

Using AI to Predict Future CPAP Adherence and the Impact of Behavioral and Technical Interventions



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Introduction

Clinical Management of CPAP Adherence

- In a study conducted on 20 years of data, a CPAP non-adherence rate of 34.1% was received (1).
- Behavioral interventions:
 - Patient outreach.
 - Coaching.
- Technical interventions:
 - Troubleshooting.
 - Resupply.

The Stages of Change Model

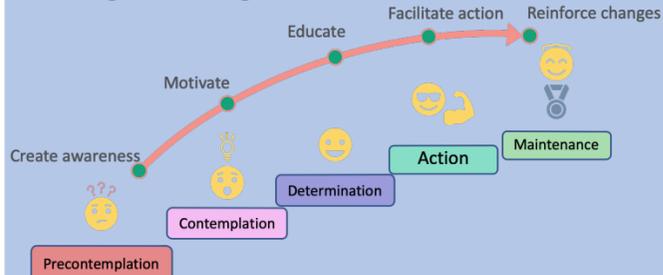


Figure 1. The Stages of Change Model. Also known as the Transtheoretical Model, this model describes people's various stages during a process of change and the actions required in order to initiate and maintain that change.

Aloia's Compliance Categories



Figure 2. Aloia's Compliance Categories. Describes the various compliance classes of a PAP user which can be utilized as triggers for different behavioral and technical interventions (2).

Motivations and Goals

- Current CPAP compliance approaches are reactive.
- Goal: Achieve a proactive algorithmic approach.
- Result: Increase staff efficiency in patient outreach.
- Hypothesis: Earlier outreach will result in more sustainable adherence and outcomes.

Methodology

The Dataset

- 14,000 patients.
- Cross-sectional cohort of 3,600 patients.
- Usage data over 455 days.
- Patient outreach notes and resupply data.
- 90-days compliance label (Yes/No).

The Rating System

- Split 30 days into 10-day groupings.
- The mode of each group was labeled with one of the following ratings:
 - A: >4 hours of usage.
 - B: <4 hours of usage.
 - C: 0 hours of usage.

Redefining the Phenotypes

Table 1. Redefining the phenotypes. Definitions of 4 phenotypes based on rating combinations.

Phenotype	Score	Rating Combination
Good User	3	AAA, AAB
Variable User	2	AAC, ABB, ABC, BBB
Occasional User	1	ACC, BBC, BCC
Non-User	0	CCC

Artificial Intelligence (AI)

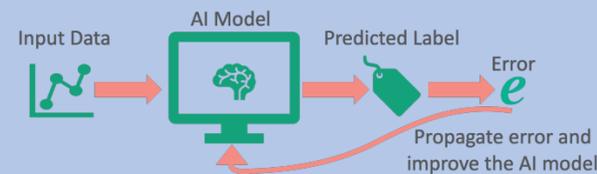


Figure 3. The Training Process. The model is trained to perform a specific task by generating predicted labels based on input data and optimizing an error function such that the predicted labels will match the true labels as much as possible.

The Suggested Workflow



Figure 4. The Suggested Workflow. Usage data of the previous 30 days is fed into an AI model. The AI model then predicts usage for the next 30 days. This prediction is converted to a 3-letter rating and an overall phenotype that represents the 30 days. This phenotype can then be used as an indicator for triggering intervention.

Results

Adherence Prediction Regression Plots

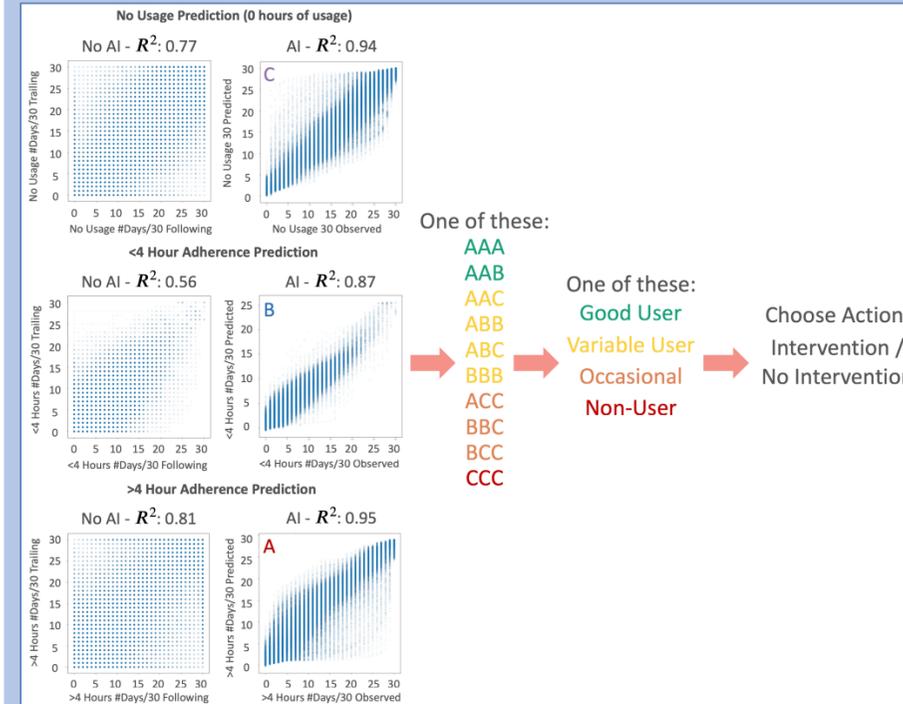


Figure 5. Adherence prediction. A comparison between the results of a non-AI predictive approach and an AI predictive model. The non-AI approach assumes that the following 30 days will be the similar to the previous 30 days. The output of the adherence prediction is then used to produce the total phenotype of the user as describe in Fig. 4.

Phenotype Prediction – Confusion Matrix and Total Metrics

Table 2. Confusion matrix for phenotype prediction. The total performance metrics (Sensitivity, Specificity, Accuracy, and Cohen's Kappa) calculated from the confusion matrix are displayed below.

	Good User	Variable User	Occasional User	Non-User
Good User	58,287	3,238	320	13
Variable User	1,817	20,315	4,148	370
Occasional User	7	6,538	39,975	9,483
Non-User	0	119	10,134	210,236

Sensitivity: 90%, Specificity: 95%, Accuracy: 95%, Cohen's Kappa: 0.83

Resupply Interventions and Adherence

Table 3. The affect of resupply interventions on adherence improvement. The mean adherence, lower and upper 95% bootstrap confidence interval, and Cohen's d were calculated for each equipment type.

Equipment	Mean Adherence Improvement (>4 hours days)	Lower 95% CI (>4 hours days)	Upper 95% CI (>4 hours days)	Cohen's d
Full Face Cushion	2.10	1.32	2.88	0.128
Filter	1.79	1.38	2.20	0.114
Pillow Cushion	1.70	1.11	2.28	0.110
Nasal Cushion	1.62	0.75	2.49	0.103
Full Face Mask	1.57	0.50	2.64	0.098

Conclusion

- Defined a new rating system for compliance.
- Used a robust AI model to predicted future adherence based on past CPAP usage.
- Identified resupply interventions correlated with an increase in adherence.
- Aid clinicians in maintaining CPAP adherence.

Future Work

- Using a higher quality and larger dataset.
- Improving the AI methodology.
- Clinical validation of predictive vs. reactive adherence alerts.
- Reinventing the intervention process.
- Applications beyond sleep medicine.

References

- Rotenberg, Brian W., Dorian Murariu, and Kenny P. Pang. "Trends in CPAP adherence over twenty years of data collection: a flattened curve." Journal of Otolaryngology-Head & Neck Surgery 45.1 (2016): 43.
- Aloia, Mark S., et al. "Time series analysis of treatment adherence patterns in individuals with obstructive sleep apnea." Annals of Behavioral Medicine 36.1 (2008): 44-53.