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Data Big and Small - The Meaning of Database Research

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Faculty Disclosure Information (Option A)

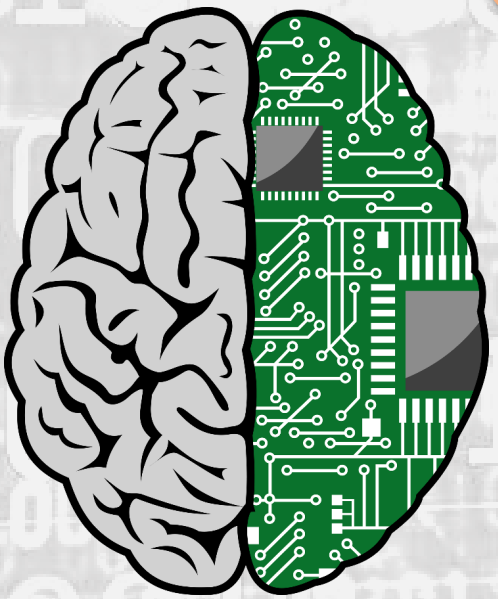
I have no relevant financial relationships with the manufacturer(s) of any commercial product(s) and/or provider(s) of commercial services discussed in this CME activity.

I **do not** intend to discuss an unapproved/investigative use of a commercial product/device in my presentation.

Learning Objectives

At the conclusion of the presentation, participants should be able to:

1. Define data science, machine learning, and their applications to pediatric critical care research
2. Identify example data science projects across the data spectrum
3. Understand the goals and challenges of “the last mile” implementation of decision support tools



Overview of Data Science

Data: From Small to Big

Informatics &
Implementation

Where to Go Next?


Computer Achievement Certificate
BENNET
QUIZ BOWL
CHAMPIONS
MATH
MATH
MATH COUNTS
COUNTS
COUNTS
MATHLET

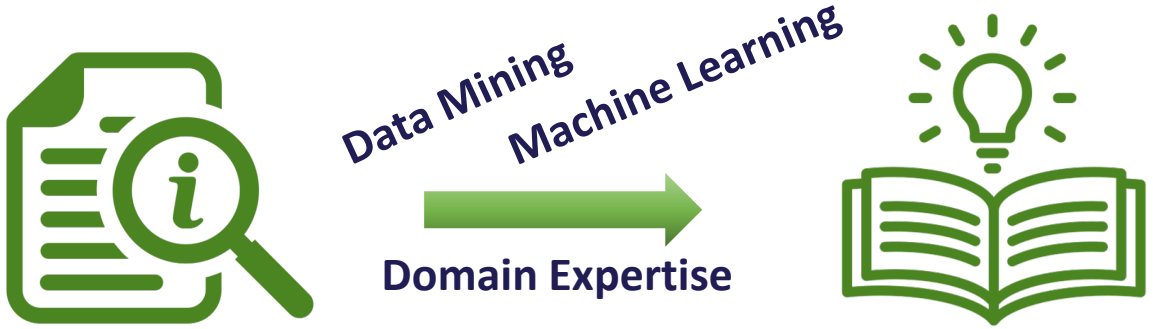
Motivation

‘There is an ethical imperative to capture “all of the data” — every heartbeat, every breath, to analyze for the benefit of our future patients.’

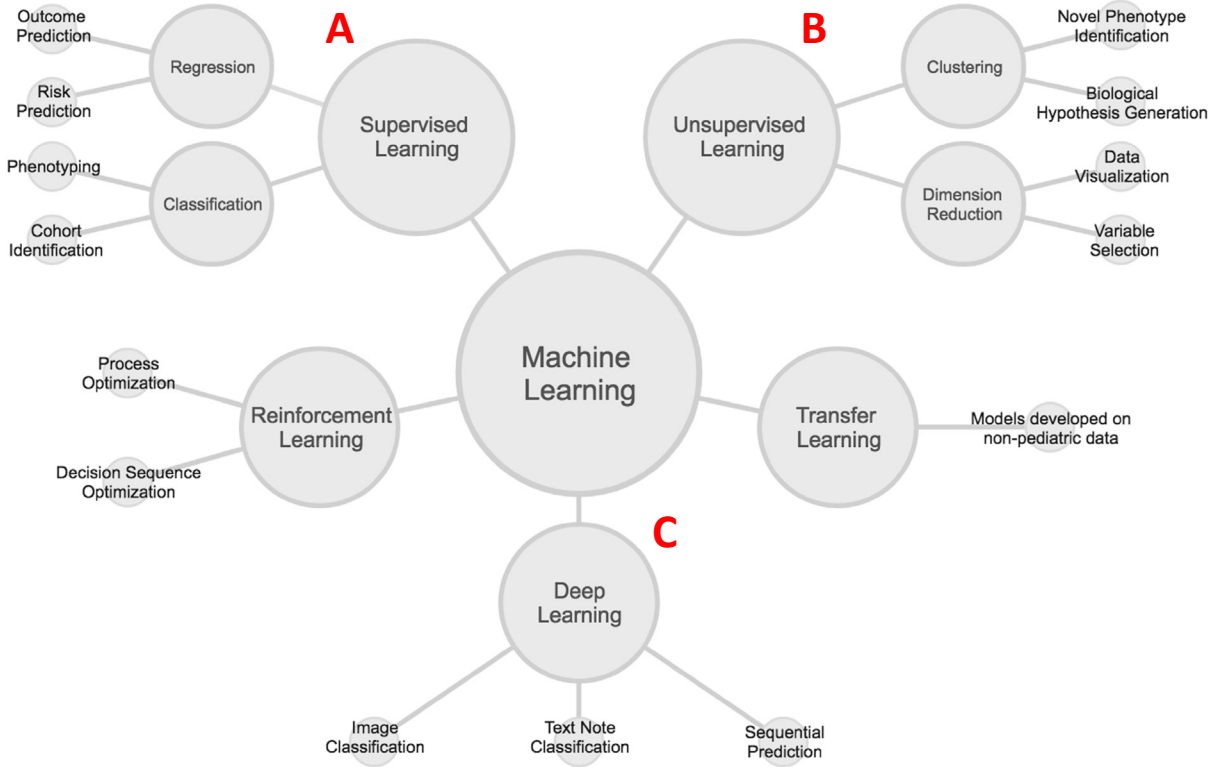
-- Randall Wetzel, “First Get the Data, Then Do the Science”, PCCM 2018

Data Science Definitions & Applications

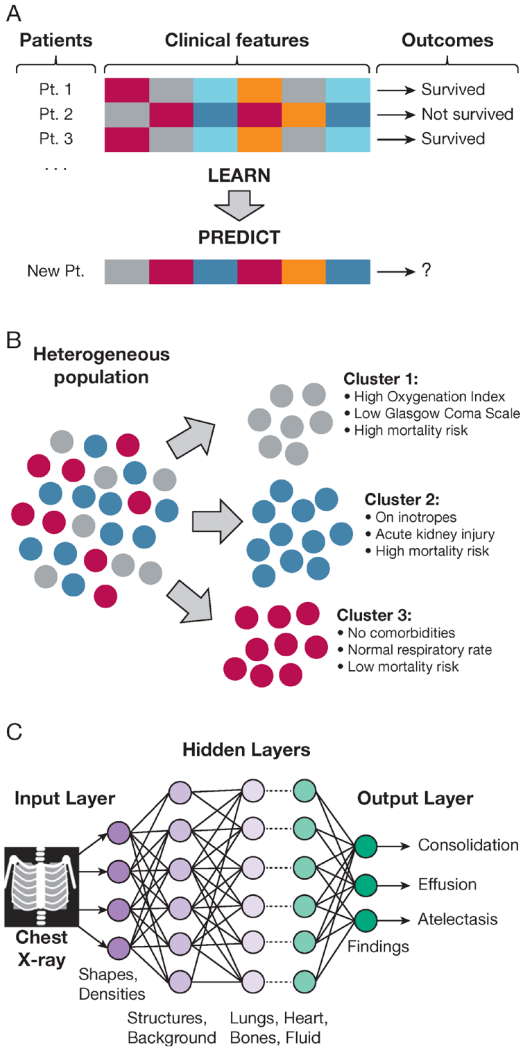
"The set of fundamental principles that support and guide the principled extraction of information and knowledge from data."



(Sanchez-Pinto & Churpek, Chest, 2018)

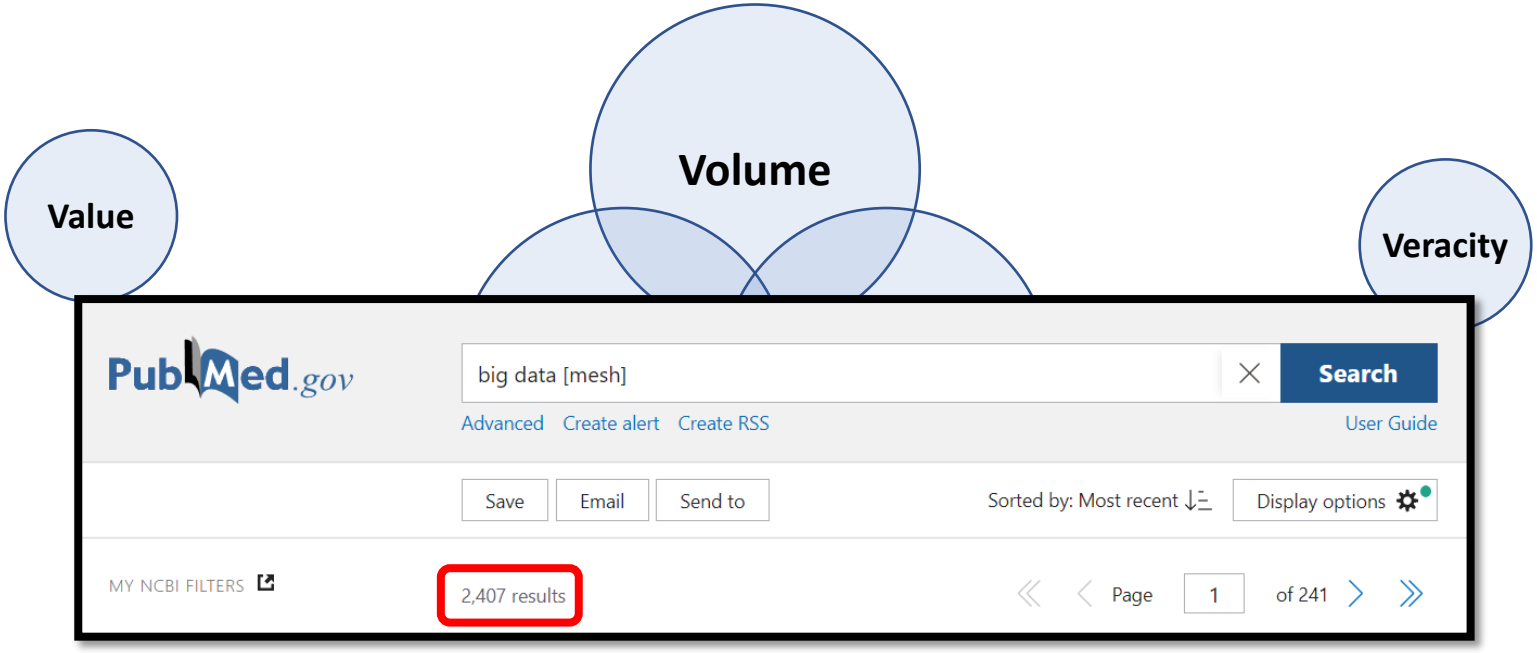


(Bennett et al, J Pediatr, 2019)



(Sanchez-Pinto & Churpek, Chest,

How big is “Big Data”?



Example Applications

Comparative Effectiveness Research

- "Functional outcome after intracranial pressure monitoring for children with severe traumatic brain injury" – *Bennett TD et al, JAMA Peds, 2017*

Predictive Modeling

- "Multicenter development and validation of a risk stratification tool for ward patients" – *Churpek MM et al, AJRCCM 2014*

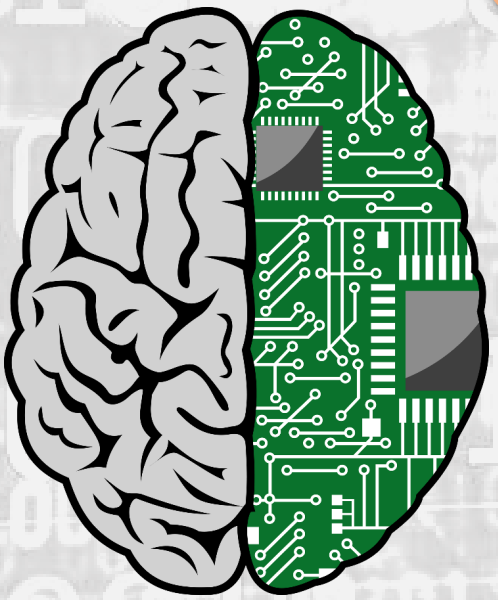
Clustering and Phenotyping

- "Derivation and validation of novel phenotypes of multiple organ dysfunction syndrome in critically ill children" – *Sanchez-Pinto LN et al, JAMA Network Open, 2020*

Natural Language Processing

Physiologic Waveform Analysis

- "Development of a Heart Rate Variability Risk Score to Predict Organ Dysfunction and Death in Critically Ill Children" – *Badke C et al, PCCM, 2021*



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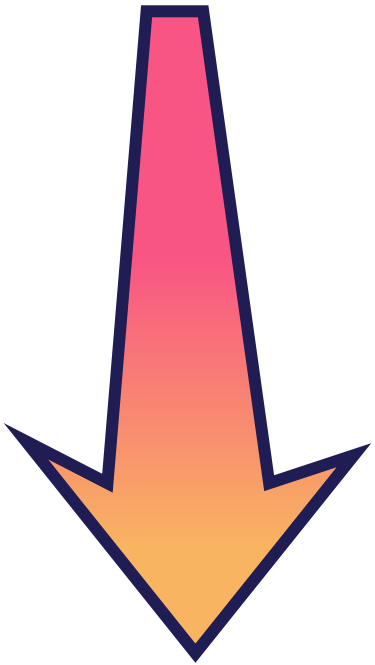
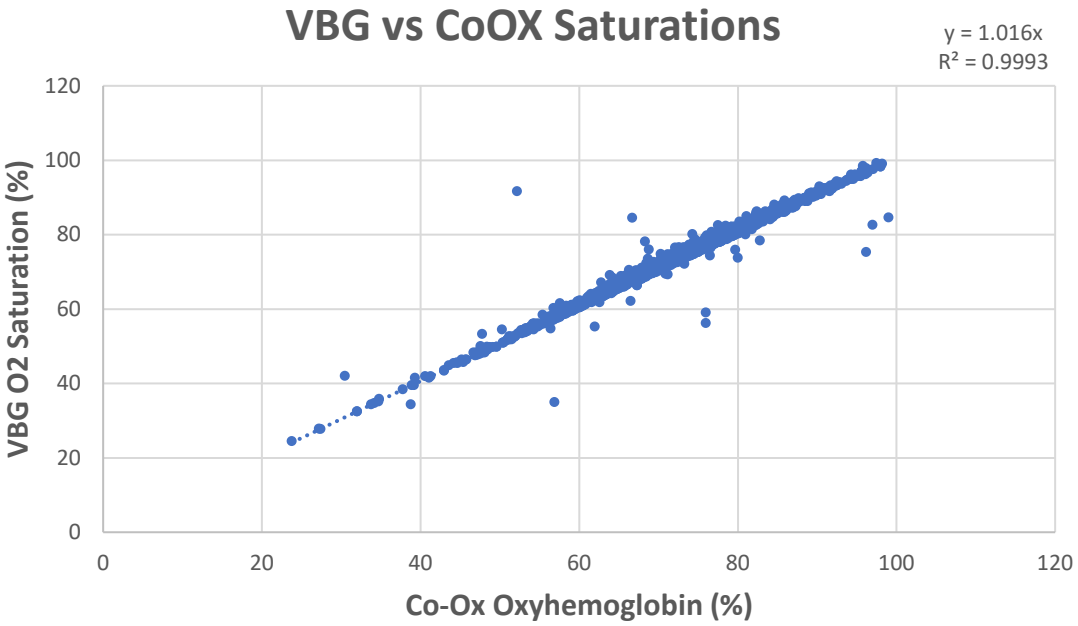
Where to Go Next?

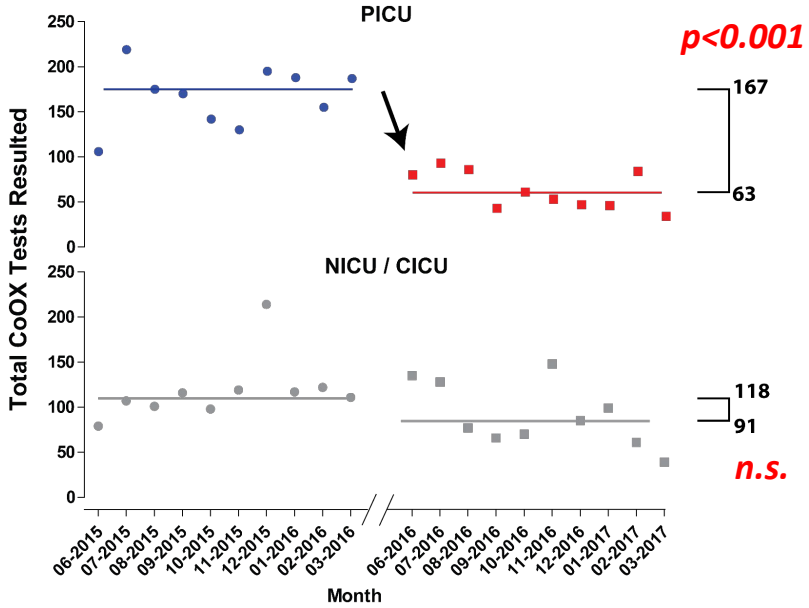
Start Local, Think Bigger



- Local QI example: *Co-oximetry & VBG*
- Local research example: *Simultaneous Hgb*
- Local validation: *PEDSnet – VPS*
- Multi-center federated: *Pediatric CDS*
- Multi-center centralized: *PICU Data Collaborative*

Local QI example: *VBG vs CoOX*

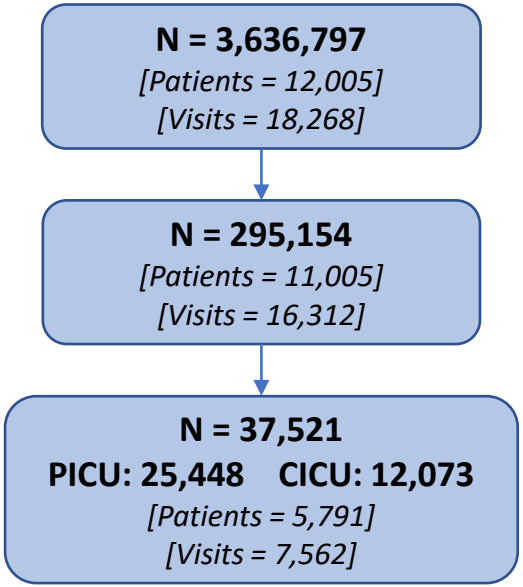




(Dziorny, Fitzgerald, Weiss. Soc Crit Care Med, 2018)

Local research example: *Simultaneous Hgb*

Objective: Measure analytic & clinical accuracy of paired Hgb results



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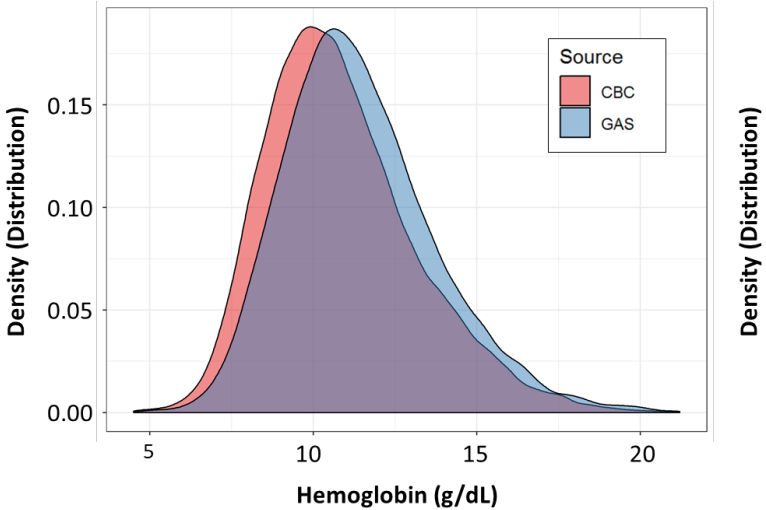
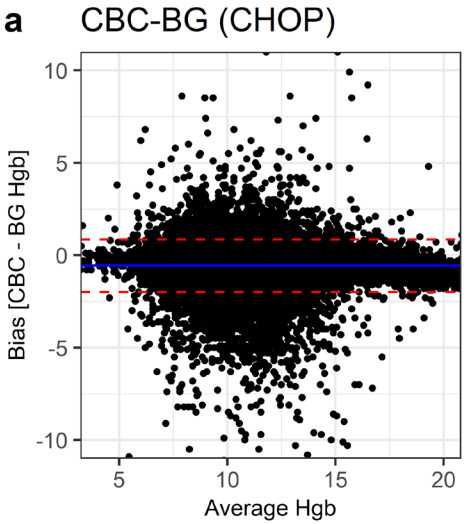
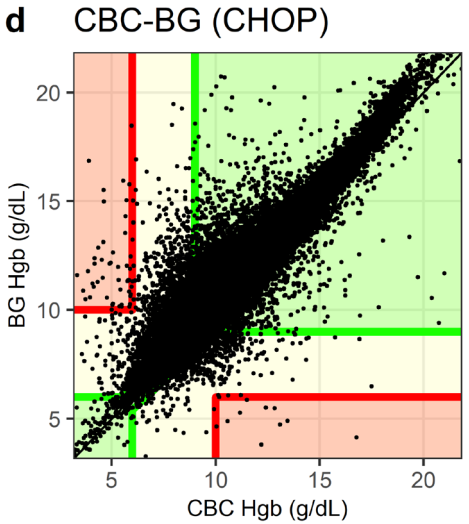


N = 37,521
PICU: 25,448 CICU: 12,073





(Dziorny, Wolfe, Srinivasan; Soc Crit Care Med, 2019 & PCCM [Under Review])

Local validation: *PEDSnet – VPS*

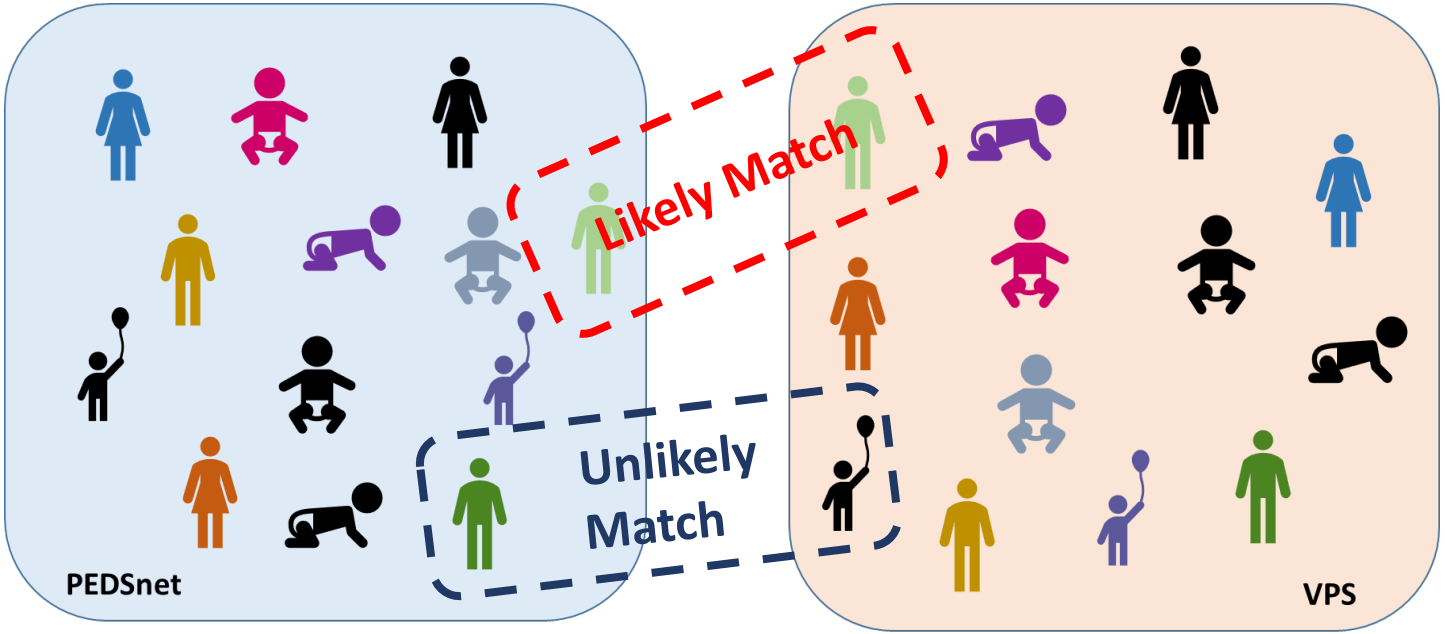
VPS LLC

- Manually abstracted database of consecutive PICU admissions from over 132 hospitals
- Low clinical detail

PEDSnet
A Pediatric Learning Health System

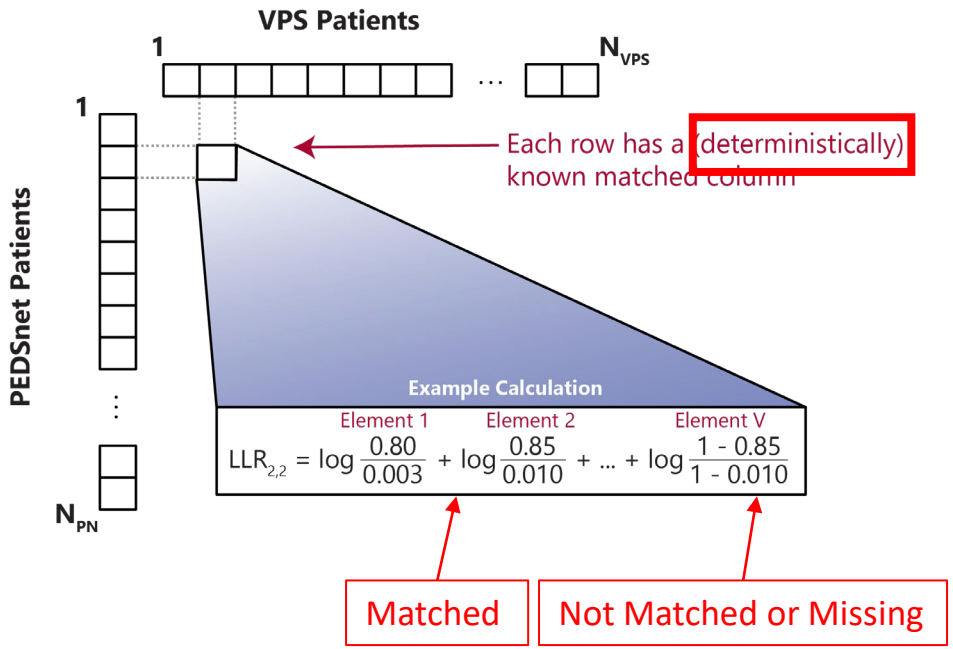
- Electronic Health Record (EHR) abstracted data from 8 children's hospitals
- Granular but suffers cohort identification

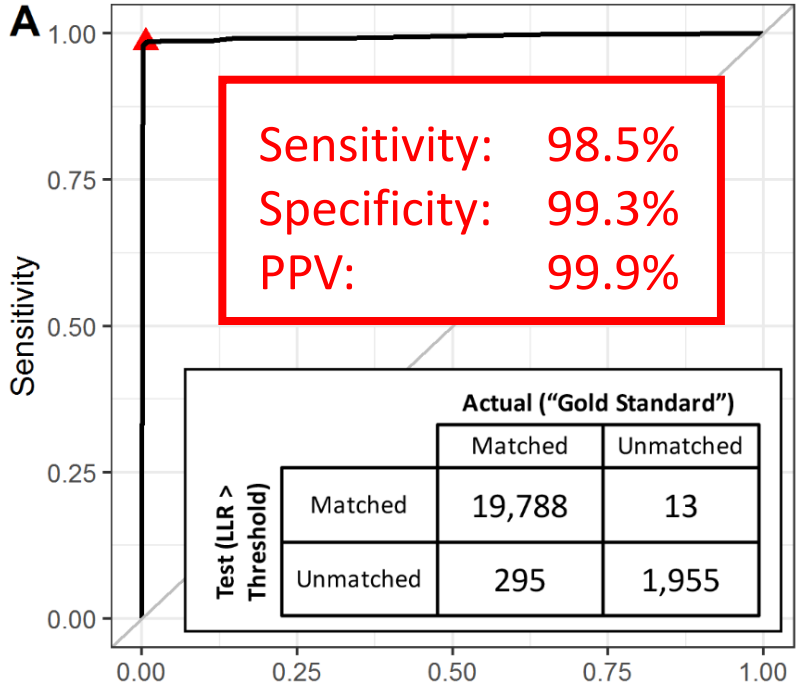
Local validation: *PEDSnet – VPS*



Goal: Find the most likely **matched subjects** between datasets by **feature matching**

Local validation: *PEDSnet – VPS*

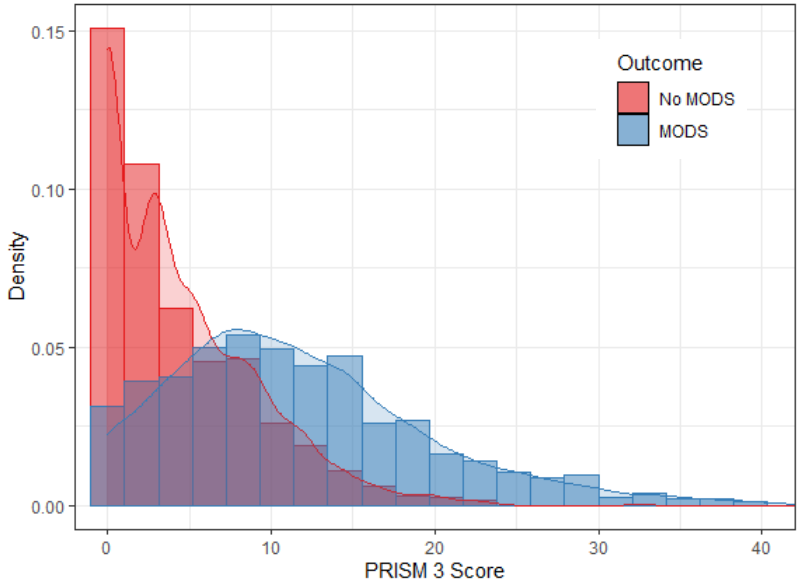




(Dziorny, Lindell, Bennett et al. PCCM, 2020)

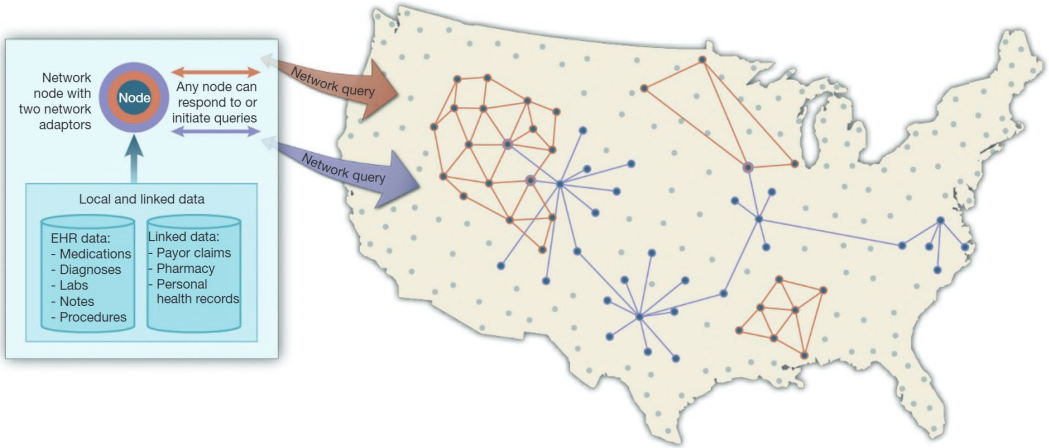
Local validation --> Multi-site: *PEDSnet – VPS*

Site ID	N, Total	N, Above Cutoff (%)
A	11,602	11,089 (95.6)
B	22,250	20,720 (93.1)
C	15,290	15,194 (99.4)
D	15,842	15,595 (98.4)
E	10,133	9,136 (90.1)
F	7,340	7,122 (97.0)
All Sites	**82,457**	**78,856 (95.6)**



(Brennan, …, Dziorny, Soc Crit Care Med, 2022)

Multi-center (federated): *Pediatric CDS*

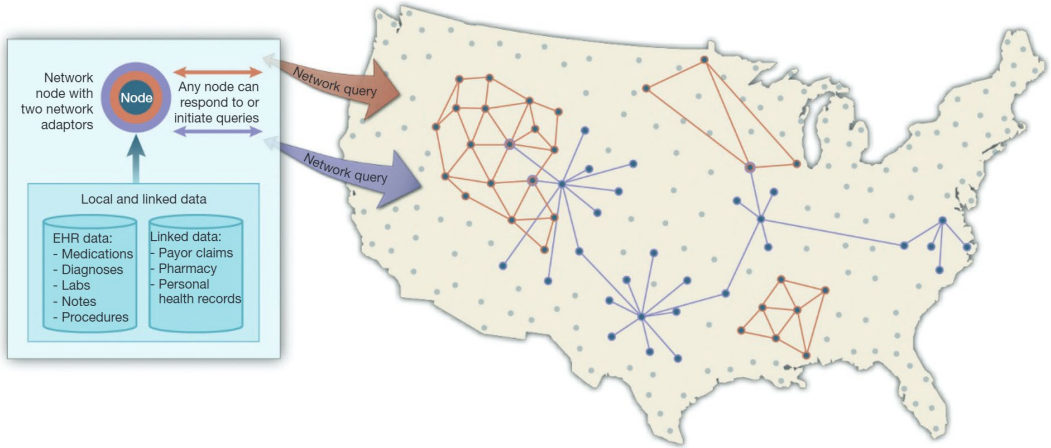


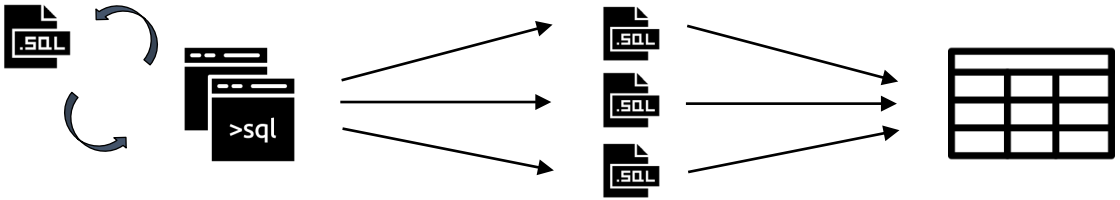
(Mandl & Kohane, Nature Biotechnology, 2015)

Objective: Measure interruptive CDS alert burden across pediatric health systems using multiple burden metrics

Multi-center (federated): *Pediatric CDS*

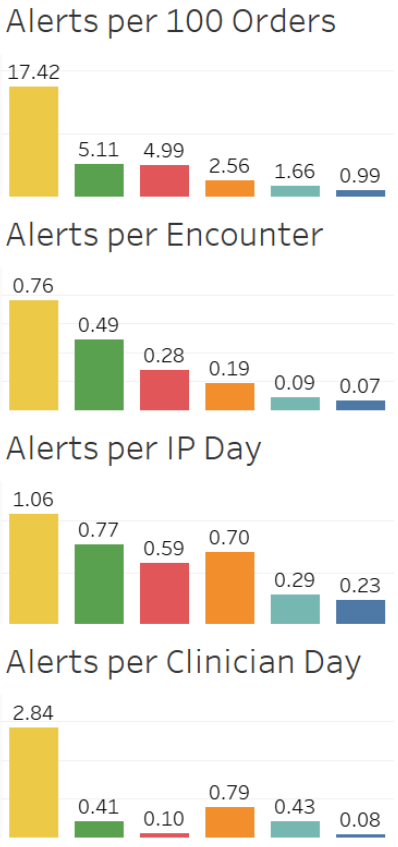
(Mandl & Kohane, Nature Biotechnology, 2015)



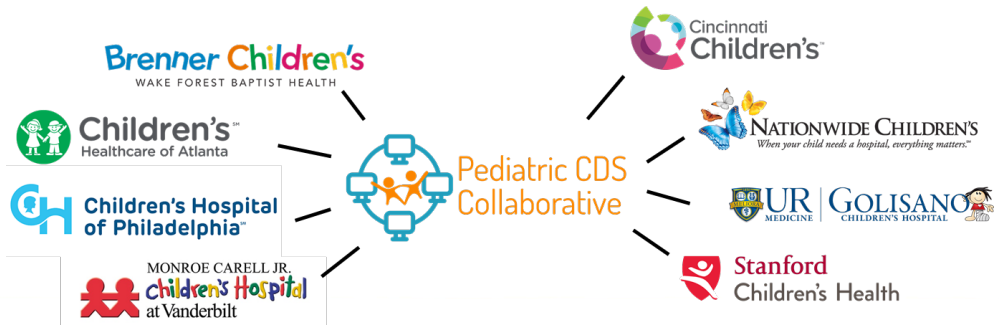


1. Queries developed at a single site, validated at a second site
2. Queries and interface shared with all sites
3. Aggregation of "limited dataset" (dates) row-level data among sites

Multi-center (federated): *Pediatric CDS*



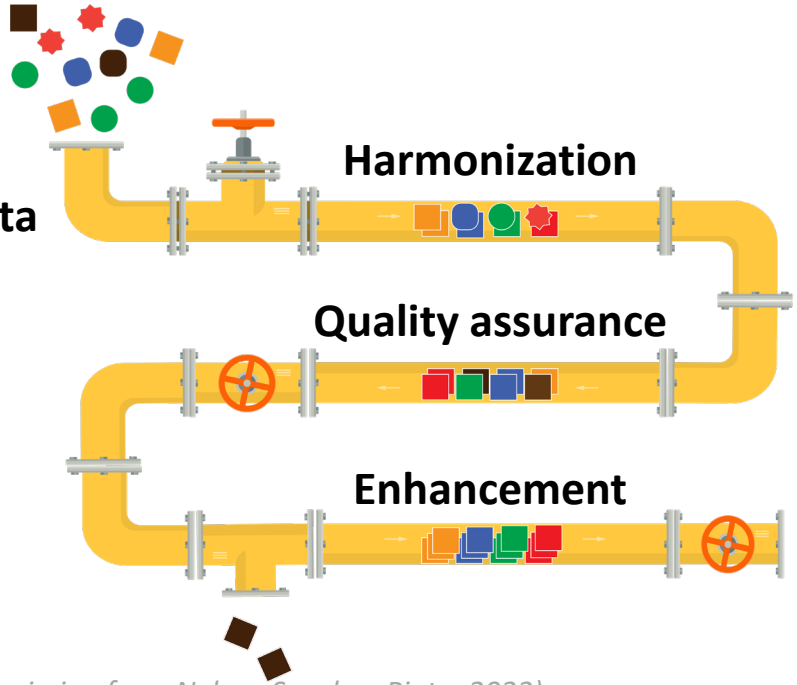
Per Encounter	Site A	B	C	D	E	F	Average
ED/UC	0.00	0.13	0.36	0.06	0.47	0.17	0.20
ICU	1.45	13.24	22.52	2.29	6.99	50.19	16.11
IP - Non-ICU	0.73	1.42	2.49	0.90	3.31	2.27	1.85
Perioperative	0.02	0.24	0.58	0.20	0.48	0.28	0.30
Ambulatory	0.04	0.03	0.18	0.02	0.03	0.74	0.17
HOD	0.21	0.14	0.13	0.41	0.02	0.11	0.17
Ancillary	0.00	0.00	0.09	0.03	0.13	0.01	0.05
Average	**0.35**	**2.54**	**3.76**	**0.56**	**1.63**	**7.68**	**2.76**



http://pediatriccds.org/

Orenstein EW, Kandaswamy S, Muthu N et al. JAMIA (2021)

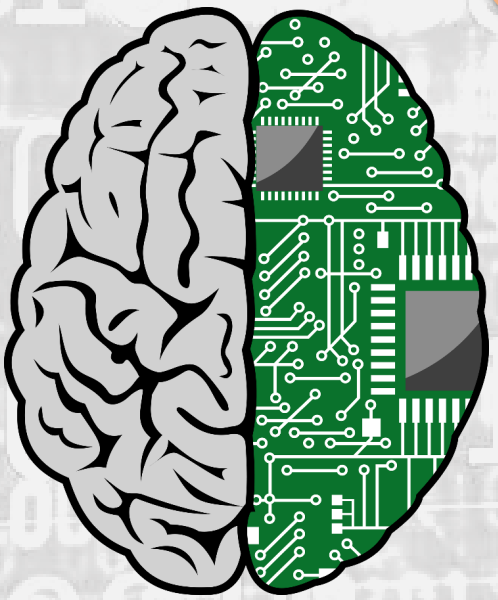
Multi-center (centralized): *PICU Data Collaborative*



Site	Patients	Encounters
A	16,415	22,540
B	12,970	17,810
C	19,624	30,681
D	10,365	16,233
E	12,972	18,120
F	8,243	11,265
G	16,979	21,857
Totals	**97,568**	**138,506**

(Adapted with permission from Nelson Sanchez-Pinto, 2022)

https://pedsdata.org/



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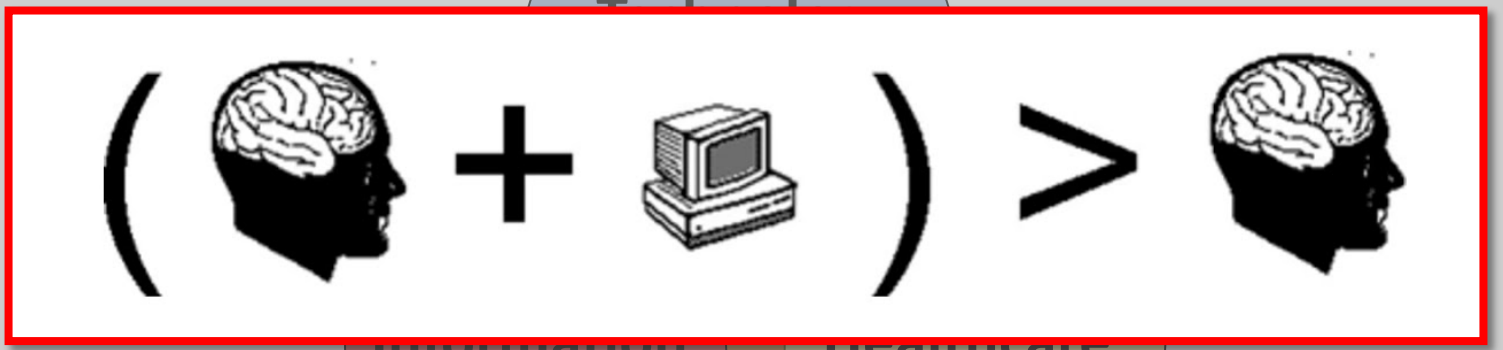
Informatics & Implementation

Where to Go Next?

What is Clinical Informatics?



(William Hersh, 2011)

(Charles Friedman, JAMIA, 2009)

Clinical Decision Support

"Knowledge and person-specific information, intelligently filtered or presented at appropriate times, to enhance health and health care"

-- Osheroff, 2007

Right information

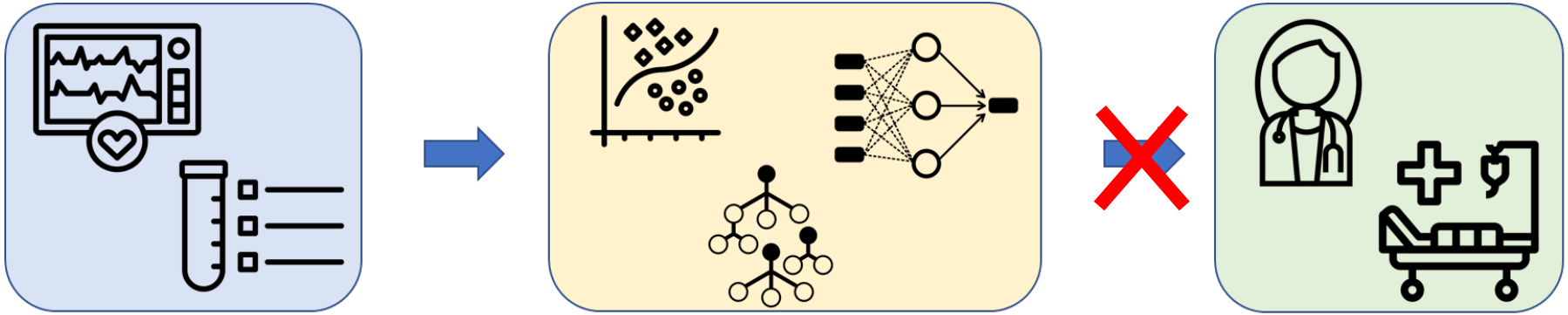
Right people

Right channel

Right format

Right time

Predictive Analytics: “The Last Mile”



The application of ML/AI to healthcare has **failed to produce meaningful changes** to patient care

Single-center ML models are **rarely extended** to multi-center validation or shared implementation

(Chen & Asch, NEJM 2017)

Not All Implementations Are Effective

A C ert
Fat

AUTHOR
Sharek,
Natalie

Computerised clinical decision support systems and absolute improvements in care: meta-analysis of controlled clinical trials

Janice L Kwan,[1,2] Lisha Lo,[3] Jacob Ferguson,[4] Hanna Goldberg,[4] Juan Pablo Diaz-Martinez,[5] George Tomlinson,[5] Jeremy M Grimshaw,[6] Kaveh G Shojania[2,3,7]

AL INVESTIGATION

Unintended Effects of a Computerized Physician Order Entry Nearly Hard-Stop Alert to Prevent a Drug Interaction

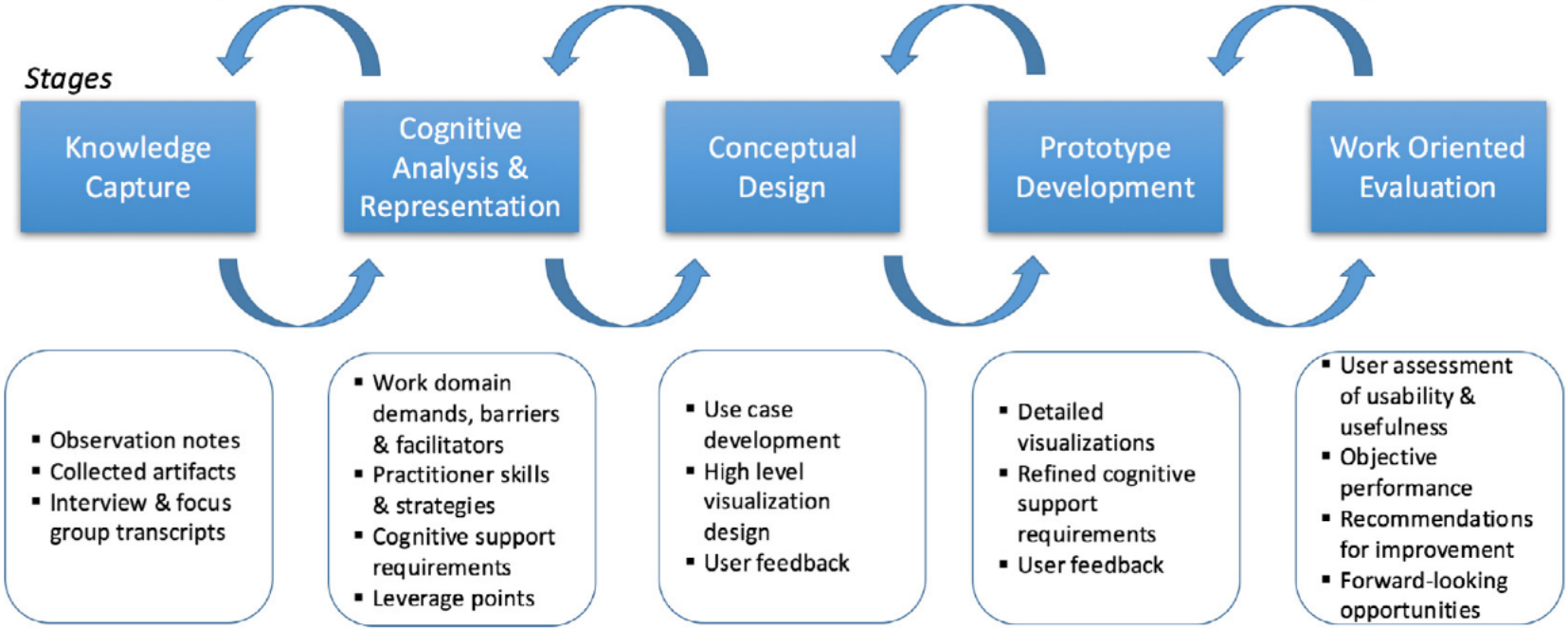
A Randomized Controlled Trial

Brian L. Strom, MD, MPH; Rita Schinnar, MPA; Faten Aberra, MD, MSCE; Warren Bilker, PhD; Sean Hennessy, PharmD, PhD; Charles E. Leonard, PharmD; Eric Pifer, MD

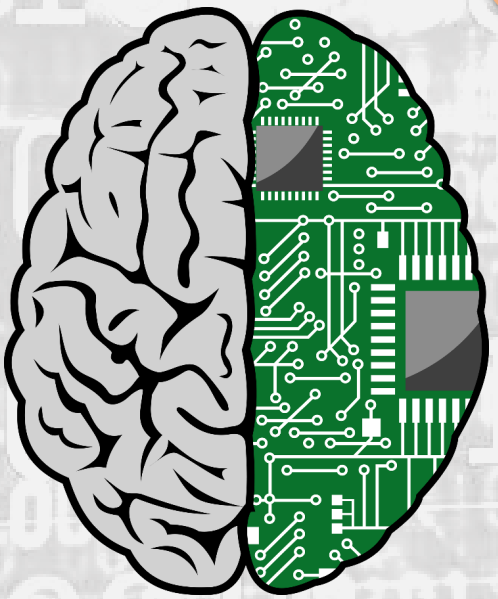
Unexpected Increased Mortality After Implementation
Sold Computerized Physician Order Entry

Yong Y. Han, MD*‡; Joseph A. Carcillo, MD*‡§; Shekhar T. Venka
Robert S.B. Clark, MD*‡§; R. Scott Watson, MD, MPH*‡§‖; Trung C. Nguyen,
and Richard A. Orr, MD*‡§

“Discovery is a Constant Process”



(Hettinger, Roth, Bisantz; J Biomed Inform, 2017)



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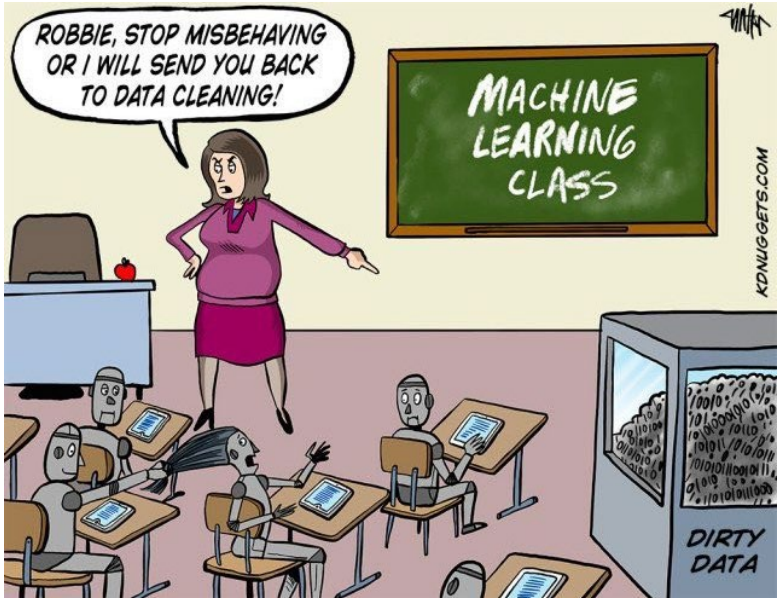
Where to Go Next?

(https://xkcd.com/1838/)

Training & Resources

- Online training programs
- Degree-granting programs
  (e.g. Certificates, Master's Degrees)
- Medical fellowship programs
  (e.g. Clinical Informatics)
- Informal (experiential) learning



Networks & Organizations

CPCCRN

PHIS

VPS LLC

PEDAL
Pediatric Data Science
& Analytics

AMIA
INFORMATICS PROFESSIONALS. LEADING THE WAY.

(http://www.palisi.org) *(http://cpccrn.org)* *(http://portal.myvps.org)* *(http://amia.org)*

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- Critical Care & Anesthesiology (Bob Berg)
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PICU Data Collaborative

- Randall Wetzel, Reid Farris, Nelson Sanchez-Pinto

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