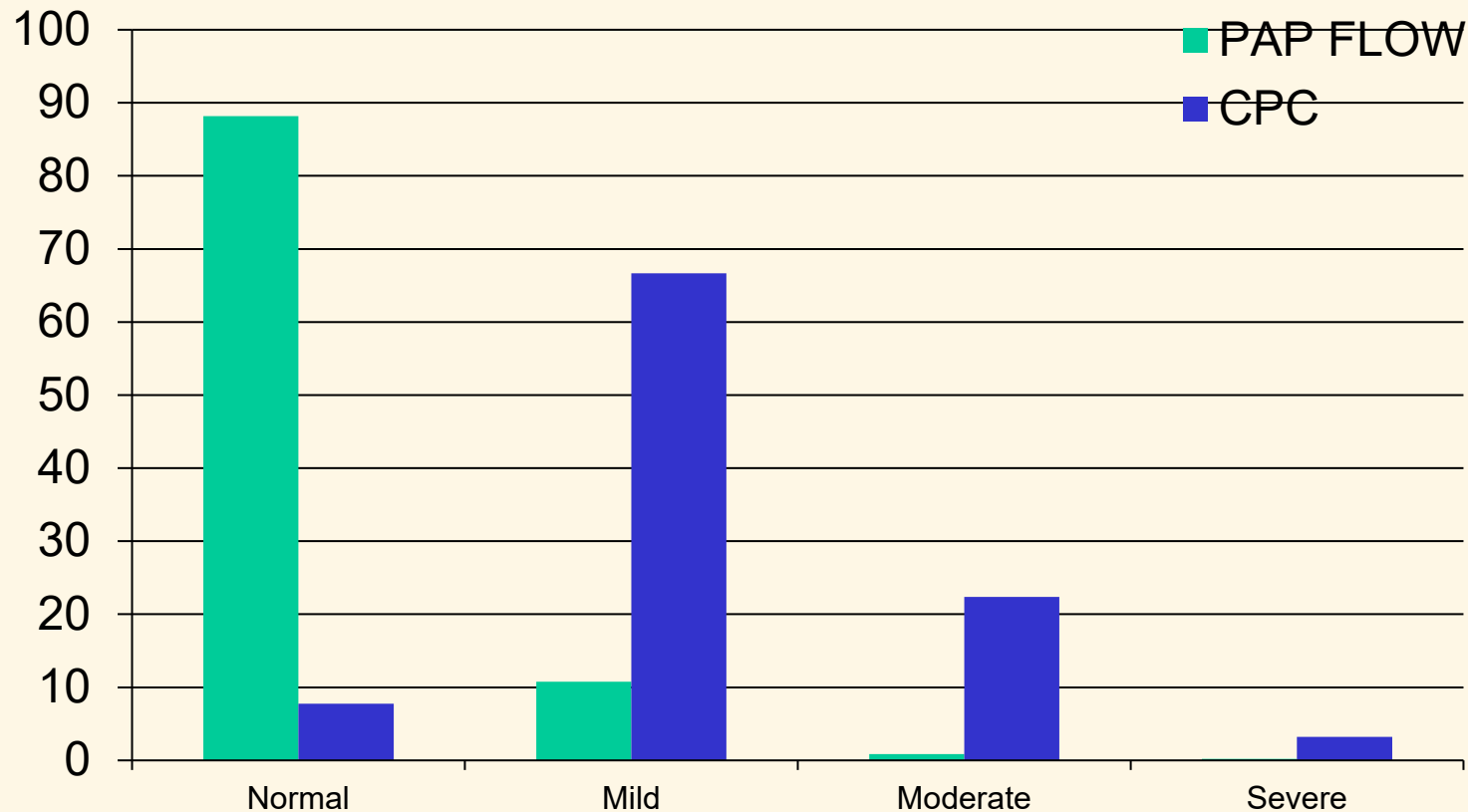
12.05 / h

Mean AHI CPC 3%

median 10.06

**Mean gap $\approx$ 9.6
events/h**

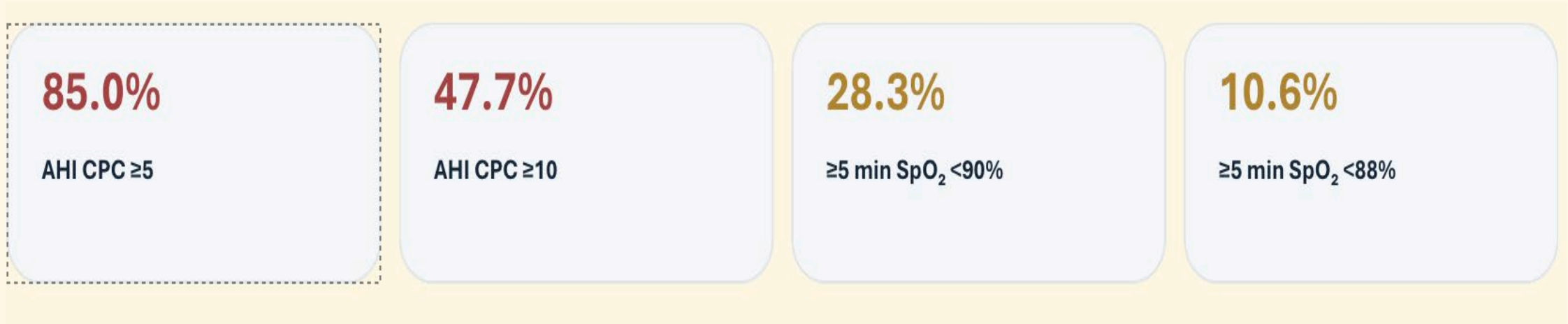
The same patients looked very different by method



**PAP: 410 / 465
classified as
AHI <5**

**CPC: 36 / 465
classified as
AHI <5**

What hid behind AHI<5?



- The largest FLOW–CPC discordance tracked with progressively worse oxygenation: among FLOW-normal/CPC-severe nights, 92.3% had ≥ 5 min below 90% and 66.7% had ≥ 5 min below 88%
- This oxygenation gradient is one of the strongest arguments that the disagreement is not merely a harmless scoring artifact

Who had residual hypoxemia?

59.7%

COPD nights

≥5 min <90%

43.4%

Stroke nights

≥5 min <90%

37.2%

Hypertension nights

≥5 min <90%

35.6%

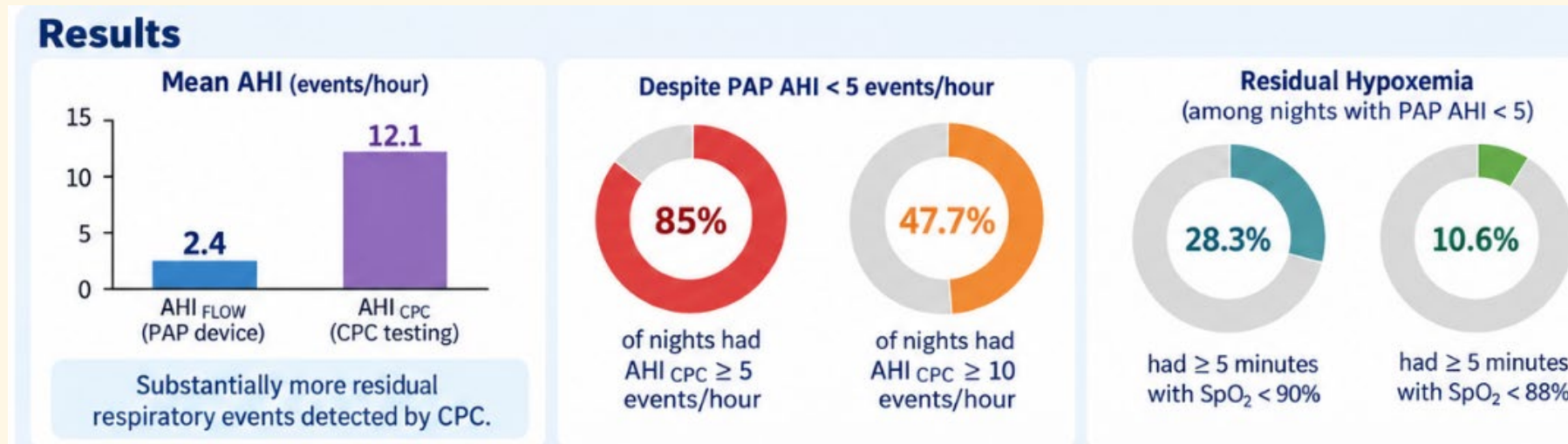
Obesity nights

≥5 min <90%

- COPD showed the strongest association
- A low AHI can coexist with clinically important nocturnal hypoxemia
- Logistic regression: higher BMI, COPD, stroke, hypertension, higher AHI FLOW, and shorter PAP usage were independently associated with residual hypoxemia

Conclusion

- Substantially more residual respiratory events detected by cardio pulmonary coupling



Best conclusion: use complementary testing selectively when symptoms, comorbidity, oxygenation, or the clinical picture do not fit the download.

What does this paper prove—and not prove?

SUPPORTED

- AHI FLOW and CPC-derived metrics can disagree substantially
- Low AHI FLOW does not exclude residual hypoxemia
- A single PAP metric can miss clinically relevant physiology

NOT ESTABLISHED

- CPC is universally more accurate than PAP
- Detecting these abnormalities improves symptoms or cardiovascular outcomes
- Hypoxemia is necessarily caused by undertreated obstruction

Critical Appraisal

Strengths

- Large longitudinal dataset
- Real-world concurrent monitoring
- Multiple oxygen-based sensitivity metrics

Limitations

- Retrospective registry; no causal inference
- No simultaneous PSG gold standard
- Selection bias from telemedicine longitudinal practice

Conflicts / funding

- Authors are is a co-inventor of the ECG/PPG spectrogram licensed to SleepImage
- No external funding

Take Home

- **A good PAP download is not always the same as good physiologic control.**
- **The paper supports a lower threshold for complementary testing in selected patients—not universal repeat testing.**
- **Complementary testing and cardiopulmonary coupling could emerge as new modalities of evaluating obstructive sleep apnea and physiology.**
- **Discussion question: Which patient with AHI FLOW <5 would make you order oximetry, HSAT, or PSG?**

Questions?

Thank You.