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Secure Analysis Federation in the Intensive Care Unit (SAFICU)

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DIFUTURE
Data Integration for Future Medicine

MEDICAL INFORMATICS INITIATIVE GERMANY

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Intensive care

- Addresses acute life-threatening conditions and diseases
- Elaborate structural and technical equipment
- Monitor and maintain vital functions
- Therapy by ventilation, infusion, artificial nutrition, …

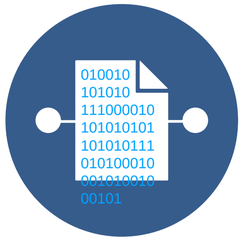
Secure Analysis Federation in the Intensive Care Unit
Motivation

Development and usage of decentralized federated algorithms
to enable Clinical Decision Support in Intensive Care

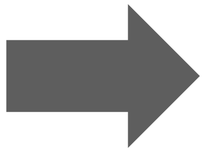
Data Integration Centers

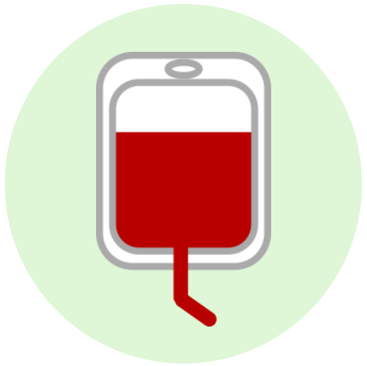
OMOP CDM

Federated learning



Secure Computation





Blood transfusion

Ventilation

Use Cases

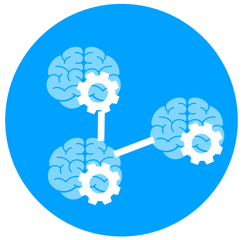
Blood transfusion

Optimisation personalized decisions for blood transfusions by capturing the clinical context and data

Patient Ventilation

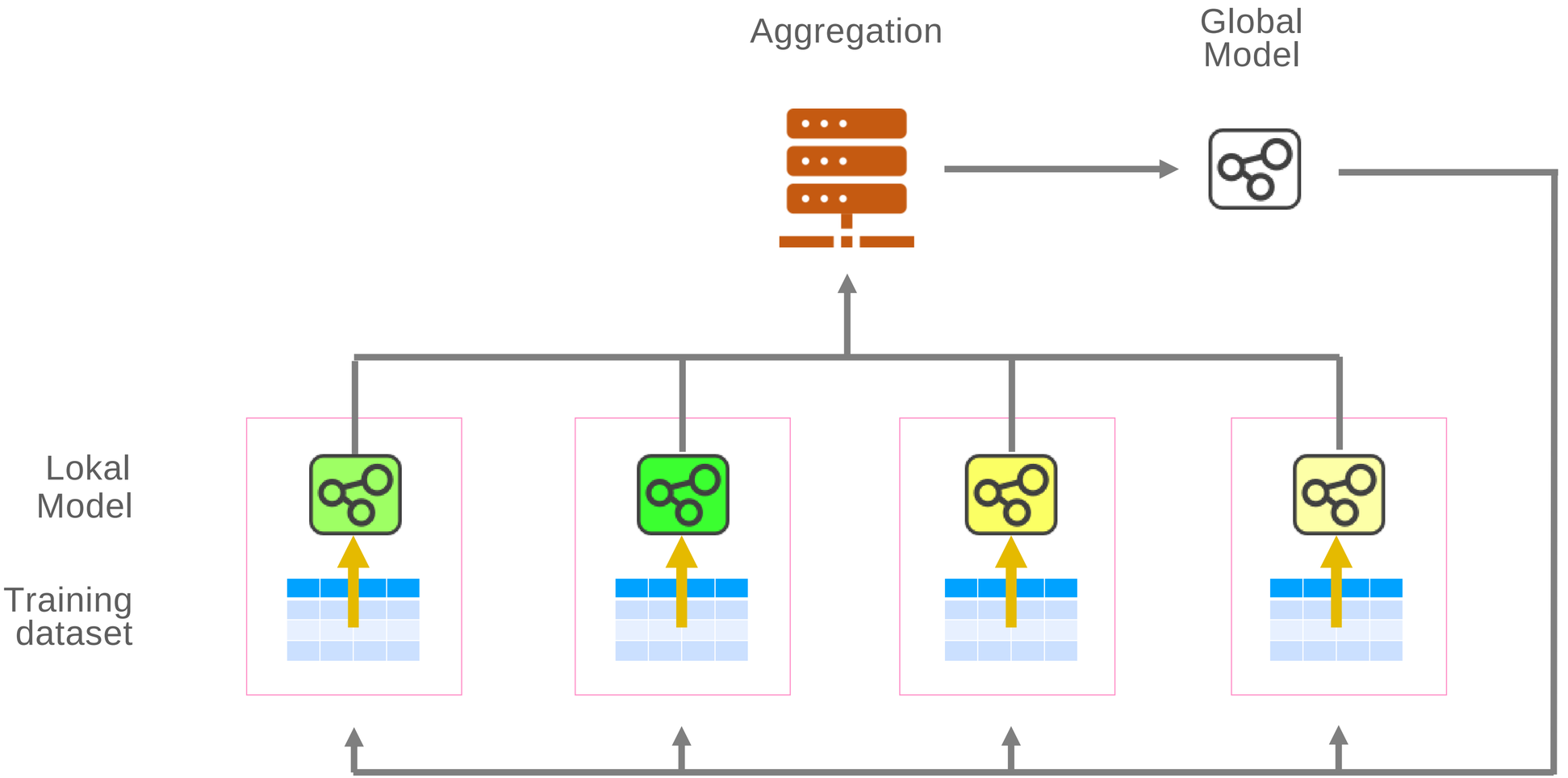
Optimize strategy of patient ventilation in the ICU

Challenges
Federated learning



- Limited data availability at single hospitals for specific diseases
- Biased models by single-institution training
- Sensitive nature of data
- Data is protected by legal and ethical practices
  ⇢ no simple data sharing

Federated Learning – Client / Server



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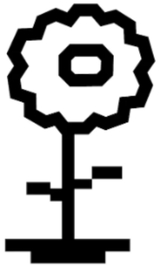
Frameworks
(Auswahl)

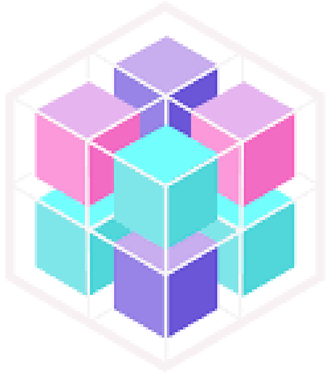
FedML

Syft

Substra

Flower



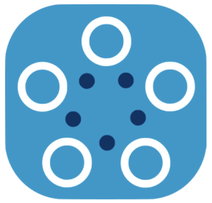


PFL
Paddle Federated Learning

NVIDIA FLARE

PHT-meDIC

FedBioMed



Open Federated Learning (OpenFL)

IBM Federated Learning

FATE

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Frameworks
(Auswahl)

	Flower	PySyft	Fed BioMed	NVFlare
ML Framework Support	Framework agnostic	PyTorch, TensorFlow	PyTorch, Scikit-learn	Framework agnostic
FL Strategy	FedAvg, FedProx, FedFS, …	FedAvg, FedSGD	FedAvg, FedProx, SCAFFOLD	FedAvg, FedOpt, FedProx, SCAFFOLD
Privacy Methods	SecAgg	DP, HE, SMPC	DP, HE, SMPC	DP, HE
Documentation and Tutorials	Good documentation	Documentation not up to date	available	available

Challenges
Data integration

- Based on the existing Data Integration Centers
- Intensive care not a use case of DIFUTURE
- Locating and extracting of required parameters time consuming:
  Vital and ventilation parameters, medication administration and progress reports, as well as further for perioperative processes (preoperative history, examination and education, intraoperative documentation and postoperative data)

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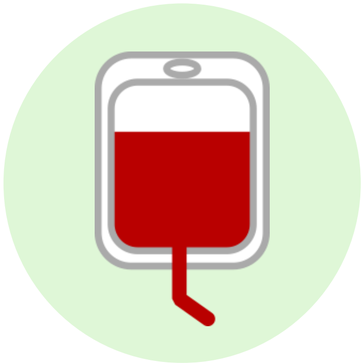
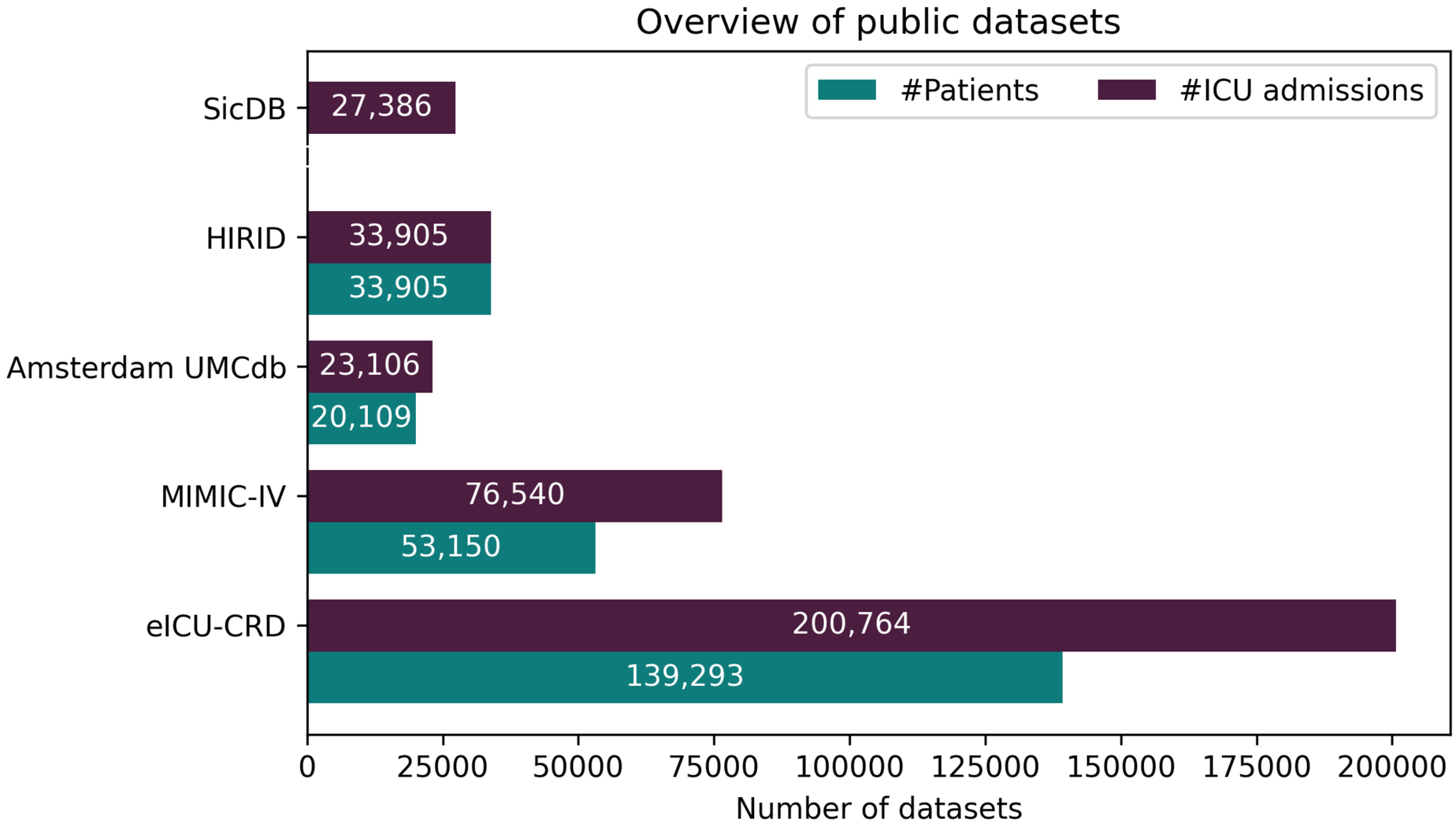
DIFUTURE Data Integration for Future Medicine SAFICU

Challenges
Common Dataset

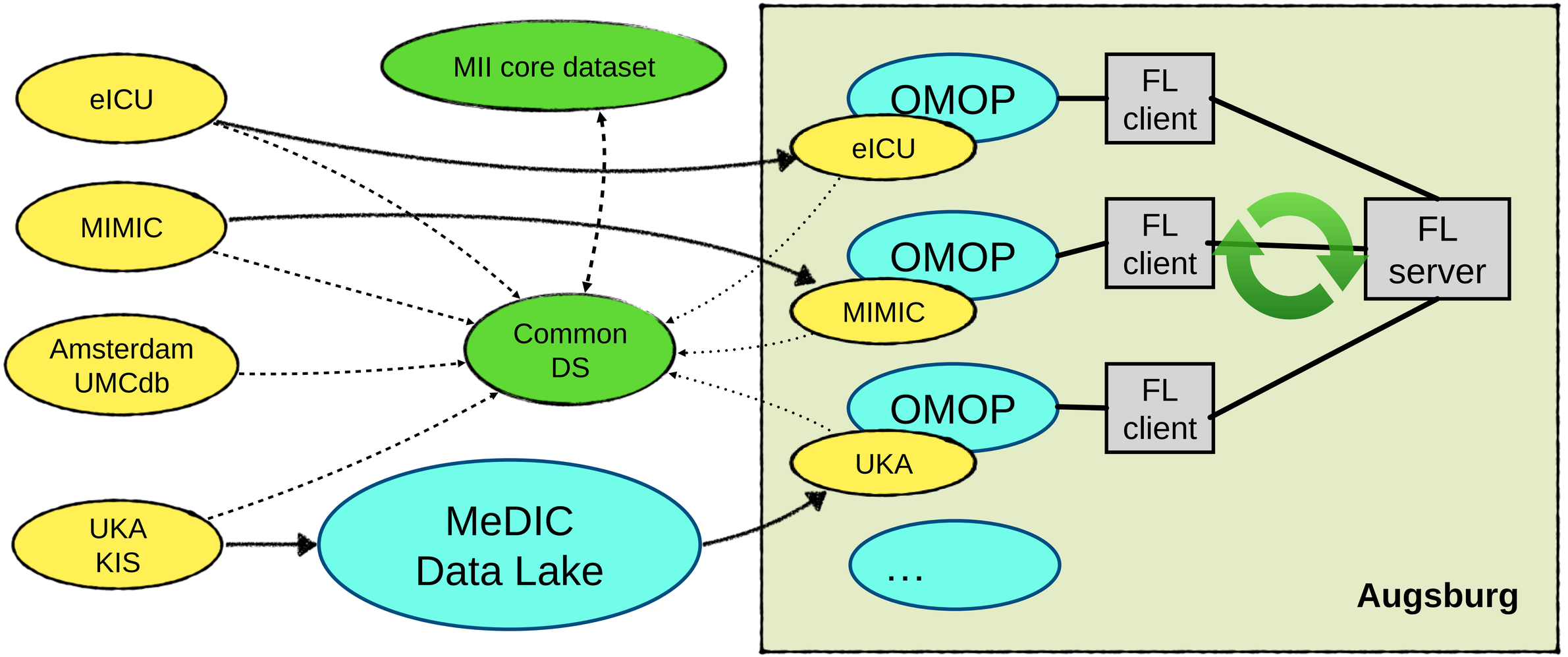
- FL requires a homogenized data basis
- OMOP CDM seems most promising (often used)
  → not optimized for ICU data



Available ICU Databases

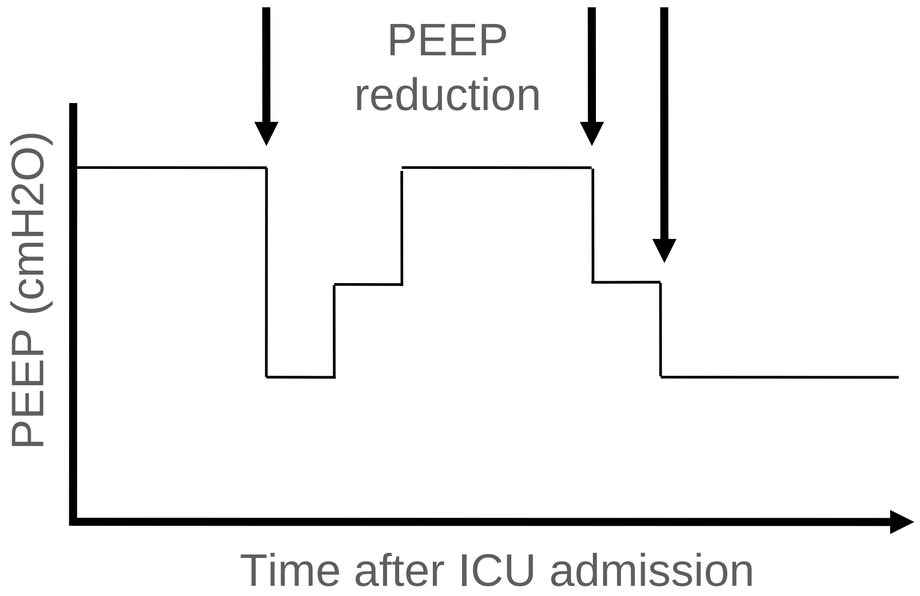


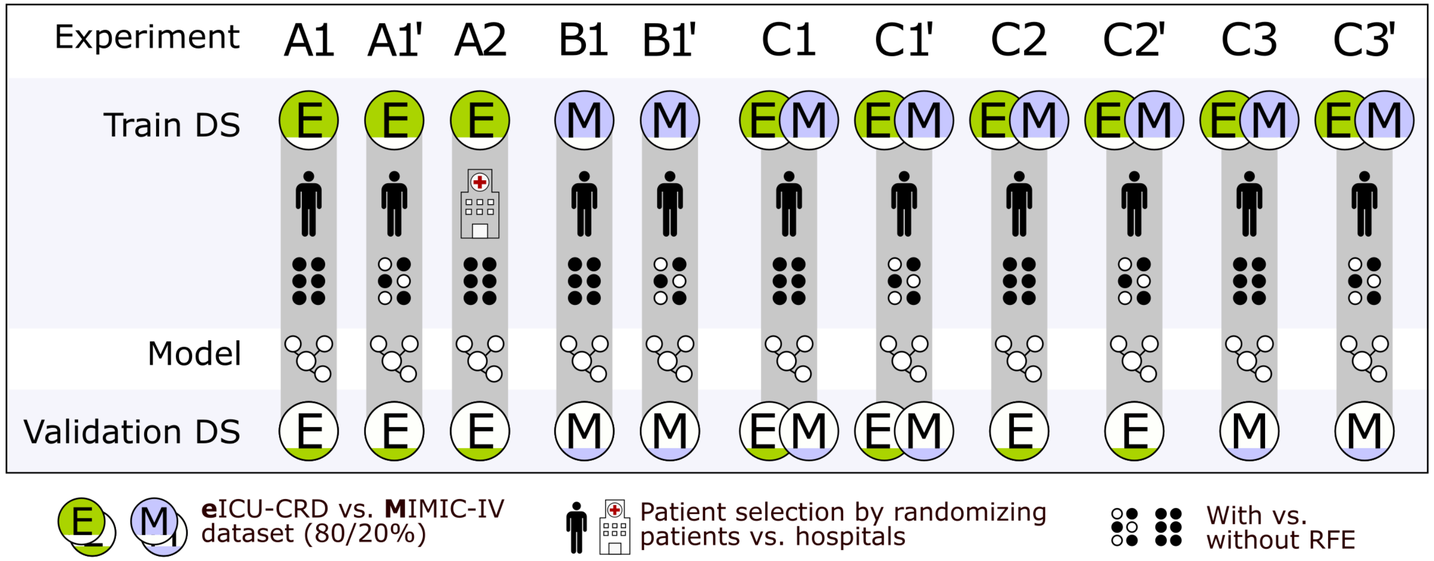
FL infrastructure



Analysis
Use Case 1 – Weaning from Mechanical Ventilation

Prediction of weaning from mechanical ventilation





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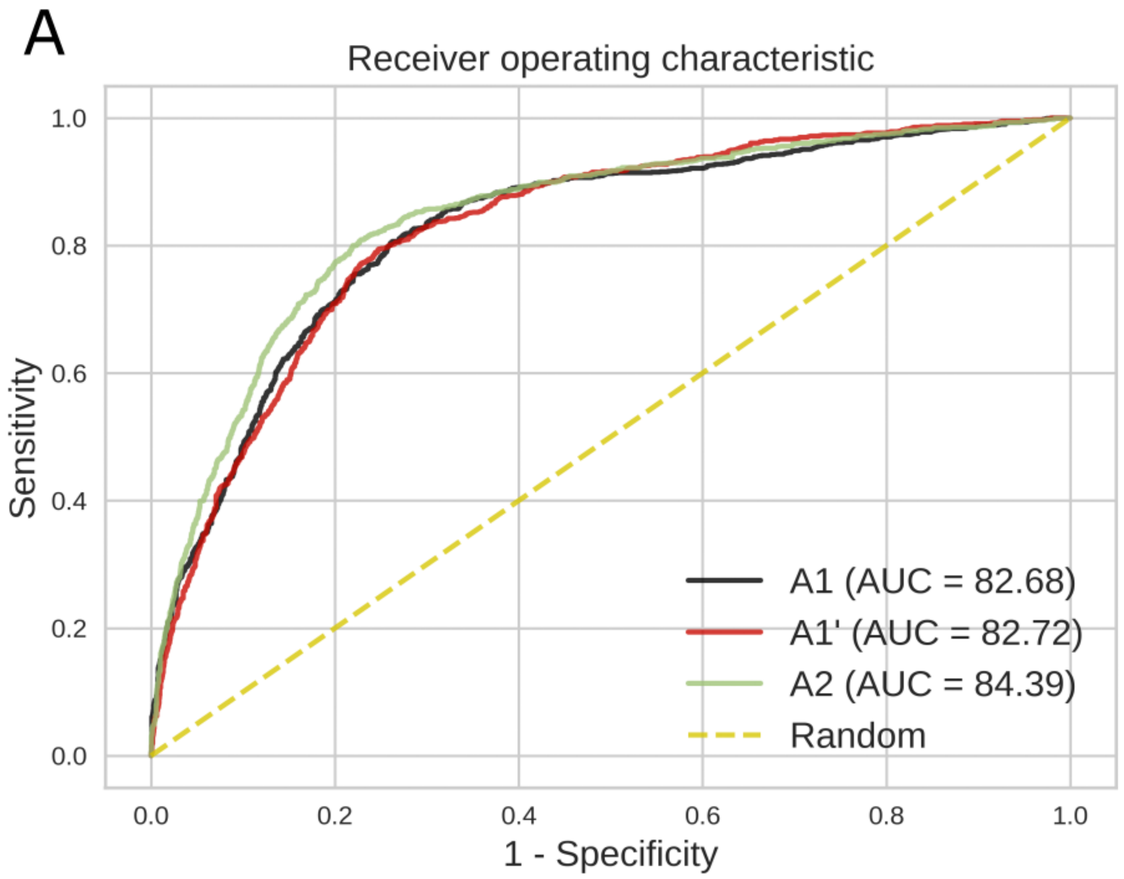
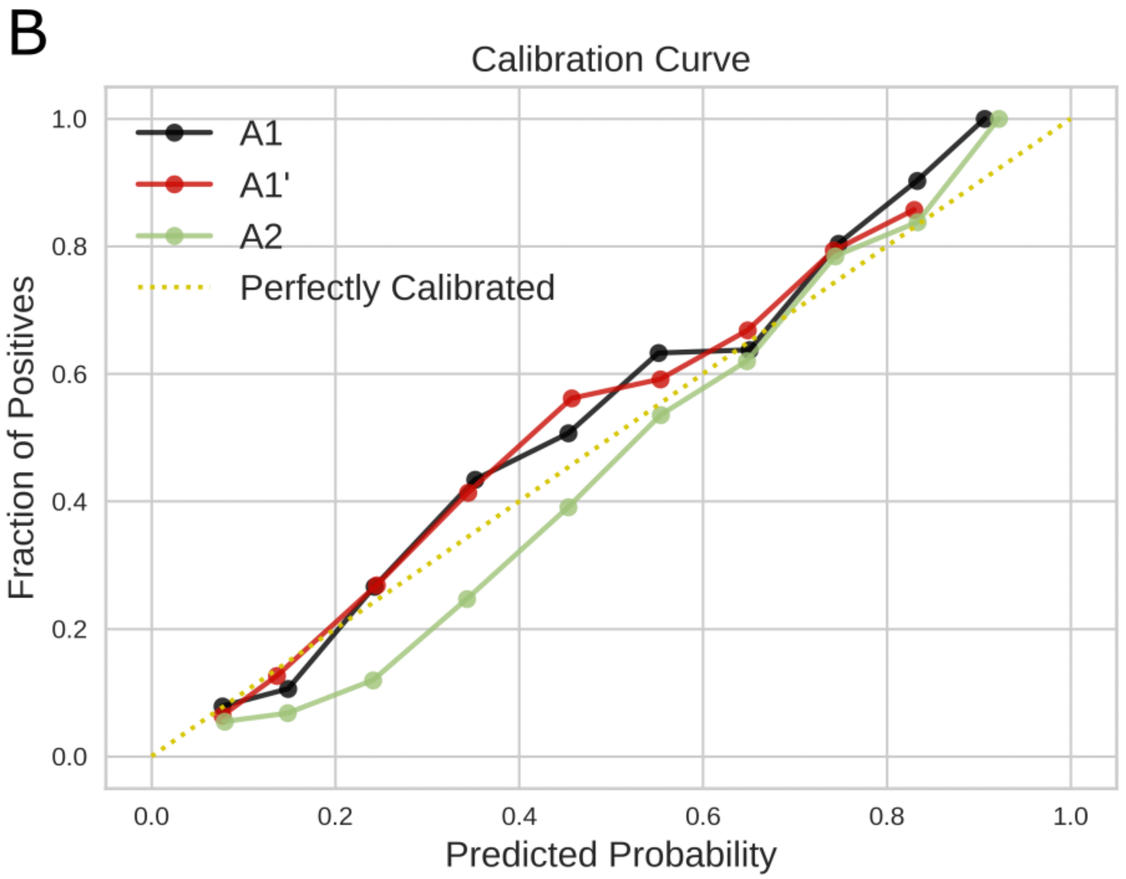
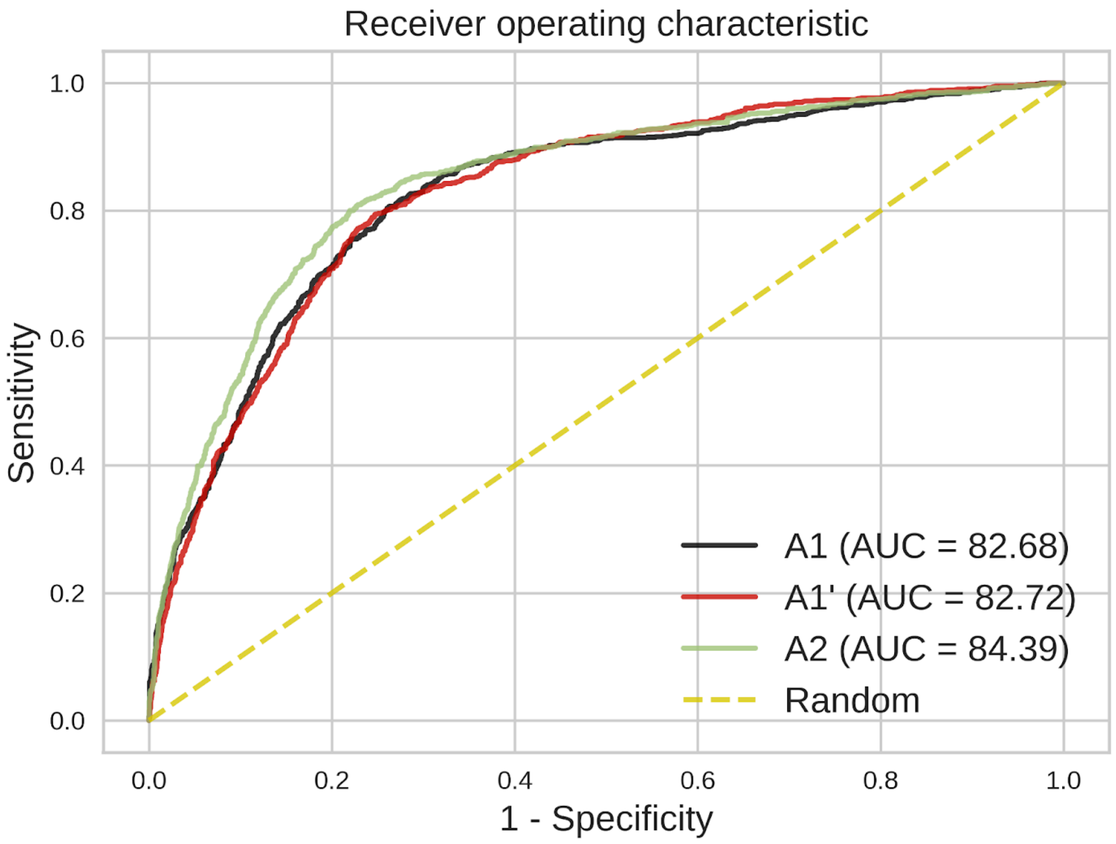


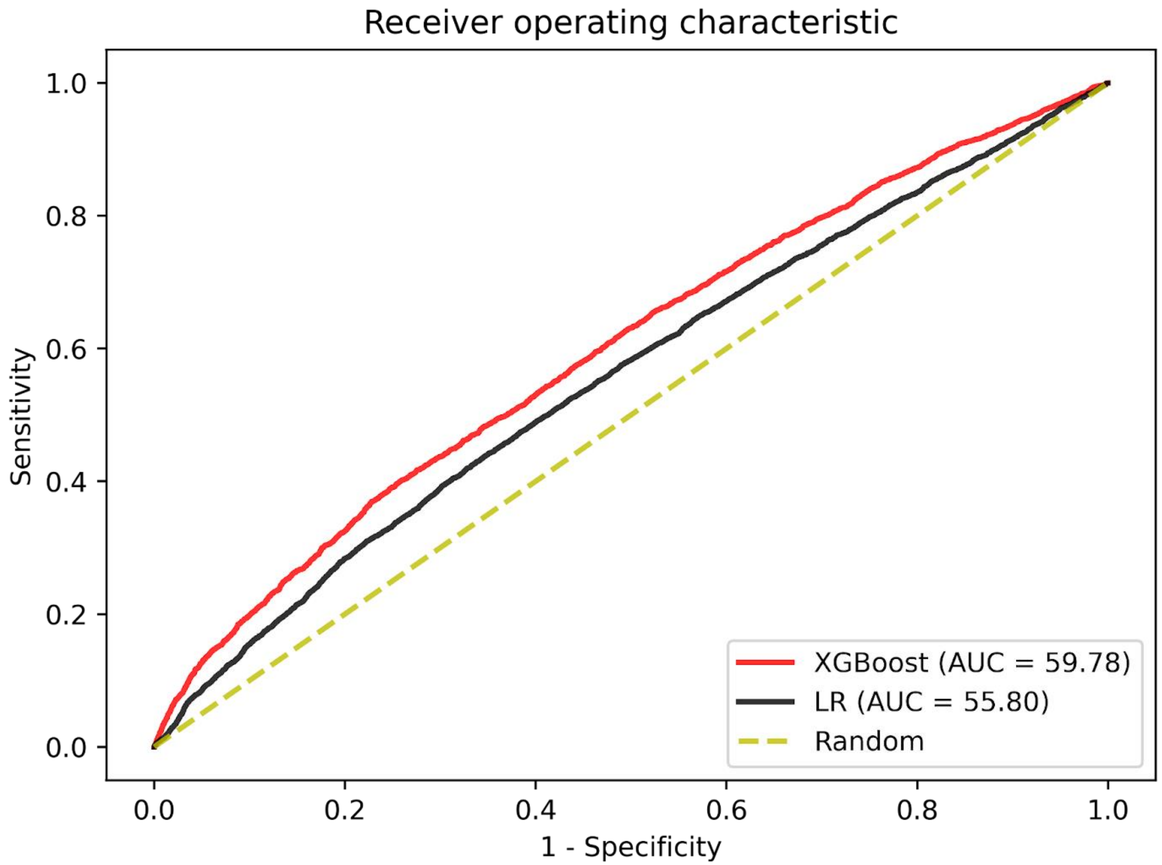


Analysis
Use Case 1 – Weaning from Mechanical Ventilation

trained and validated on one database



trained on MIMIC, validated on eICU



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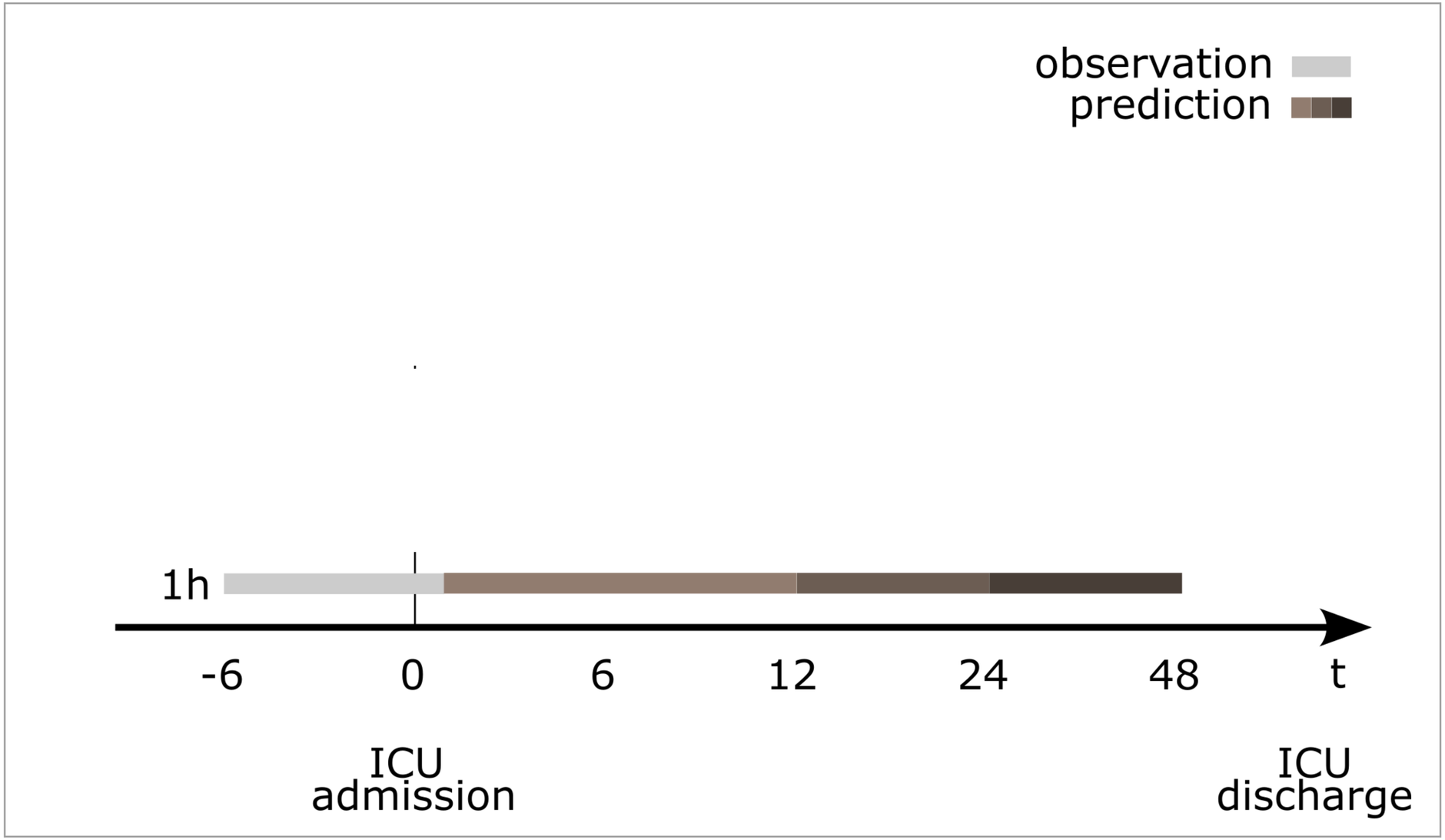
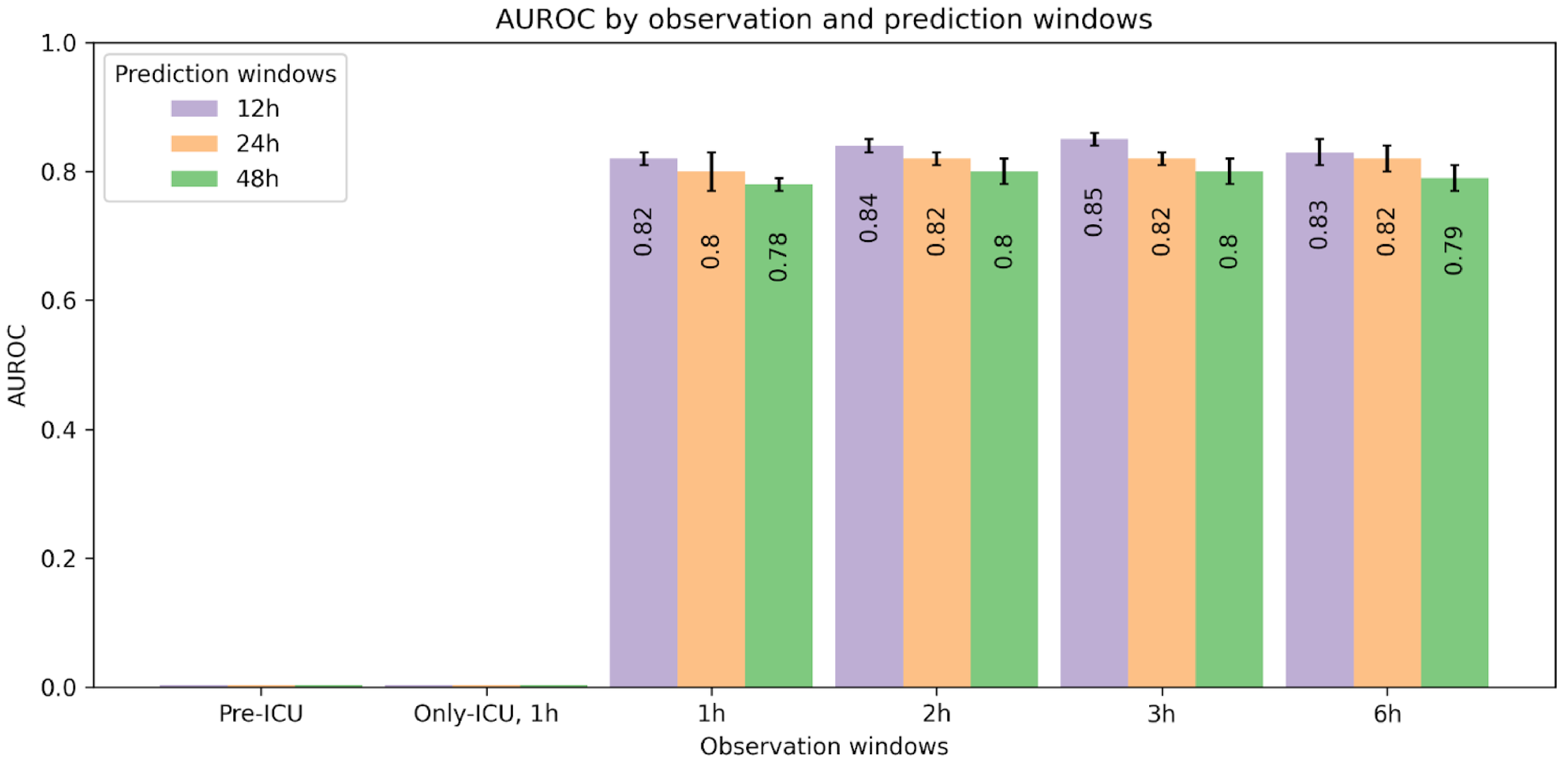
Analysis
Use Case 2 – Prediction of need for blood transfusion



Analysis
Use Case 2 – Prediction of need for blood transfusion



Testing ETL tools

- Background:
  - Many databases
  - Mapping to OMOP
- Goal:
  - Searching for the ideal ETL tool
  - Simple processing with standard tools

Real FL scenario – Apache IV

Background

- Acute Physiology score for common understanding of disease severity
- Latest update (Apache IV) in 2006, done on 110k patients in 45 US hospitals

Objective

- Test the calibration of the APACHE IV score in a european-based cohort
- Recalibration of the APACHE IV variables using federated machine learning

Team

Chair:

- Prof. Christian Hinske

Core group:

- Dr. Mathias Kaspar
  (Lead)
- Dr. Seyedmostafa Sheikhalishahi
  (PostDoc)
- Johanna Schwinn
  (PhD candidate)
- Sebastian Goss
  (MD candidate, training MI)
- Matthäus Morhart
  (Technical Assistant)

Associated:

- Dr. Dorothea Lange
- Ben Geisler (MD, external advisor)

Secure Analysis Federation in the Intensive Care Unit

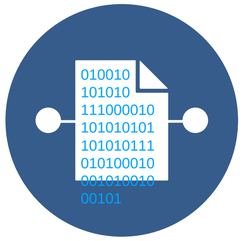
DISCUSSION

Development and usage of decentralized federated algorithms
to enable Clinical Decision Support in Intensive Care

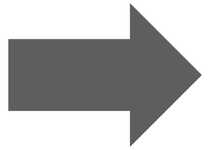
Data Integration Centers

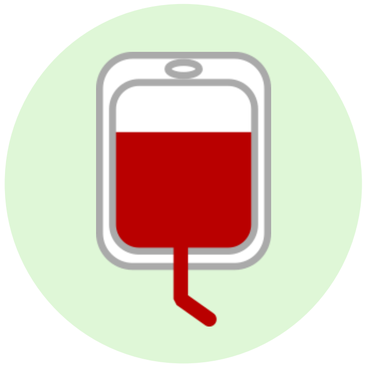
OMOP CDM

Federated learning



Secure Computation





Blood transfusion

Ventilation