



Innocens.

AI in the NICU

The Importance of data in decision-making applied in Late onset Sepsis

(It's) About (Time).

Research & Development Project at University Hospital
Antwerp (UZA)

Classifier for Late onset Sepsis / Surgical NEC on clinical
time series data

Build Technology for inference at bedside

Medtech Start-up spin-off company

Mission:

Increase efficiency of healthcare workers by accelerating
decision making



Content.

Introduction

Time Series Classification using Machine Learning

Artificial Intelligence Technology

Next Steps

A sepsis episode will occur 1 in 5 VLBW infants will when admitted in Neonatal Intensive Care. Time is a life-saver!

There is **curative treatment**
available

IV. ANTIBIOTICS



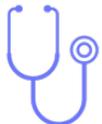
Outcome and prognosis **remains**
poor

10% mortality
risk for neurodevelopmental delay ↑
+19 days in ICU

Sepsis: why can't we do better?



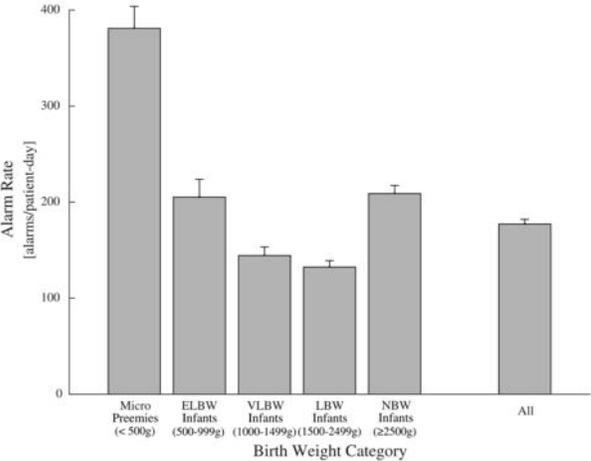
Early symptoms of sepsis are very subtle



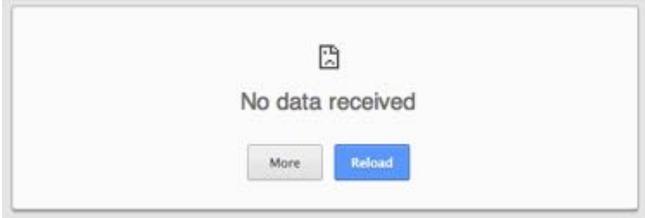
Diagnosis by clinical intuition



24/7 Governance of 25+ patients



Alarm fatigue



Data potential not used

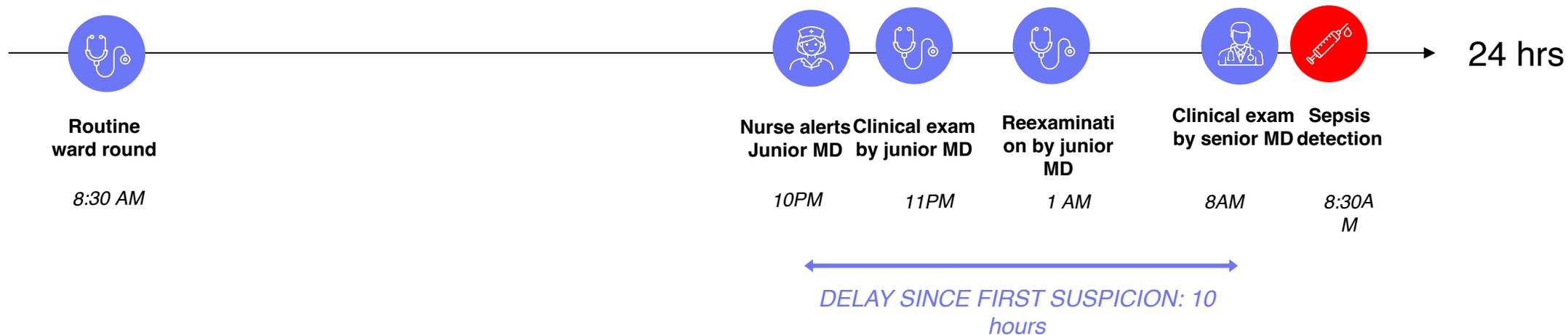


Flexible staffing occupancy

Series of events of sepsis episode **in routine care**

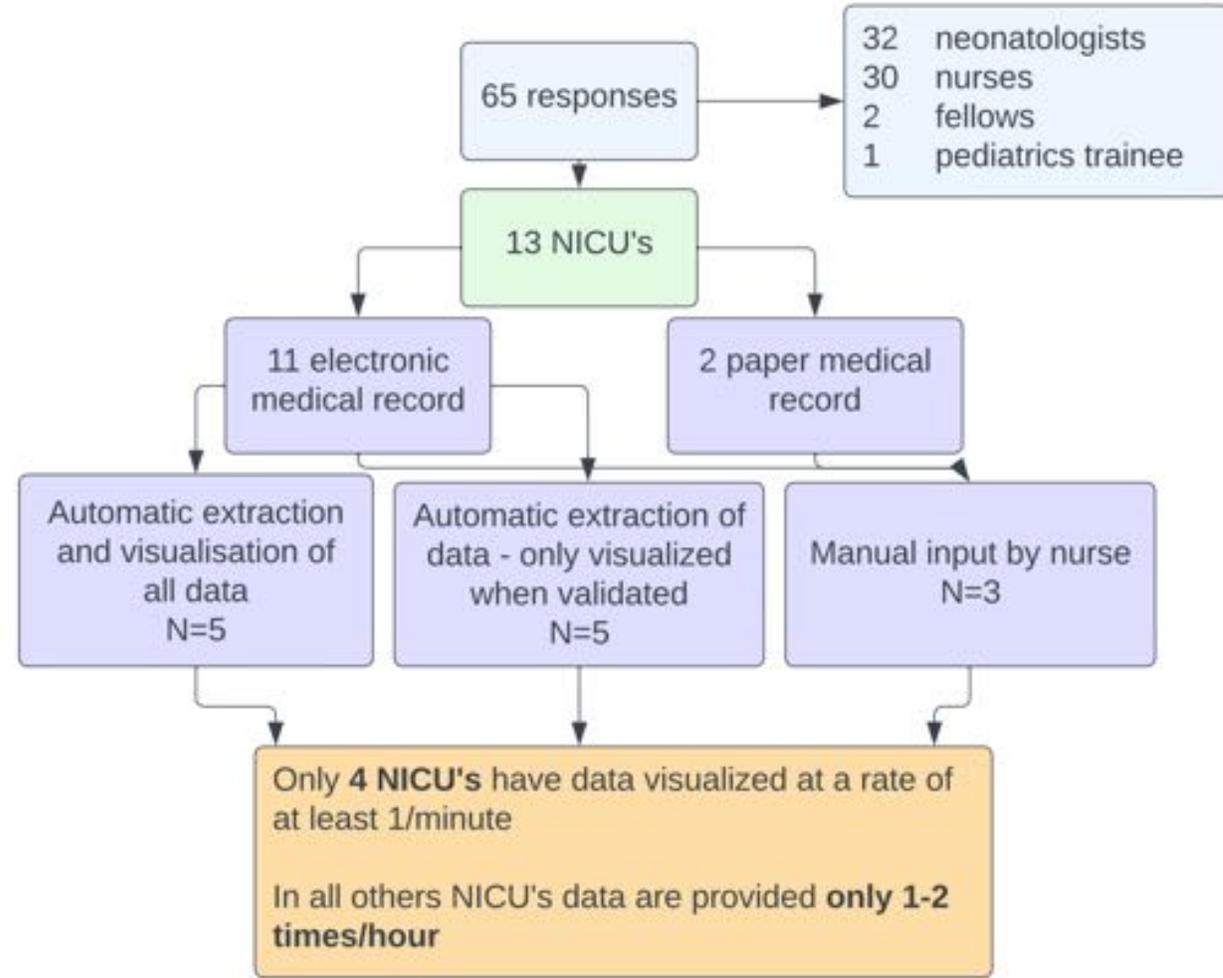
Case:

- ▶ Patient born at 27 weeks
- ▶ Birth weight; 1000 gr
- ▶ Sepsis on day 7



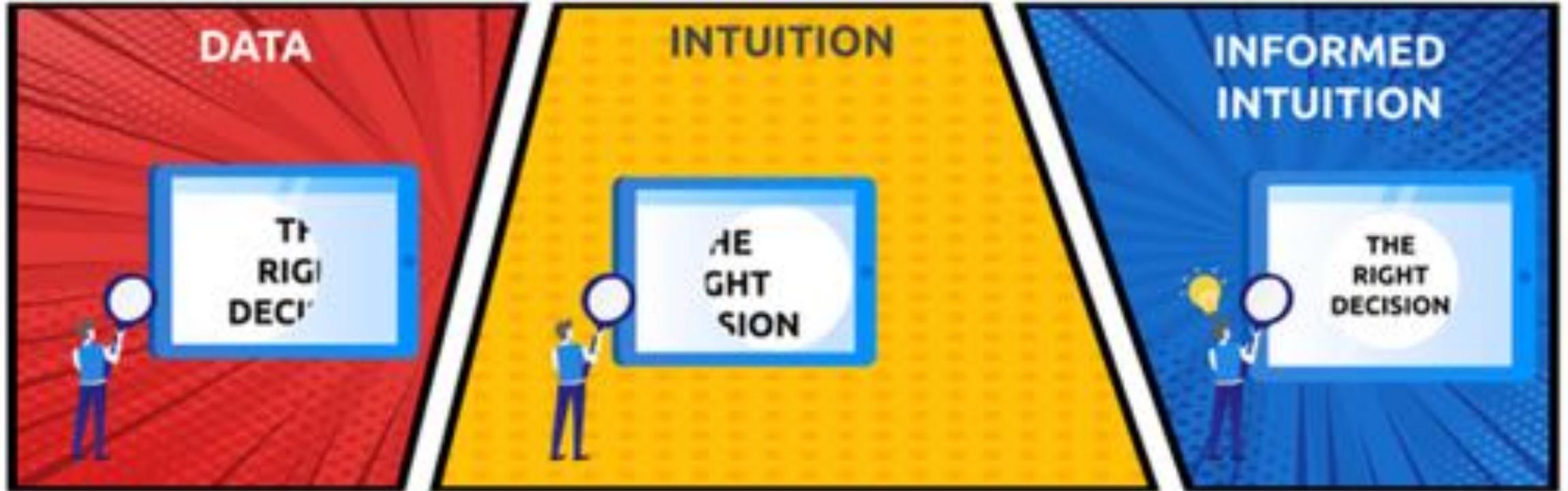
Problem 1.

Data availability?



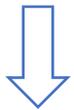
Survey in Belgium NICU's on the level of digitalization

Why can't we do better?.

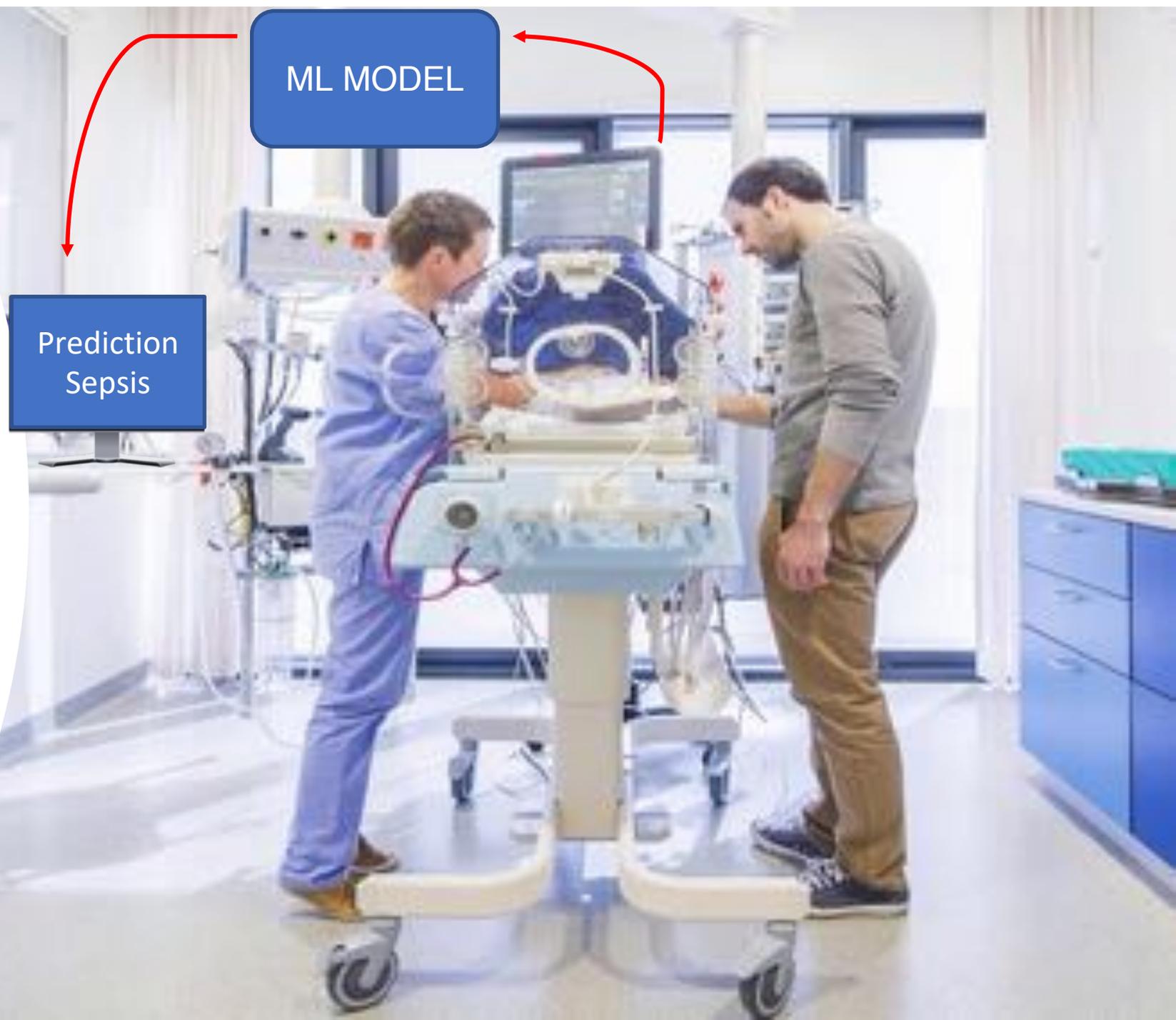


ARTIFICIAL INTELLIGENCE DECISION SUPPORT

digital support at every bed
checking data every 30 mins



alert "real" MD
if sepsis pattern detected



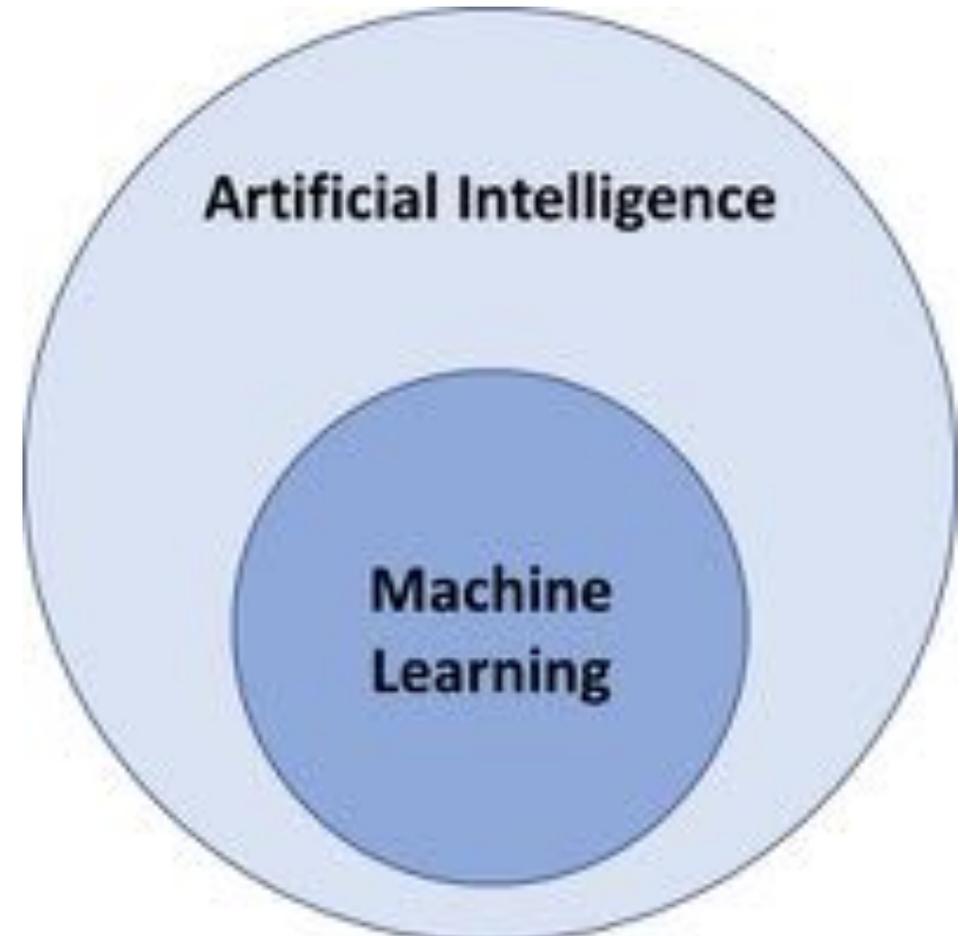
Machine Learning.

Subset of Artificial Intelligence

=Train an algorithm on a certain dataset to perform a certain task (regression, classification,...)

Supervised vs Unsupervised Learning

Deep Learning



Innocens Project

Research & Development project



Research

Retrospective study

Machine Learning Model
Late onset sepsis
Surgical NEC

Historical NICU dataset
> 1000 VLBW infants

Time series data from
sensors & observations

Approved by Local IRB



Prerequisites

Machine Learning

Detect majority of LOS
(Sensitivity)

Acceptable False positive
(Precision)

Faster than MD
(Time-gain)



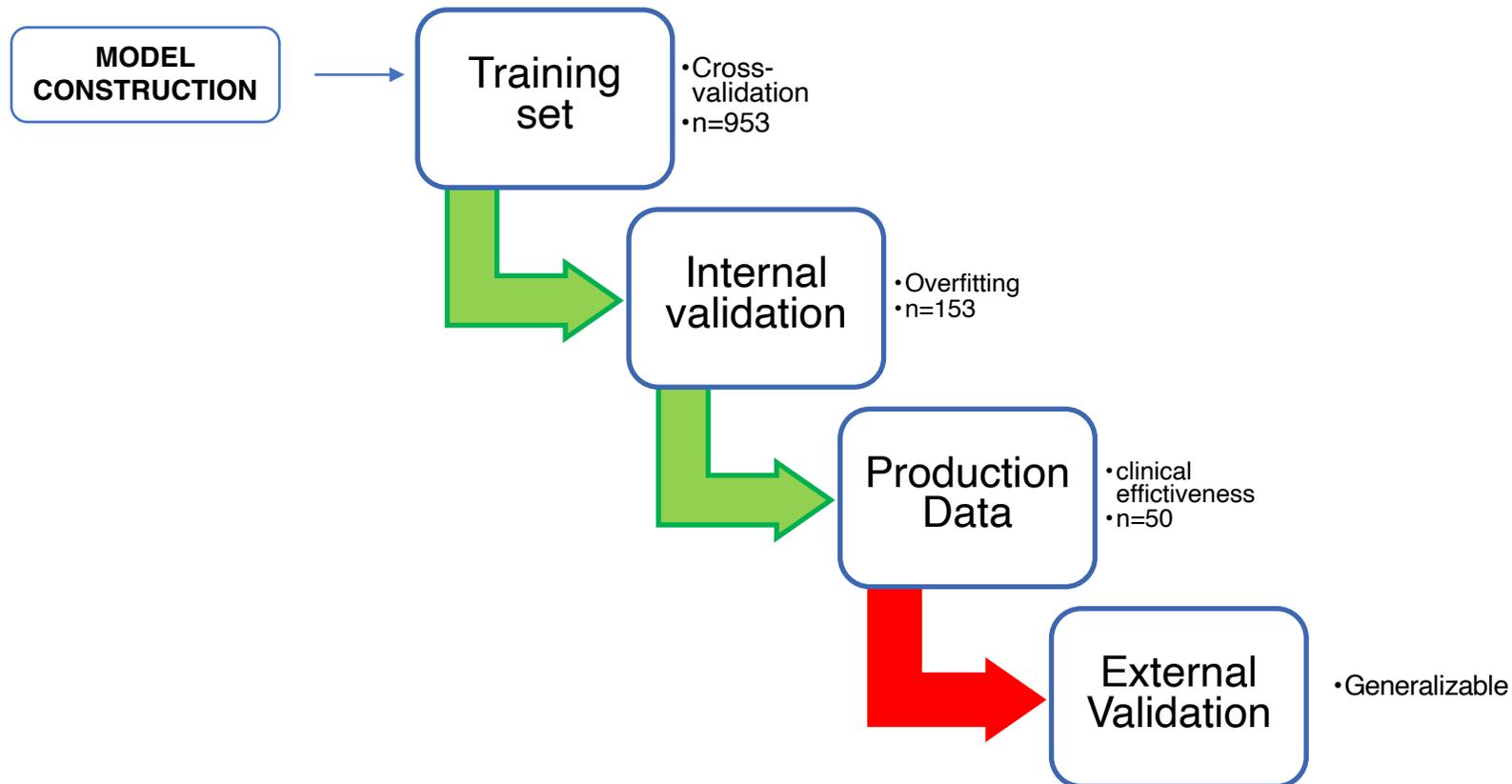
Team

UZA

IBM

Universiteit
Antwerpen

ML model pipeline.



Training
n=953

Retrospective study
All patients < 32 weeks
2012-2019

Gestational age (weeks)
29,4 (27,6-30,9)

Birthweight (grams)
1290 (950-1550)



The NICU data

**Readily available clinical time series data
obtained in routine clinical care**

Existing
Monitoring equipment

Electronic
Medical Record

dataset > 1000 VLBW infants
°2012-2021
high frequency time series data
from admission to discharge (+/- 50d)

Step 1: Data engineering.

Labelling

Late onset Sepsis

Surgical NEC

Label 1

**NEO
KISS**

Time stamp
Order entry blood culture

**BELL's Staging
NEC**

Time stamp
X-ray pneumatosis



Label 2

Severe episode

Step 2: Data engineering.

Signal processing and feature engineering

SIGNALS INCLUDED

Sensor data sampled at 0,016Hz

ECG (3-lead)

Plethysmography

Observational data randomly sampled

Temp

Glucose

FiO2

Demographic data

Gestational age

birthweight

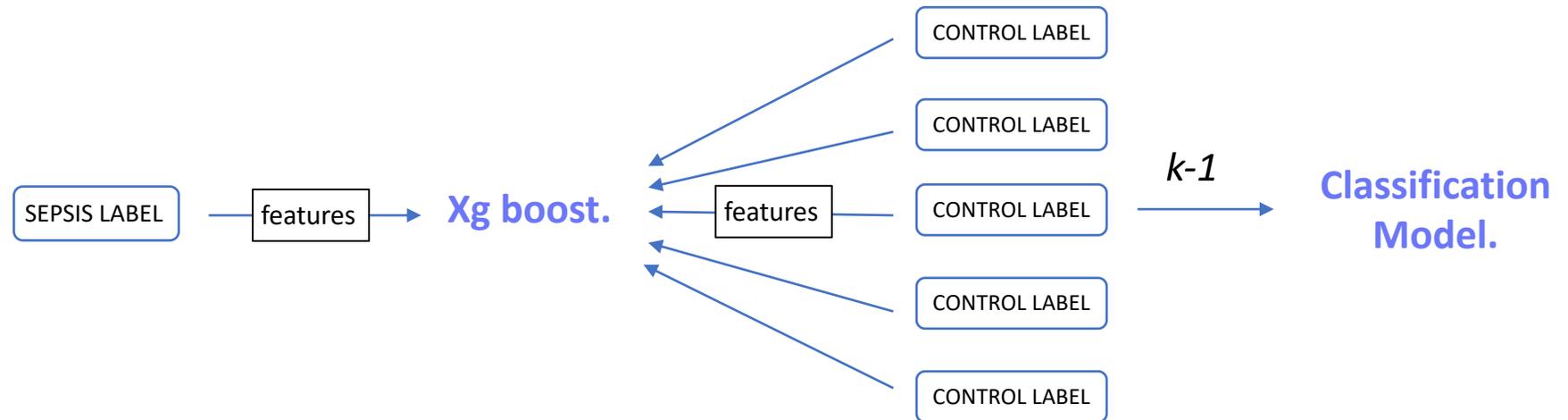
Postnatal age

FEATURES

- 6 subsignals
- 26 features
- explainability

Step 3: ML Model Training.

Supervised Machine Learning & Hyperparameter tuning



Caveat:

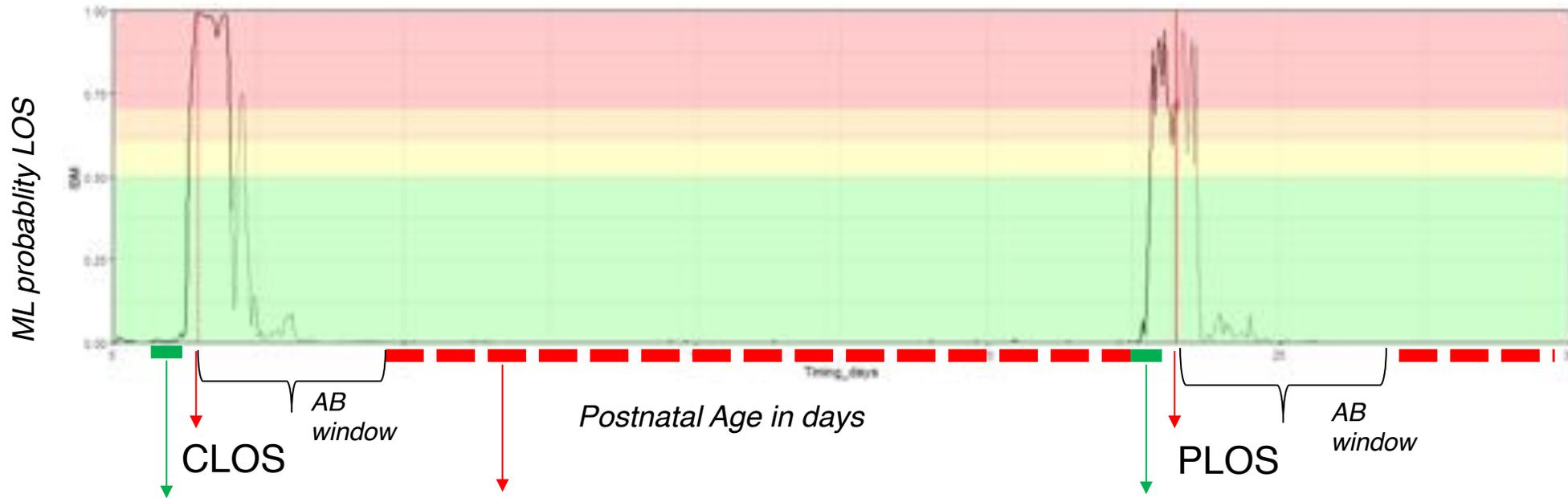
Imbalanced datasets

Sepsis episode = 0,4% of total time series data

Step 4. ML performance metrics.

Precision and recall

Continuous ML output plot in patient 29w 1200g



RECALL (sensitivity)
=TP/TP+FN

PRECISION (PPV)
=TP/TP+FP

TRUE POSITIVE:
Any spike < 24 hour before sepsis onset

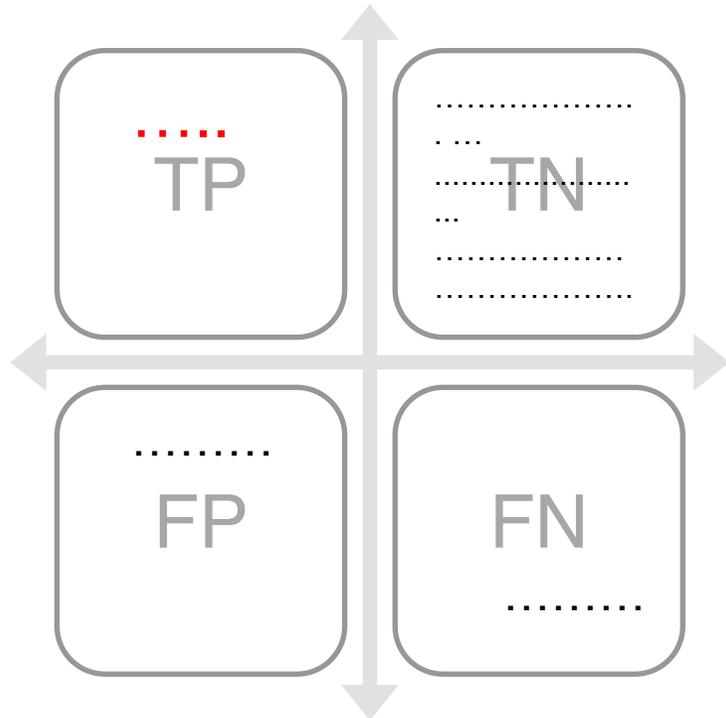
FALSE POSITIVE:
Any spike in 12hour outside 24 hr before sepsis (from age 72hrs) (not in AB windows)

TRUE POSITIVE:
Any spike < 24 hour before sepsis onset

Problem 3: Class imbalance & ROC.

Quantification of continuous performance analysis

AUC can be False high in **class imbalanced** datasets!
(Innocens dataset class imbalance 0,4%)

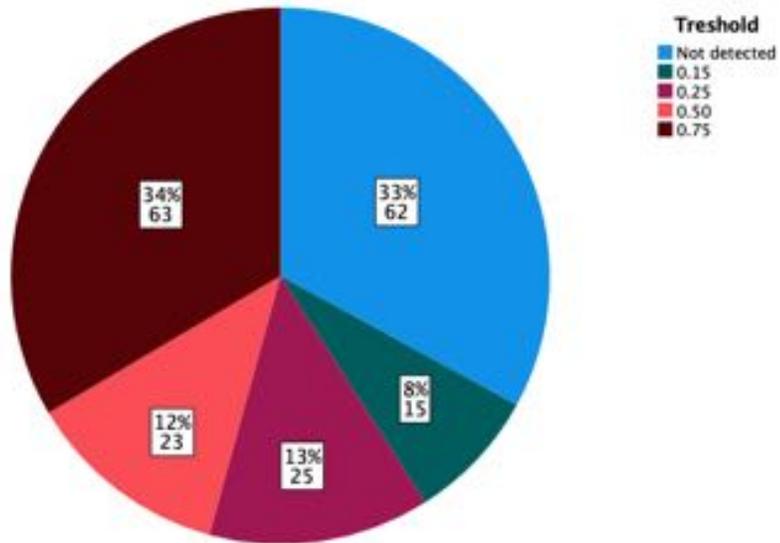


sensitivity

$$1\text{-specificity} = \frac{\text{FP}}{\text{FP} + \text{TN}}$$

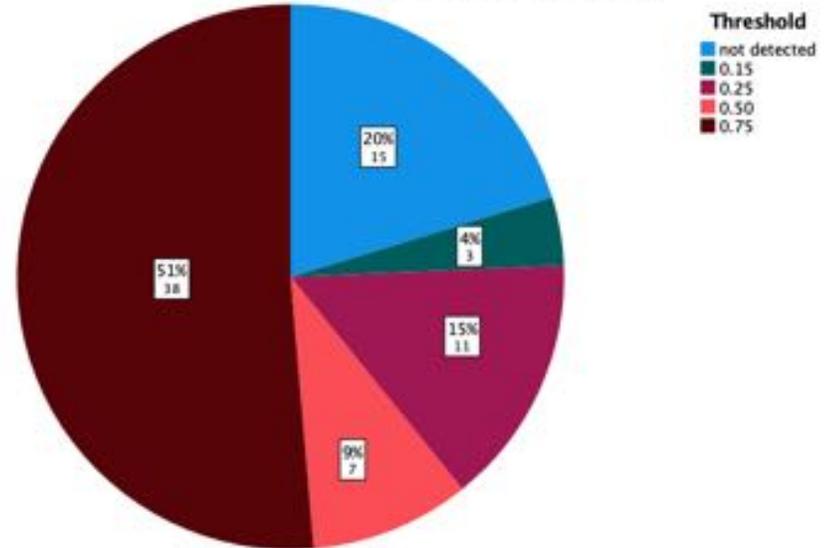
ML Model: Recall or Sensitivity.

Pie Chart: All sepsis/NEC episodes (n= 188)



All sepsis episode: sensitivity 67%

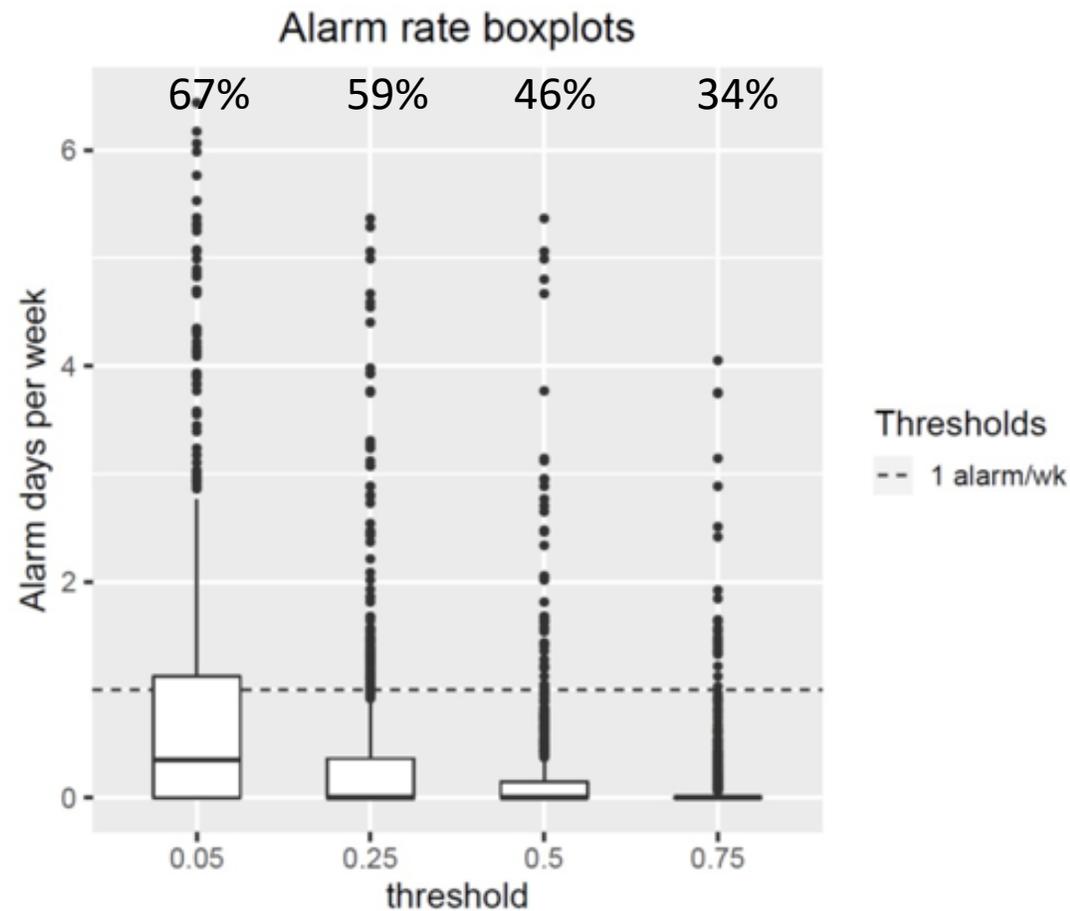
Pie Chart: Recall Severe Sepsis/NEC (n=74)



Severe sepsis episodes: sensitivity 80%

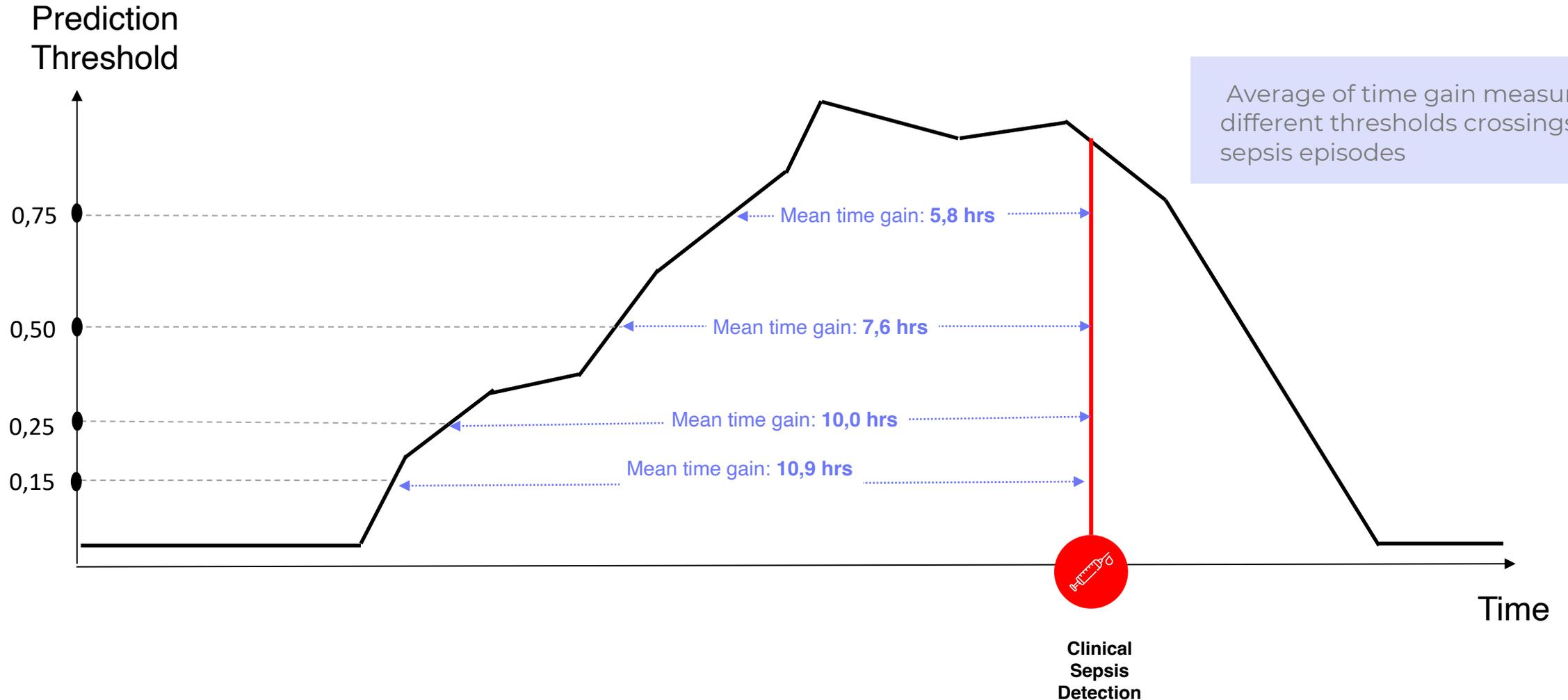
ML Model: precision.

All sepsis episodes (n= 188) :1 alarm day/patient/week!



ML Model: Time gain.

Severe sepsis time range: 10,9 - 5,8 hrs



Technology.

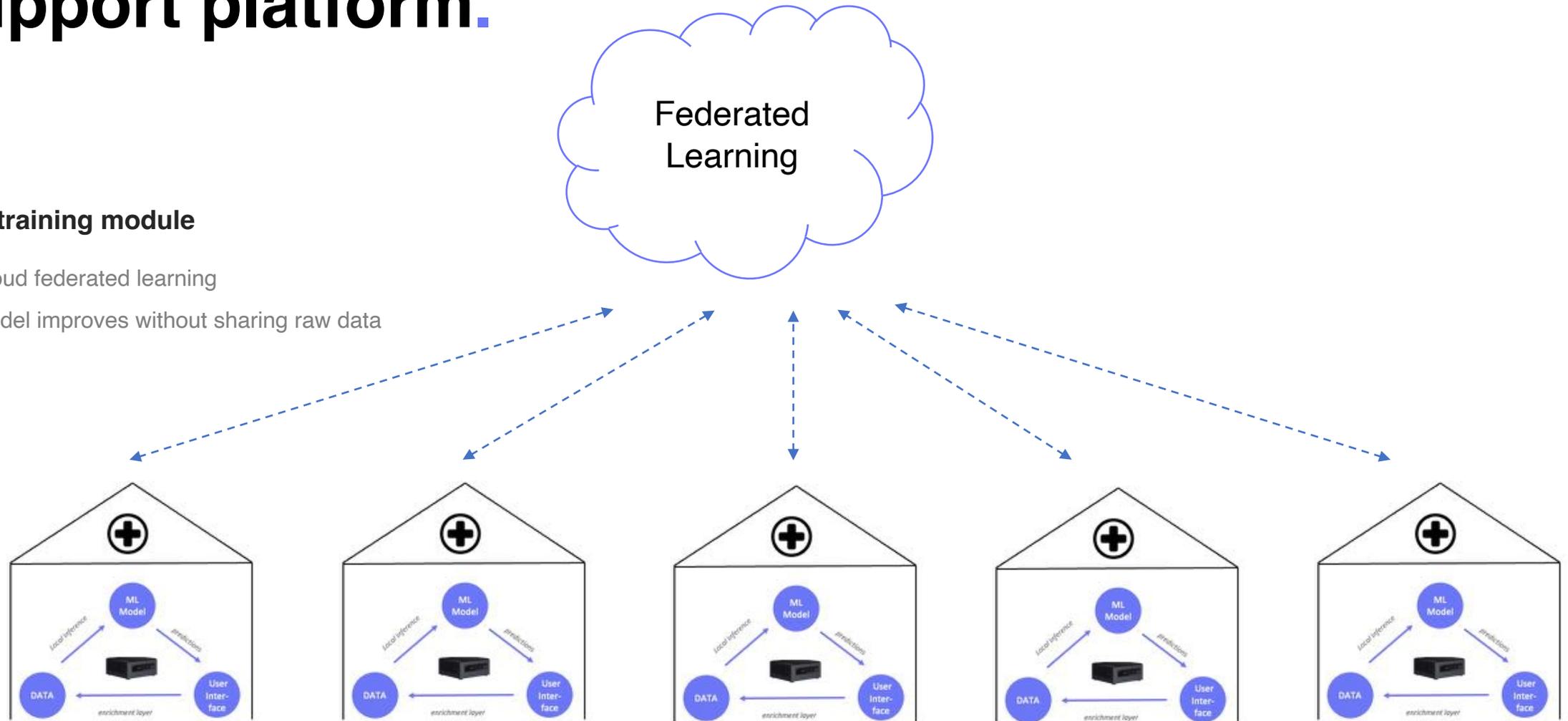


Edge Cloud AI Decision Support platform.

Retraining module

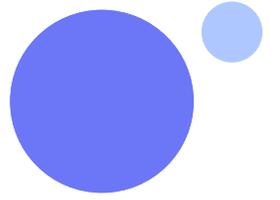
Cloud federated learning

Model improves without sharing raw data

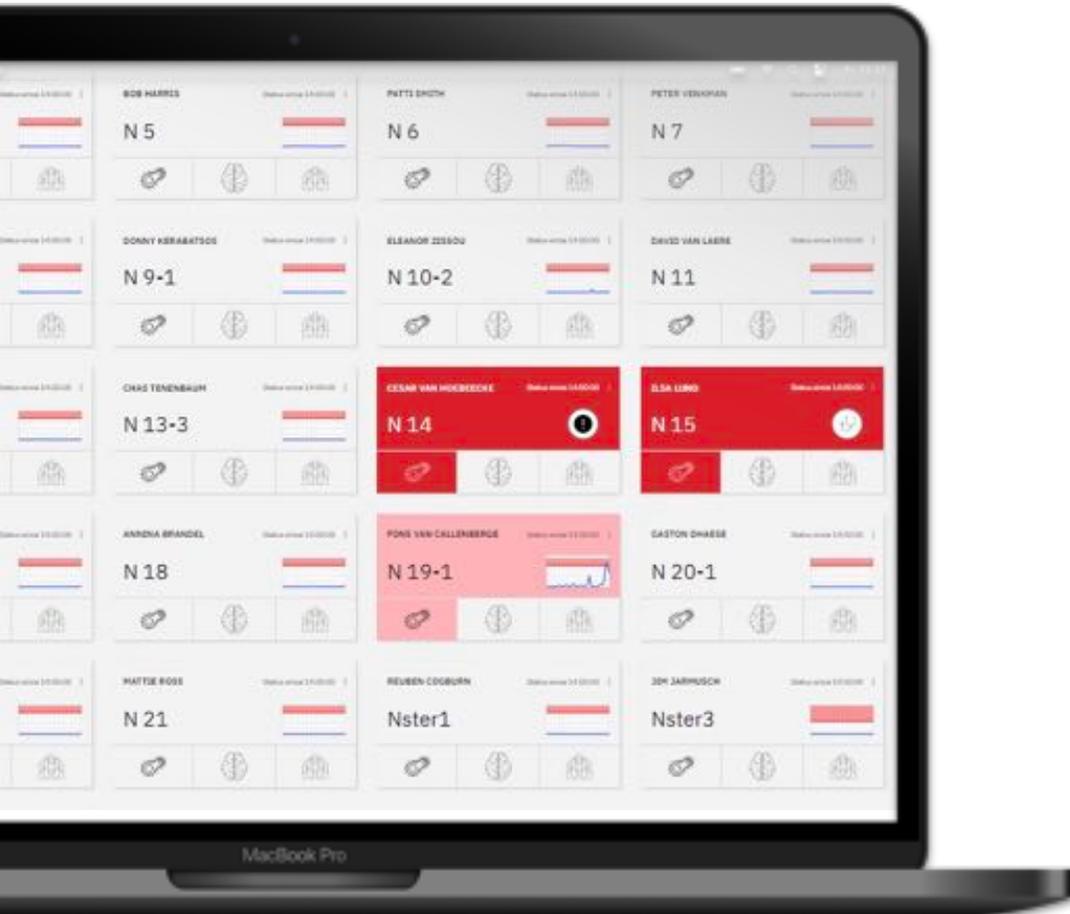


Explainable AI.

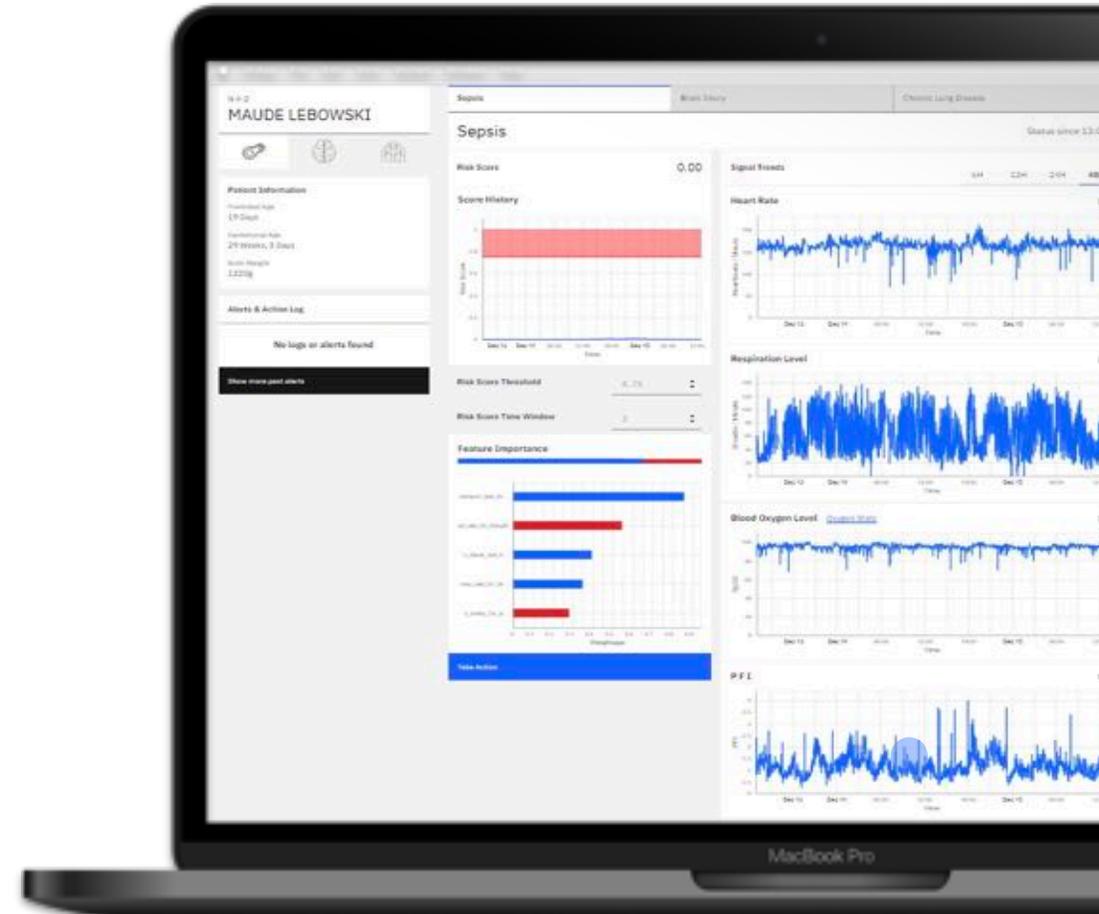
a digital support at every bed doing scanning data every 30 mins



Ward governance at a glance

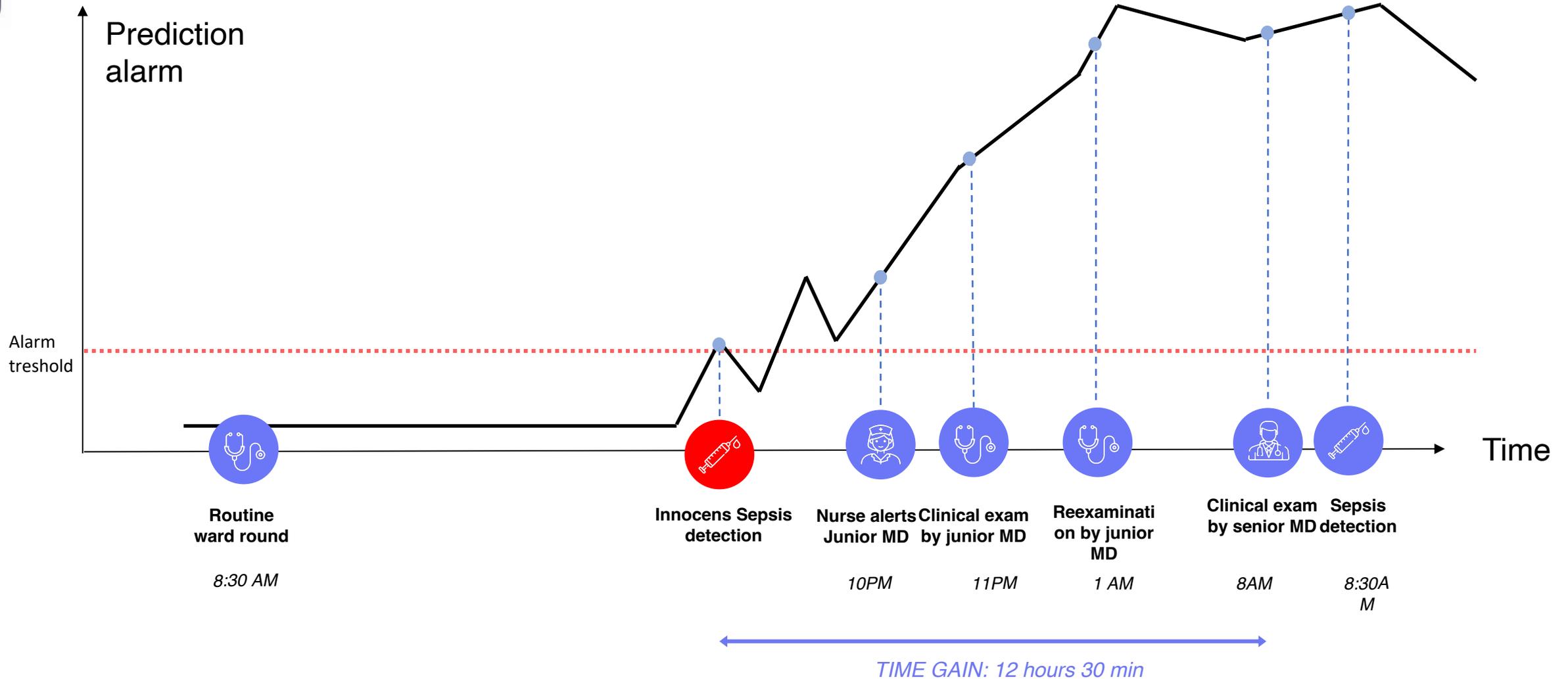


Feature importance



Series of events with Innocens prediction

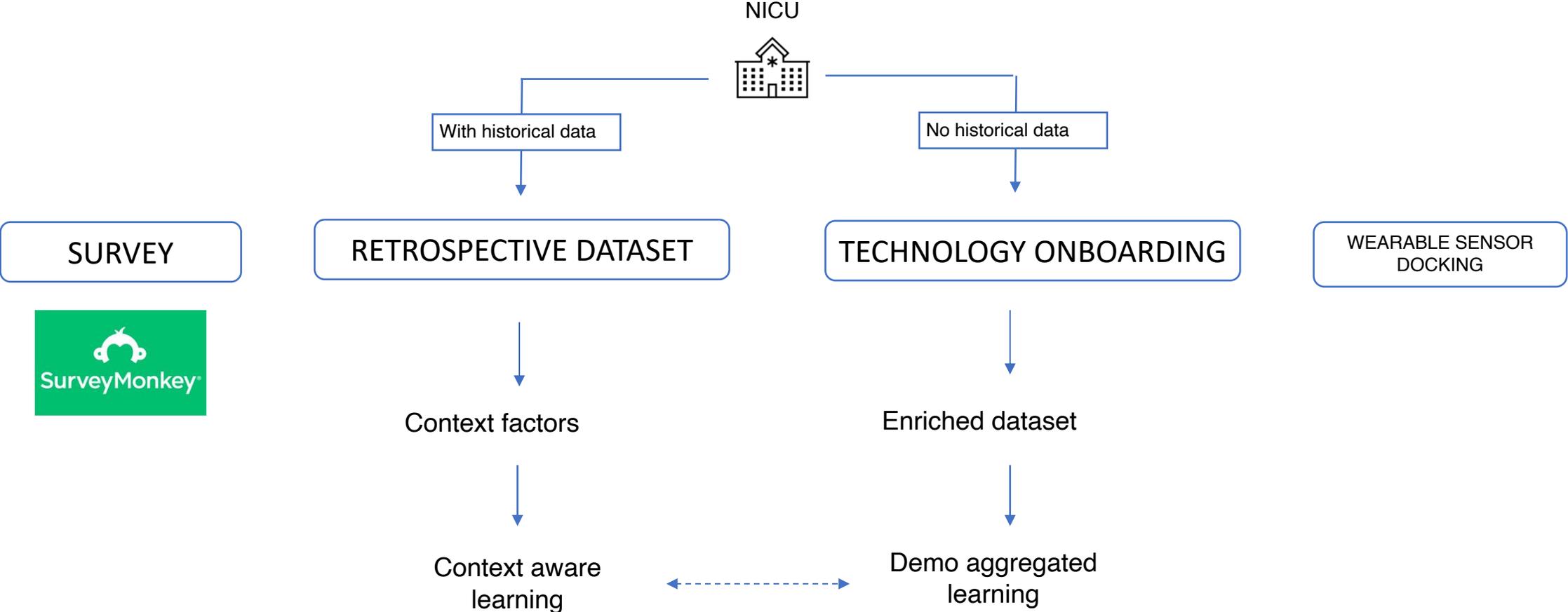
- Case:
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 - ▶ Sepsis on day 7



What's next.

External validation of ML Model

We are looking for EU NICU's to participate in a scientific study validating the Machine Learning Model & technology



Contact.

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