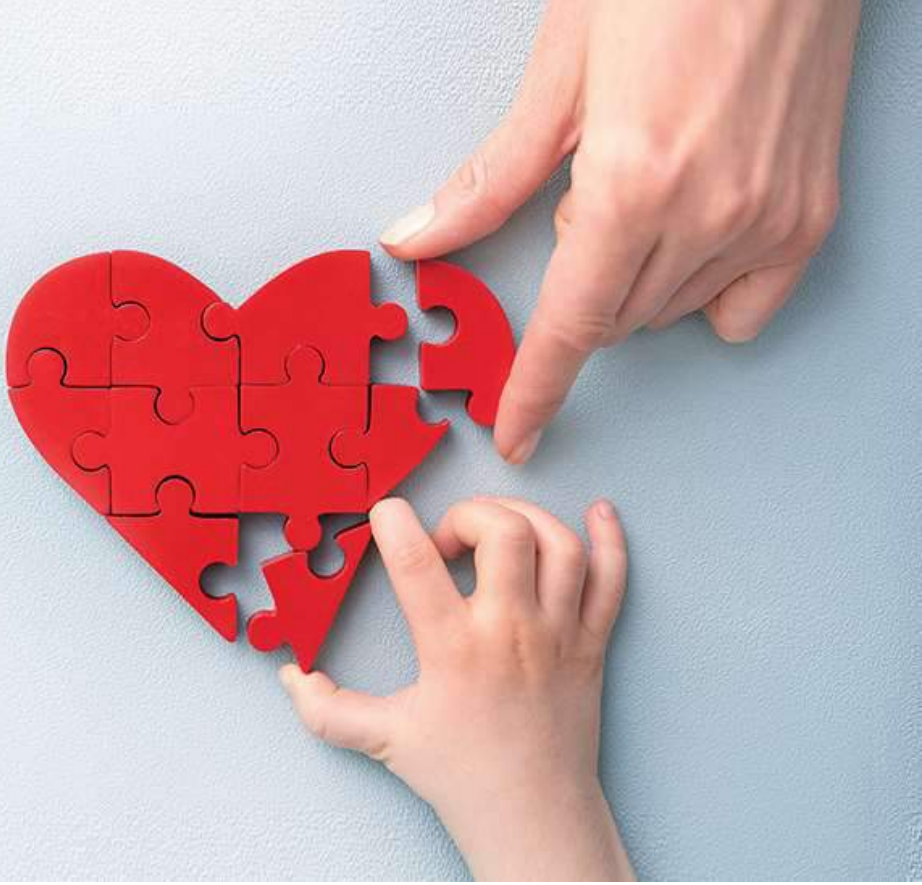
CARDIOLOGY 2024

CAN MACHINE LEARNING INFORM ACUTE PATIENT CARE?

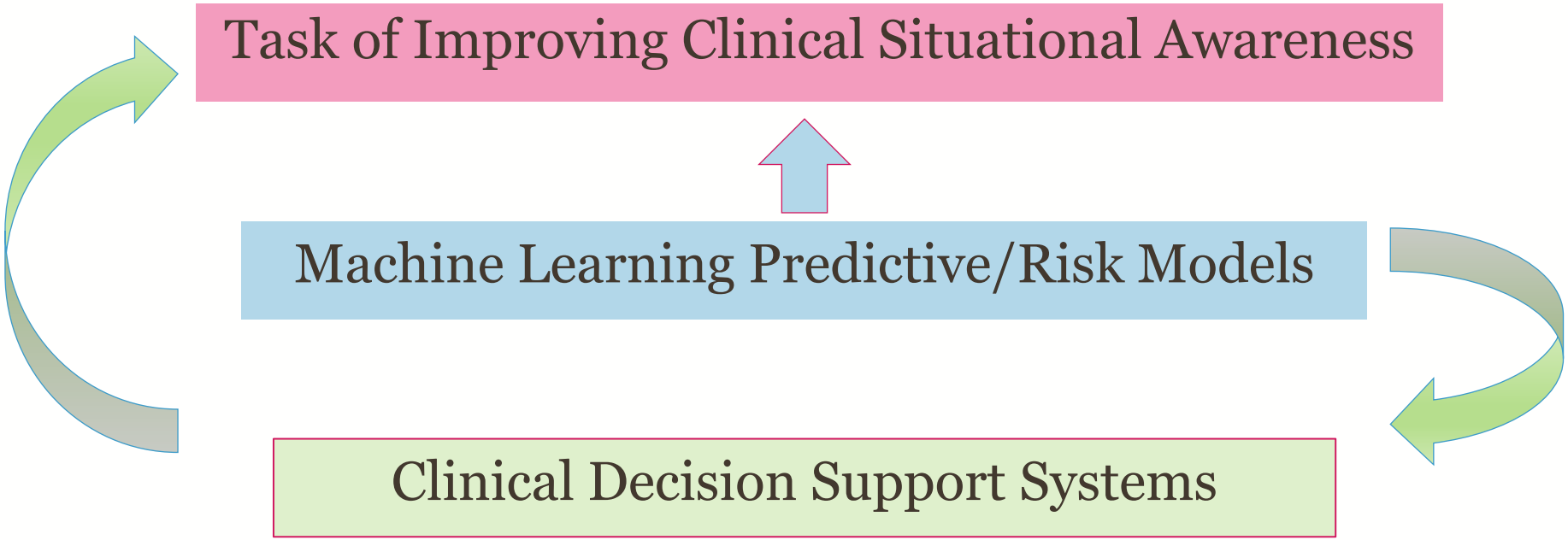


MICHAEL GOLDSMITH, MD
Cardiac Critical Care Medicine
Children's Hospital of Philadelphia

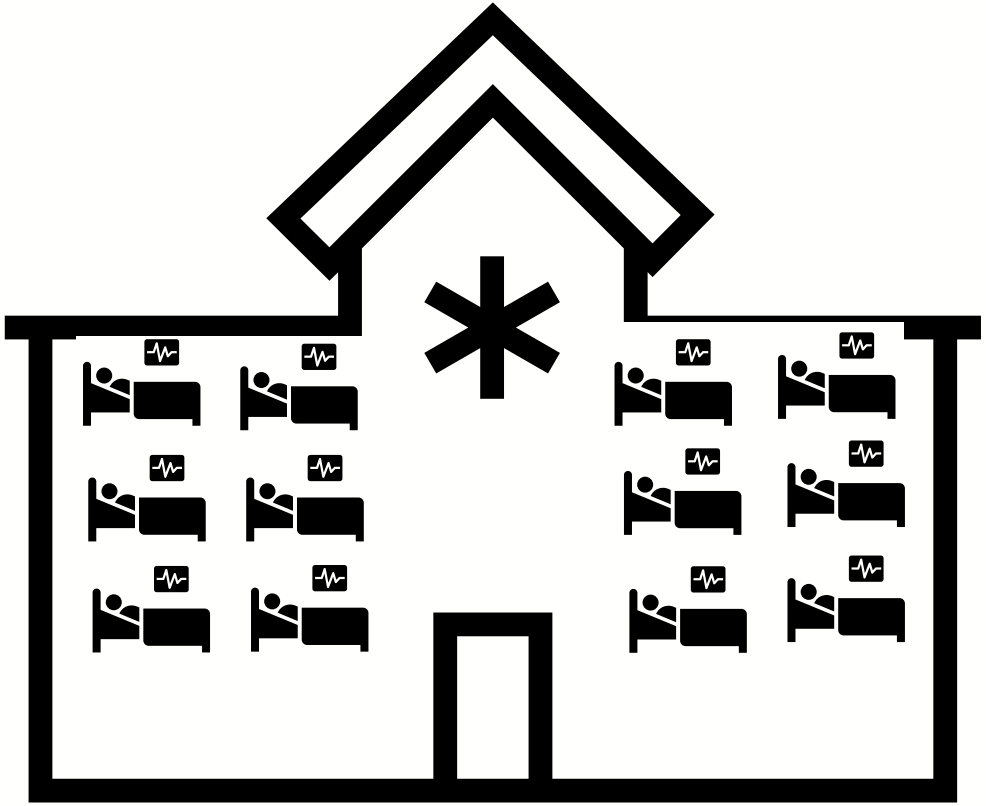
February 15th, 2024

Children's Hospital of Philadelphia
Cardiac Center

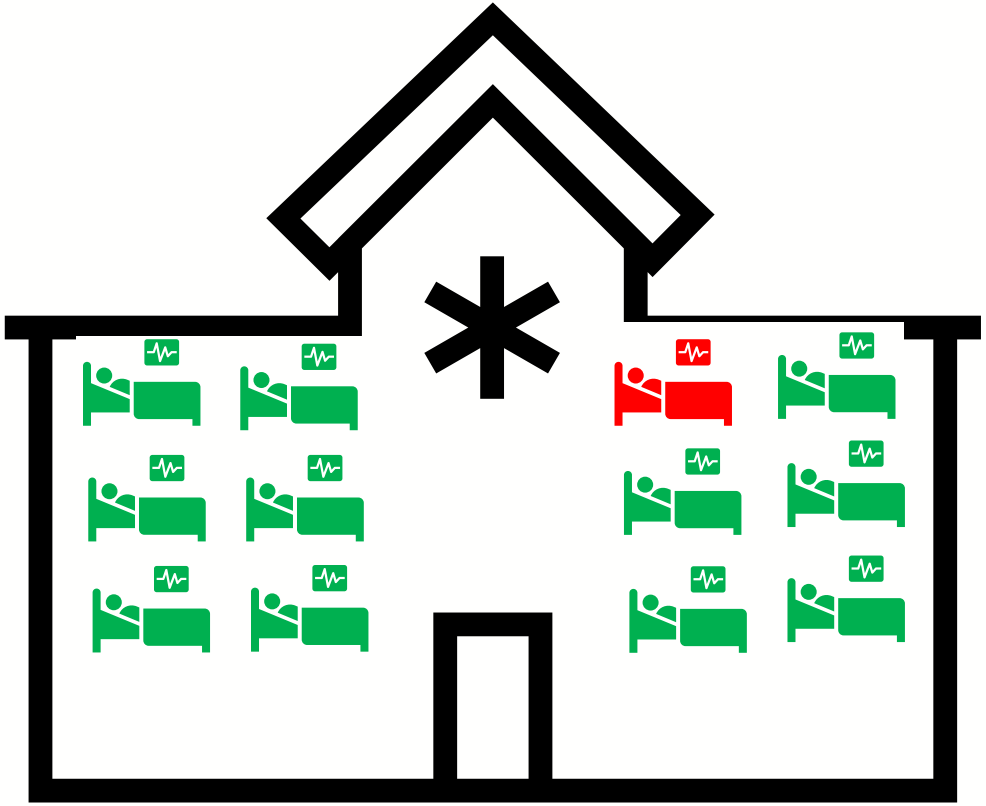
SUMMARY


Task of Improving Clinical Situational Awareness
Machine Learning Predictive/Risk Models
Clinical Decision Support Systems

Task of Improving Clinical Situational Awareness

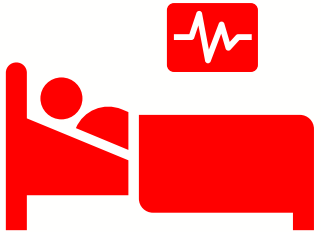


Task of Improving Clinical Situational Awareness



Task of Improving Clinical Situational Awareness

1 hr: ◀	21-22	22-23	23-00	00-01	01-02	02-03
HR 8>12 YR						
● Heart Rate	260 240 220 200 180 160 140 120 100 80 60 40 20 0					
Significant Events						
Observations						
Vital Signs						
Pulse	132	130	128	122+	132	132
Respiratory Rate	26	39	38	44+	40	43
BP	96/51	104/50	101/46	93/47		93/45

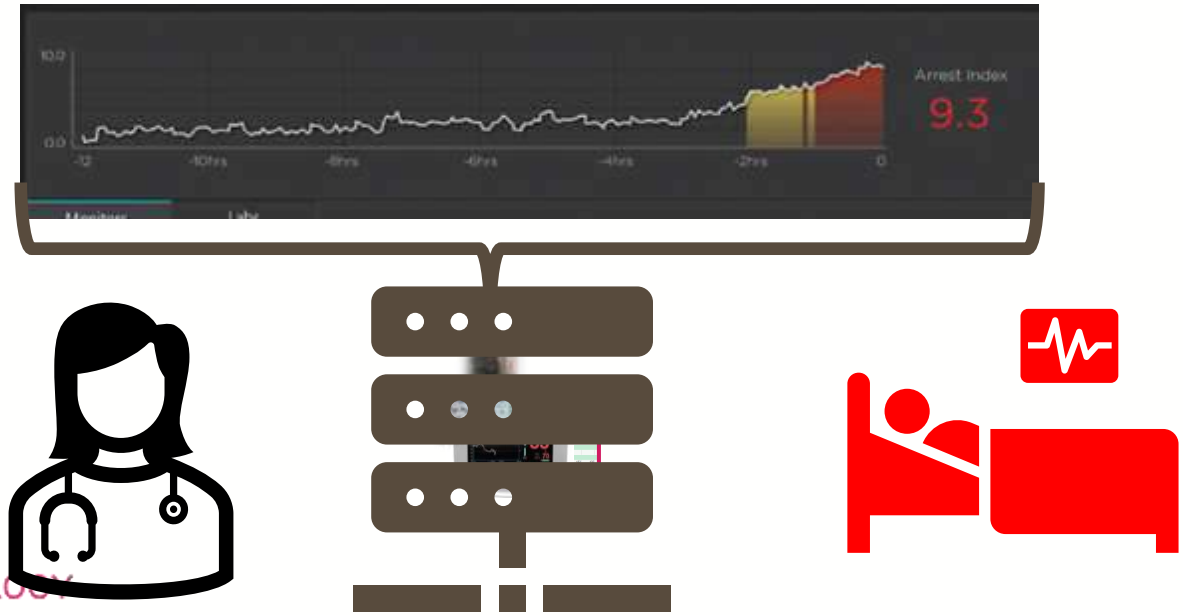


Task of Improving Clinical Situational Awareness

	132	130	128	122*	132	132
Respiratory Rate	26	39	38	44*	40	43
BP	96/51	104/50	101/46	93/47		93/45

Task of Improving Clinical Situational Awareness

Machine Learning Predictive/Risk Models



Early ~~Machine Learning~~ Predictive/Risk Models

Pediatric Risk of Mortality
PRISM
Crit Care Med. 1988

Pediatric Early Warning Score
PEWS
Paediatric Nursing. 2005

Rothman Index
J Biomed Inform. 2013

Pediatric Index of Mortality **PIM**
Intensive Care Med. 1997

Modified Early Warning Score
MEWS
QJM. 2001

Ped Index of Card Surg Intensive Care Mortality
PICSIM
PCCM 2015

Cardiac CHEWS
C-CHEWS
J Ped Nursing. 2013

Expert Selected/Limited Variables

Require Clinician Input

Static

Infrequently update

Machine Learning Predictive/Risk Models

I-WIN Single Ventricle Risk Model
JTCVS 2021

Rusin et al. Sickbay Single V Deterioration Risk Model
JACC 2021

CORTEX Traffic Light
Frontiers in Pediatrics 2022

Inadequate Delivery of Oxygen Index (IDO2)
Etiometry Inc
Resuscitation 2019

Virtual PICU Recurrent Neural Network Mortality Prediction
PCCM 2021

Early prediction of clinical deterioration using data-driven machine-learning modeling of electronic health records

Victor M. Ruiz, PhD,[a] Michael P. Goldsmith, MD,[b,c] Lingyun Shi, MS,[a] Allan F. Simpao, MD,[b,c] Jorge A. Gálvez, MD,[b,c] Maryam Y. Naim, MD,[b,c] Vinay Nadkarni, MD,[b,c] J. William Gaynor, MD,[b,c] and Fuchiang (Rich) Tsui, PhD, FAMIA[a,b,c]

The Journal of Thoracic and Cardiovascular Surgery • Volume 164, Number 1 **July, 2021**

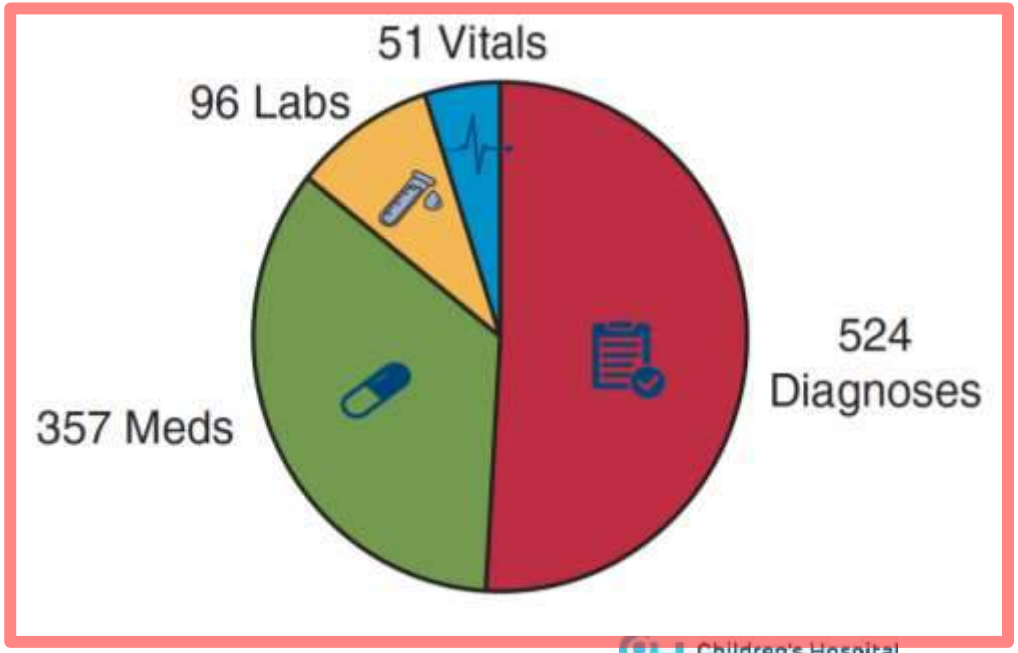
- Retrospective Single Center
- Training Set:
  - 488 Single Ventricle Interstage Infants admitted to CICU

- 203 Deterioration Events
  - 130 - Unplanned Intubation
  - 34 - CPR
  - 29 - E-CPR
  - 10 - ECMO

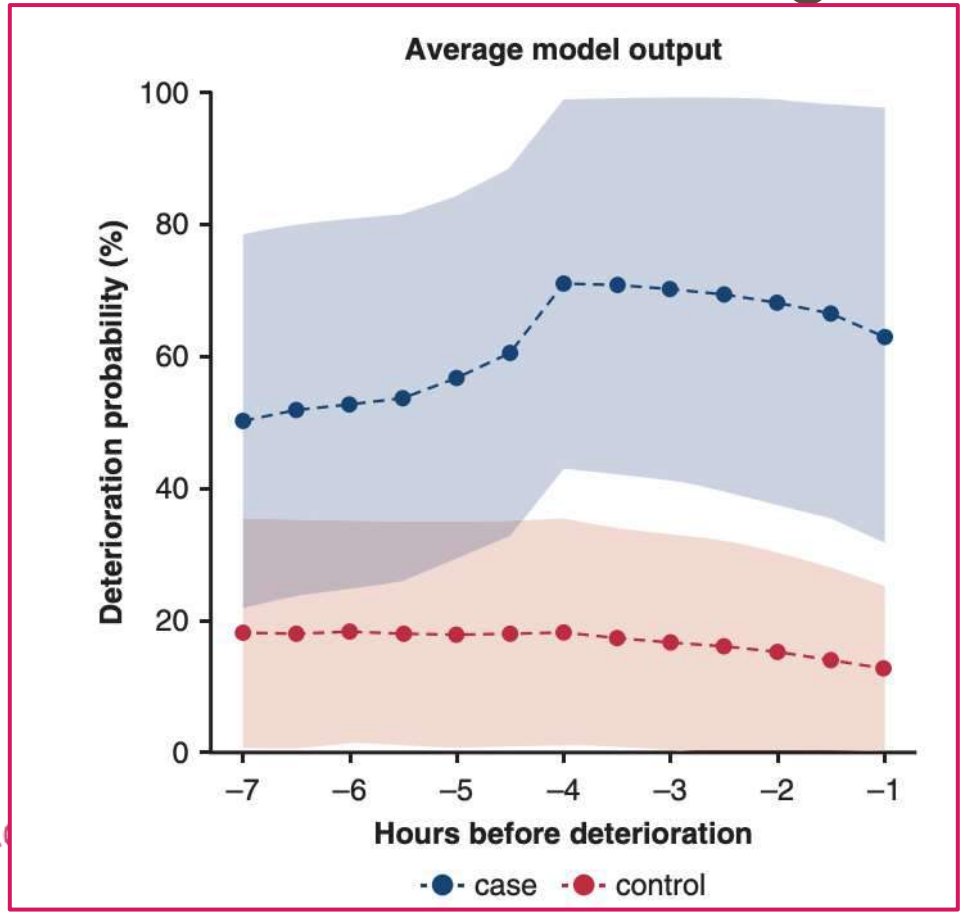
DEVELOPMENT OF *I-WIN* MACHINE LEARNING ALGORITHM

Ruiz, Goldsmith et al *JTCVS* 2021

- Data extracted from Electronic Medical Record
- N = 1028 Variables
- **Extreme Gradient Boosting Machine Learning Model**
- Calculated q 30 minutes



I-WIN Machine Learning Model Prediction



Ensemble Model AUC
0.92 (0.84-0.98)

- Ruiz, Goldsmith et al *JTCVS* 2021

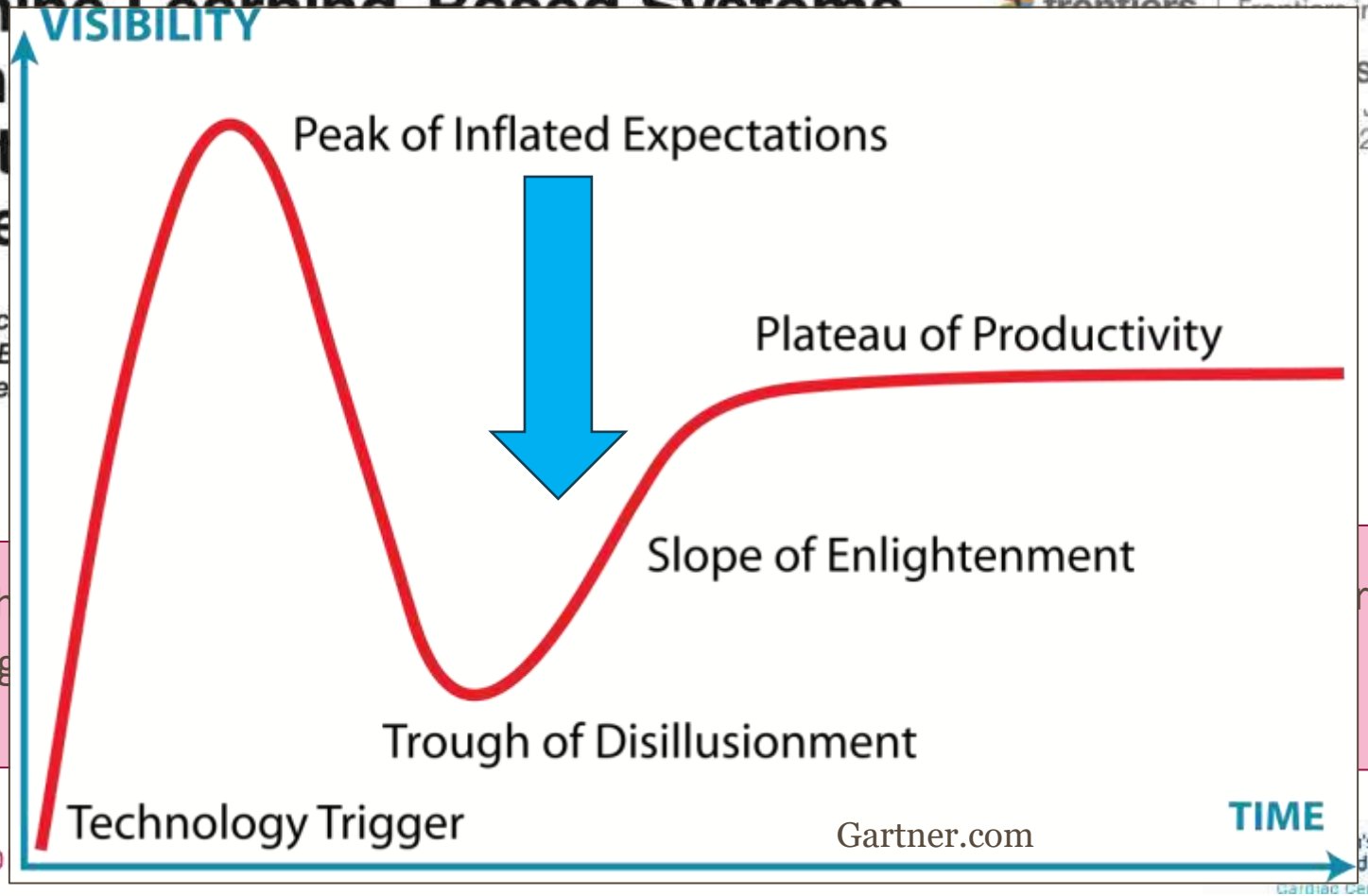
Mach
for th
Event
Surge

Patricia Garc
Arnau Valls-E
Joan Sanche

frontiers | Frontiers in Pediatrics

SPECTIVE
June 2022
22.930913

18 Mach
predicting
Clinical



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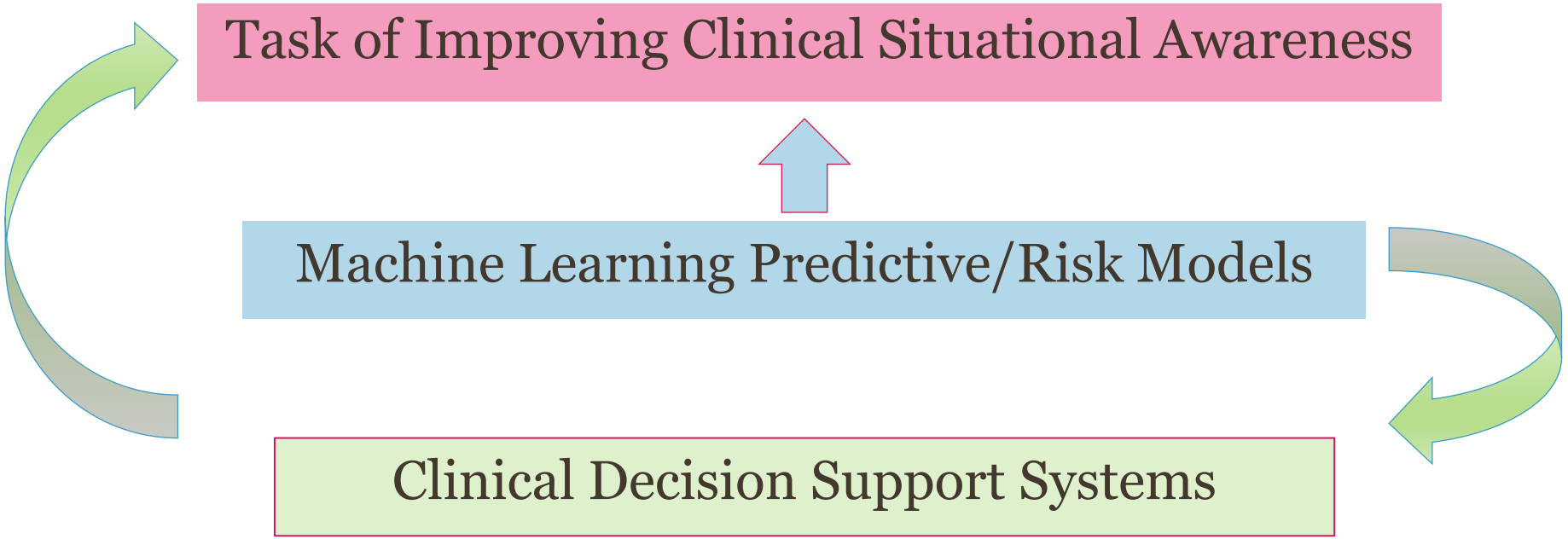
Cardiac Center

SUMMARY


Task of Improving Clinical Situational Awareness
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Clinical Decision Support Systems

KEY PRINCIPLES

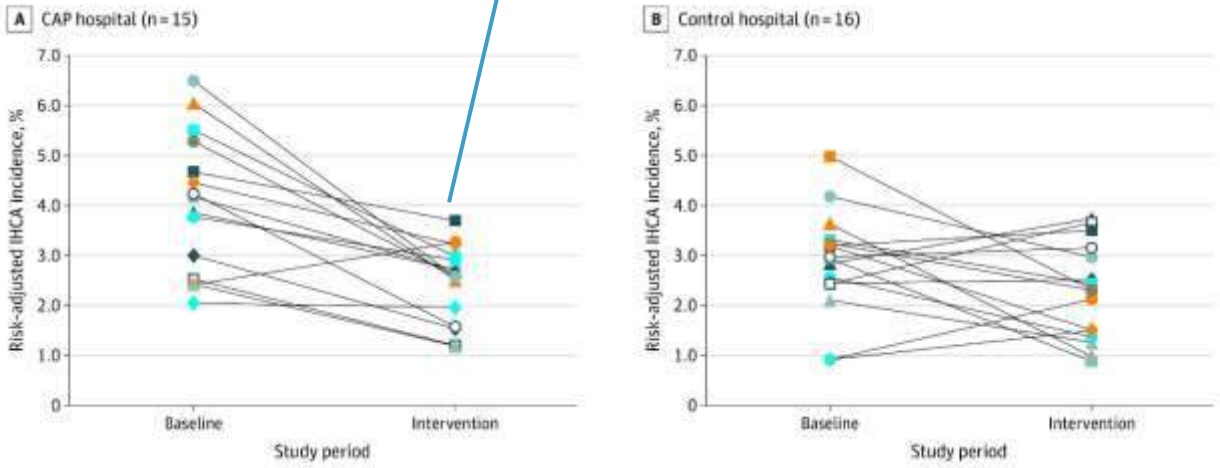
- Right Person
- Right Time/Place
- Right Information
- Understandable
- Facilitate actionable decision

Horsky J. et al. Interface design principles for usable decision support: a targeted review of best practices for clinical prescribing interventions. *J Biomed Informatics*. 2012

PREVENTING CARDIAC ARREST IN THE PEDIATRIC CARDIAC INTENSIVE CARE UNIT THROUGH MULTICENTER COLLABORATION

ALTEN ET AL. FOR THE PC4 CAP COLLABORATORS. *JAMA PEDIATR*. 2022 OCT

30% Relative Risk Reduction



11 Fewer Cardiac Arrests/Month post-intervention

INTERVENTIONS*

- CAP Safety Huddle
- Vital Sign Discussion
- Discussion of Pre-sedation
- Emergency medications at bedside
- Formal Code Review

CARDIOLOGY 2024

Children's Hospital of Philadelphia Cardiac Center

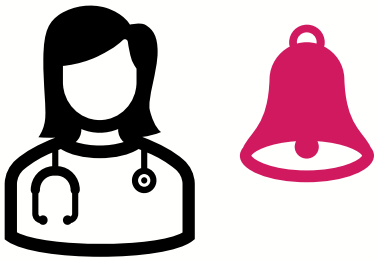
The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL ARTICLE

Automated Identification of Adults at Risk for In-Hospital Clinical Deterioration

Gabriel J. Escobar, M.D., Vincent X. Liu, M.D., Alejandro Schuler, Ph.D., Brian Lawson, Ph.D., John D. Greene, M.A., and Patricia Kipnis, Ph.D.

N ENGL J MED 383;20 NEJM.ORG NOVEMBER 12, 2020



Rapid Response Team

Prospective Staggered Deployment

548K Admissions at 19 Kaiser Permanente Hospitals

EMR Based – Discrete time Log Regression Model

Escobar et al, *J. Hosp Med.* 2012
Kipnis et al *J. Biomed Informatics*. 2016

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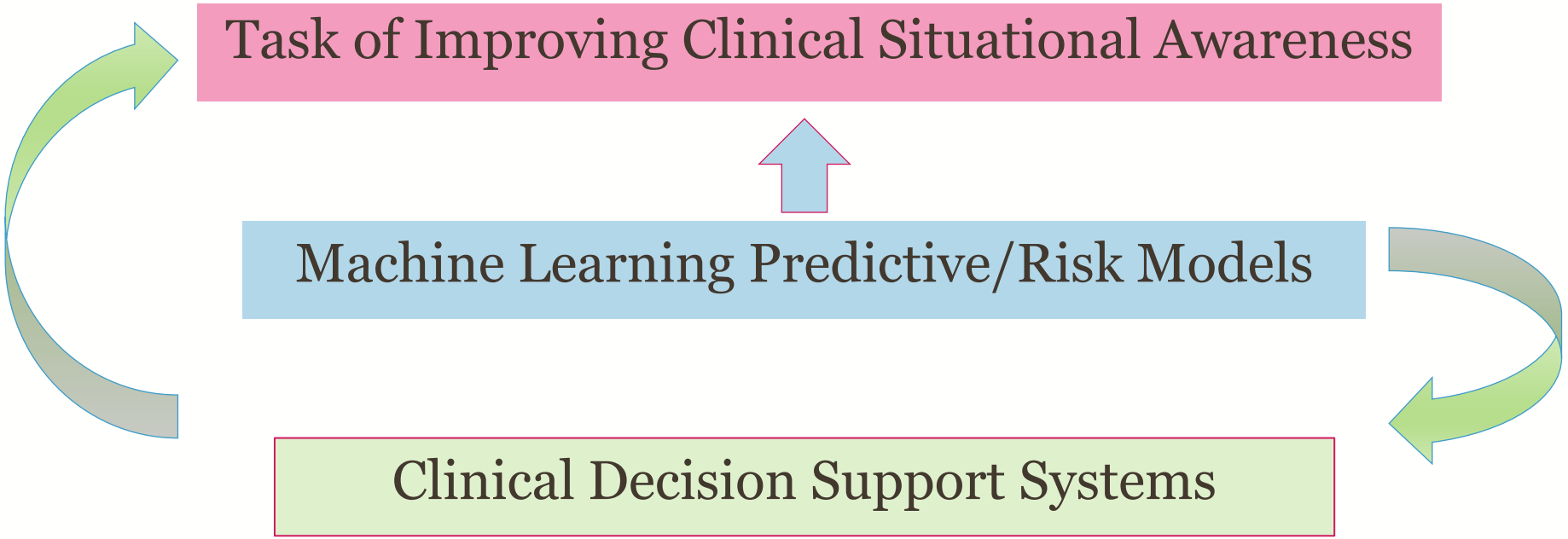
30-day Adjusted Mortality Relative Risk
0.84 (0.78-0.9)

ICU Admission
17.7% vs 20.9%

LOS
6.5 vs 7.2 days

Escobar et al, *J. Hosp Med.* 2012
Kipnis et al *J. Biomed Informatics*. 2016

SUMMARY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CAN MACHINE LEARNING MODELS IMPROVE CLINICAL DETERIORATION PREDICTION?

Single Children's Hospital, 18-Month Pilot of Machine Learning Algorithm "Deterioration Risk Index" (Lasso-regularized Log Regression)

Incorporated into existing situational awareness program, Watchstander

77% Reduction in out-of-ICU deterioration events

New Alarms/Day/Unit

Cardiac 1.05 → 1.49

Hosp Med 1.47 → 1.91

CARDIOLOGY 2024

Rust LO. Et al. The Deterioration Risk Index: Developing and Piloting a Machine Learning Algorithm to Reduce Pediatric Inpatient Deterioration. ***Pediatric Critical Care Medicine.*** **24(4):p 322-333, April 2023.**

CAN MACHINE LEARNING MODELS IMPROVE EFFICIENCY OF CLINICAL CARE?

- Prospective Randomized Stepped-Wedge
- 3 Tertiary Academic Cardiac ICUs
- 2020-2022
- Clinical Decision Support System
  - **Automatically Identify Patients ready for Vasoactive Infusion Weaning**

Goldsmith MP Et al. *Crit Care Explor*. 2021

Gazit A Et al.. *Unpublished data, Manuscript in edit*. 2024

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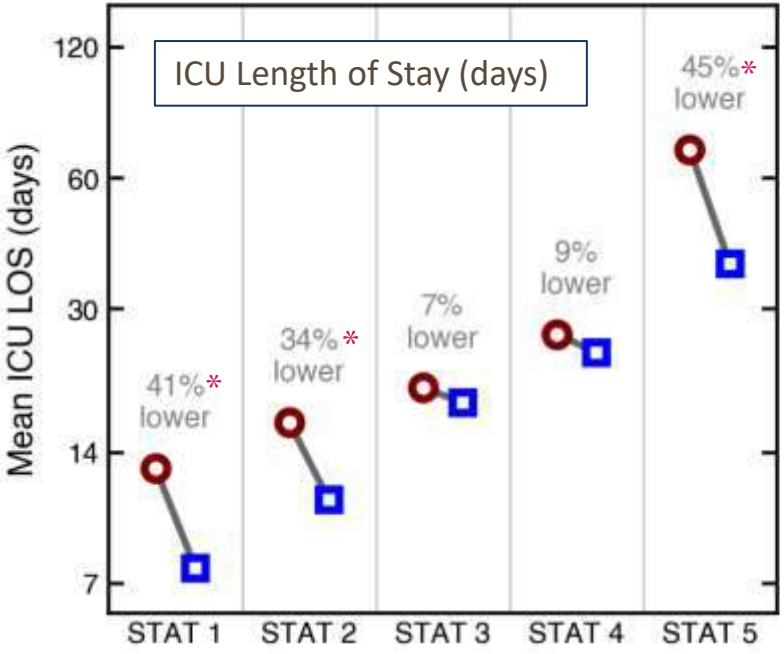

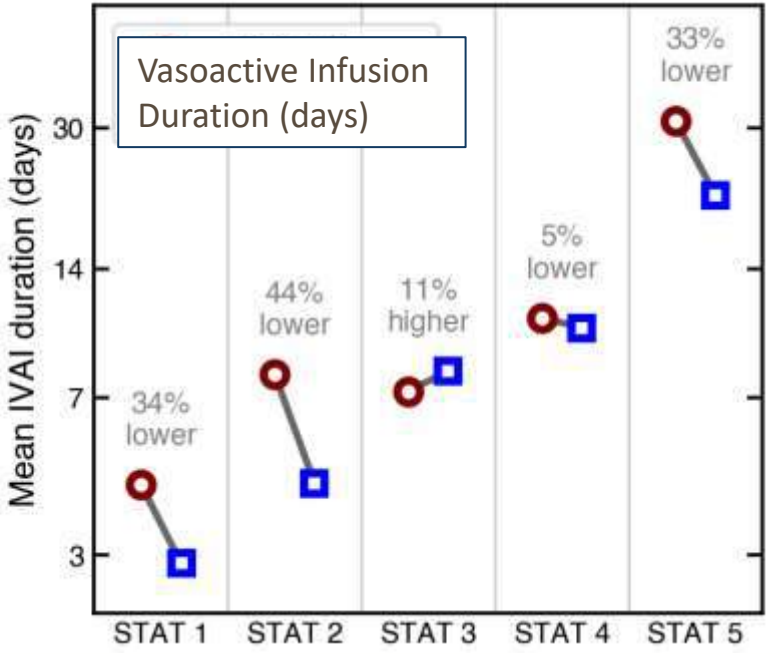

Control
Intervention

Goldsmith MP Et al. *Crit Care Explor*. 2021
Gazit A Et al.. *Unpublished data, Manuscript in edit*. 2024

Children's Hospital of Philadelphia Cardiac Center

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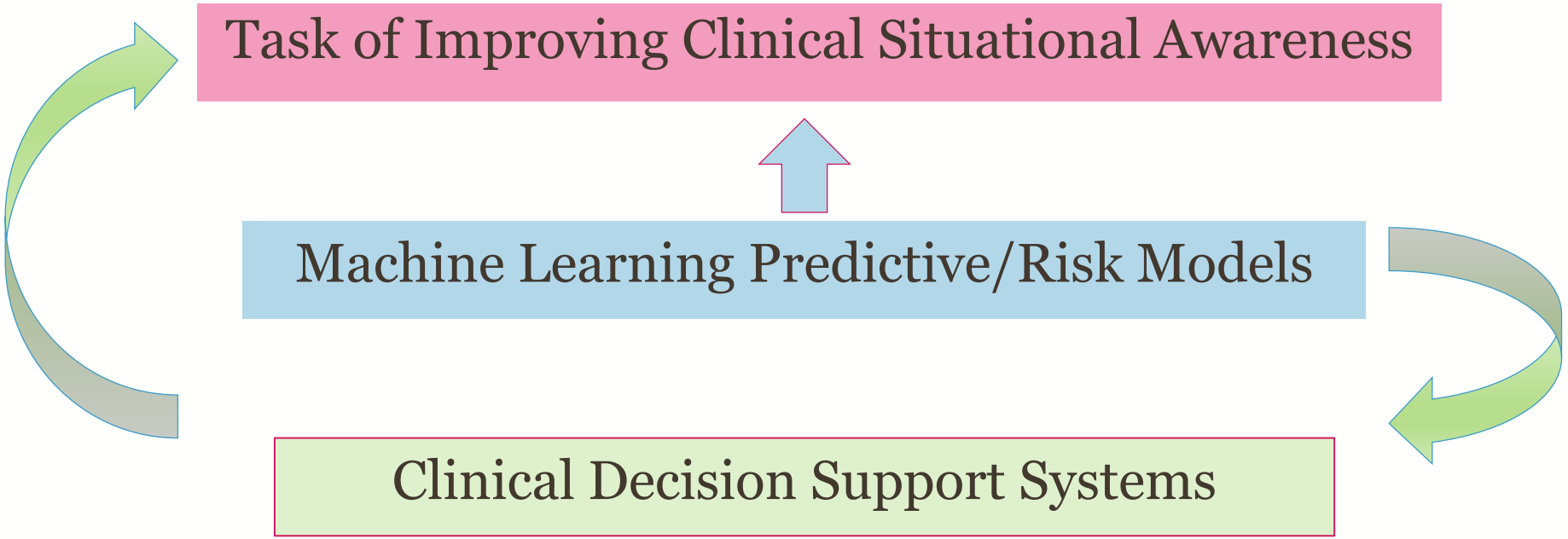
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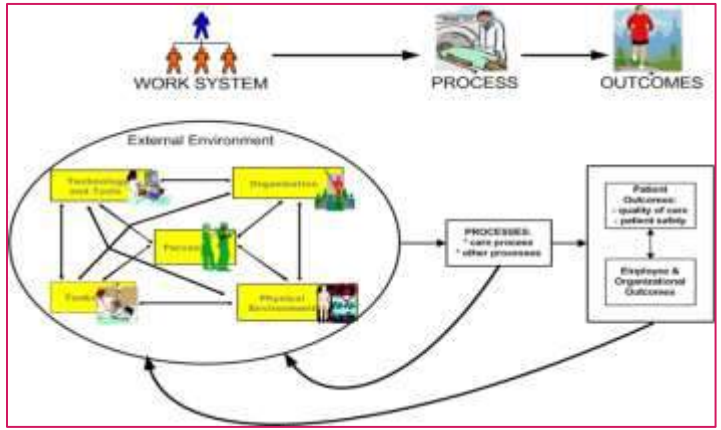
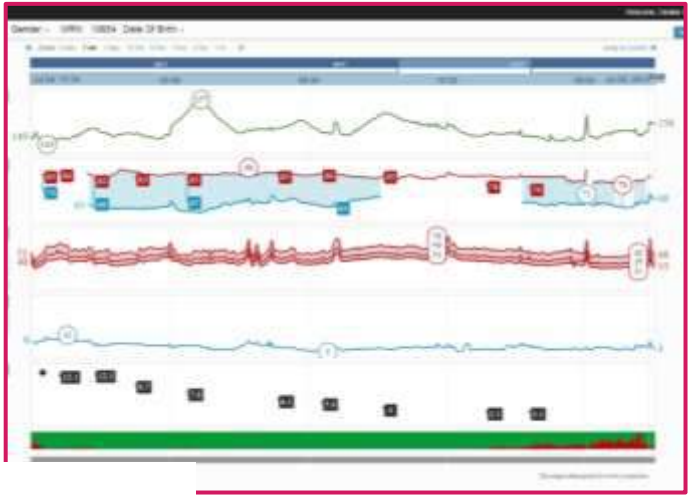
THANK YOU

GOLDSMITM1@CHOP.EDU

INCORPORATING ML MODELS INTO CARE ENVIRONMENT





Huddle Required:

Is a huddle needed?

Yes - complete huddle documentation | No

ECMO

Should this patient be considered for early ECMO? (If yes, consider calling surgical and ECMO teams)

Yes | No

Key roles identified if arrest occurs

☐ Leader ☐ Chest compressor ☐ Medication administrator ☐ Documenter ☐ Drawing meds for medication administrator

Lines/Access

Does the patient have adequate vascular access if a resuscitation is needed?

Yes | No

Where are you going to give your emergency meds?

PIV | Umbilical line | Right atrial line | PICC | Other

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Children's Hospital of Philadelphia
Cardiac Center

CLICK TO ADD CONTENT TITLE

Click to add text
- Click to add bullets