

The Intelligent Stroke Unit

AI-assisted monitoring of acute stroke



*Julian Klug, 2026
Geneva Stroke Lab
Department of Intensive Care Medicine, CHUV*

Preamble

Prognostication

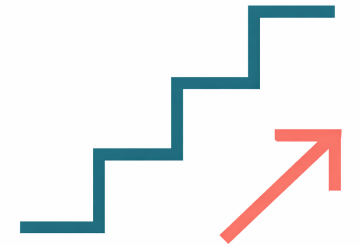
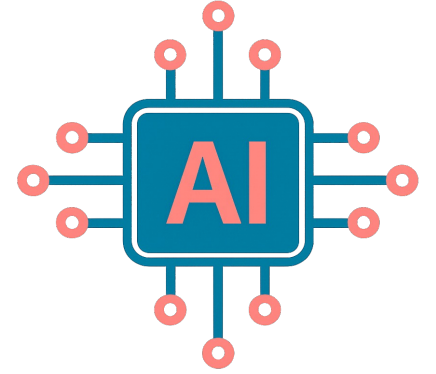
Dynamic systems

Creating the intelligent stroke unit



Preamble

- AI $\neq$ intelligent
- Continuous learning is not allowed
- Development phases
 1. Training
 2. Internal validation
 3. External validation
 4. Prospective validation -> impact?



Preamble

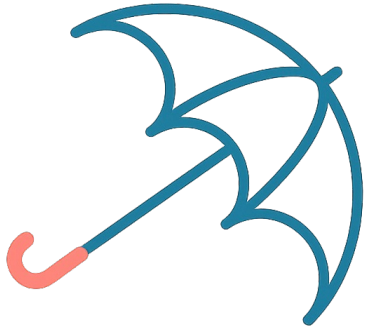
Prognostication



Dynamic systems

Creating the intelligent stroke unit

From classification to prognostication



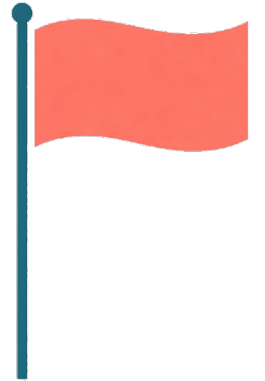
Prevention



Planning

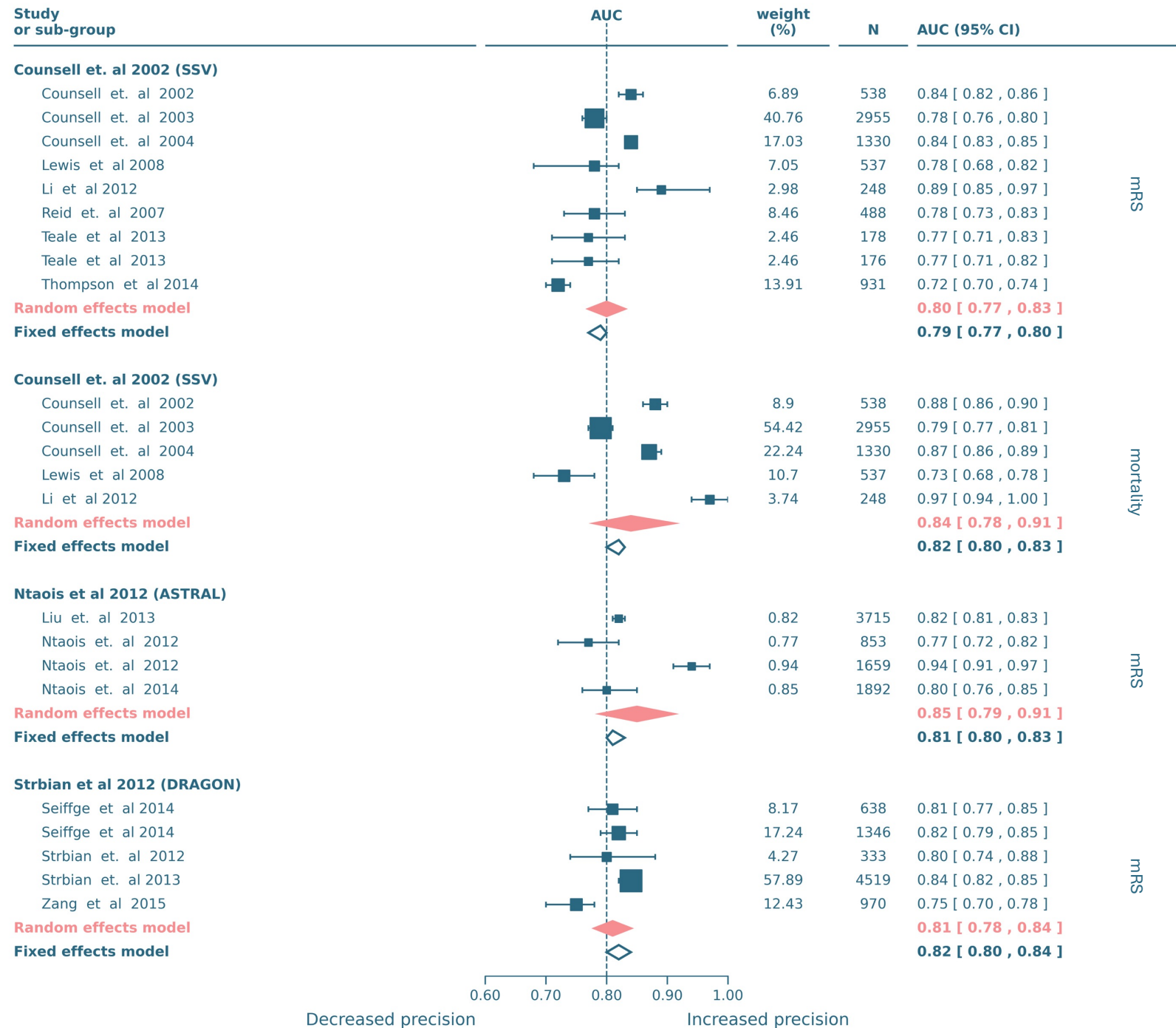
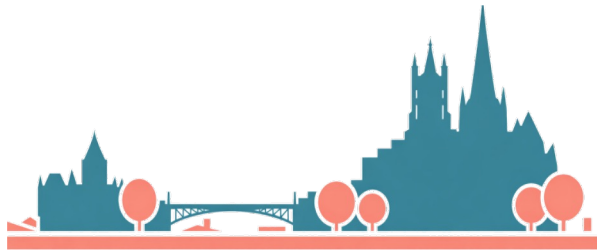


Early detection



Risk
stratification

Classical models



Prognostication



You

Provide a unique estimate of the mRS value at 3-months following mechanical thrombectomy of an anterior circulation ischemic stroke of the patient with the following characteristics: Age: 35 years ; Sex: Male ; Previous mRS: 0 Comorbidities: Atrial fibrillation: No ; Heart failure: No ; Arterial hypertension: No ; Diabetes mellitus: No ; Dyslipidemia: No ; Coronary artery disease: No ; Current smoking: Yes ; Active cancer: No ; Current medications: Oral anticoagulation: No ; Antiplatelets : No ; Statins: No ; Last-Time-Seen-Well-to-door delay (minutes): 180 ; NIHSS at admission: 9 ; Admission systolic blood pressure (mmHg): 124 ; Admission glucose (mg/dL): 107 ; ASPECTS score: 10 ; Intervention type: Thrombolysis and thrombectomy ; Last-Time-Seen-Well-to-needle time if IV thrombolysis (minutes): 740 ; Occlusion site: M1 ; Tandem occlusion: No ; Last-Time-Seen-Well-to-puncture time (minutes): 429 ; General anesthesia during mechanical thrombectomy: No ; Final mTICI score: 2c ; Total number of device passes: 2 ; Last-Time-Seen-Well-to-reperfusion time (minutes): 545.



ChatGPT

Considering the provided information and the generally positive indicators for a favorable outcome, a unique estimate for the mRS at 3 months following mechanical thrombectomy could be 1.

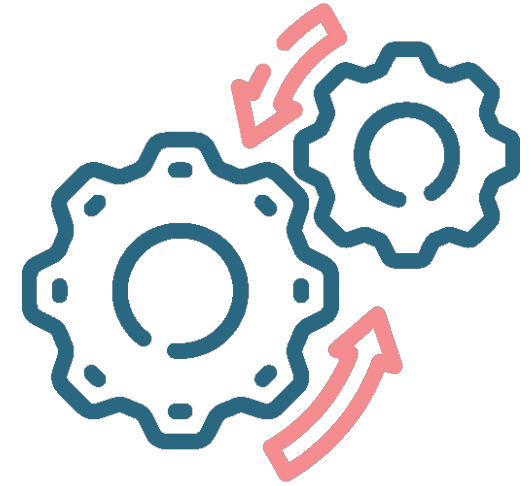
Accuracy 49%

Preamble

Prognostication

Dynamic systems

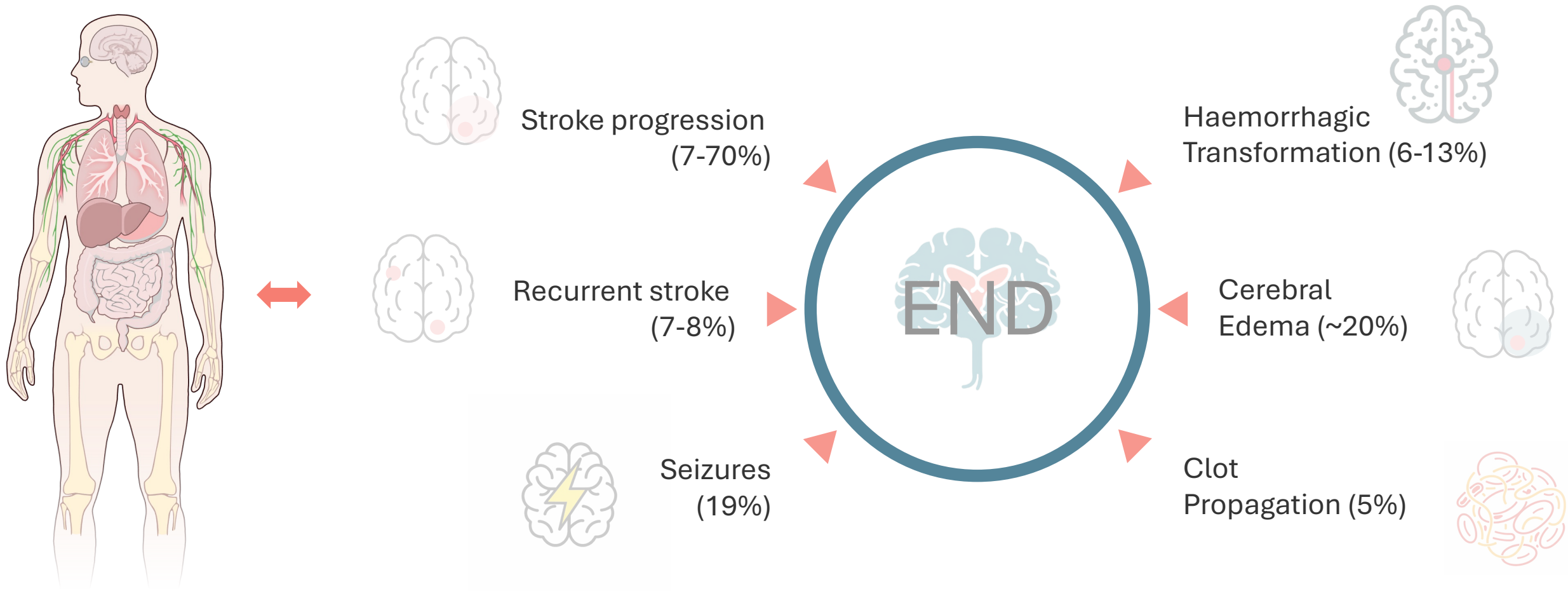
Creating the intelligent stroke unit



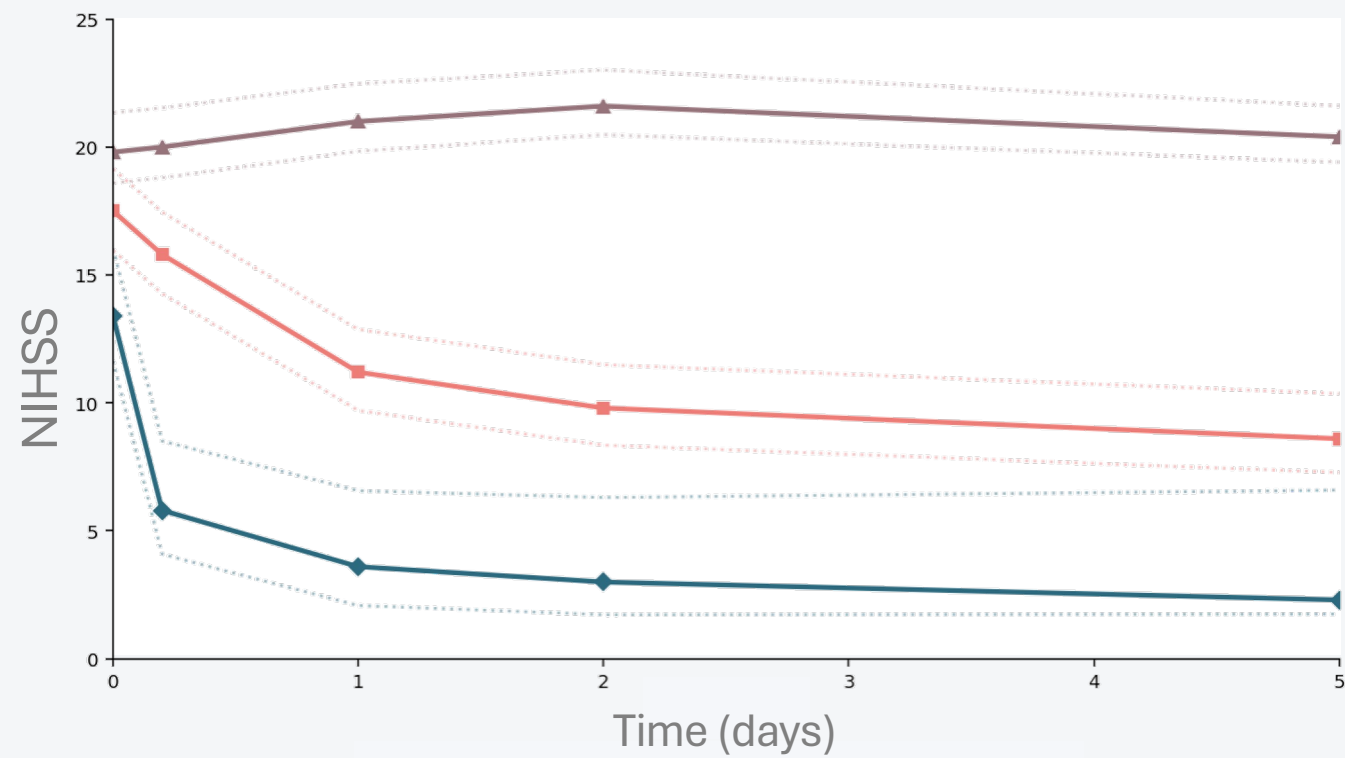
Dynamic?



Early neurological deterioration



NIHSS Trajectory

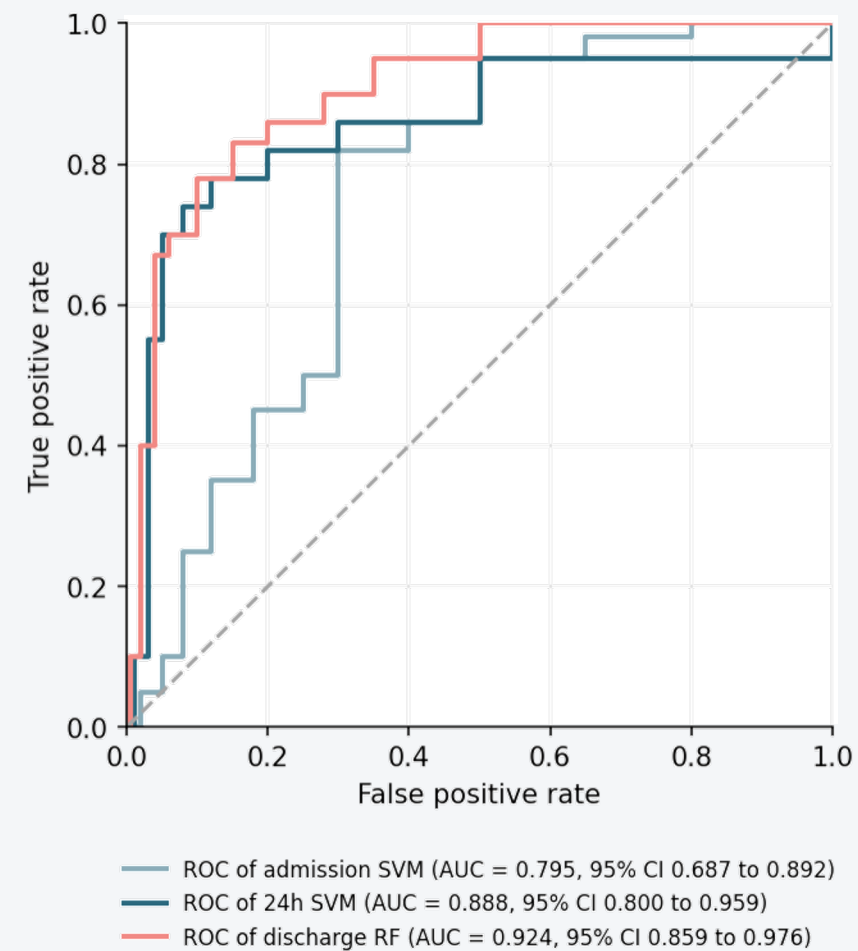


 3%

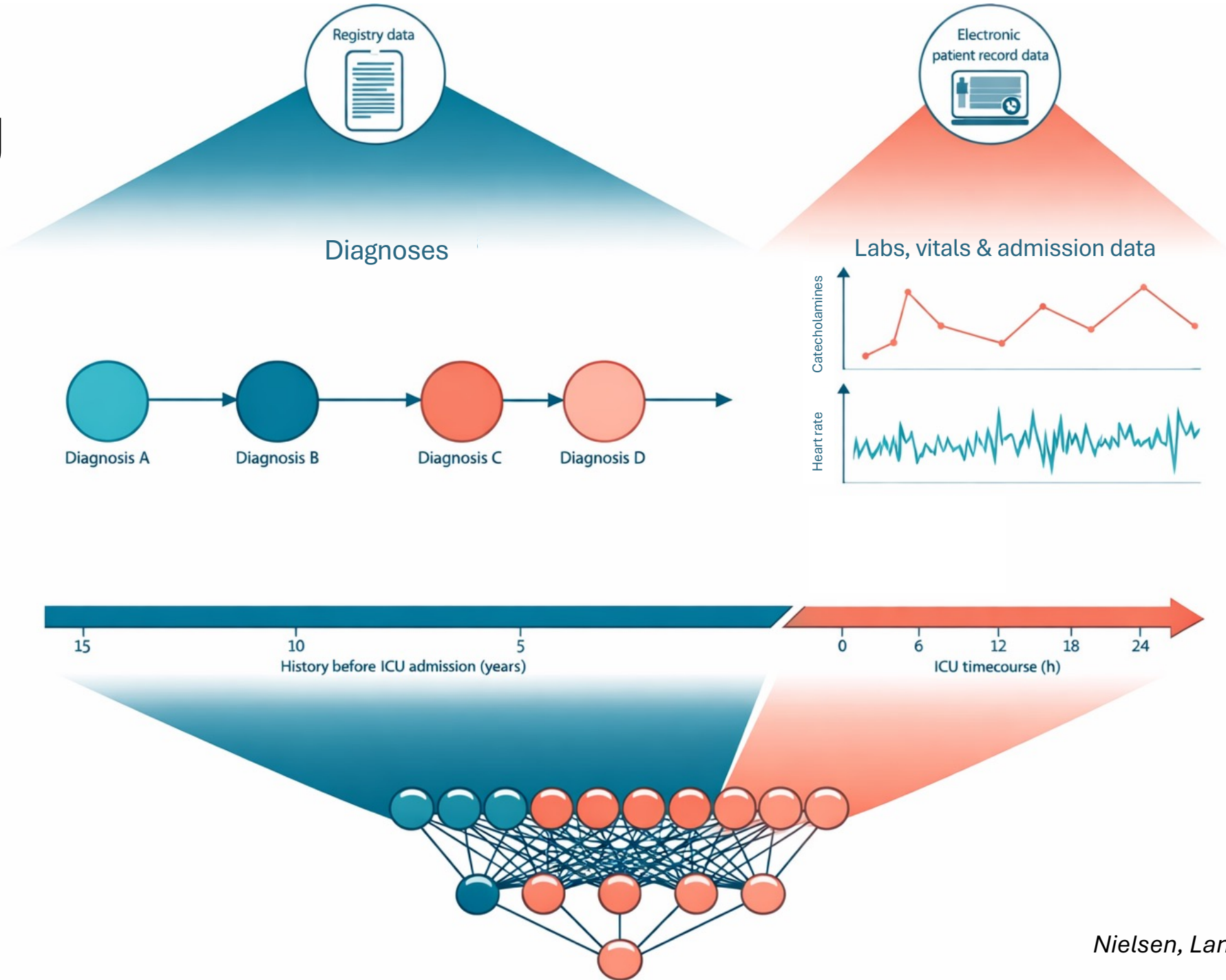
 11%

 44%

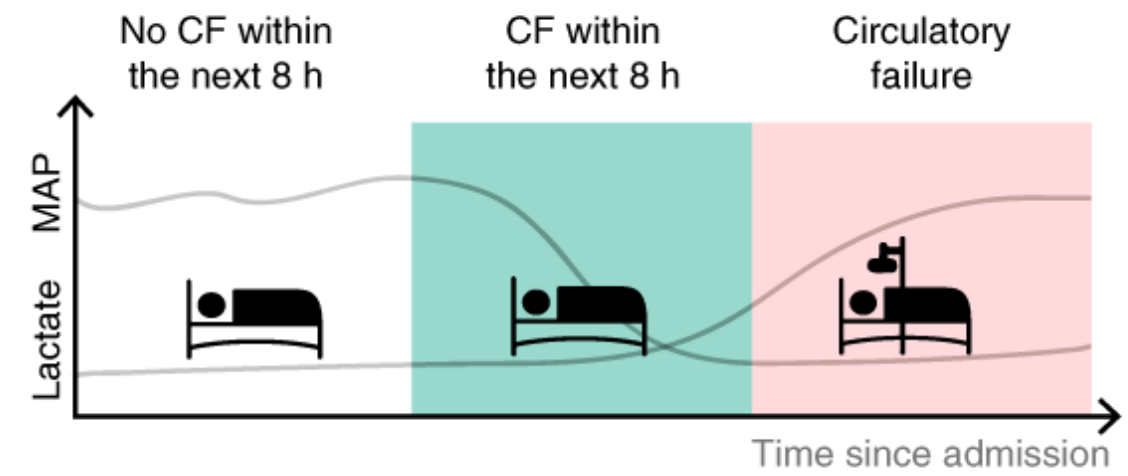
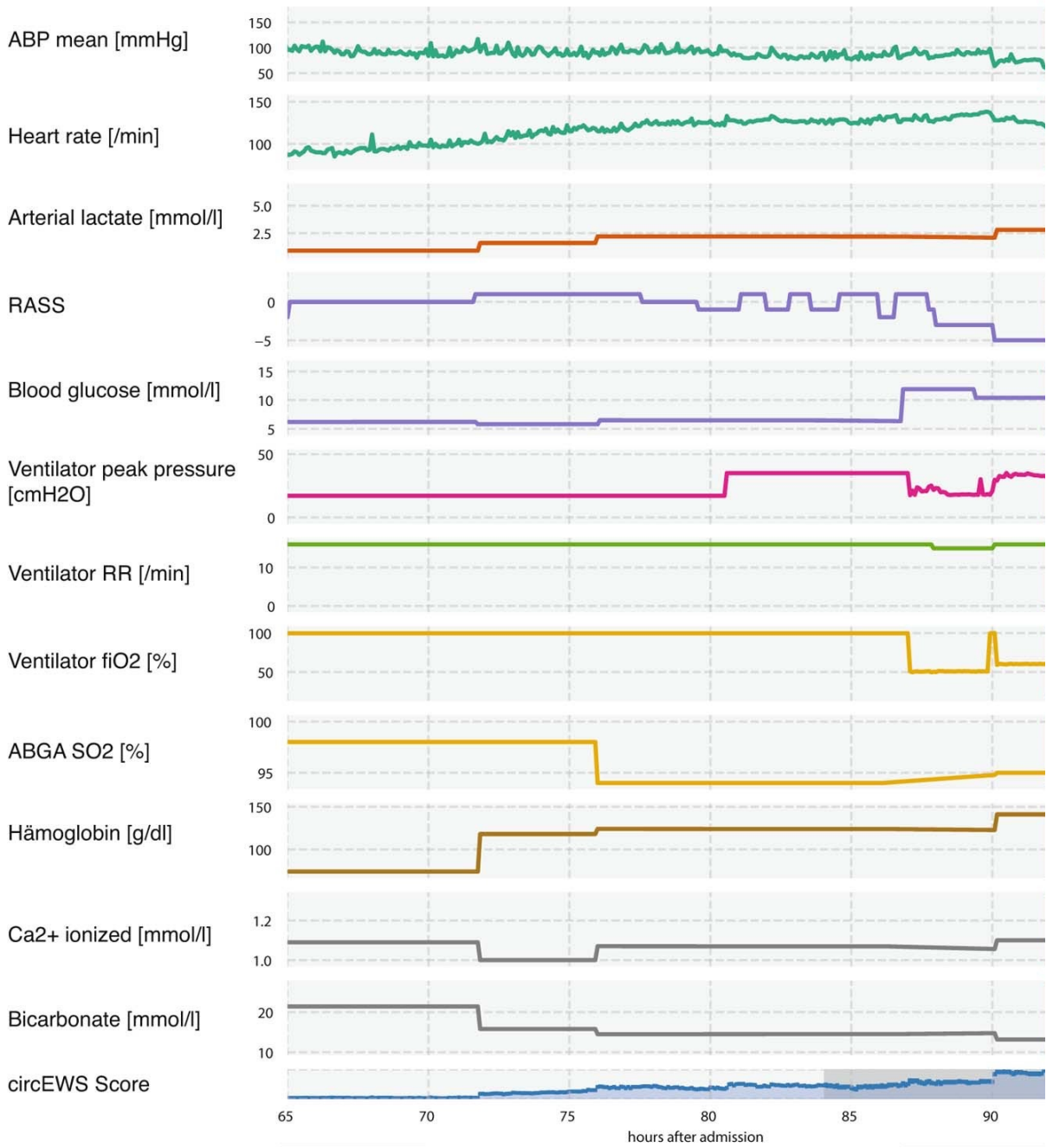
Prognostic value



ICU



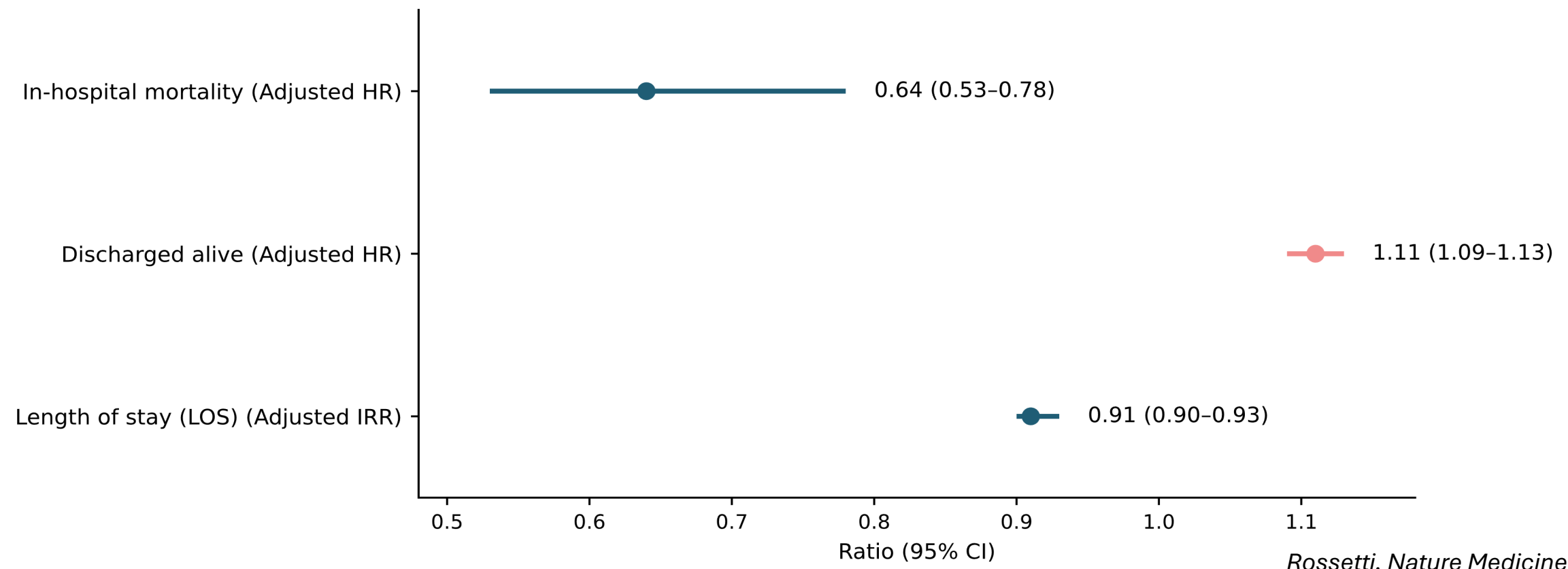
Variables





Cluster-randomized
controlled trial

60'893 patients



Preamble

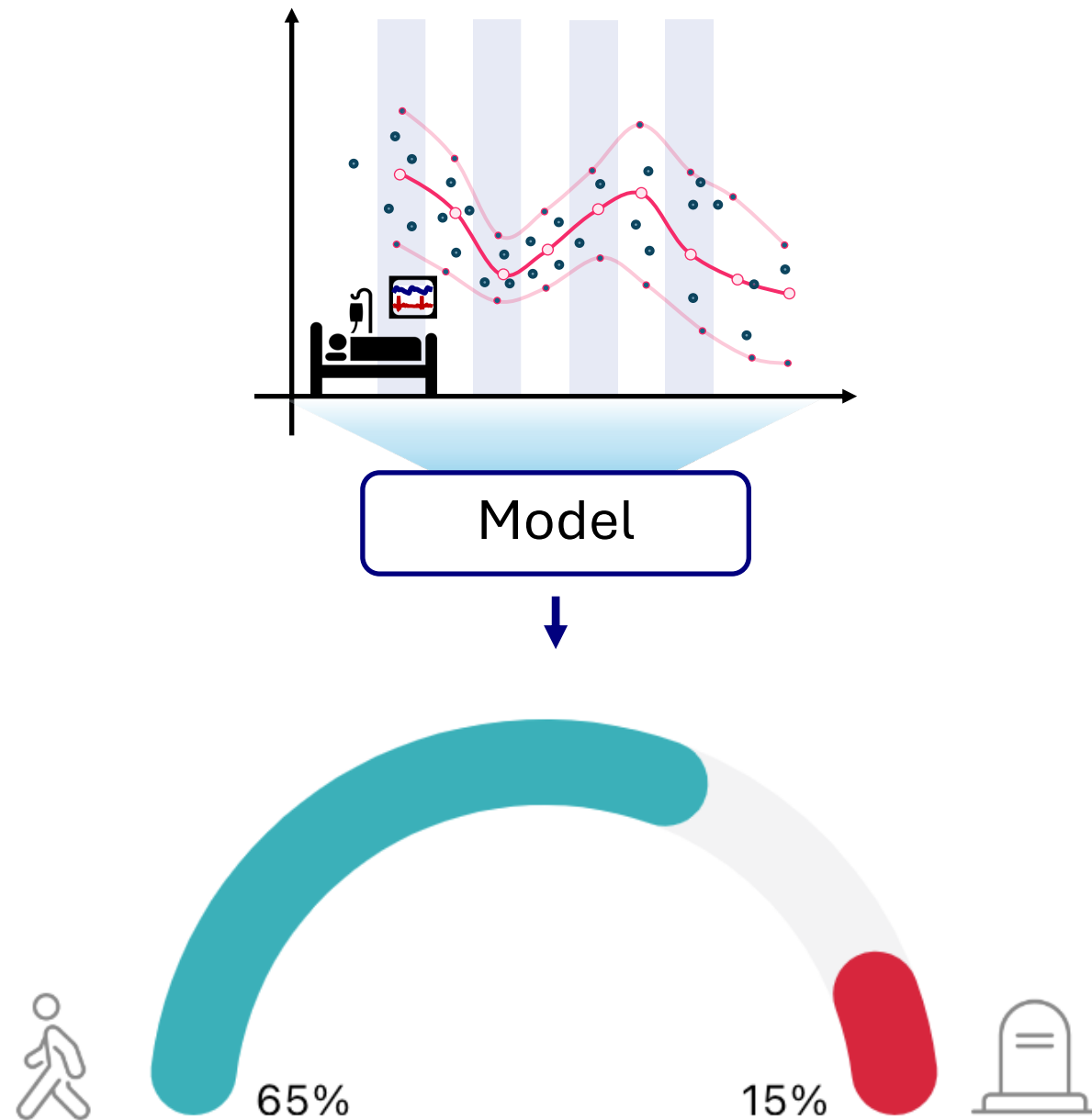
Prognostication

Dynamic systems

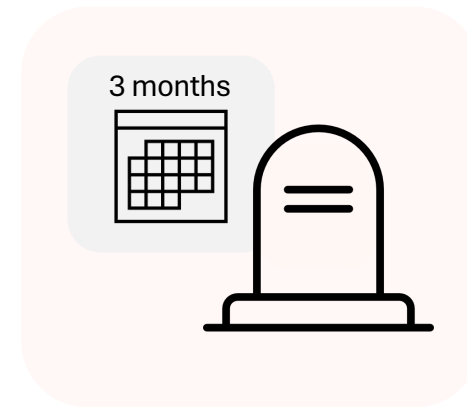
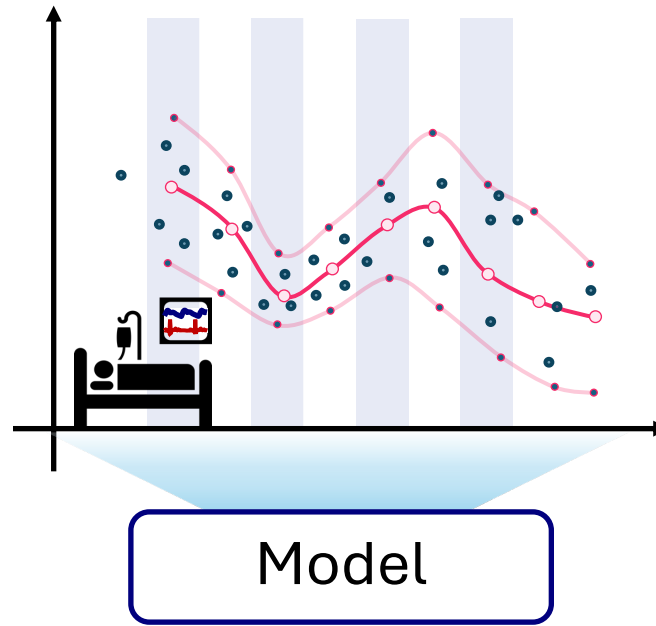
Creating the intelligent stroke unit



Intelligent stroke unit



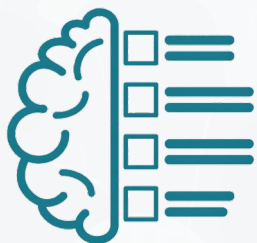
Intelligent stroke unit







Development
Geneva Hospital
2018-2021



NIHSS 3

2359 Patients

77 years

55% male

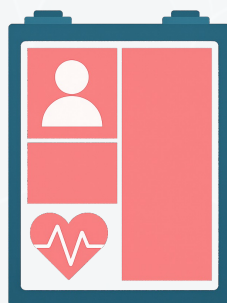


24 kg/m² BMI

68% Hypertension

21% Diabetes

20% Afib





Development
Geneva Hospital
2018-2021



NIHSS 3

2359 Patients

77 years

55% male

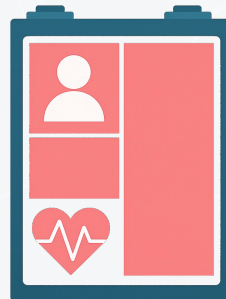


24 kg/m² BMI

68% Hypertension

21% Diabetes

20% Afib



247 Patients

73 years

49% male

30 kg/m² BMI

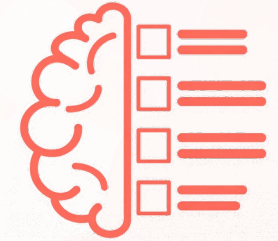
68% Hypertension

21% Diabetes

31% Afib

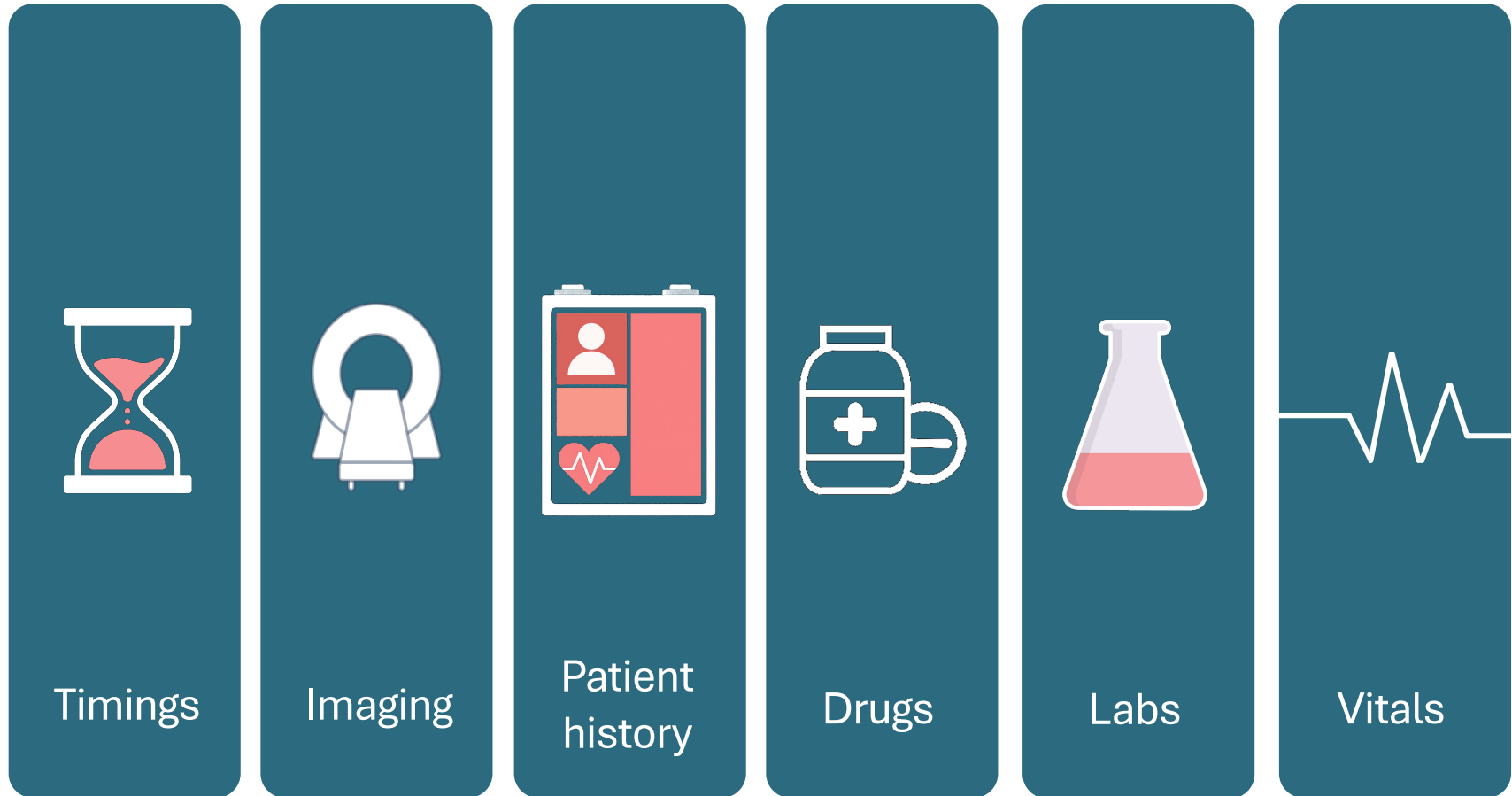


External validation
Beth Israel Deaconess
2008-2014
MIMIC-III

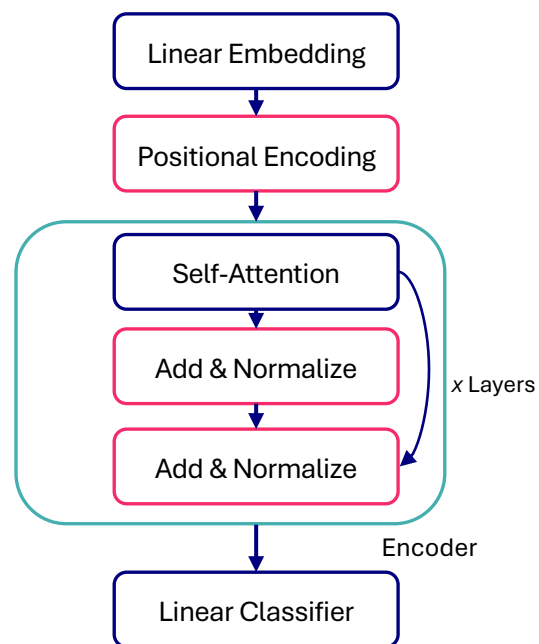


NIHSS 13

84
variables
72 hours



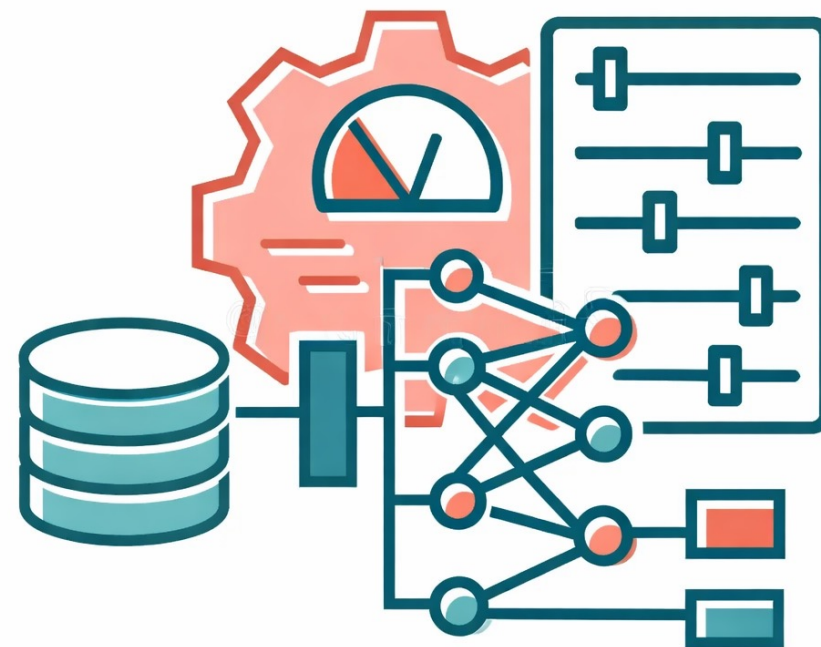
Transformer



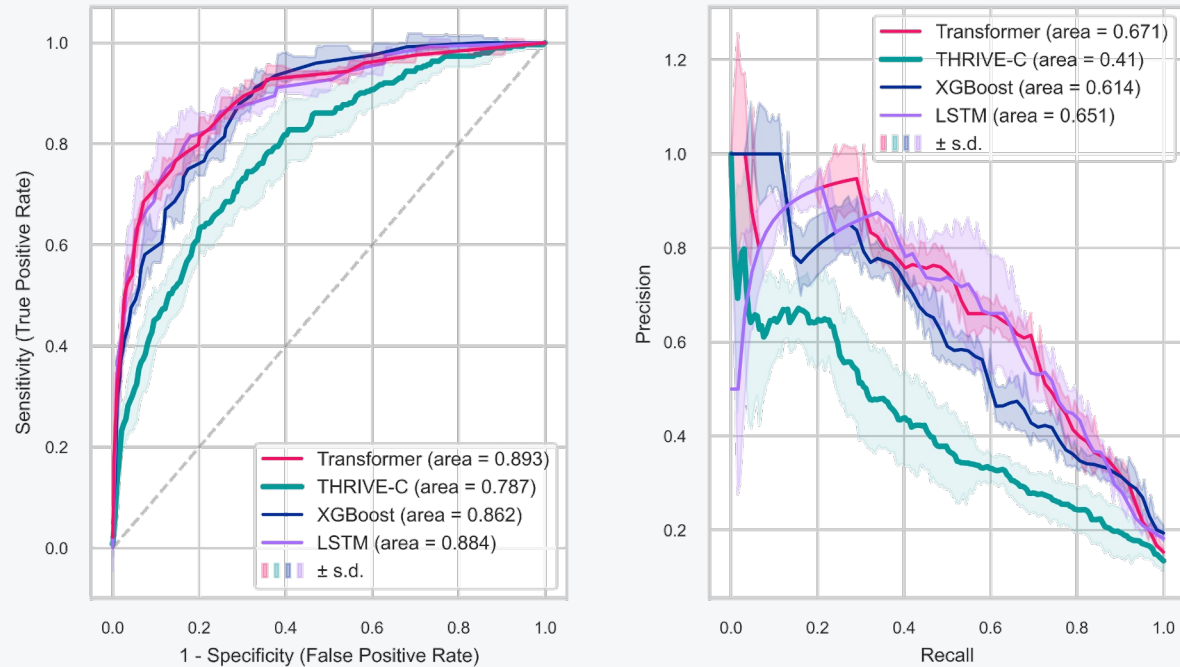
6 layers

1024 hidden dimension

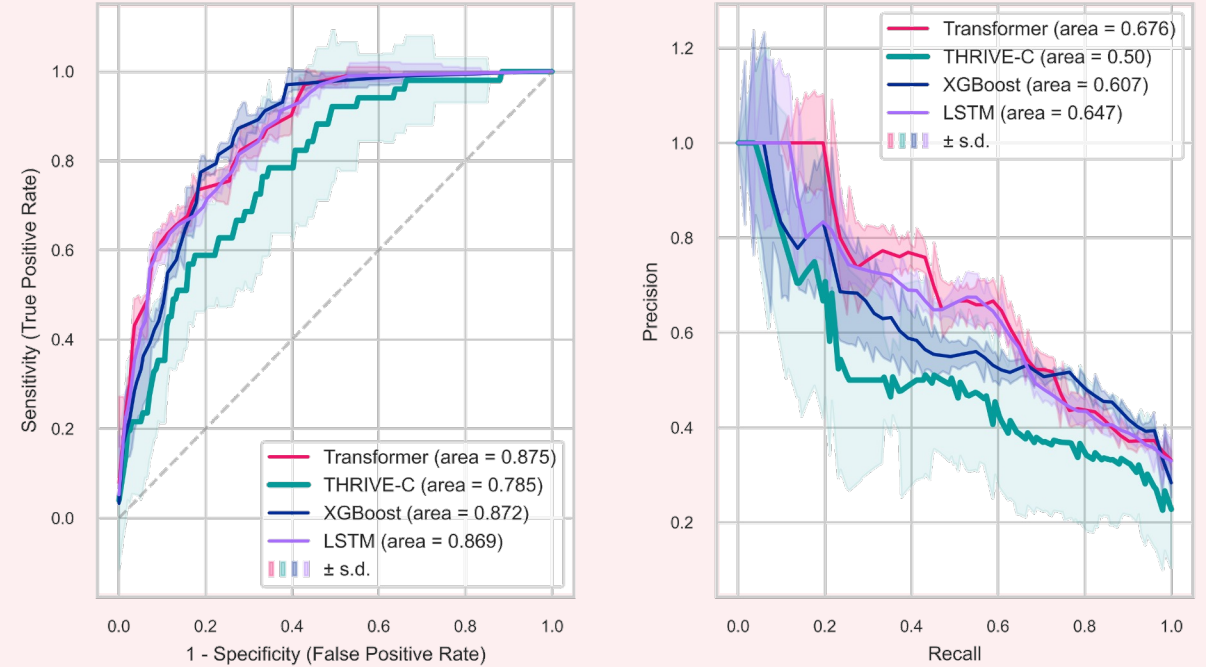
151M parameters



Intelligent stroke unit

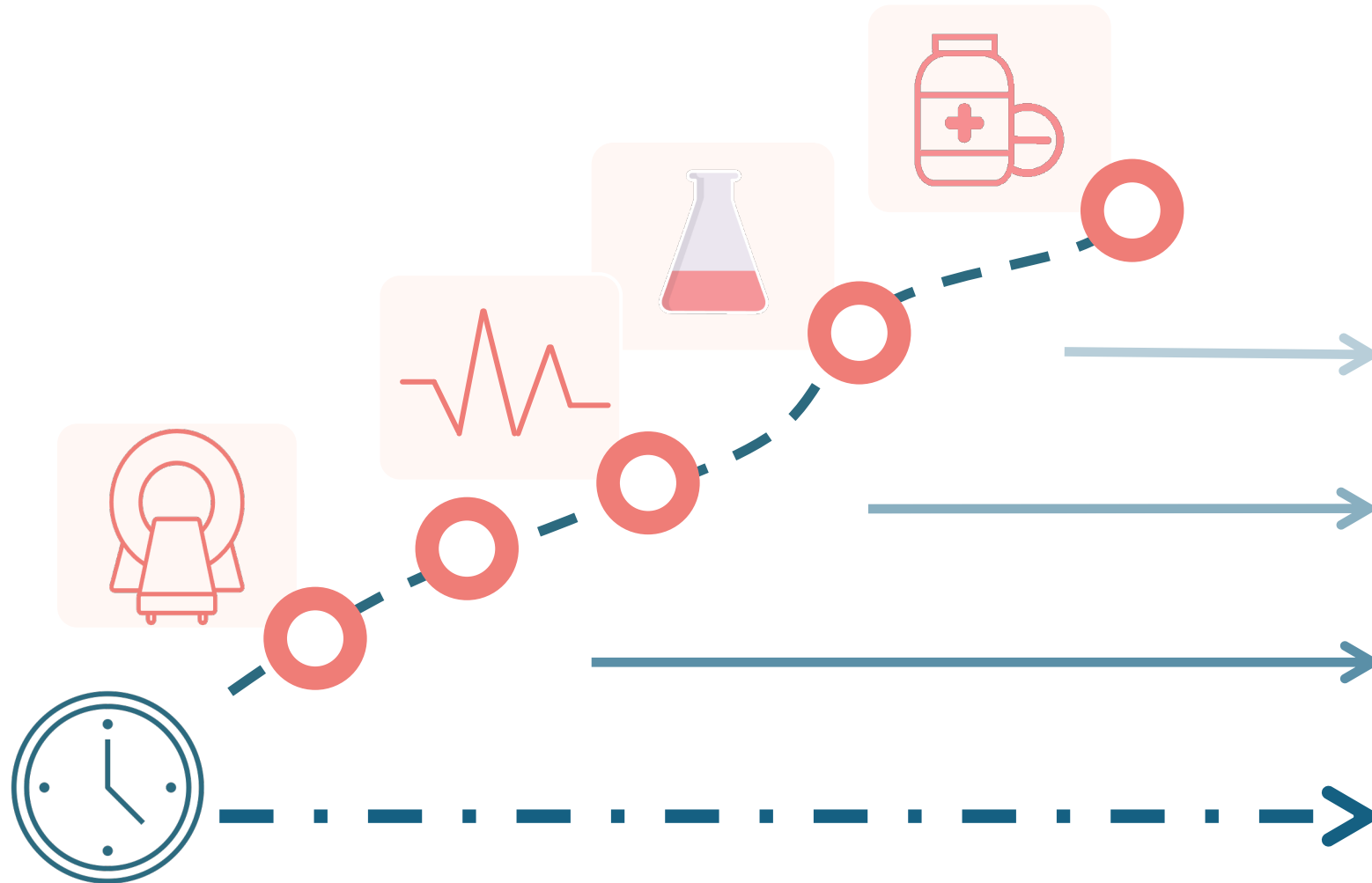


Geneva Stroke Dataset



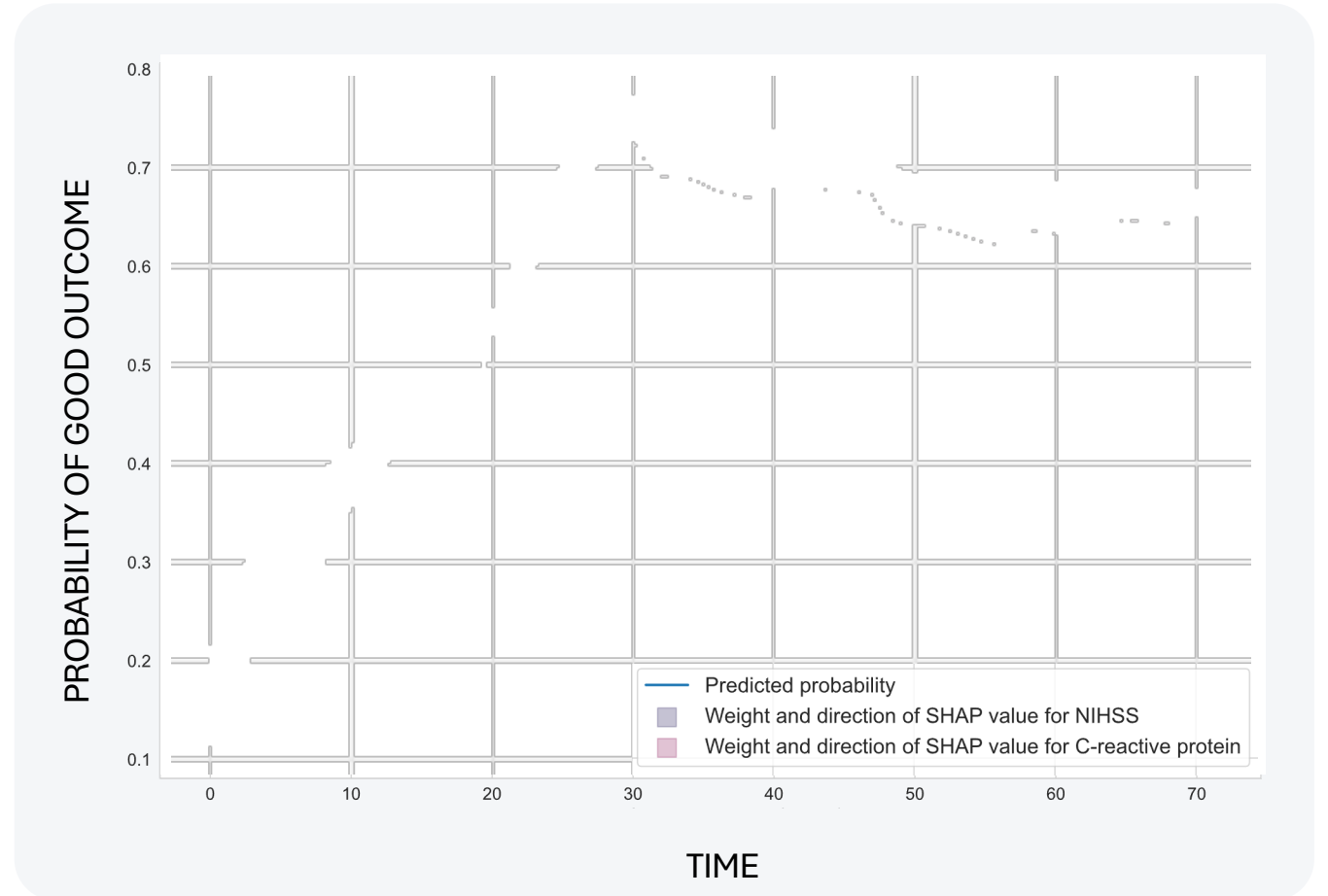
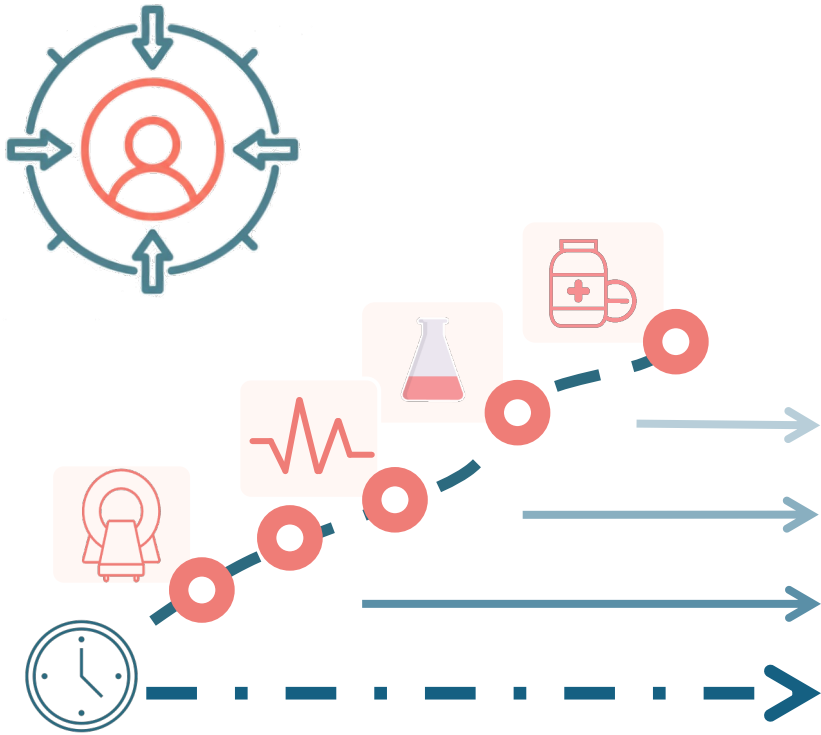
MIMIC-III

Intelligent stroke unit

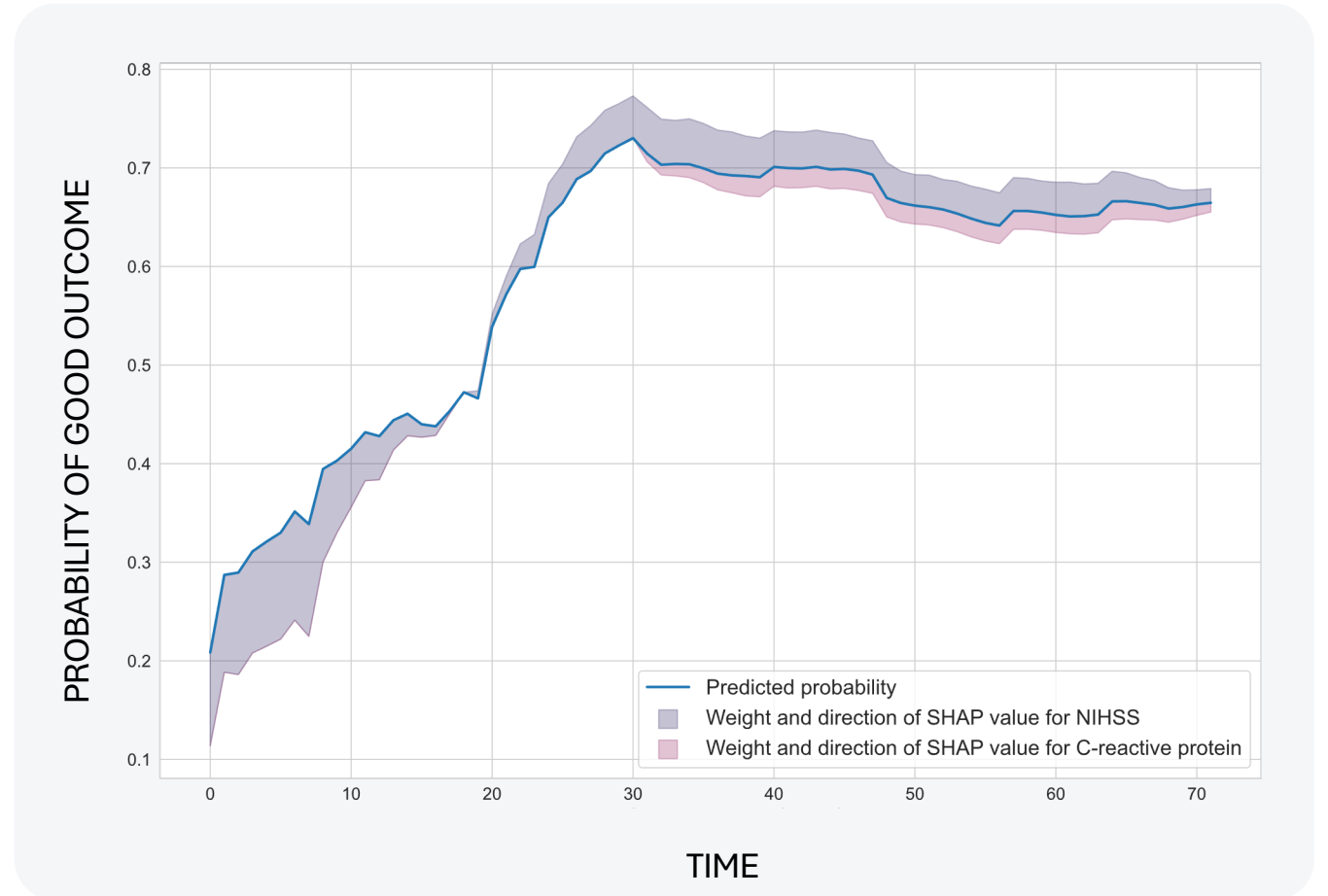
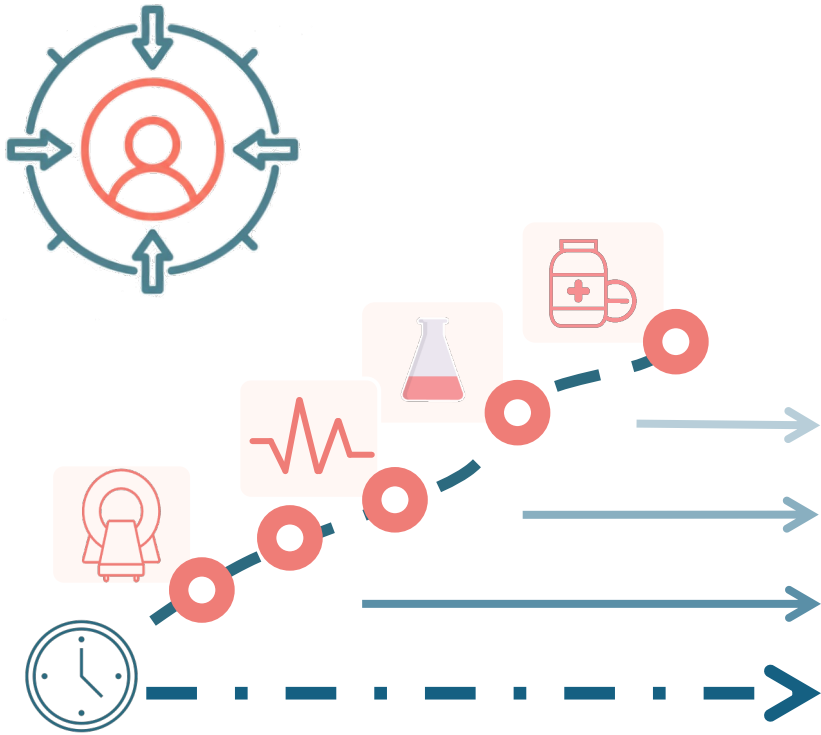




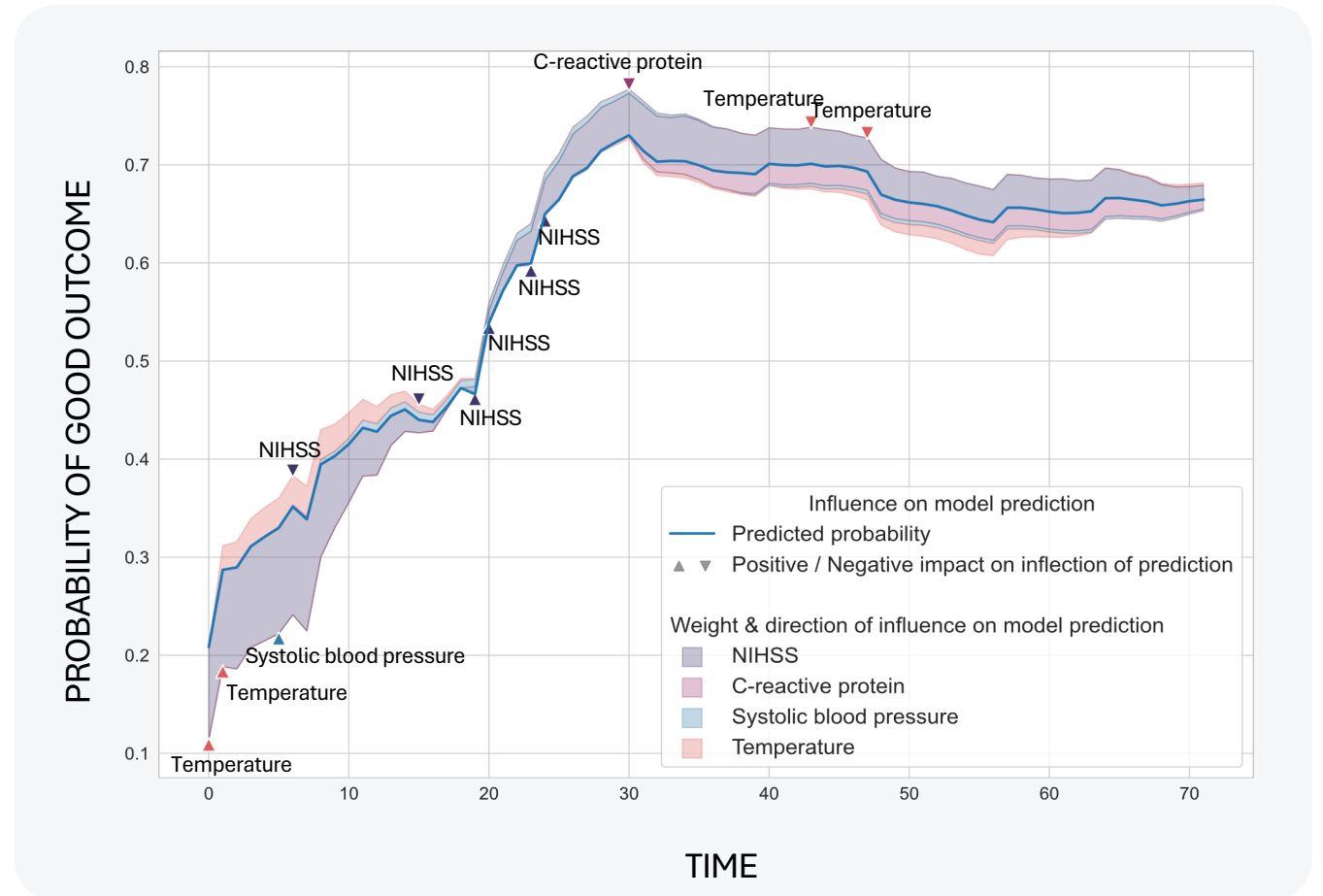
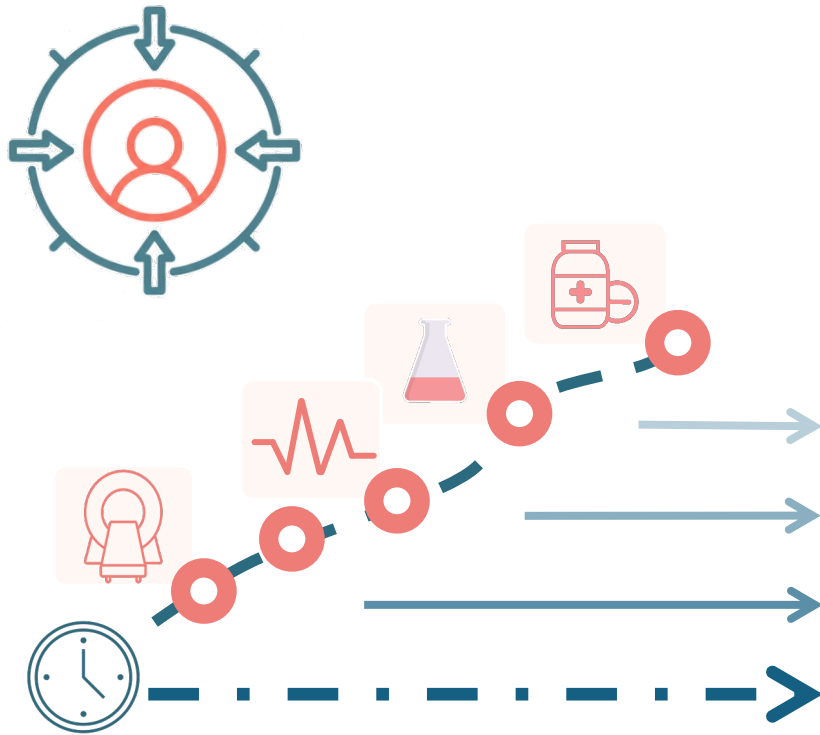
Intelligent stroke unit



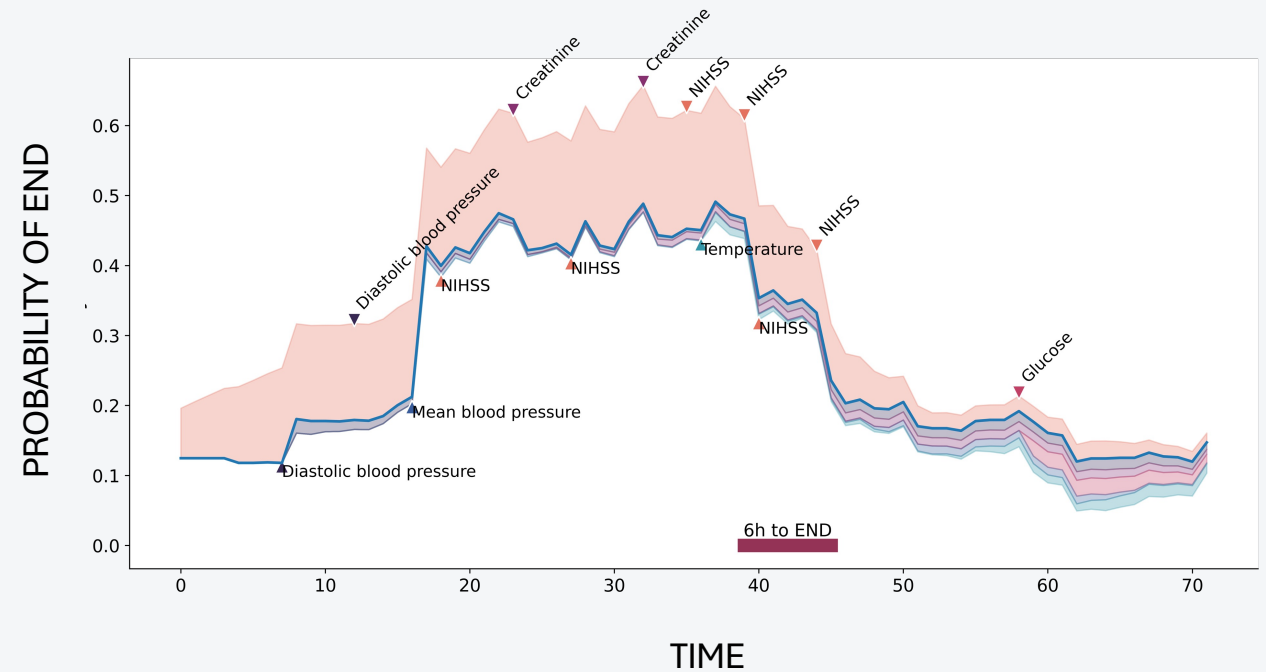
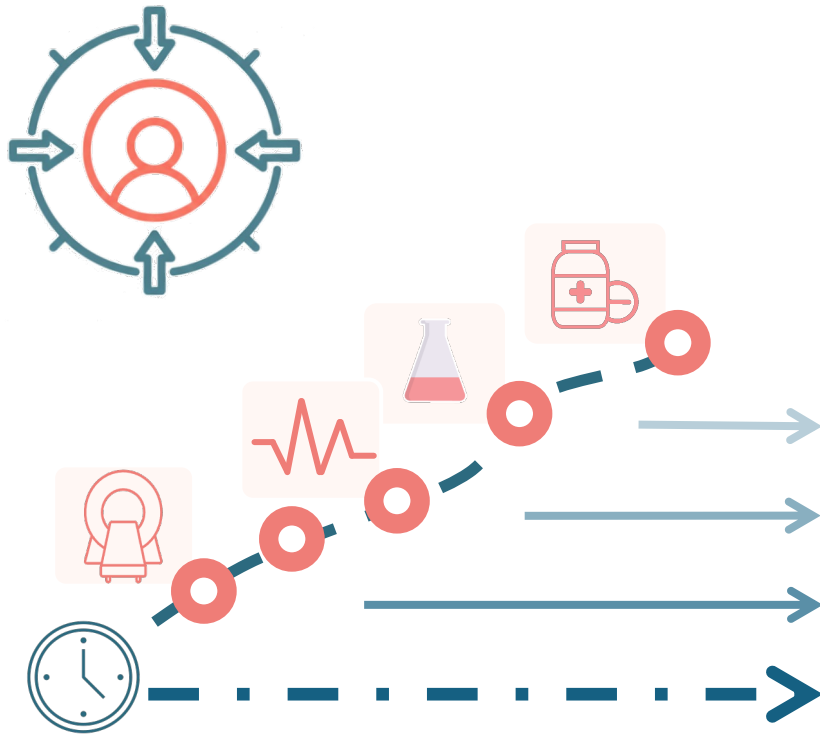
Intelligent stroke unit



Intelligent stroke unit



Intelligent stroke unit



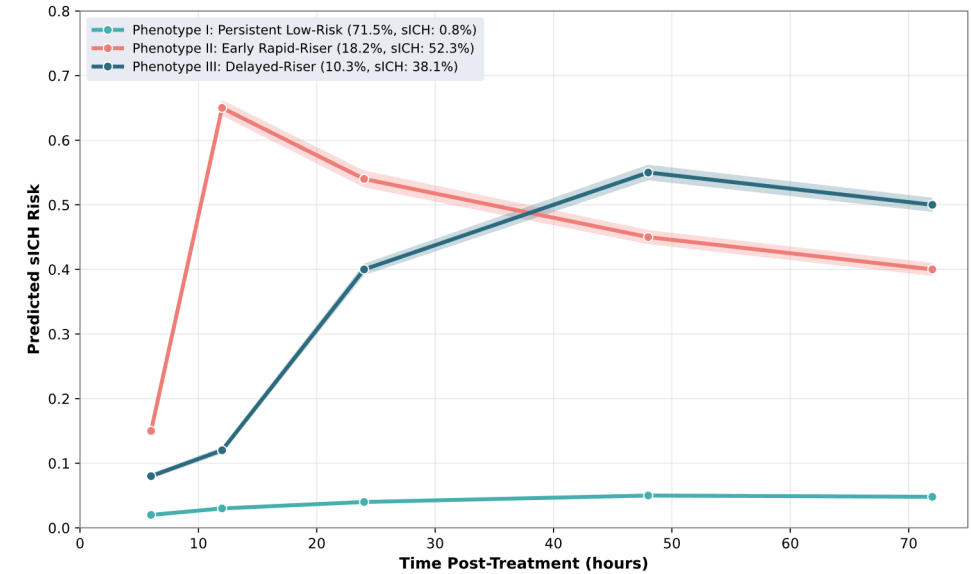
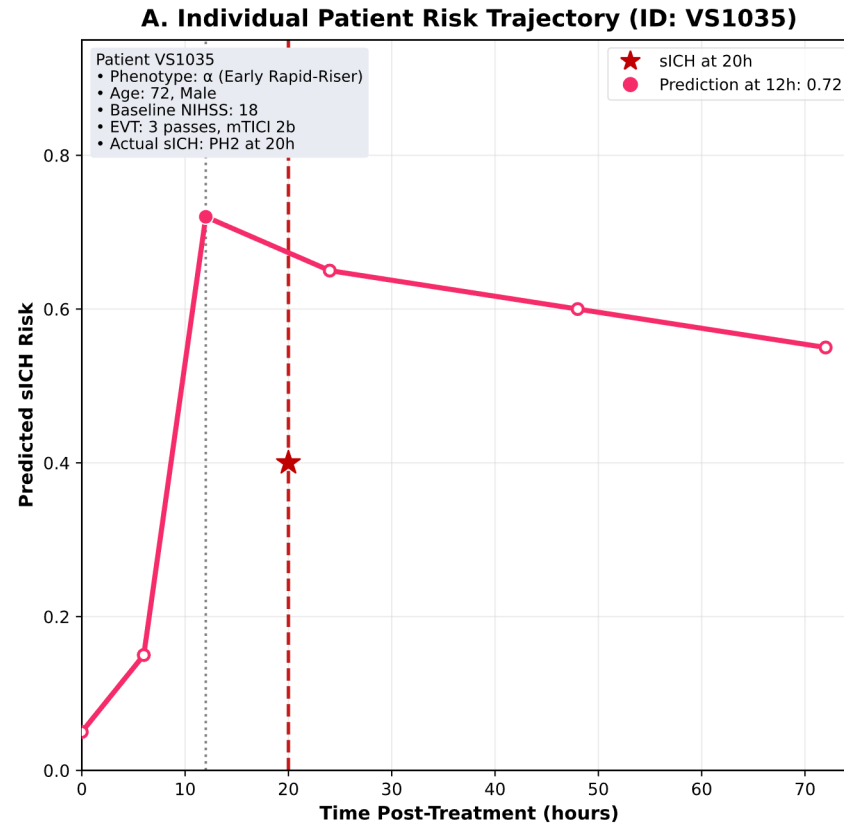
Specific complications



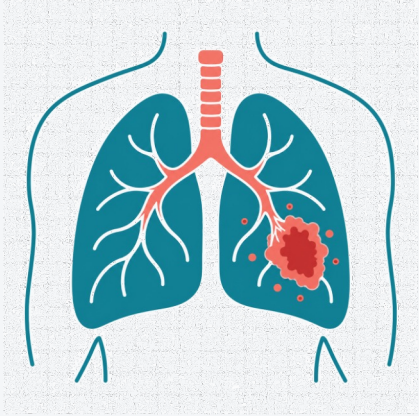
Haemorrhagic
transformation

Sn 85%

Sp 92%

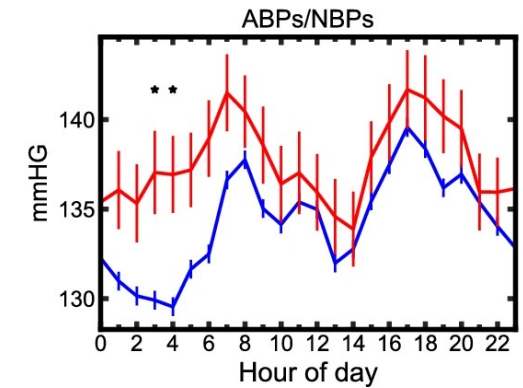
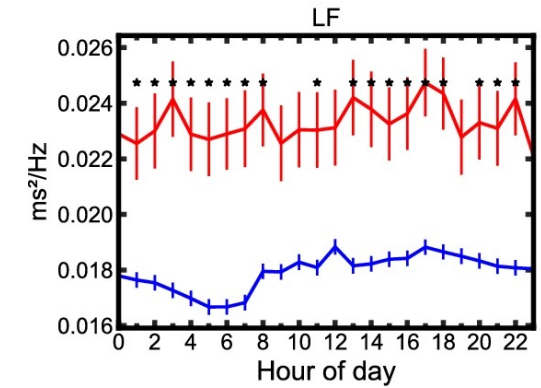
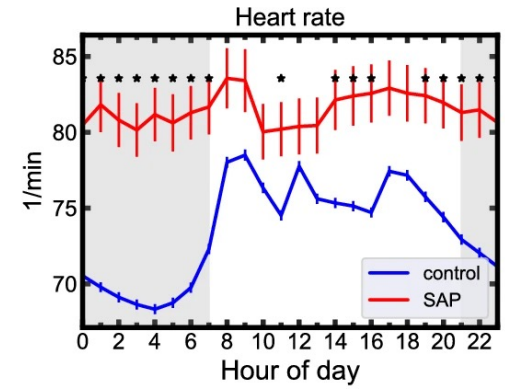
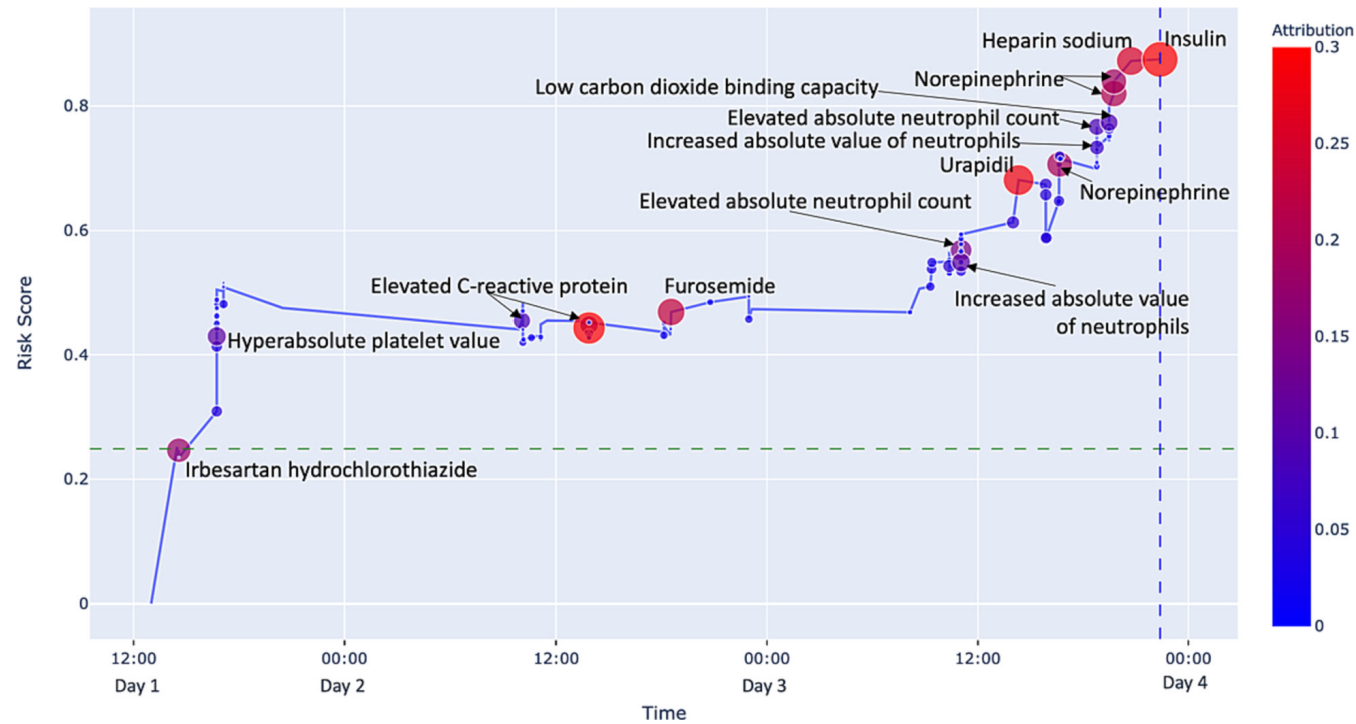


Specific complications



Pneumonia

AUC 0.89



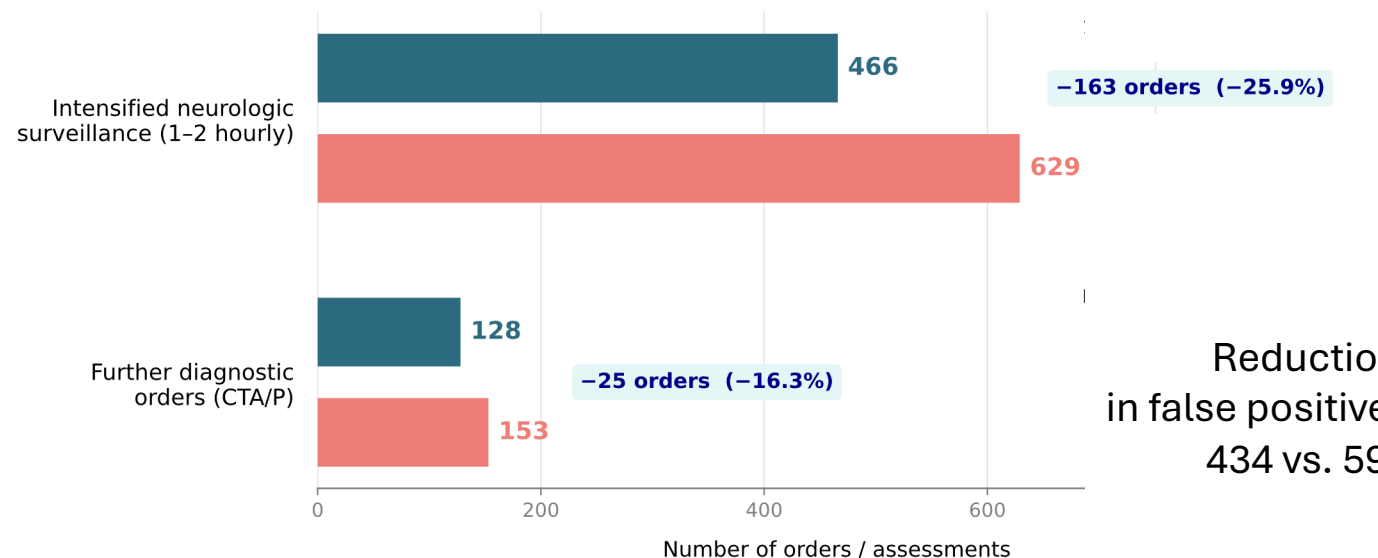
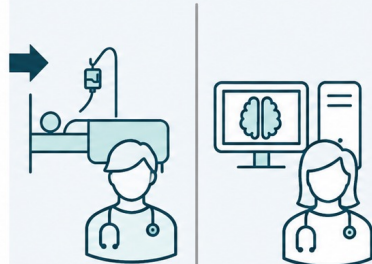
DCI after SAH



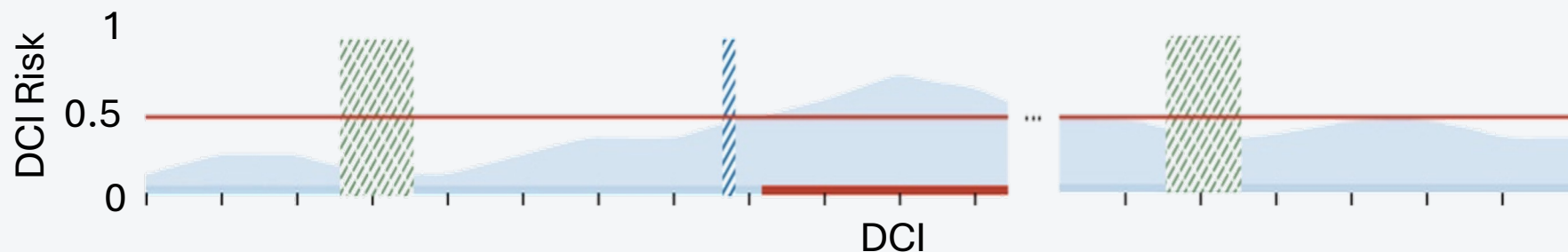
Prospective
silent validation
trial

63 patients
17 DCI events

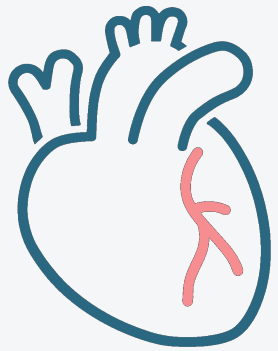
Clinical decisions vs.
DCI prediction + MD



Reduction
in false positives
434 vs. 597



Intelligent stroke unit



Afib

Sn 39%

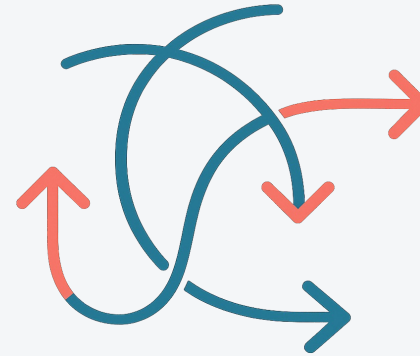
Sp 90%



Intracranial
hypertension

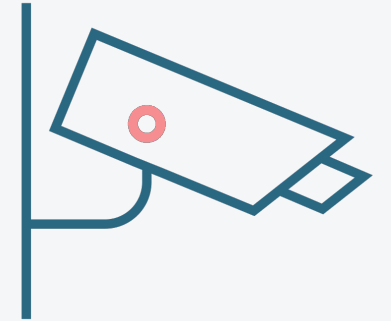
Sn 74%

Sp 73%



Delirium

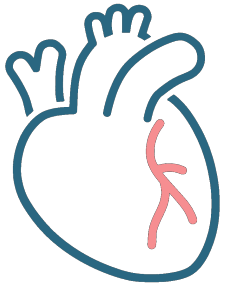
AUC 70%



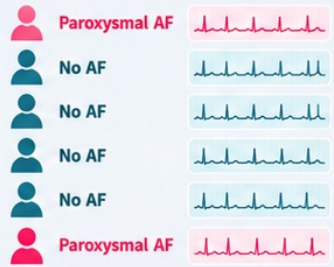
Falls

Intelligent video
surveillance

Atrial fibrillation



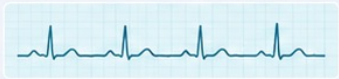
ECG during sinus rhythm



Identification of paroxysmal AF



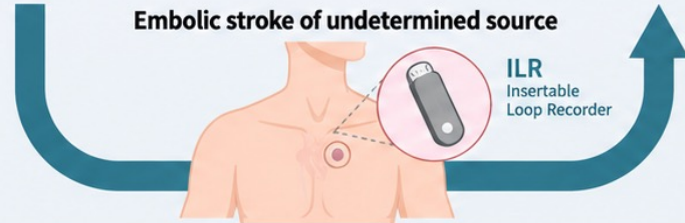
Sinus rhythm



Paroxysmal atrial fibrillation

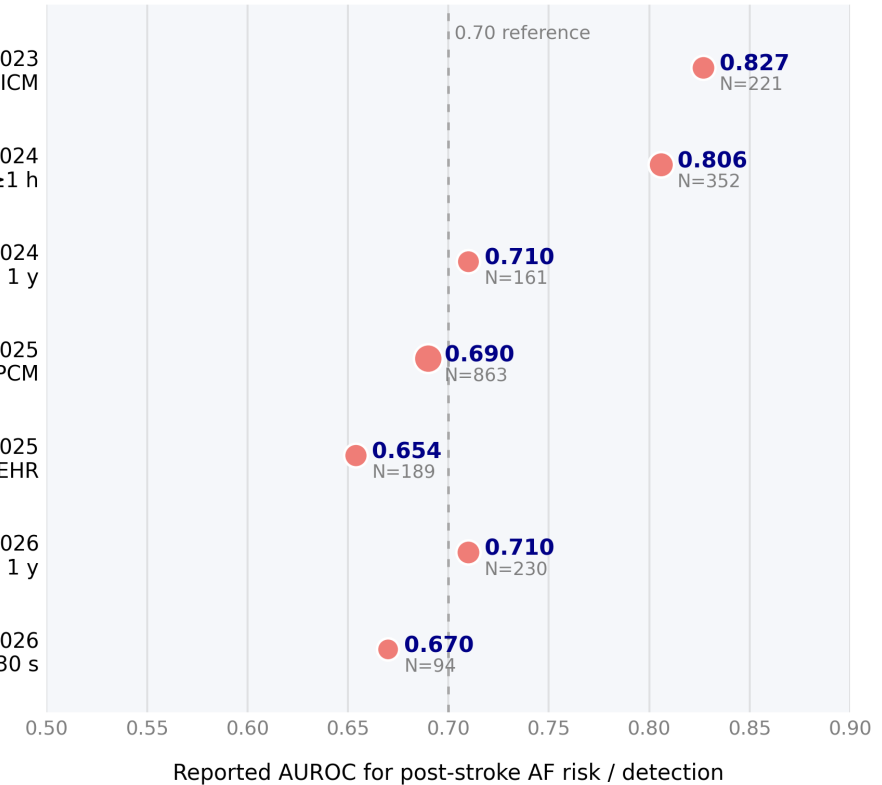


Embolic stroke of undetermined source



ILR
Insertable
Loop Recorder

- Jeon et al. 2023
ESUS + ICM — AF detected by ICM
- Choi et al. 2024
ESUS + ICM — AF ≥ 1 h
- Shah et al. 2024
Cryptogenic + ILR — AF >30 s within 1 y
- Holmes et al. 2025
Ischemic stroke + PCM — Any AF on PCM
- Vafaei Sadr et al. 2025
Cryptogenic stroke — PAF; multimodal ECG+EHR
- Wouters et al. 2026
Cryptogenic/TIA + ICM — AF within 1 y
- Tomura et al. 2026
ESUS + ILR — AF >30 s

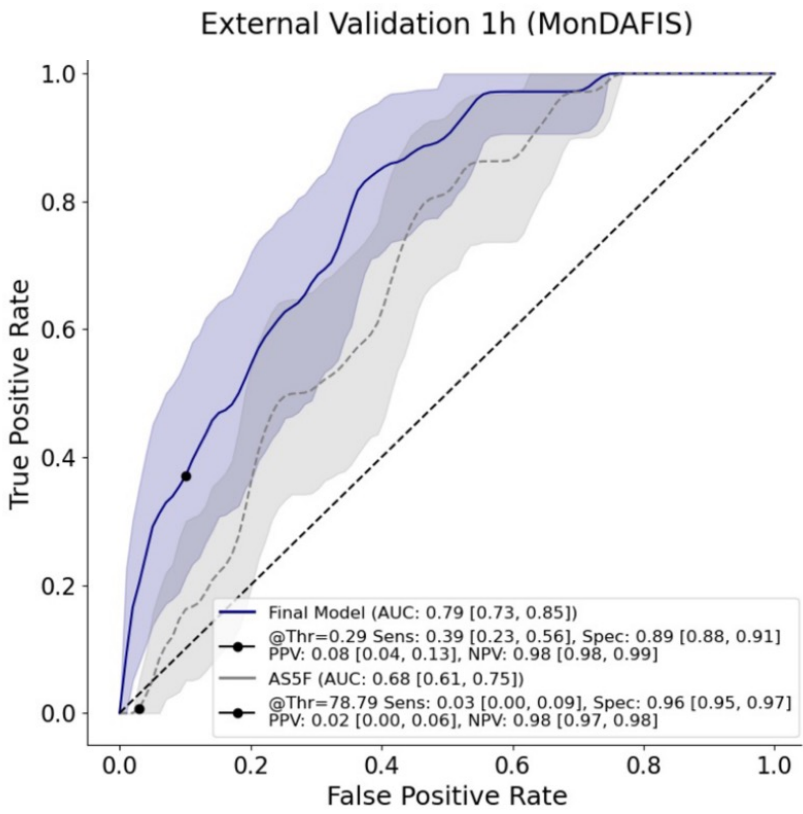


Choi, Heart Rhythm 2024

Holmes, Mayo Clinic Proc 2025

Jeon, Korean Circ J 2023

Atrial fibrillation



Multimodal Data Approach

Clinical Data



Baseline Characteristics
Concomitant Diagnoses
ICA-Stenosis > 50%

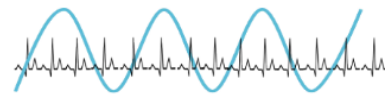


Troponin
GFR

CEM Data



Analyzable Raw ECG



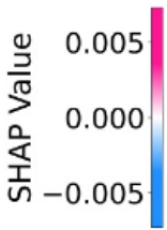
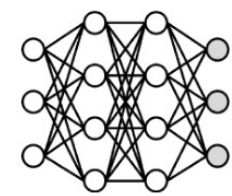
Heart Rate Variability Metrics

Stroke /
TIA

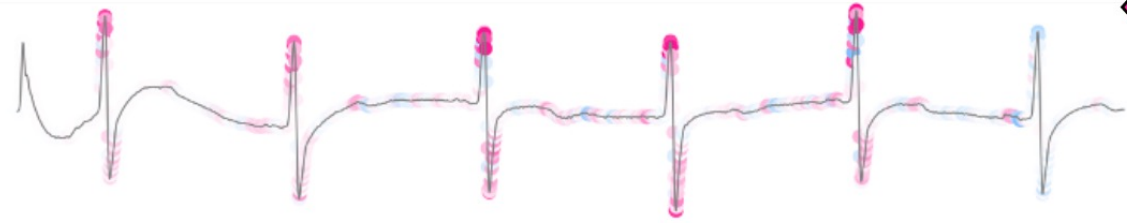
Stroke Unit
Workup 24 – 72h

Data Analysis /
AF-Prediction

Selection
for PCM

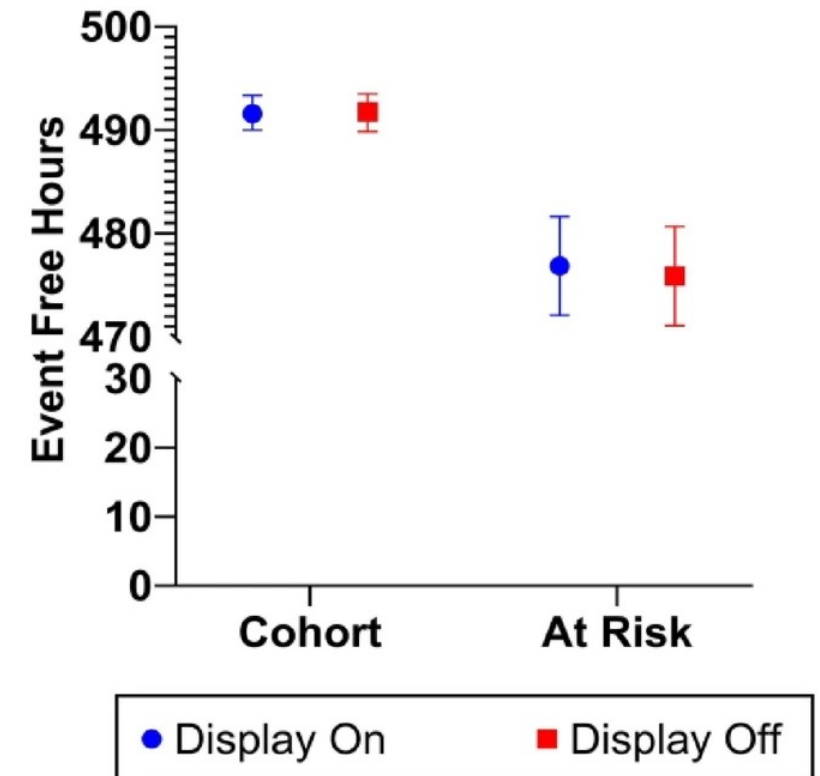
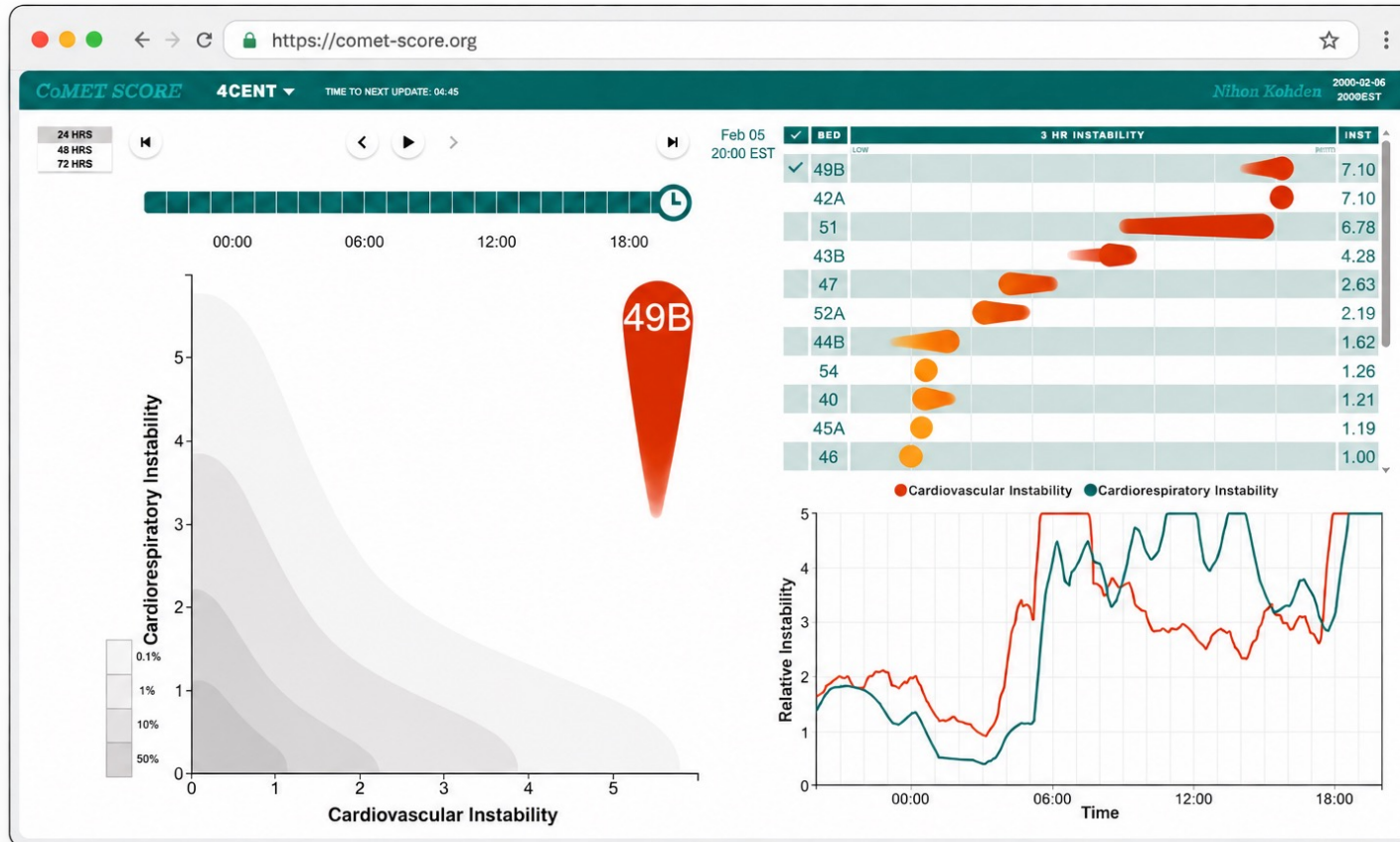


Patient with Newly Detected AF (Segment Prediction: 0.77)



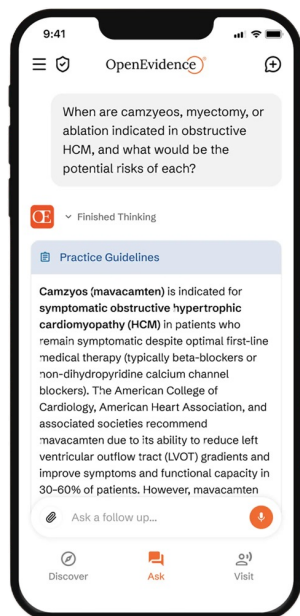
Limitations

Randomized
controlled trial
10'422 patients



Cardiac & Cardiac surgery units

LLMs

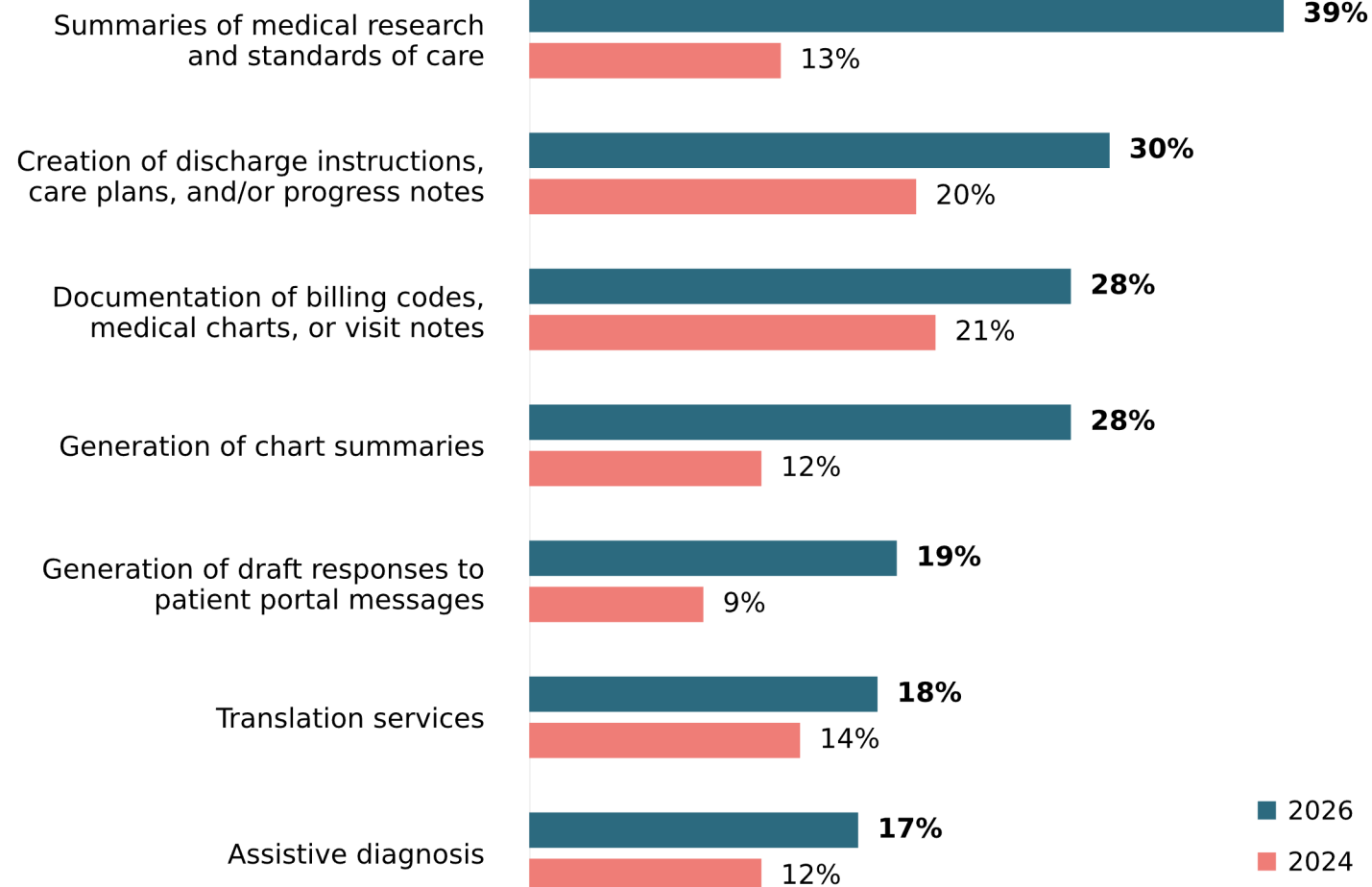


80% physicians
report use of AI

Use cases live in physician workflows

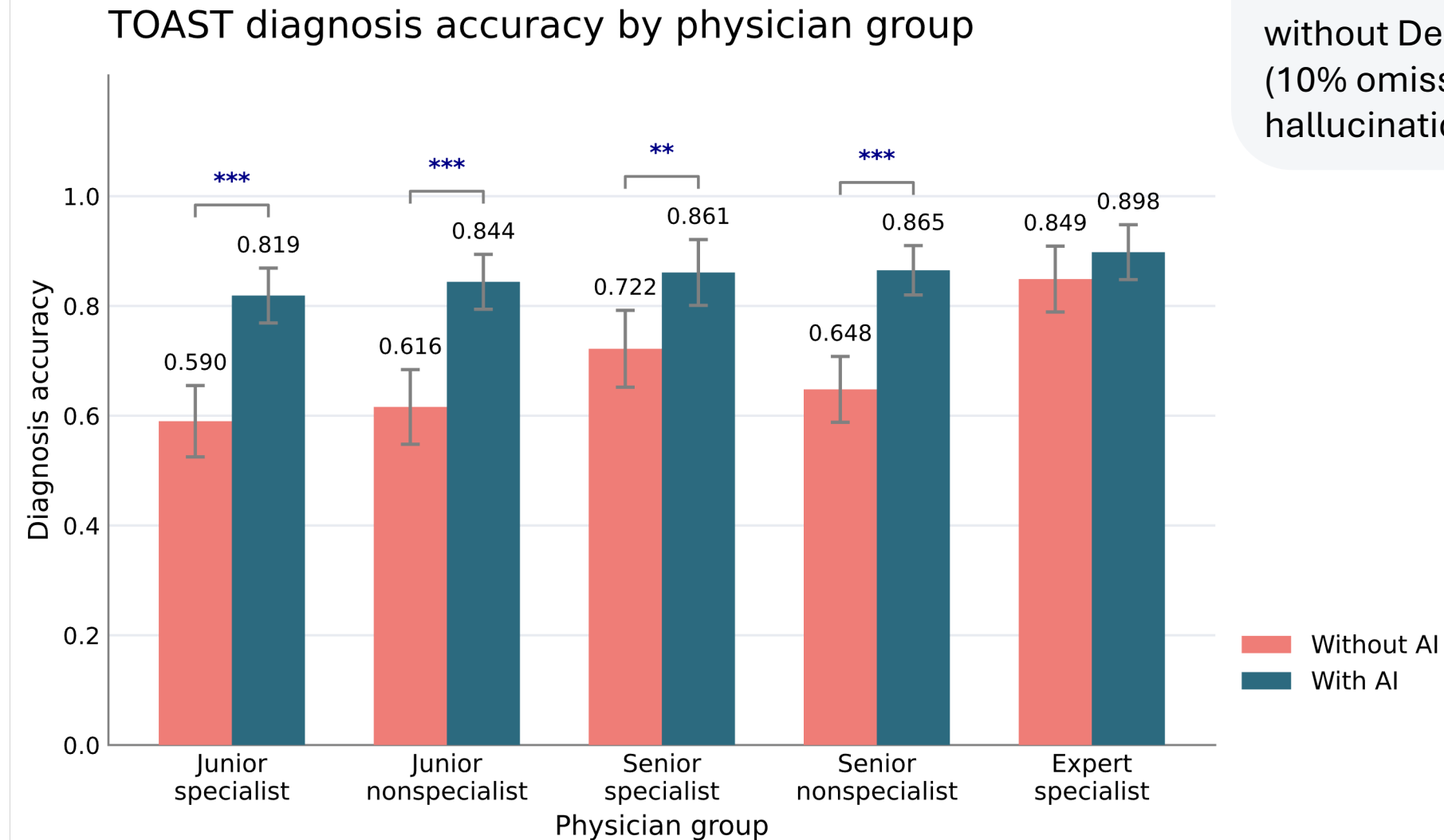
Q: Which, if any, of these AI use cases do you currently incorporate into your practice?

n = 1,342 (2026); 1,183 (2024)



LLMs

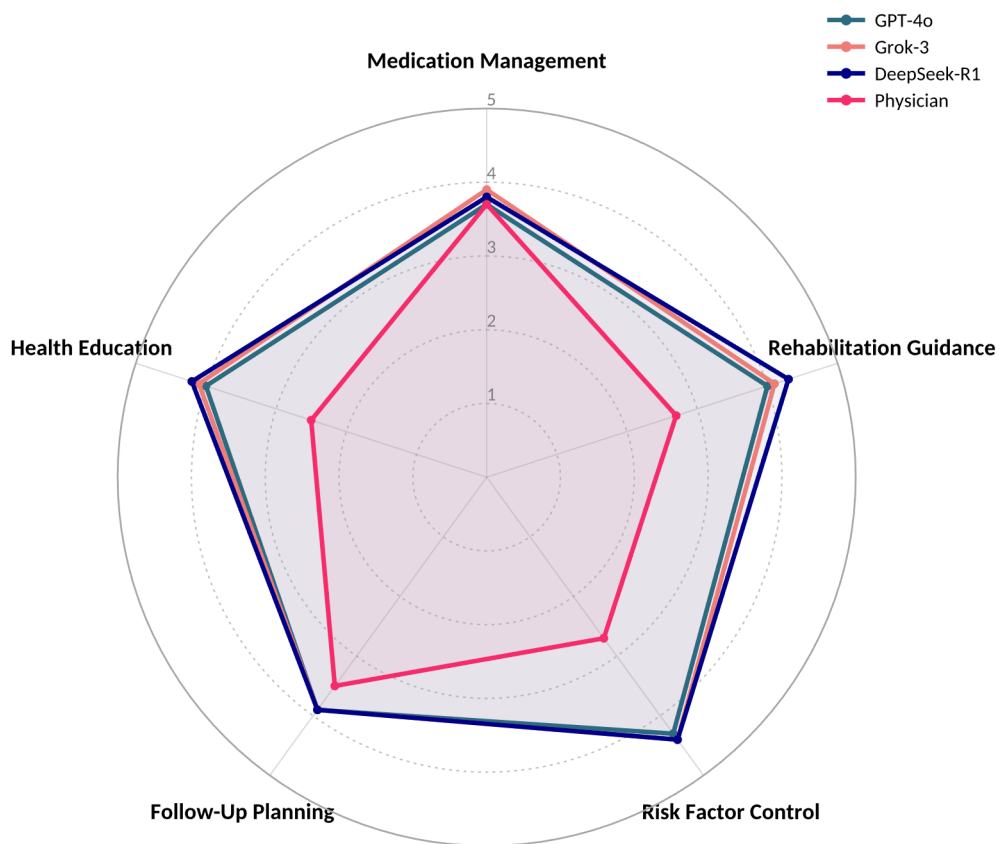
132 patients
prospectively enrolled
12 physicians with and
without Deepseek R1
(10% omission, 14%
hallucinations)



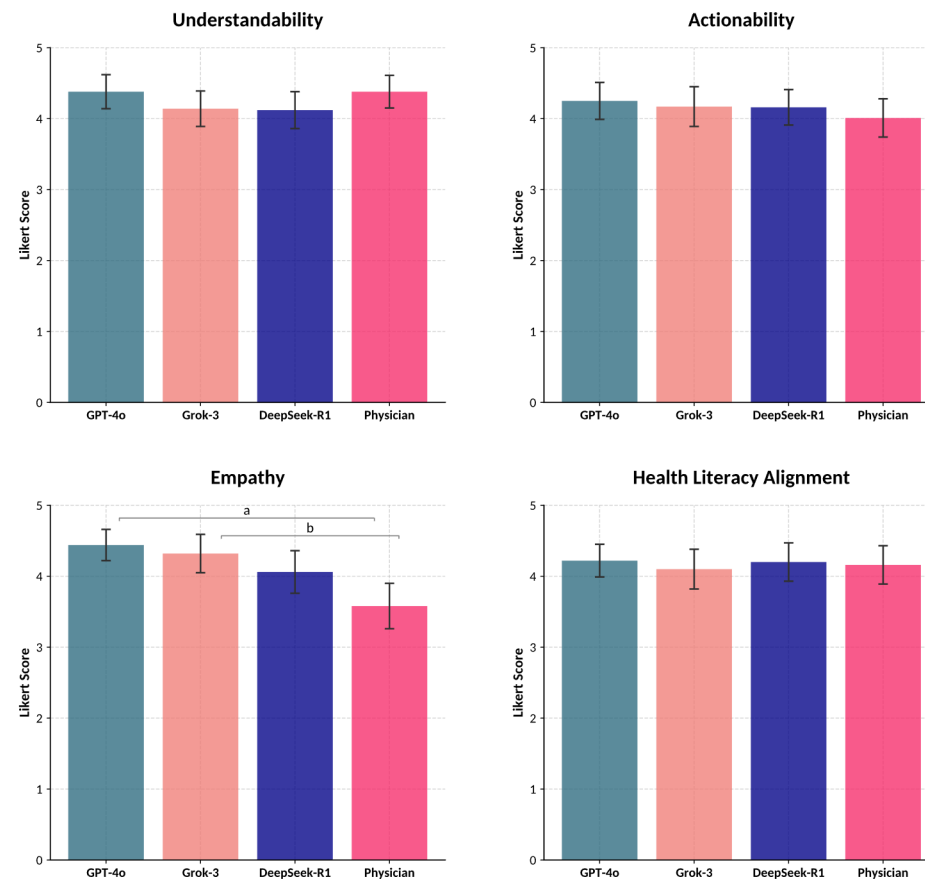
LLMs - Discharge Education

67 patients
retrospectively enrolled

Completeness-Oriented Expert Evaluation



Patient-Centered Evaluation



N=50 (17 excluded / lost)

Yin, Stroke 2026

LLMs

63 clinical questions
from Neuro-ICU care
8 reviewers

Evaluate answer 1

12345

Alignment with guidelines

Question comprehension

Logical reasoning

Relevance & completeness

Harmlessness

Fairness

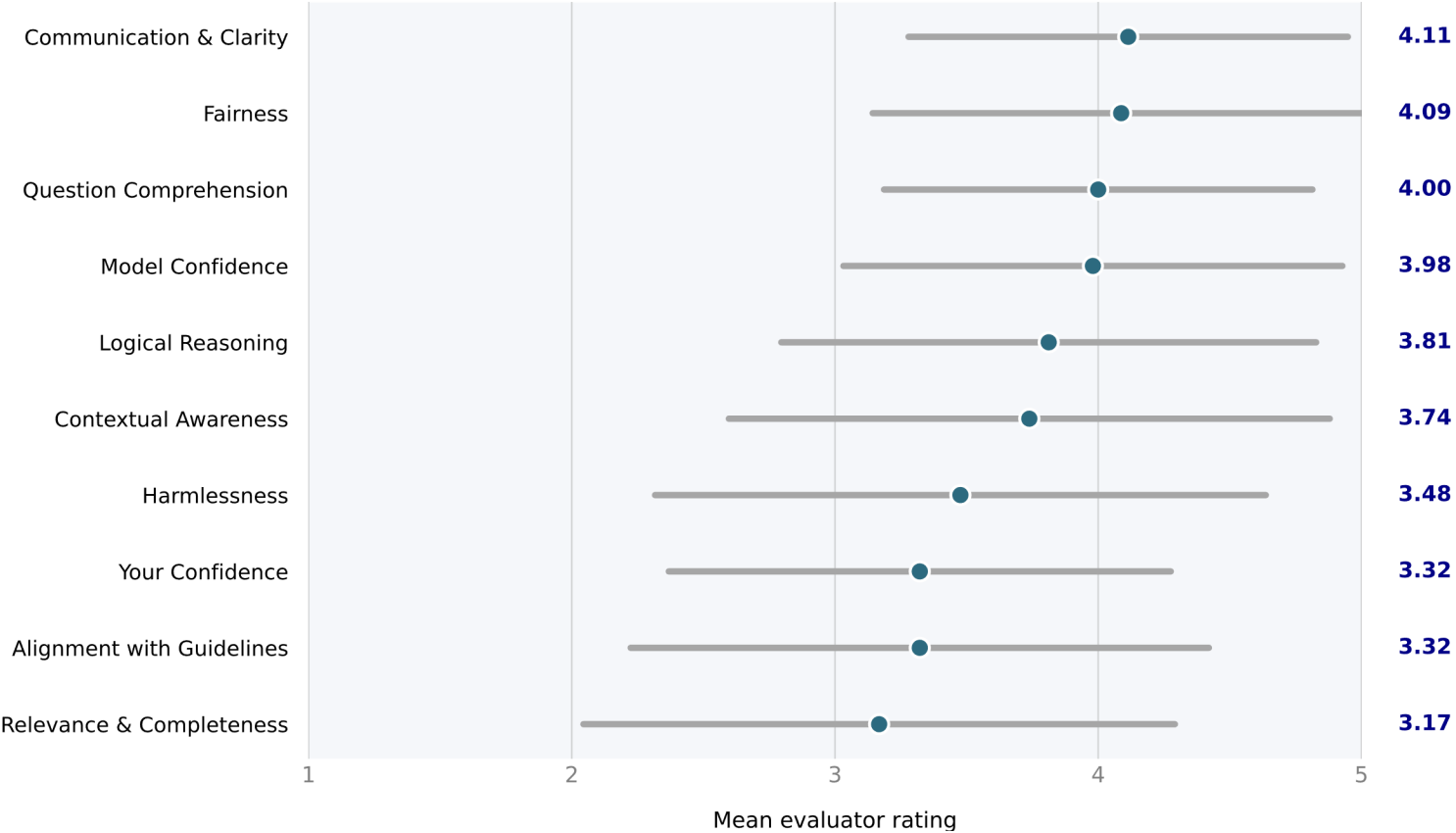
Contextual awareness

Your confidence

Model confidence

Communication

Clarity



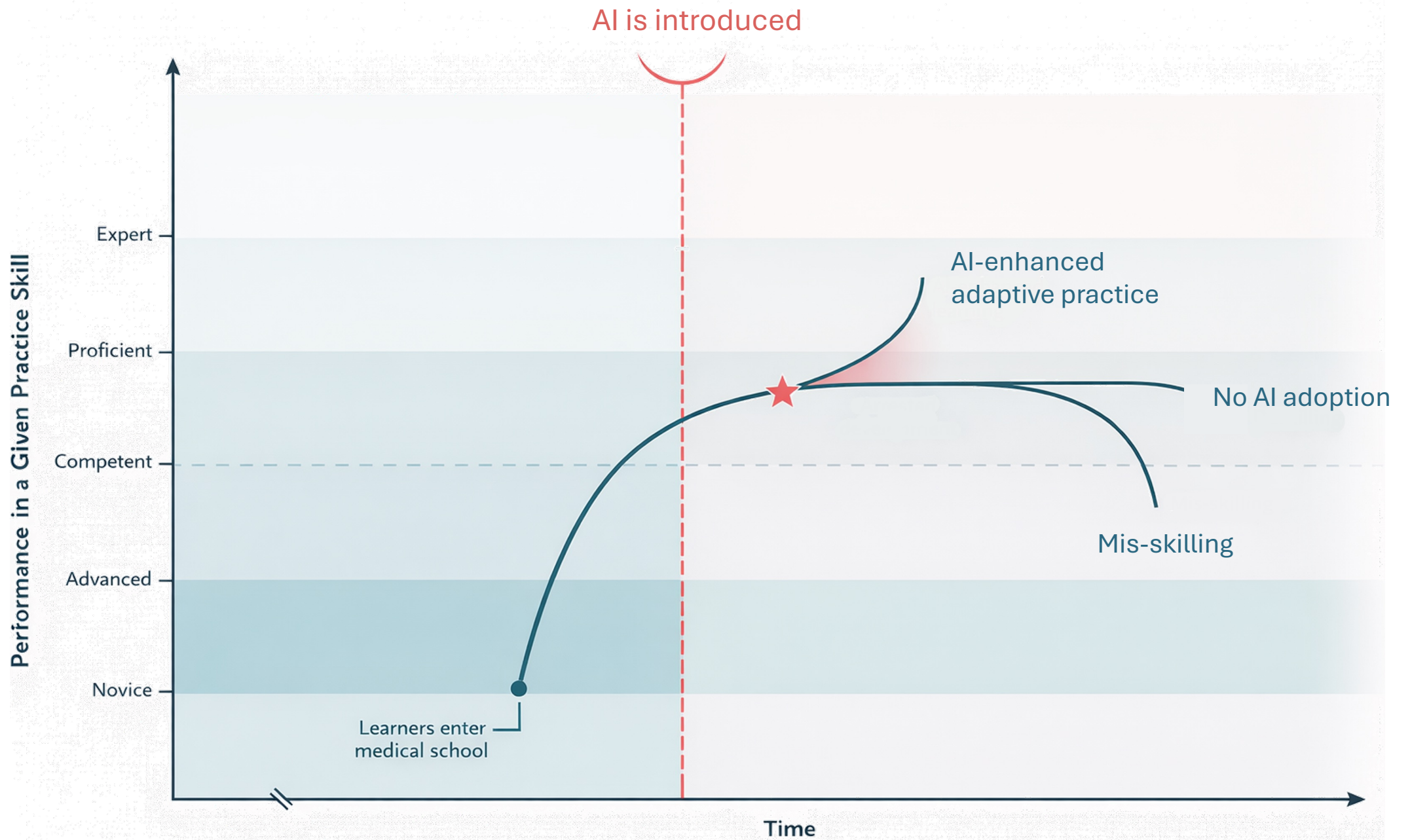
Next steps



Impact on
decision
making ?

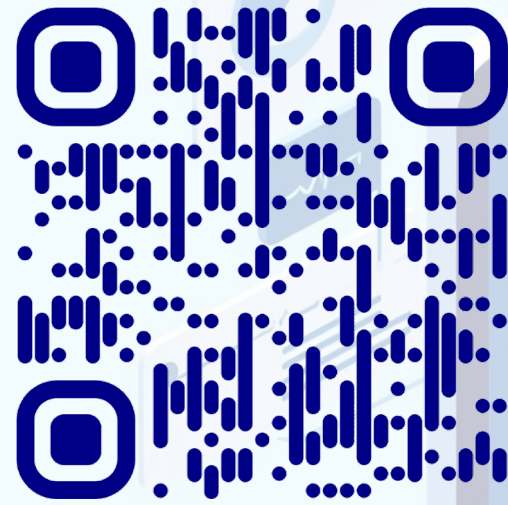


Impact on
outcome?



AI-assisted monitoring of acute stroke

Geneva Stroke Lab
Emmanuel Carrera
Elisabeth Dirren
Gabriel Byczynski
Nicolas Broc



Julian Klug, 2026
julian.klug@chuv.ch

