Development of a **Clinical Decision Support System** for **Hospital-Acquired Pressure Injuries:**

a **Nurse – Data Scientist Collaboration** Example

Sophie Pouzols [1,2], ***Snežana Nektarijević*** [3,4], Jérémie Despraz [1,4], Jean-Louis Raisaro [1,4], Cédric Mabire [1,2]

1. Lausanne University Hospital (CHUV), Lausanne
2. IUFRS, University of Lausanne , Lausanne
3. Swiss Data Science Center, EPFL, Lausanne
4. Biomedical Data Science Center, CHUV, Lausanne

Background

Hospital-acquired pressure injuries

HAPI

Nursing-sensitive outcome

Most frequent complication

Negative impact on patient & health system

Risk assessment

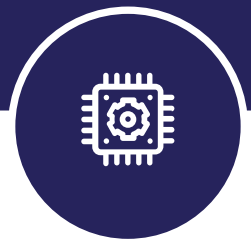
BRADEN

First step of prevention

Braden = gold standard

Limited performance & accuracy

Early risk detection



ML

↗HAPI risk assessment using routinely collected EHR

LSTM model = better performance than Braden

Our goal

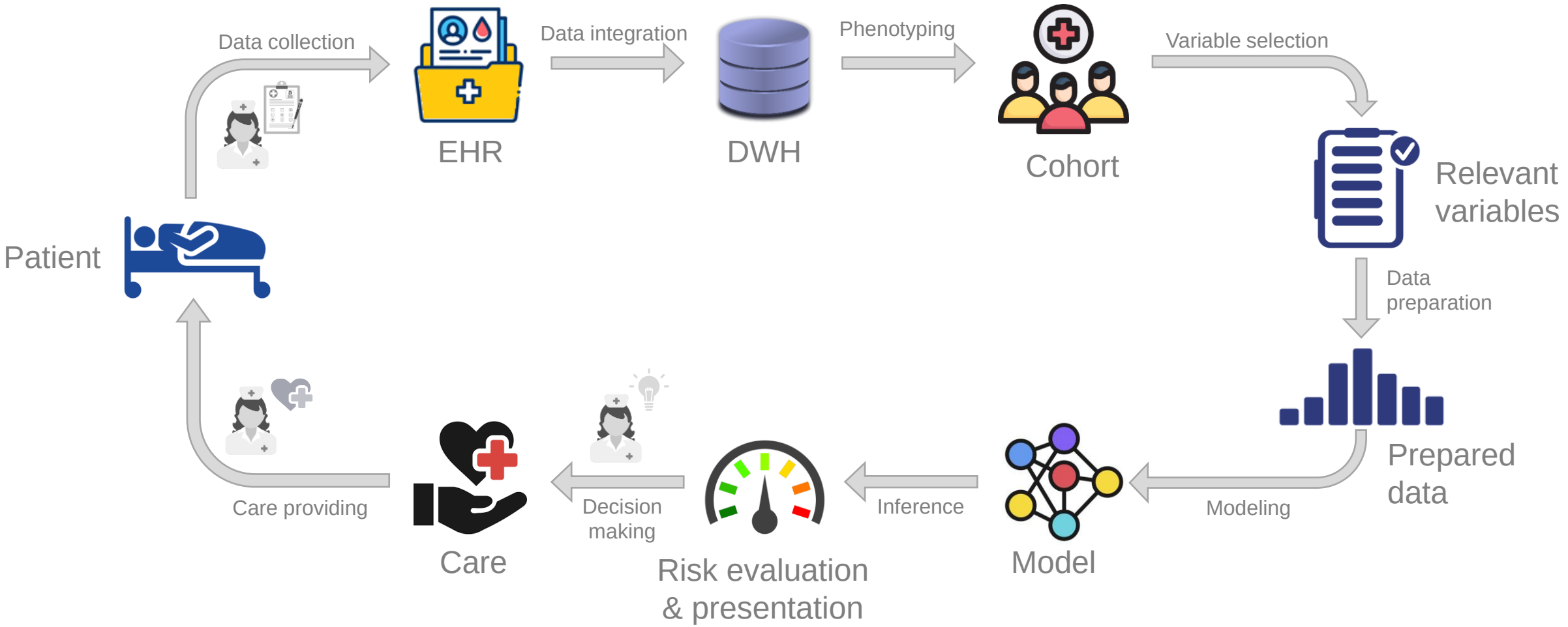
CDSS

Translate the risk score into operational recommendations

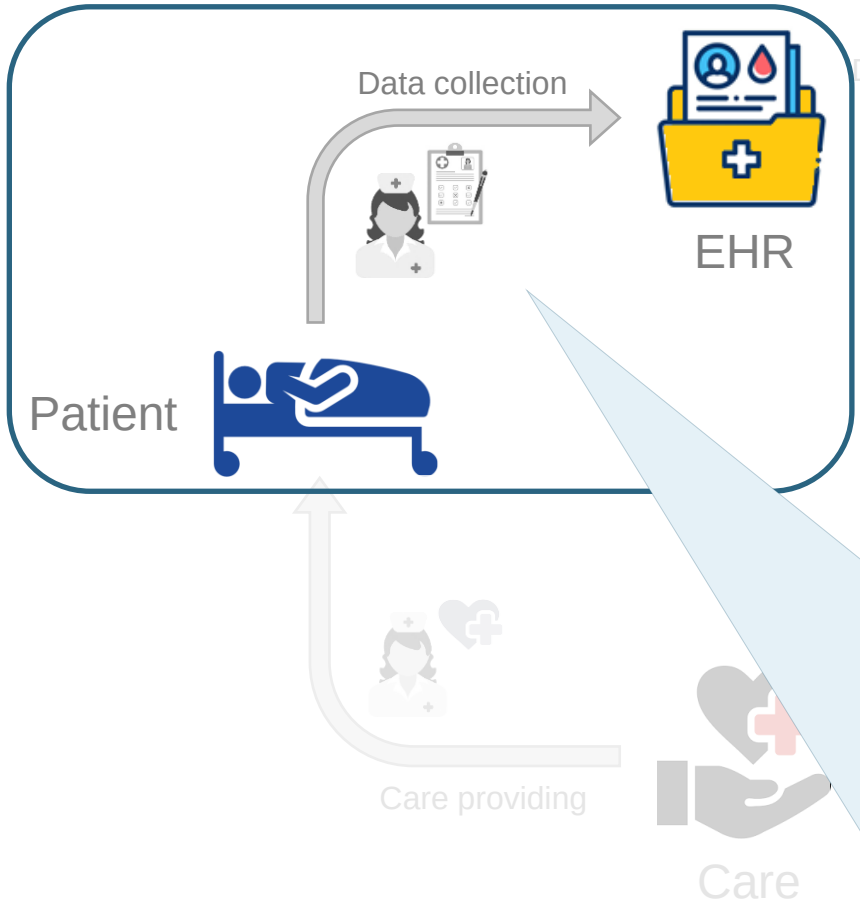
CDSS implementation in clinical practice

(Mudge et al., 2019, Murphy et al., 2020, EPUAP, 2021)

Data flow


Data collection
EHR
Data integration
DWH
Phenotyping
Cohort
Variable selection
Relevant variables
Data preparation
Prepared data
Modeling
Model
Inference
Risk evaluation & presentation
Decision making
Care
Care providing
Patient

Data collection



- Approx **30 forms** for recording **health parameters** and **interventions**
- Filled by **nurses**
- At irregular times, **every couple of hours**

Soins - SoTech. Plaie 1 26.04.2023

Heure du soin	13:19
Saisi par	Sophie Pouzols, Madame
Nature du soin prescrit	
CONTEXTE	
Plaie 1	Escarre
Localisation	
Latéralité	
Contexte	acquise dans l'unité
Cathéter incisionnel	oui
SURVEILLANCES	
Pansement	
Photo prise	
Dessin dans Diagrammer	oui
Type de suture	
Longueur (cm)	
Largeur (cm)	
Profondeur (cm)	
Sous-minage	
Catégorie d'escarre	catégorie 4 - Perte tissulaire
Contexte d'acquisition de l'escarre	Acquis dans l'unité

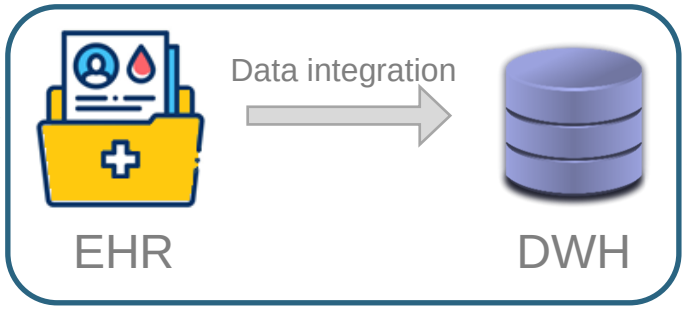
Syst. - Mobilité/Locomotion/Déplacement 26.04.2023

Heure de saisie	13:11
Saisi par	Sophie Pouzols, Madame
Nature du soin prescrit	
MANIFESTATIONS	
Articulation	
Amplitude de mouvement limitée	
Motricité	
Membre - force et tonus	
Force et tonus musculaire	
Echelle de force musculaire	
Capacité de positionnement	
Capacité de transfert	
Capacité de marche	
Déplacements limités par	
Douleur	
Saignement	
Observation(s), commentaire(s)	
PROBLEME / DIAGNOSTIC 1 (Mobilité)	
Mobilité précoces	
Problème / diagnostic	Mobilité physique réduite
Gravité estimée	
Objectif	
Périmètre de marche souhaité (m)	
Objectif détaillé	
Evolution	

Soins de base - Installation et Transfert 26.04.2023

Saisi par	Sophie Pouzols, Madame
TRANSFERT-DEPLACEMENT	
Dispositif de transfert	
Suppléance et réalisation (transfert)	
Type de soins - Transfert	
Dispositif d'aide au déplacement	
Type de soins - Marche	
Périmètre de marche effectué (m)	
INSTALLATION	
Emplacement / installation	
Durée de la séance installation (min)	
POSITIONNEMENT-PREVENTION - CONFORT	
Support de réduction de pression et de positionnement	(1) Matelas dynamique (à..
Positionnement	(1) Décubitus dorsal
Angle du dossier de lit (degrés)	
Protection de la peau	(1) Hydratation de la pe..
Effleurage	oui
Changement de la litterie	
Dispositif de contention physique	
Suppléance et réalisation (positionnement)	Suppléance totale (Soins ré
Type de soins - So. Mob. Positionnement	
Participation proche - So. Mob.	
Observation et commentaire	

Data integration



- Data from all sources integrated in a DWH
- Updating once per day

Data collection
Patient
Relevant variables
Data preparation
Prepared data
Modeling
Model
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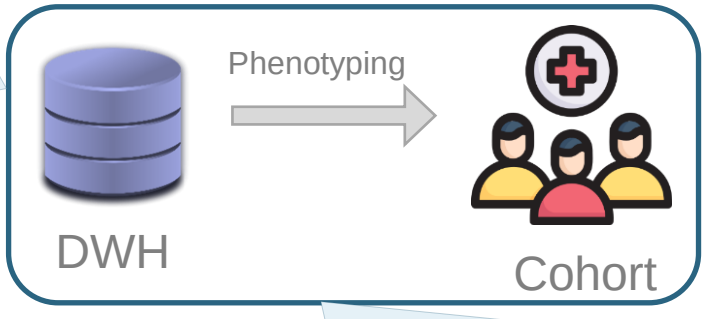
Decision making
Care
Care providing

Phenotyping

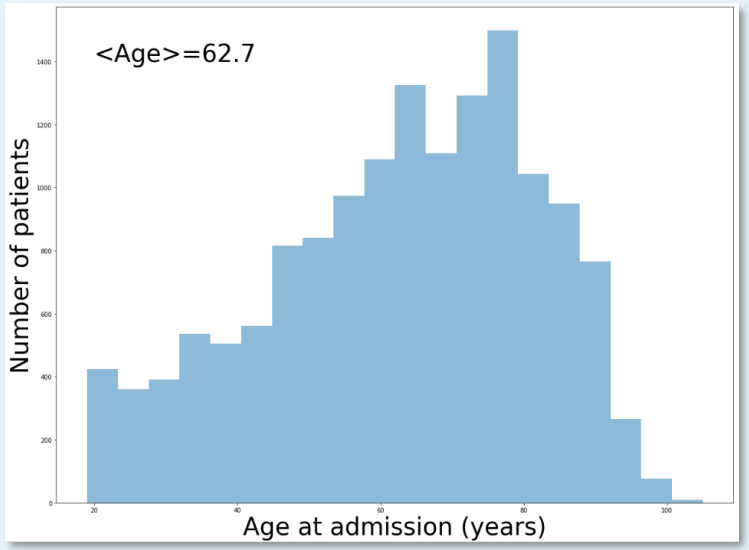
- Selection criteria:
  - 18+ yo patients
  - Hospitalised for >48h
  - Period: 1 April 2019 to 31 March 2020
  - HAPI documented >24h after admission

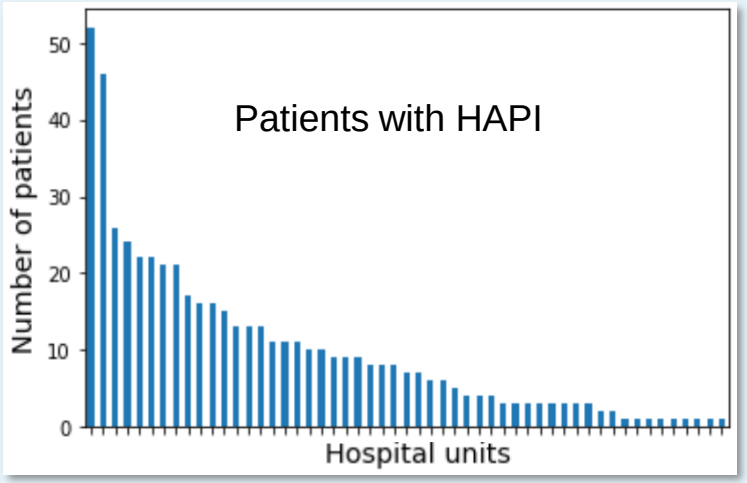


Variable selection

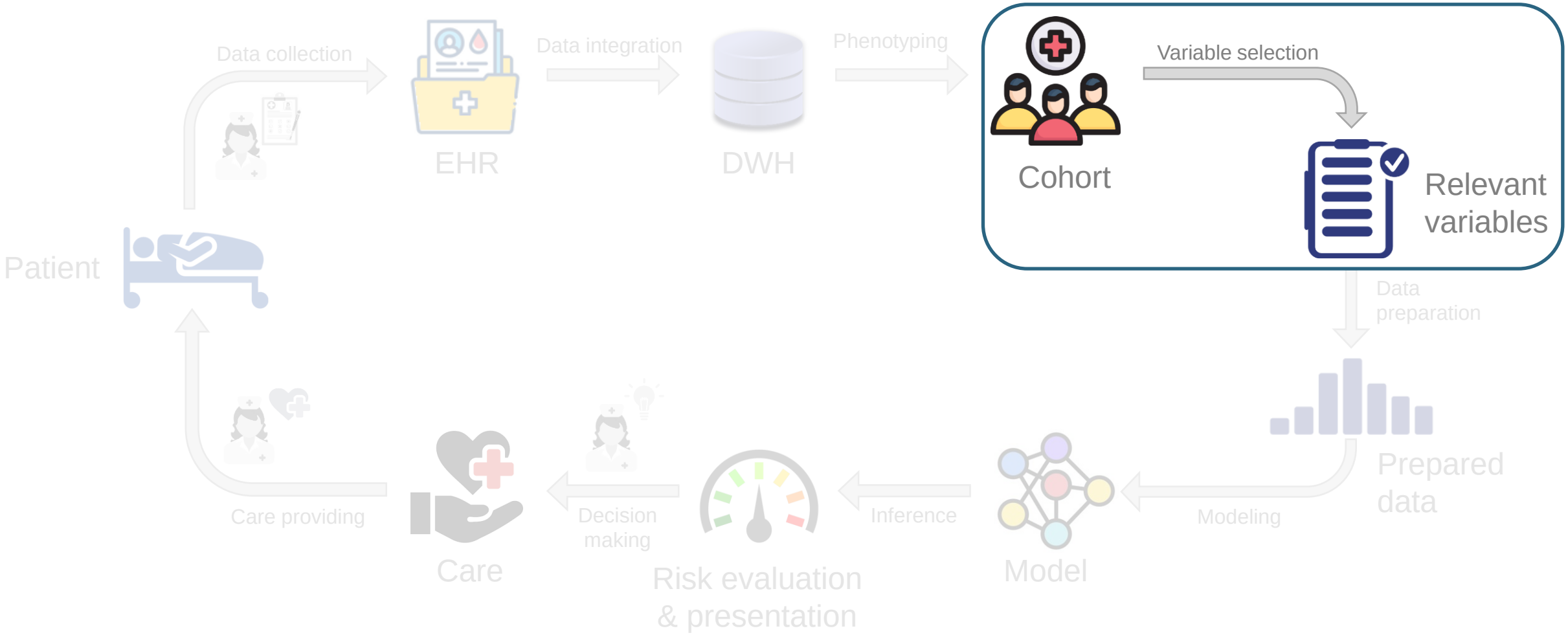
Relevant variables

- Cohort
  - ~16k patients,
  - ~24k hospitalisations
  - 49% are 65+
  - 2.4% stays with HAPI





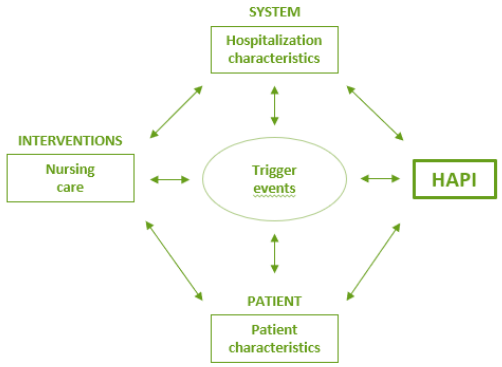
Variable selection



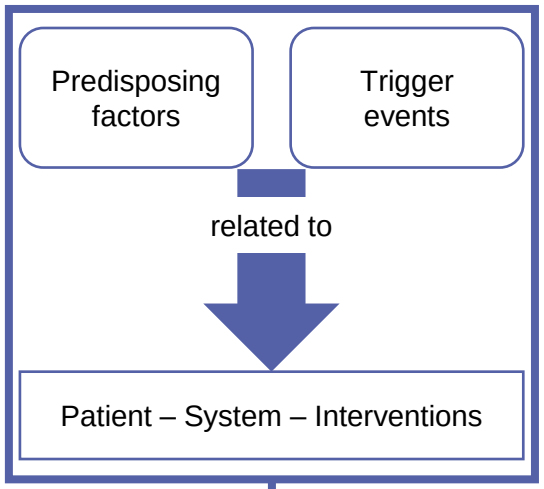
Variables selection

Cascade iatrogenesis

Adaptation of Thornlow's conceptual model of cascade iatrogenesis to the development of HAPI



(Thornlow et al., 2009)



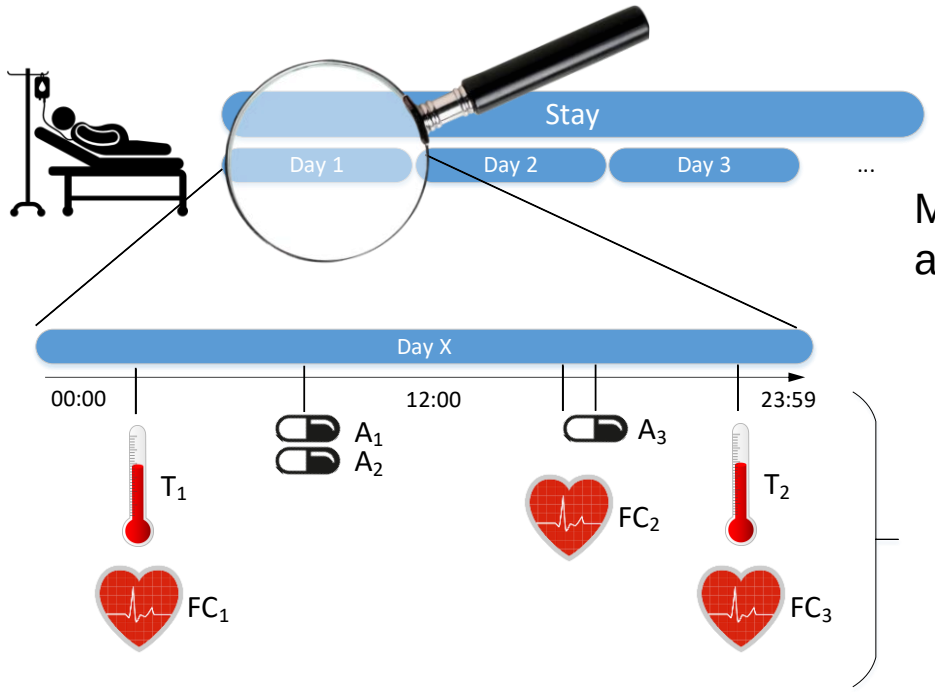
Transformation into variables

Data availability in EHR

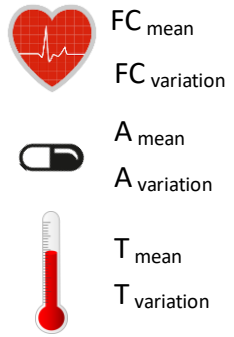
65 variables

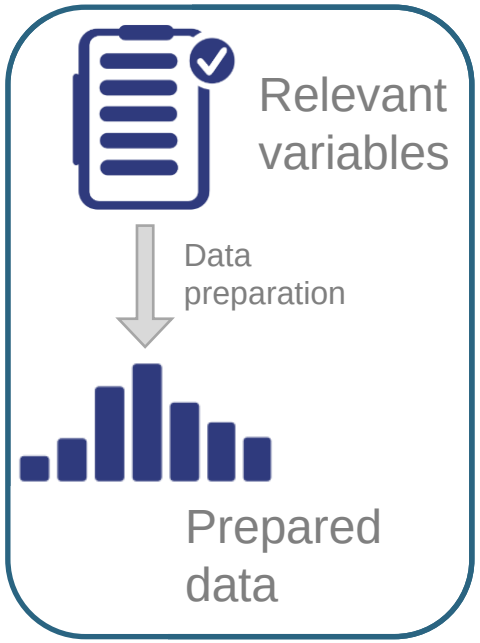
into the predictive model

Data preparation – aggregation & imputation



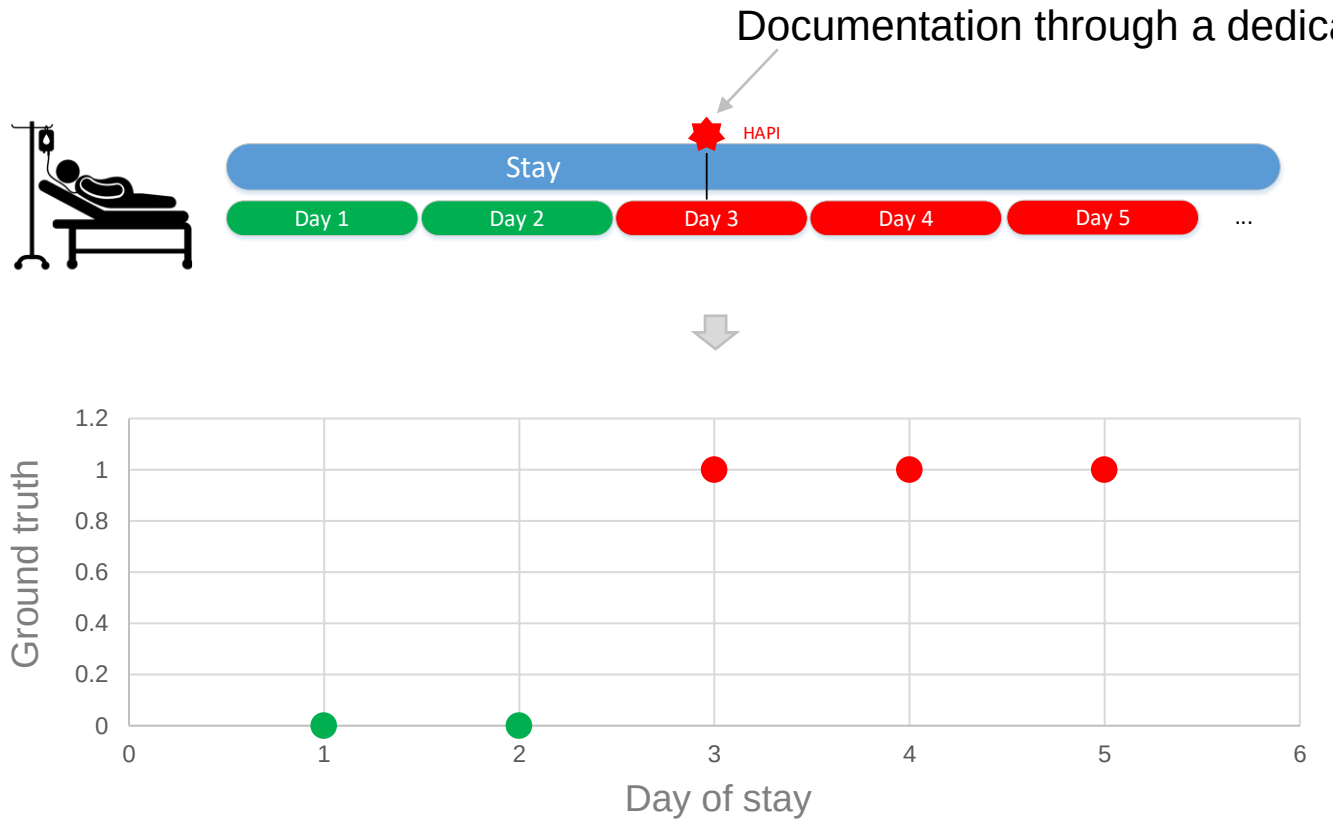
Mixture of **binary flags** and **continuous values**

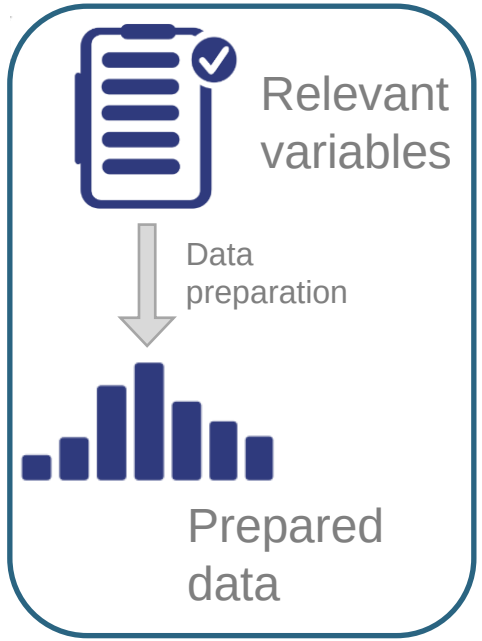




- **>10% non-missing** values
  → **65 variables**
- Missing values filled: **kNN** method

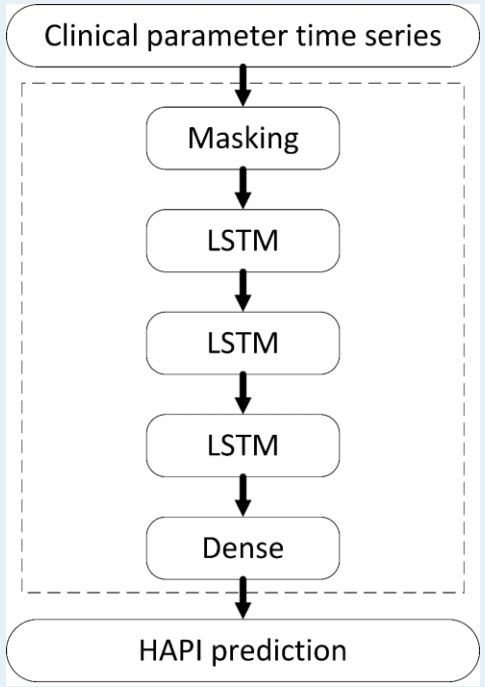
Data preparation – truth labeling

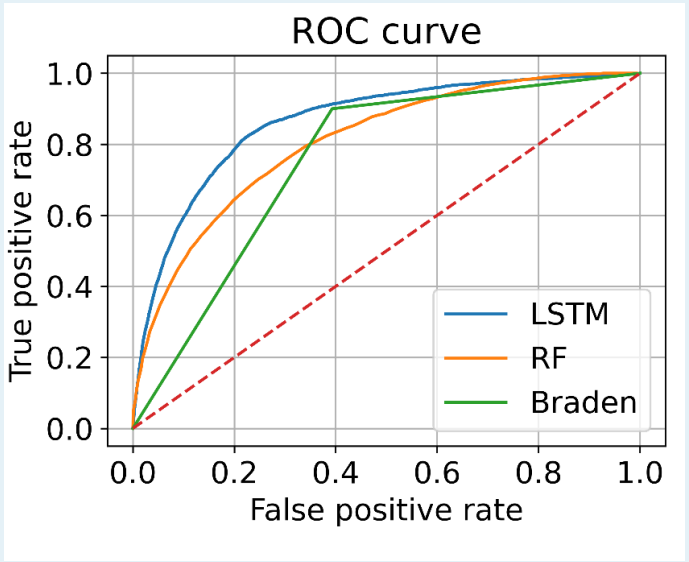


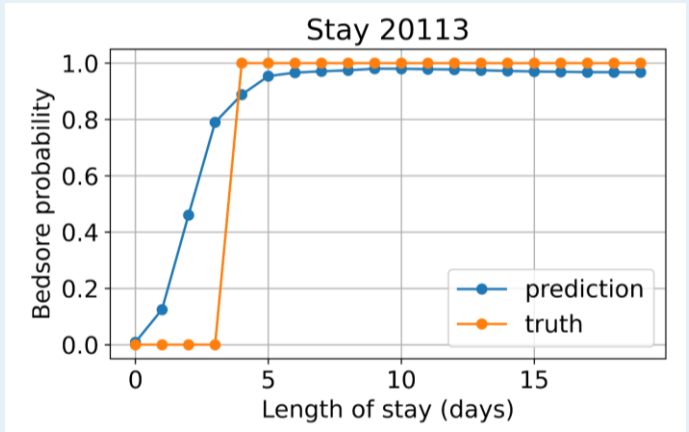


All stays are standardized to a **20 days** length (pre-filled or truncated)

Modeling

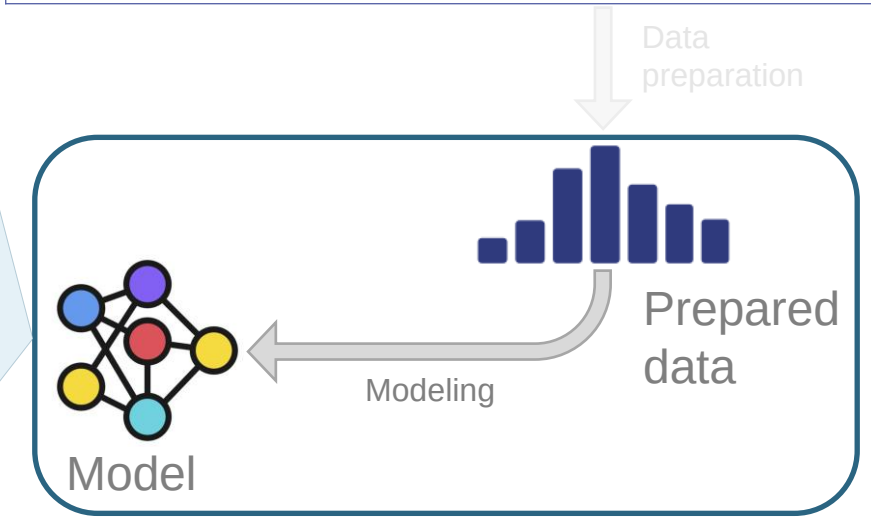






Model	AUROC	Sensitivity	Specificity	Accuracy
Braden scale		**0.88**	0.61	0.61
Random forest	0.80	0.73	0.72	0.72
LSTM	**0.87**	0.74	**0.82**	**0.82**

Currently working on validating the model performance on an independent cohort.



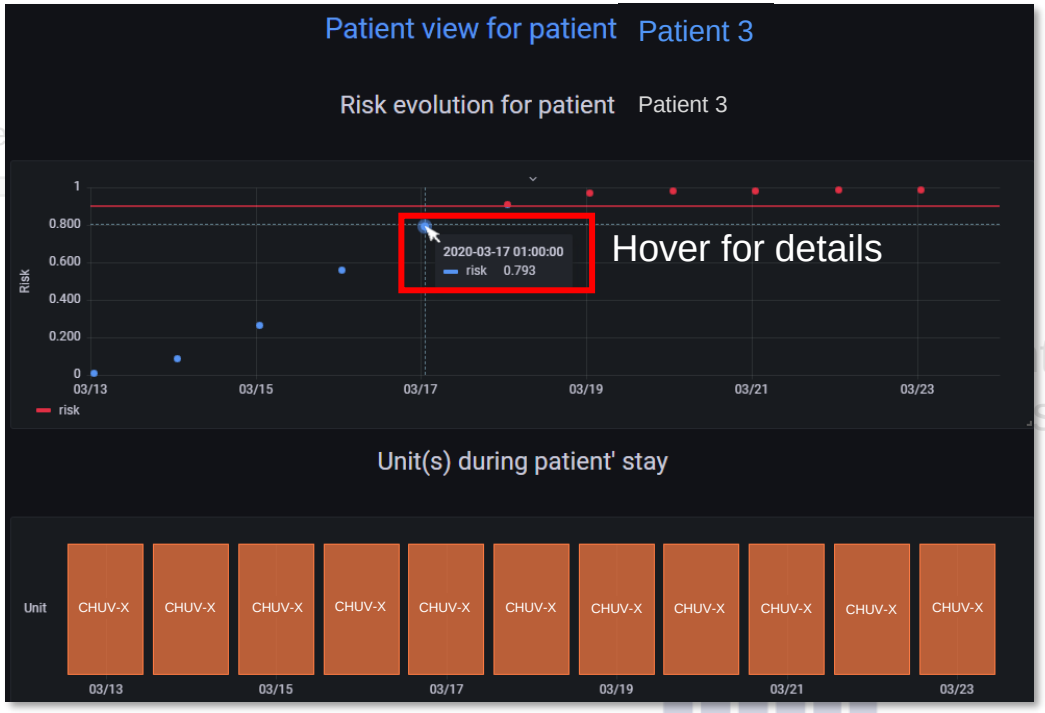
Risk evaluation & presentation

Unit selection

Hover for details

Clickable patient list

Time window selection



Care providing

Decision making

Care

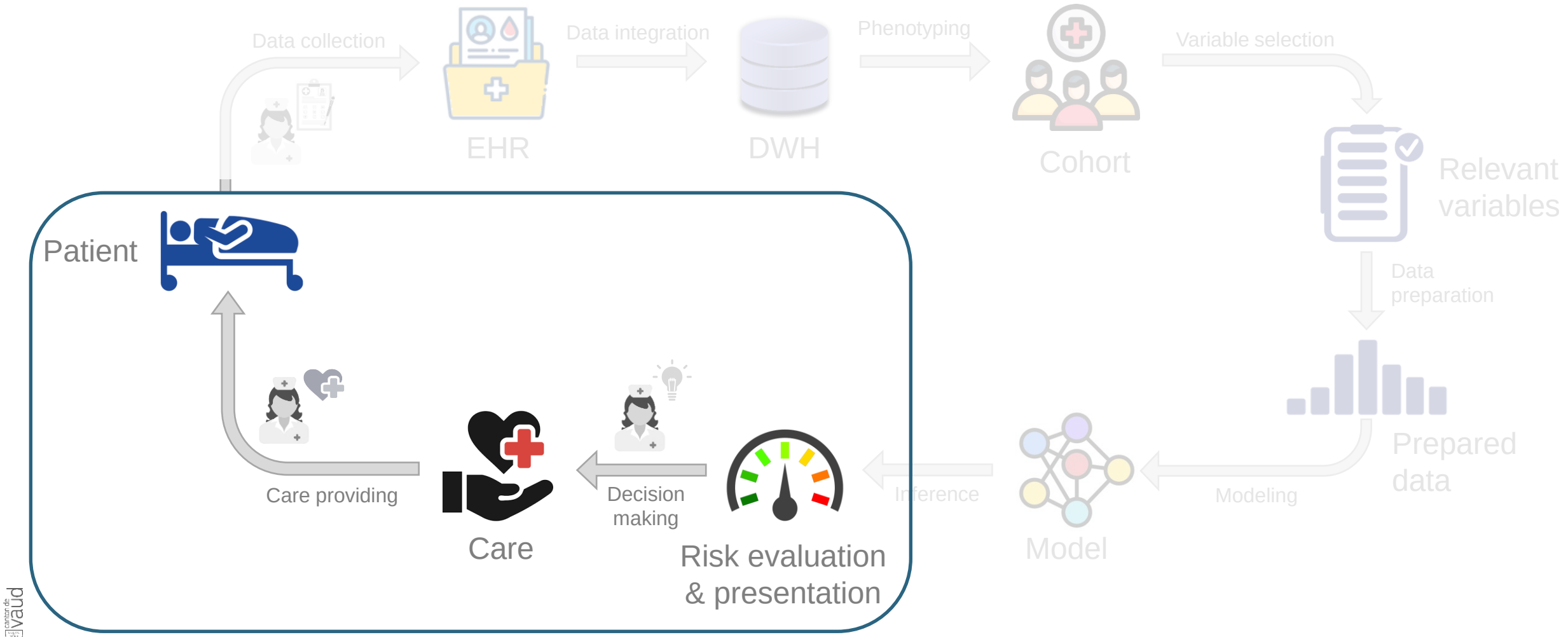
Inference

Risk evaluation & presentation

Model

Currently evaluating risk daily, working towards a close-to-real-time risk evaluation

CDSS implementation



CDSS Implementation

Exploration phase

To describe the **determinants** of the CDSS implementation

- Focus group with resource groups
- Interview group with stakeholders
- Data collection and analysis

Preparation phase

To develop the implementation **strategies**

- Selection of effective strategies
- Planning, implementing, and adapting
- Data collection and analysis

Implementation phase

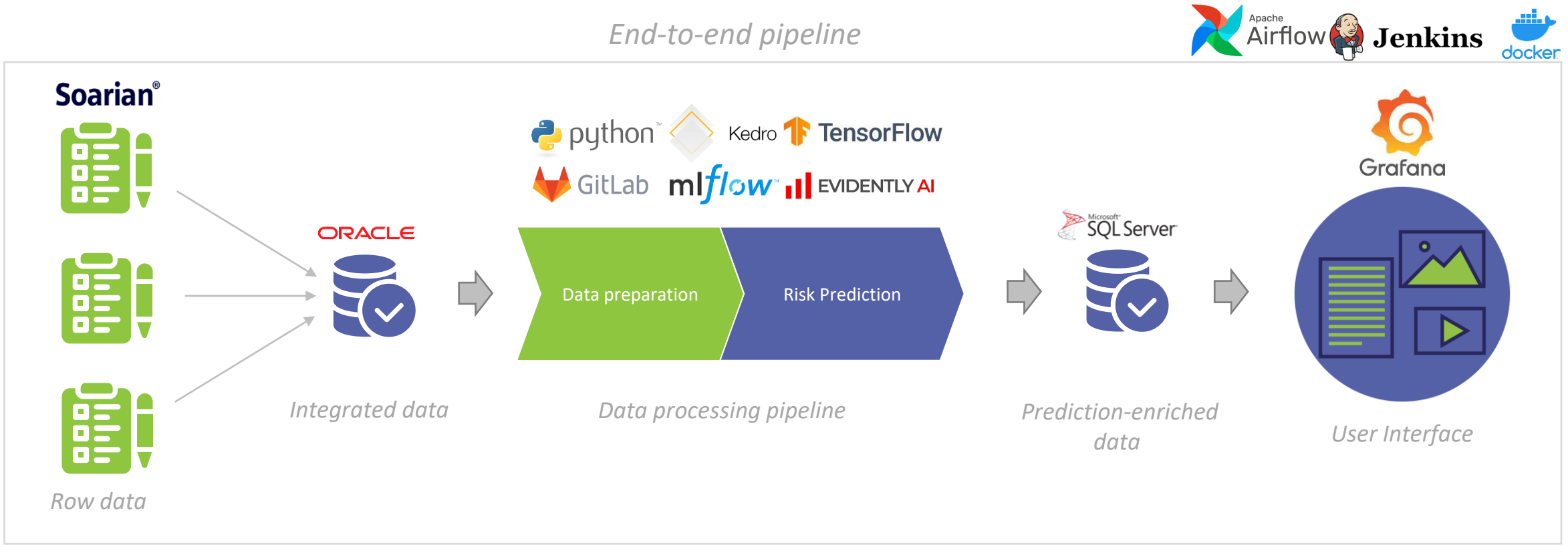
To **test implementation strategies** on acceptability, appropriateness, and feasibility of CDSS use

To **test association** between CDSS use and health clinical outcomes

- Hybrid type II study

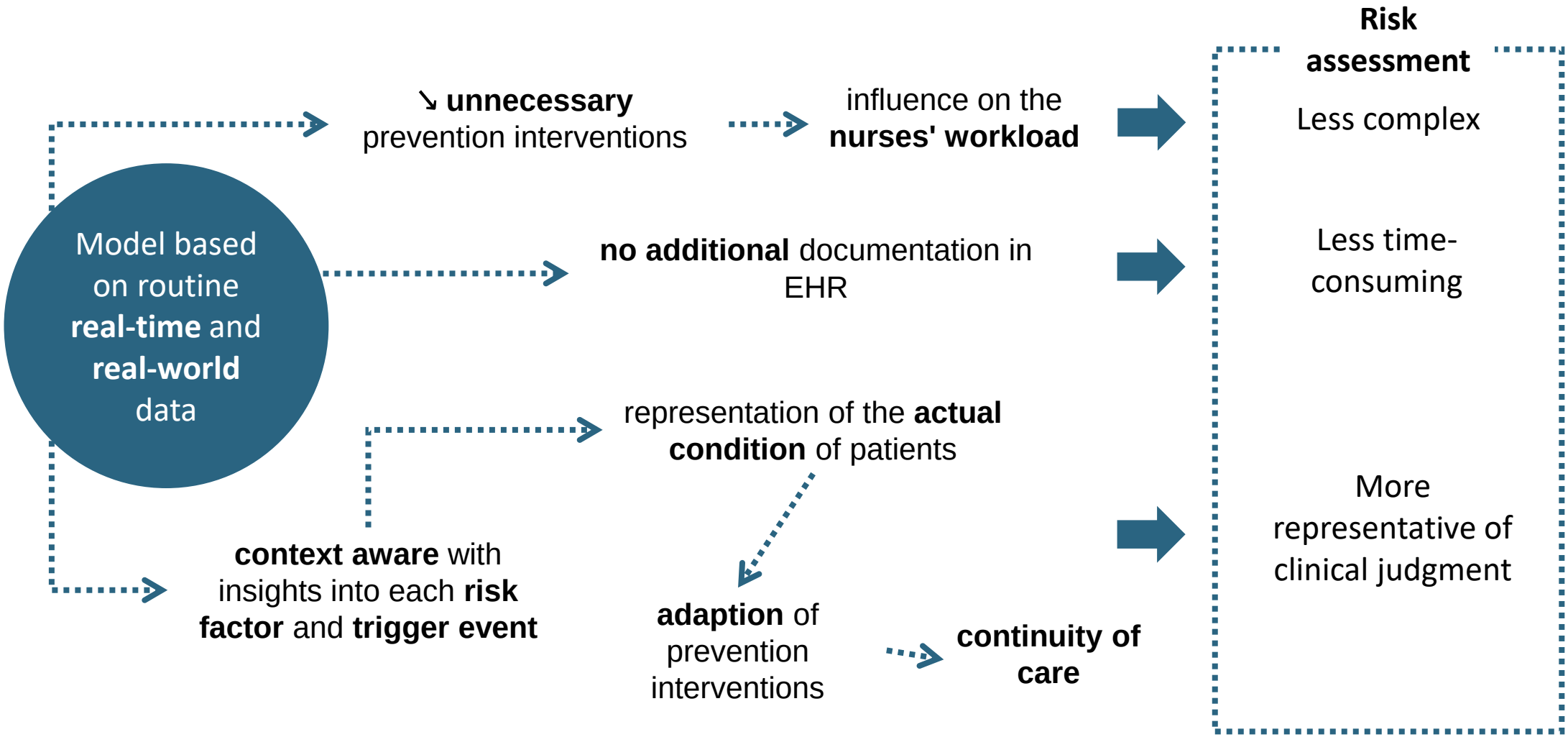
(Curran et al., 2012, Damschroder et al., 2022)

End-to-end pipeline



All components are built in a modular architecture to facilitate agile modifications or extensions

Relevance to nursing



Potential for significant improvement in nursing work

Conclusion

HAPI and other complications

- Use of **LSTM model** in this domain
- Risk assessment **only with EHR** documentation
- Operational deployment of an automated intelligent system into the hospital information system

CDSS implementation

- Data-science **and** implementation science
- Implementation **methodology**

Our hospital

- First AI project in the hospital aiming at using EHR data in real-time for clinical decision support
- **Proof of concept** for next projects
- **Collaboration** between nurses and data-scientists

Thank you for your attention

UNIL | Université de Lausanne
Faculty of Biology and Medicine
Institute of Higher Education
and Research in Healthcare

Swiss Data Science Center

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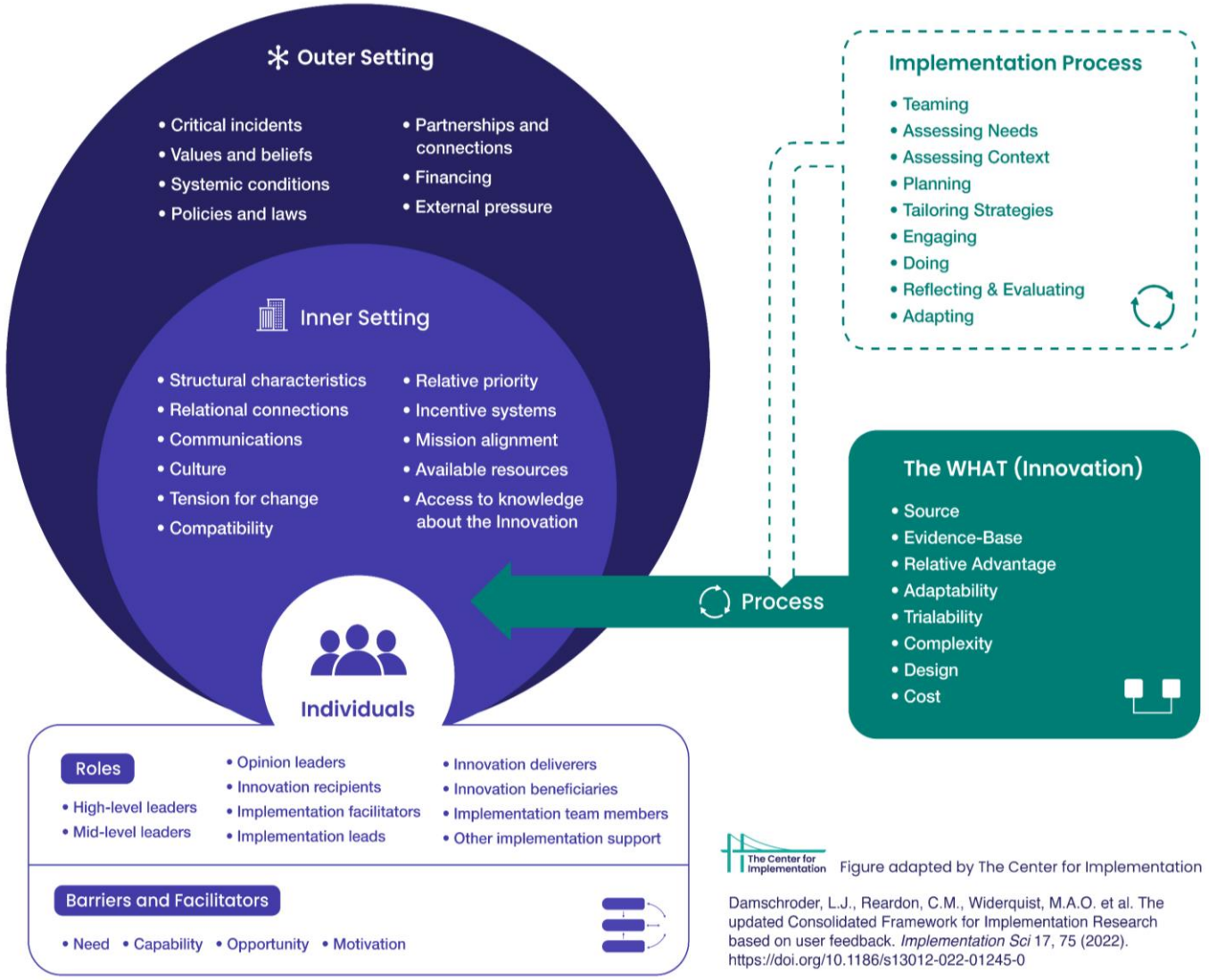
Consolidated Framework for Implementation Research (CFIR) 2.0



The Center for Implementation Figure adapted by The Center for Implementation

Damschroder, L.J., Reardon, C.M., Widerquist, M.A.O. et al. The updated Consolidated Framework for Implementation Research based on user feedback. *Implementation Sci* 17, 75 (2022). https://doi.org/10.1186/s13012-022-01245-0

Consolidated Framework for Implementation Research (CFIR) 2.0 — The Center for Implementation