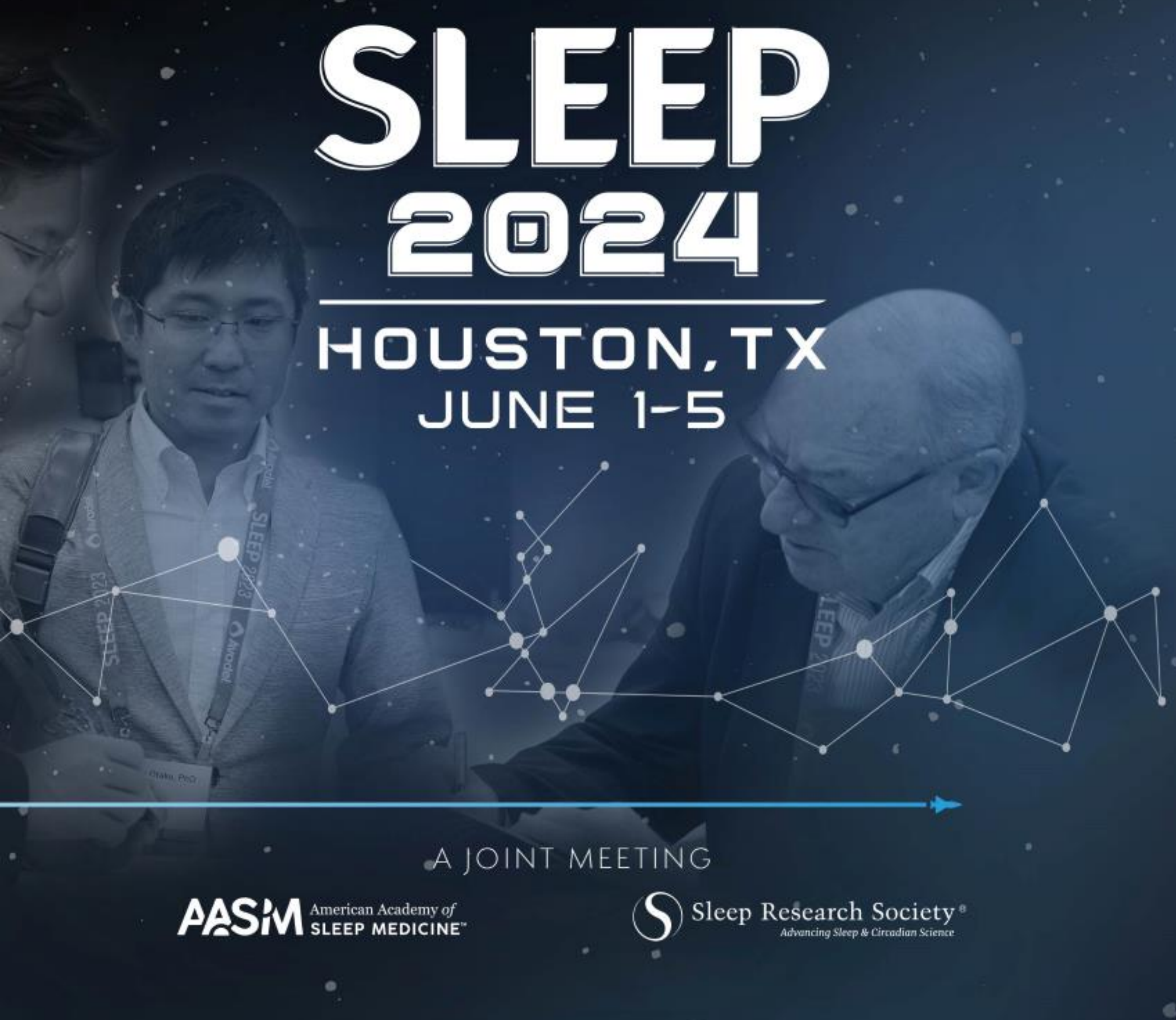

Improved Sleep Apnea Screening After Stroke Using Multimodal Wearable Sensors and Machine Learning

Jacob Sindorf

Conflict of Interest Disclosures for Speakers

SLEEP 2024

To review this speaker's disclosure information, please visit sleepmeeting.org.

SLEEP 2024 Photography Policy

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Learning Objectives

Upon completion of this activity, participants should be able to:

- Understand the need to monitor sleep early in patients with stroke
- Identify the importance of patient acceptance in sleep apnea screening
- Describe the advantages of machine learning and wearable devices for sleep apnea screening

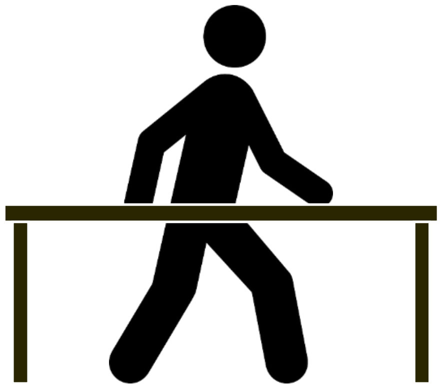
Background

Sleep is an essential factor in the **stroke recovery process**

Sleep facilitates:

- neural plasticity, learning, and memory consolidation.[1-3]

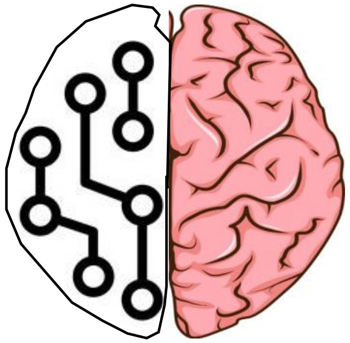
But, 50-70% of stroke survivors suffer from sleep apnea.[4]



Background

Early Continuous positive airway pressure (CPAP) improves:

- neurological and functional recovery.[5-10]



Therefore there is a need to **address sleep apnea early in stroke.**

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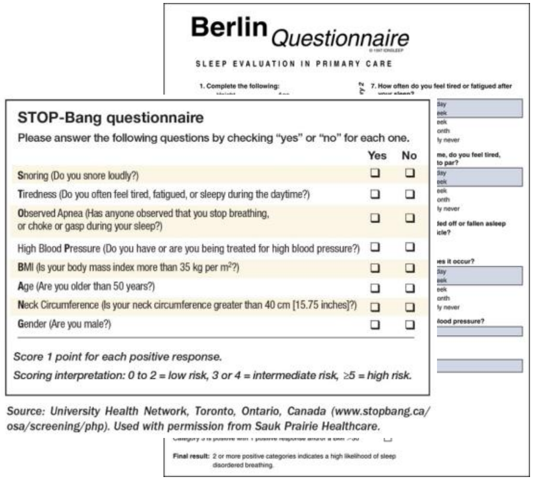
Background



Berlin Questionnaire

SLEEP EVALUATION IN PRIMARY CARE

1. Complete the following:

7. How often do you feel tired or fatigued after your sleep?

Final result: 2 or more positive categories indicates a high likelihood of sleep disordered breathing.

STOP-Bang questionnaire

Please answer the following questions by checking "yes" or "no" for each one.

	Yes	No
Snoring (Do you snore loudly?)	☐	☐
Tiredness (Do you often feel tired, fatigued, or sleepy during the daytime?)	☐	☐
Observed Apnea (Has anyone observed that you stop breathing, or choke or gasp during your sleep?)	☐	☐
High Blood **P**ressure (Do you have or are you being treated for high blood pressure?)	☐	☐
BMI (Is your body mass index more than 35 kg per m^2?)	☐	☐
Age (Are you older than 50 years?)	☐	☐
Neck Circumference (Is your neck circumference greater than 40 cm [15.75 inches]?)	☐	☐
Gender (Are you male?)	☐	☐

Score 1 point for each positive response.

Scoring interpretation: 0 to 2 = low risk, 3 or 4 = intermediate risk, ≥5 = high risk.

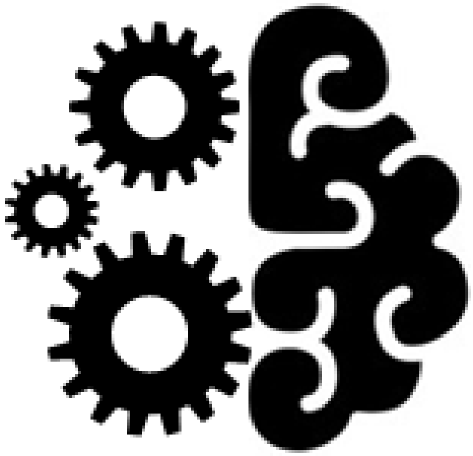
Source: University Health Network, Toronto, Ontario, Canada (www.stopbang.ca/osa/screening/php). Used with permission from Sauk Prairie Healthcare.

Current methods to screen apnea pose **challenges** in inpatient rehabilitation

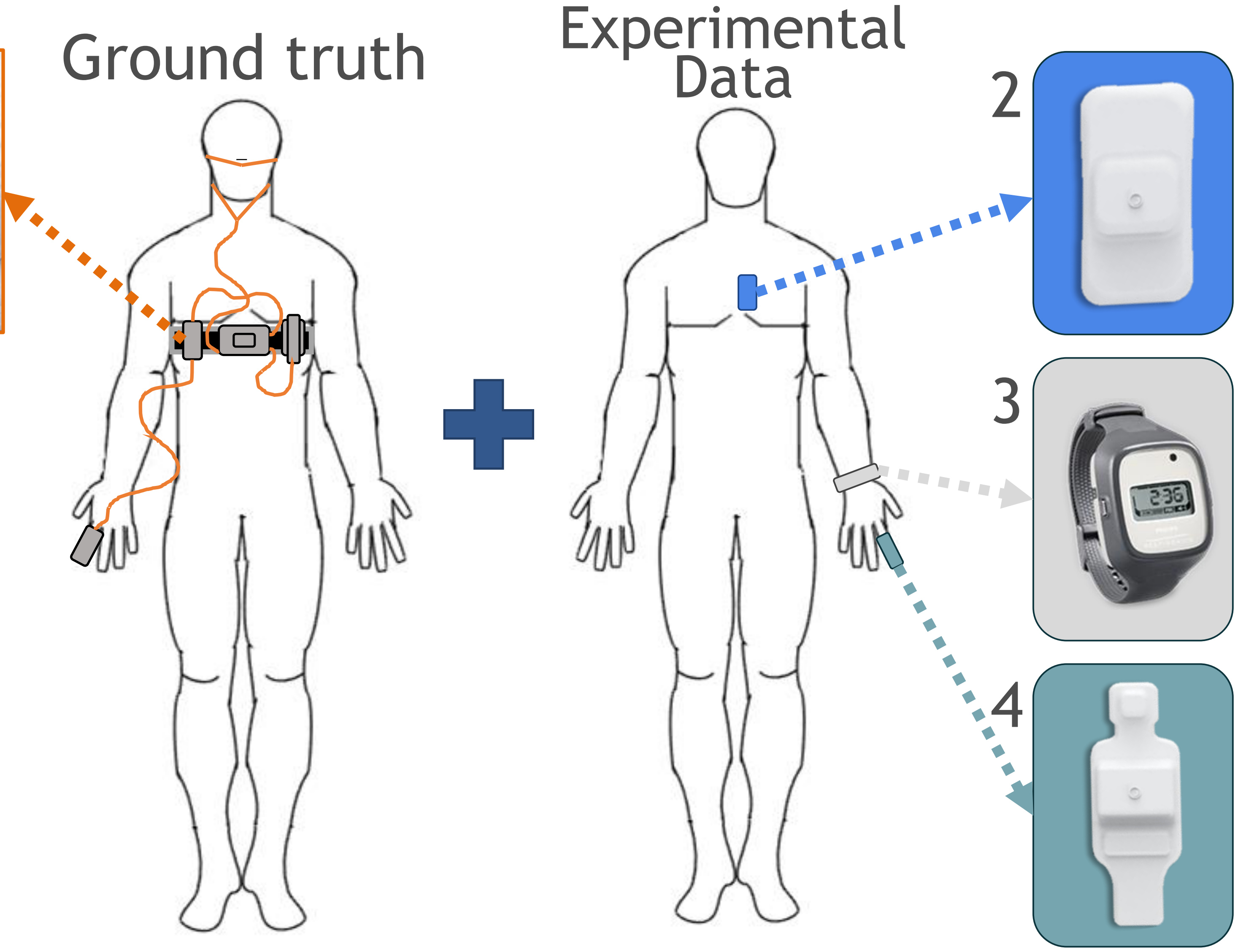
- **PSG and HSAT**: resource intensive, low patient acceptance/comfort.
- **Questionnaires**: risk assessment only.

Our Research

This study aimed to **address these limitations** by developing and validating a sleep apnea screening system for individuals with stroke, utilizing **wearable sensors** and **machine learning** which could be worn by patients during early hospitalization and post-acute care

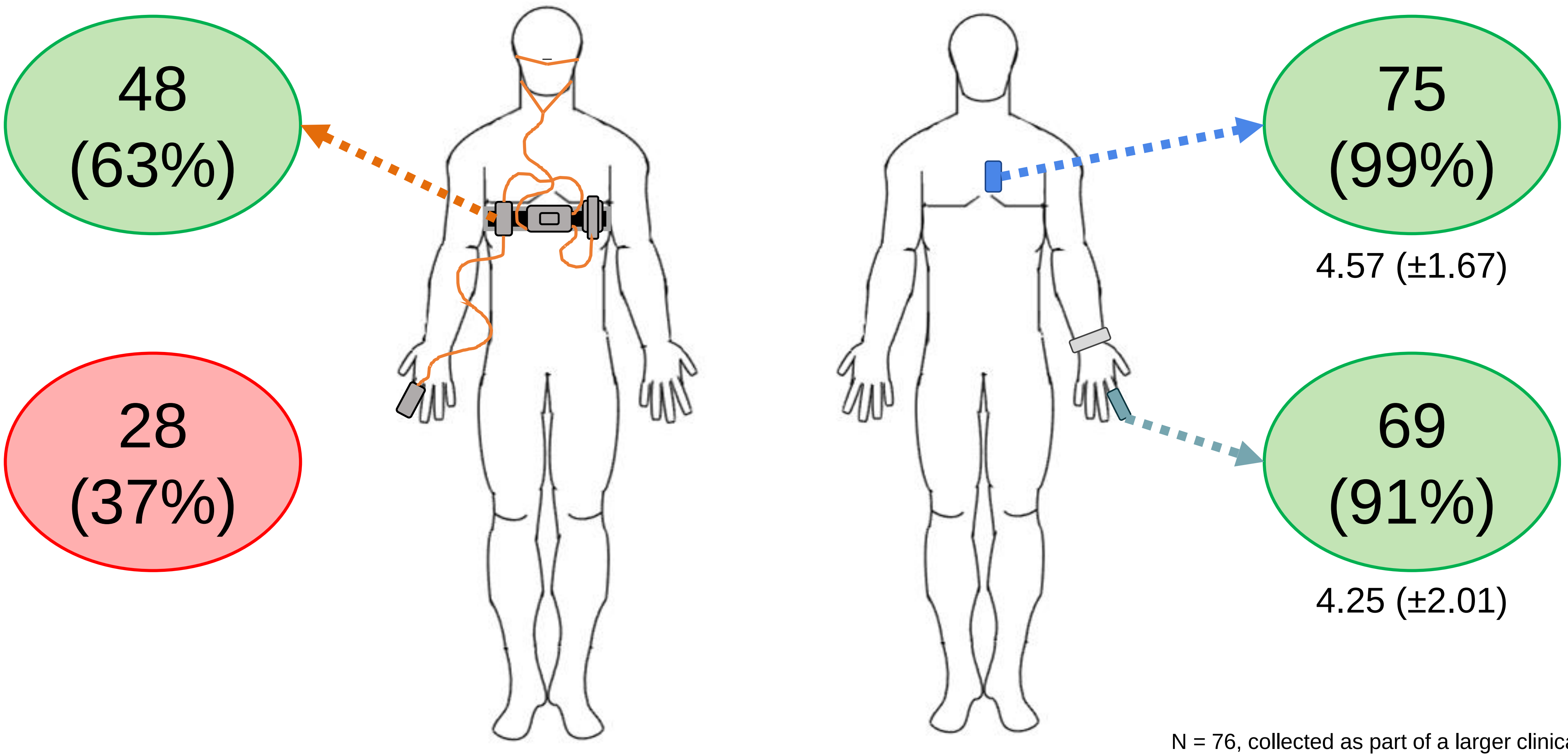


Devices



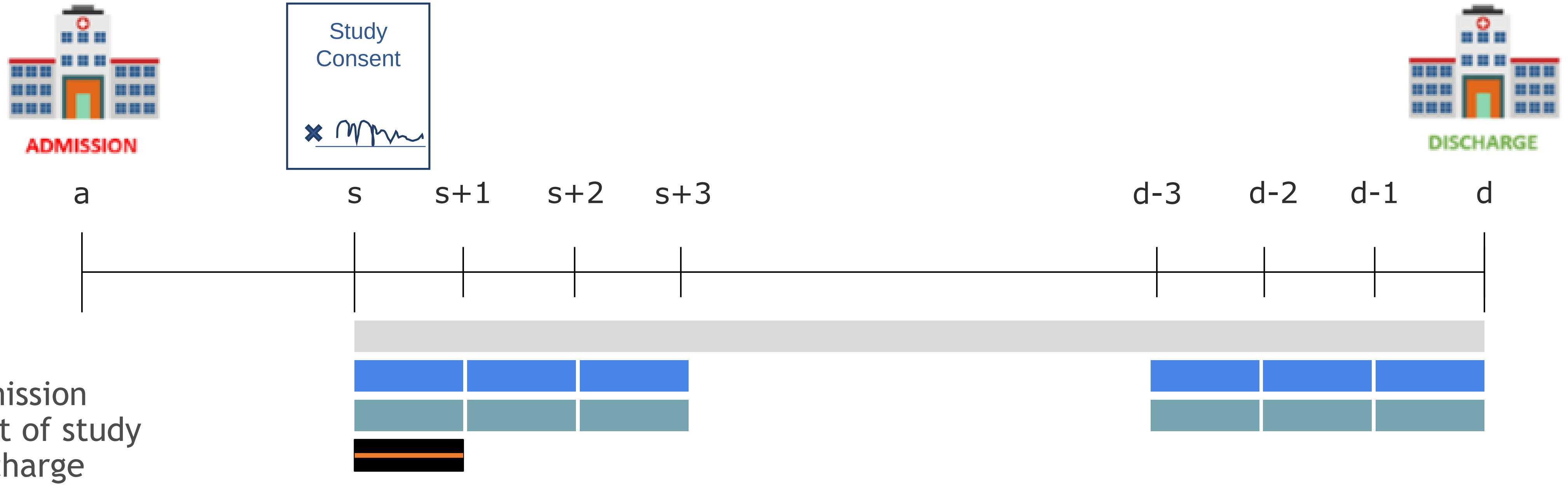
[1]ApneaLink Air HSAT
[2]Advanced NeoNatal Epidermal (ANNE) Chest
[3]ActiWatch Spectrum watch
[4]Advanced NeoNatal Epidermal (ANNE) Finger

Device Acceptance (N = 76)



N = 76, collected as part of a larger clinical trial, SIESTA-Rehab (ClinicalTrials.gov: NCT04254484)

Device Timeline



a: admission
s: Start of study
d: discharge

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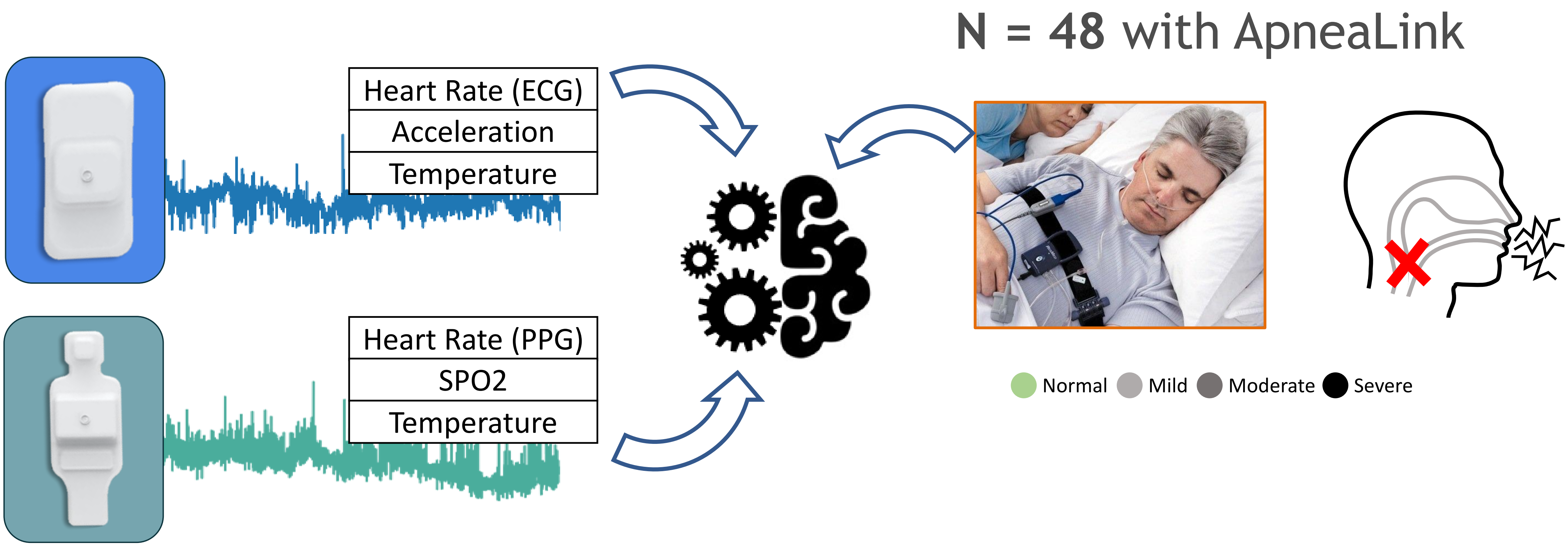
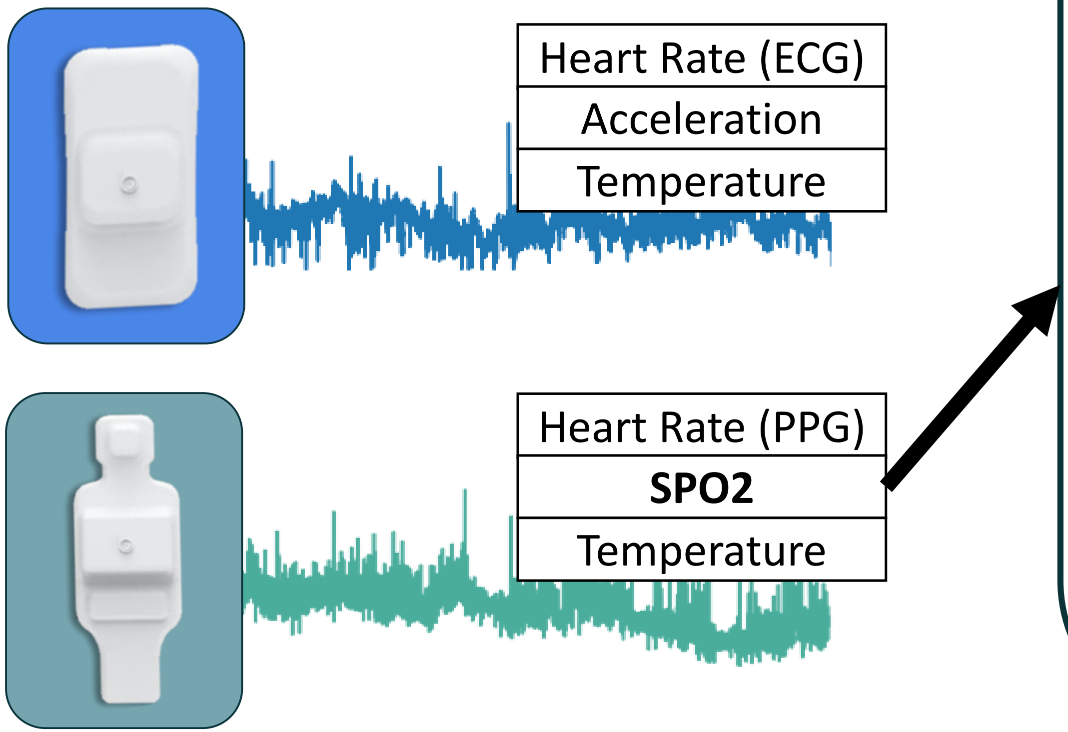
Devices for Machine Learning

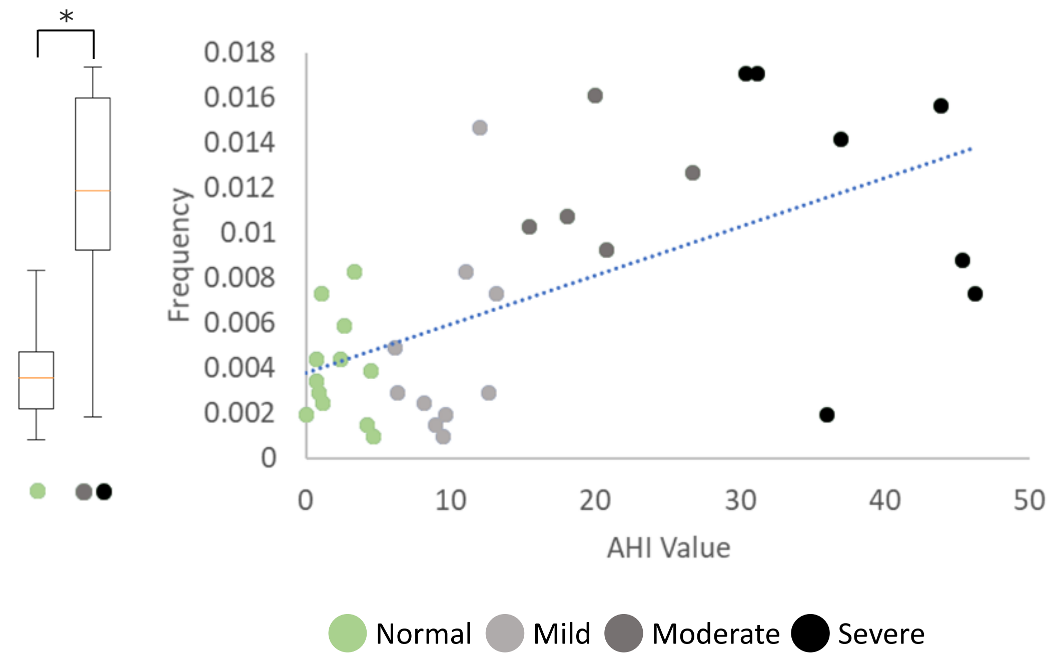


Machine Learning: Feature Design



Feature Design:

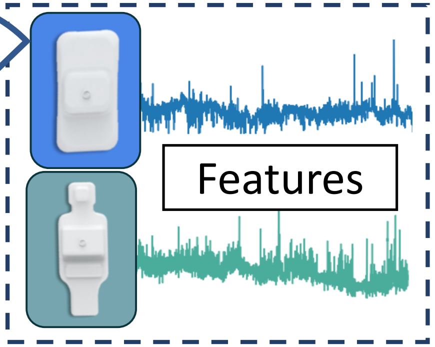
Example SpO2 PSD median frequency feature



Machine Learning: Pipeline

N=1k

Data Shuffle Split



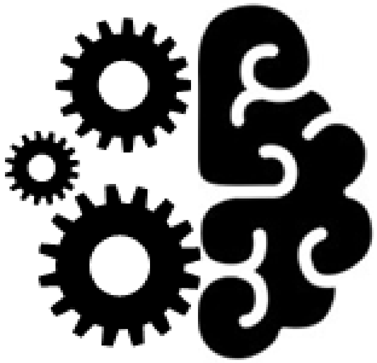
Random Search Pipeline

Feature Selection:
Variance Threshold,
SelectFromModel (Logistic Regression)

Logistic Regression

N=500

Sleep Apnea Prediction

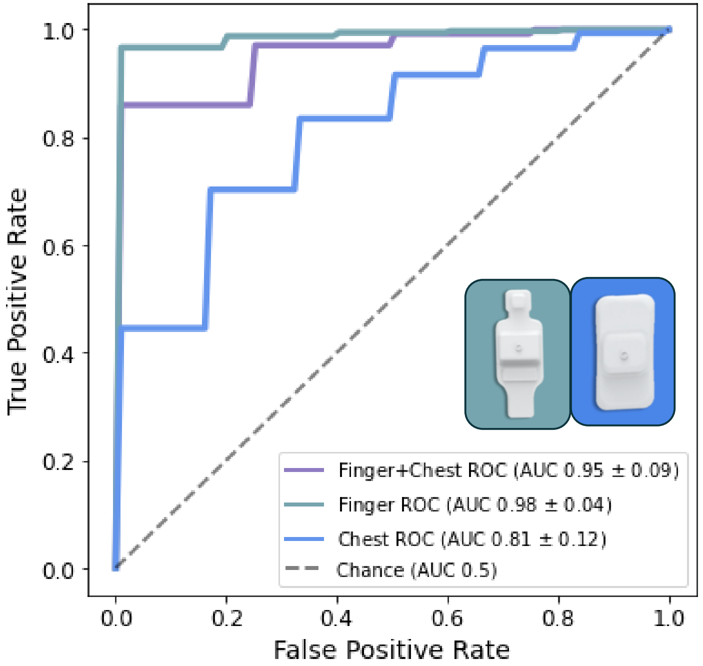


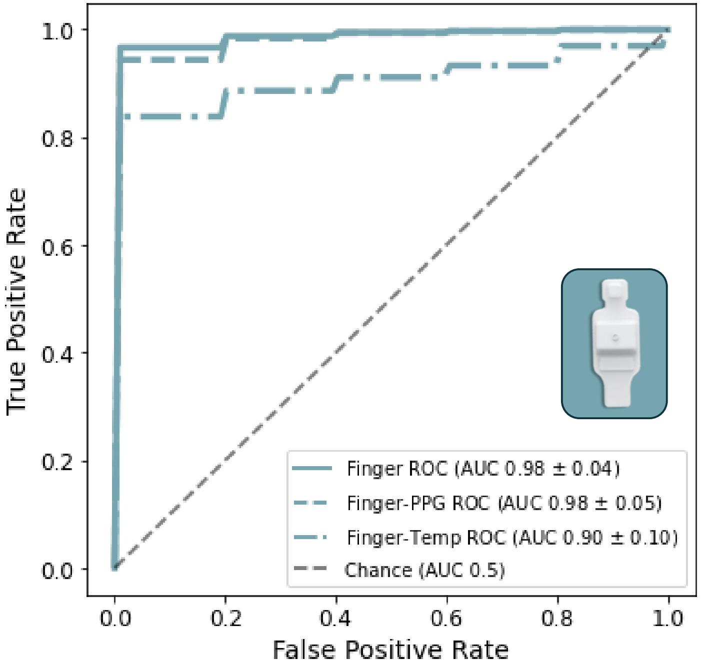
1. Normal Vs. Mild, Severe, Moderate
2. Normal, Mild Vs. Severe, Moderate
3. Normal Vs. Severe, Moderate

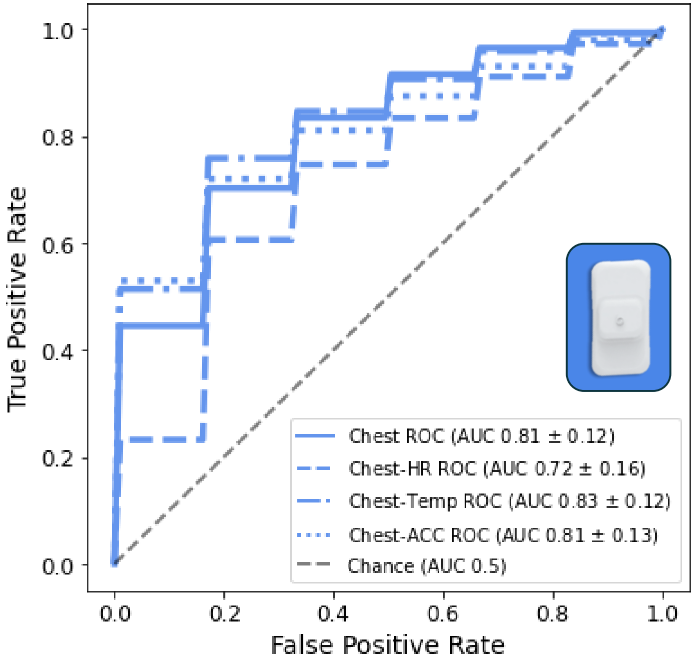
Machine Learning: Results

3 Normal Vs. Severe Moderate

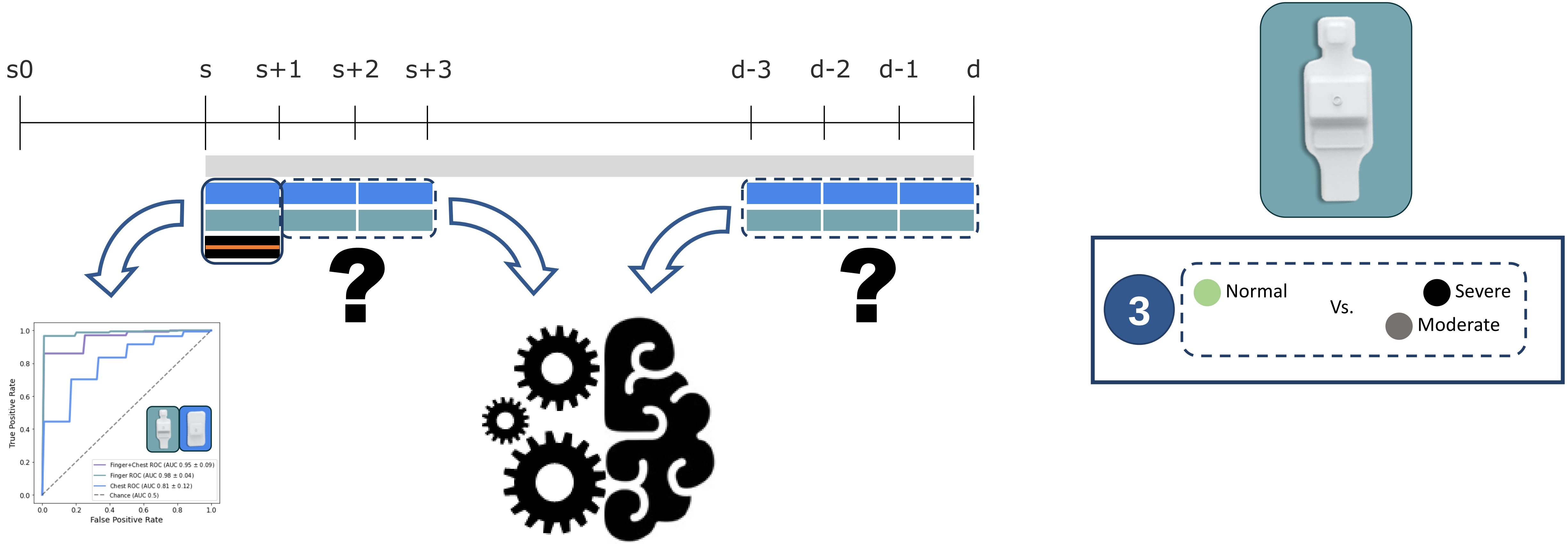
Best model:  Finger derived features







Model Deployment in Acute Care



Model Deployment in Acute Care-Validation

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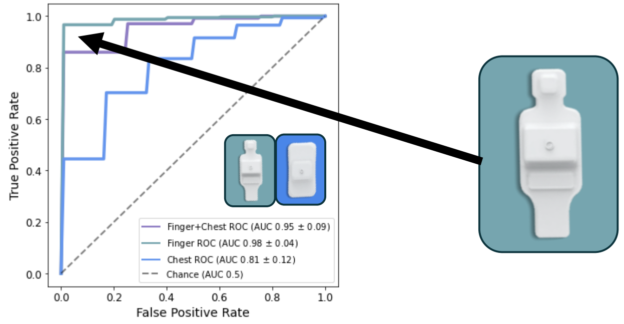
Best Performing Model:

Finger Sensor, set 3

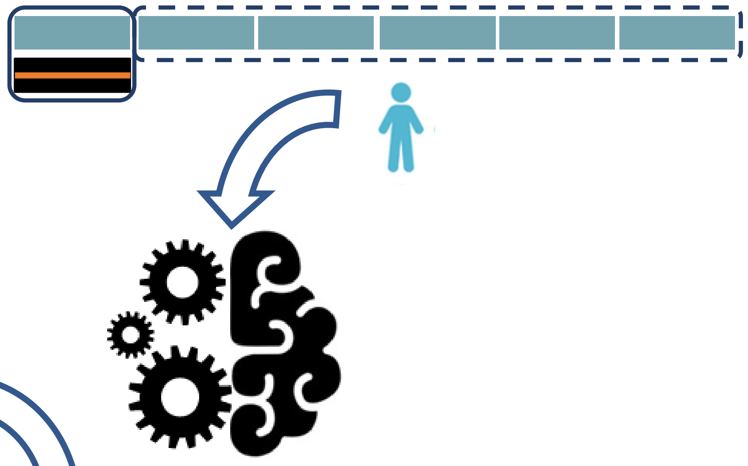
3

Normal
Severe
Moderate

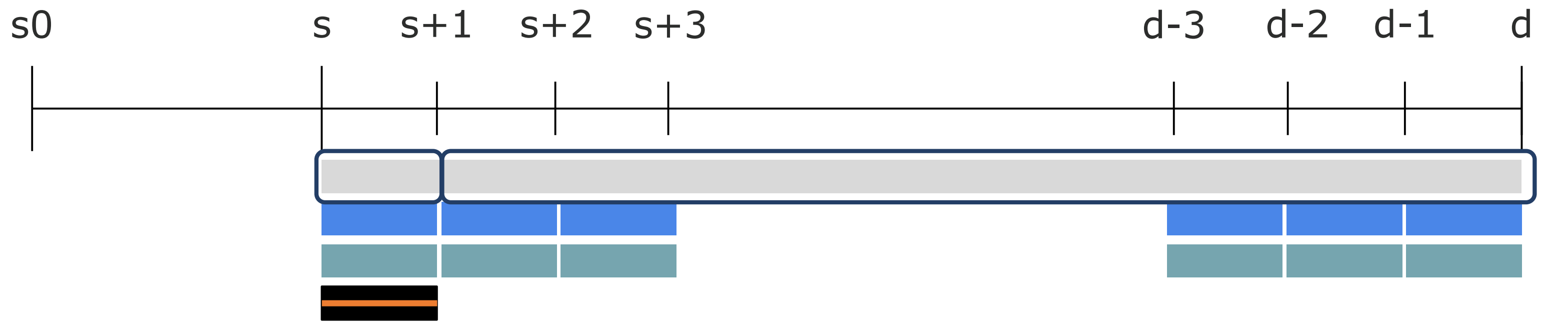


Retrain:
on all but one

Validate:
on the one excluded



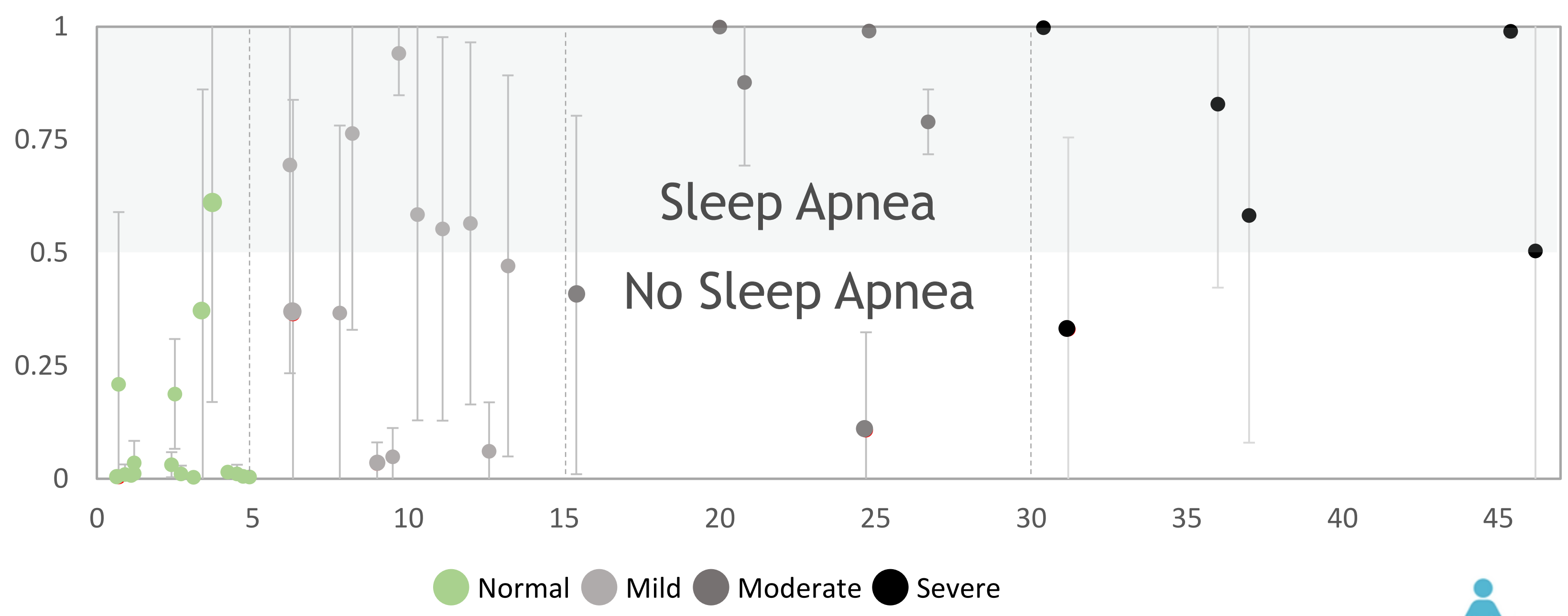
Impact of Abnormal Sleep

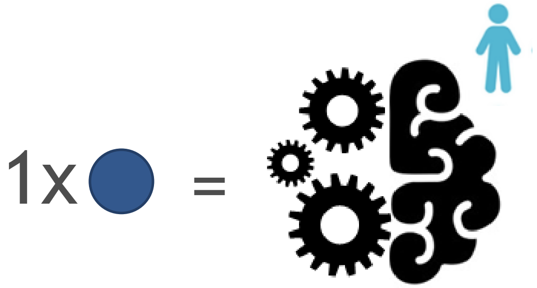


N = 8 with abnormal sleep

- ⬇ Efficiency
- ⬆ Activity Count
- ⬆ Wake After Sleep Onset
- ⬆ Fragmentation

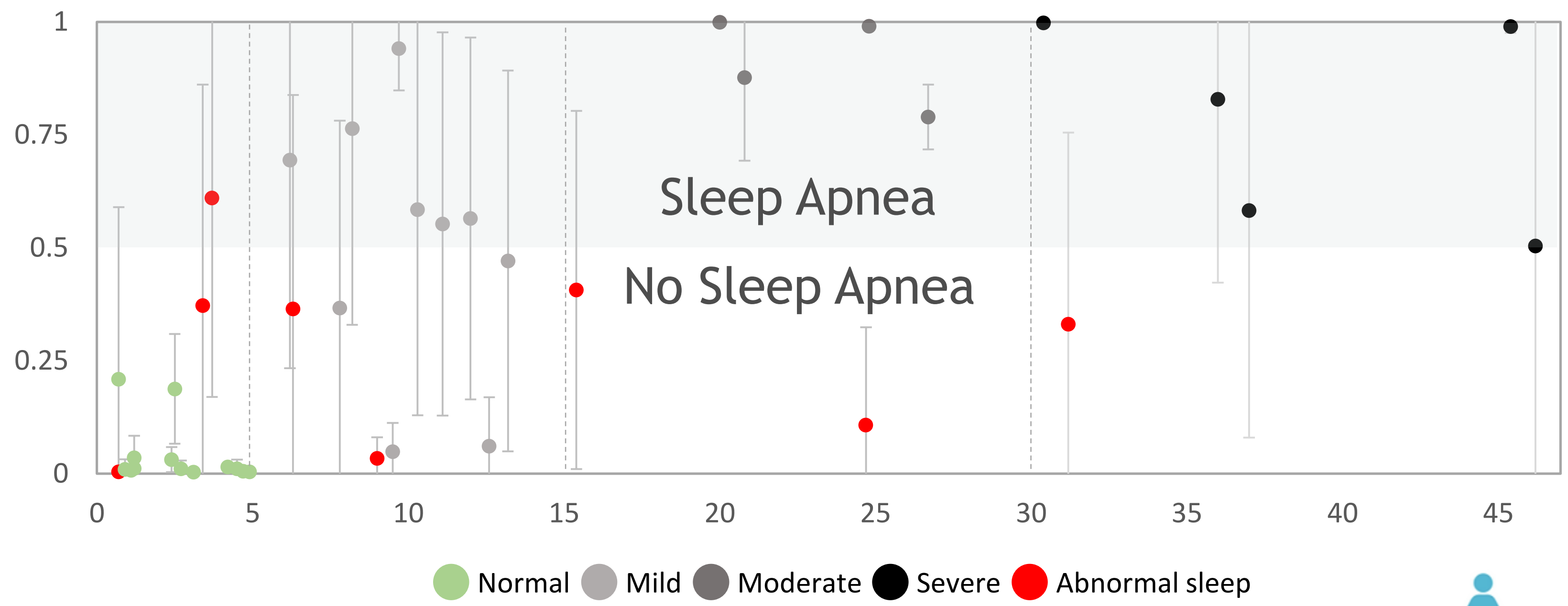
Model Deployment in Acute Care-Results

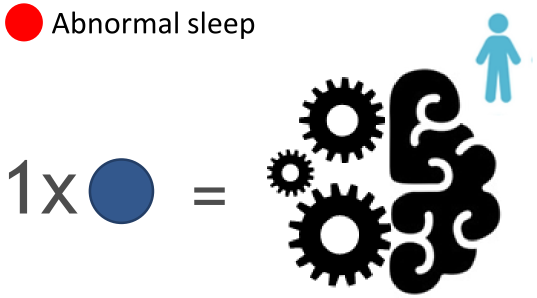




Model Deployment in Acute Care- Results

- Efficiency
- Activity Count
- Wake After Sleep Onset
- Fragmentation





Conclusion

This work highlights the potential of integrating easy-to-use, non-invasive wearable technology, continuous recordings, and automated analyses into sleep apnea screening, offering a promising avenue for improving sleep, patient care, and outcomes.

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