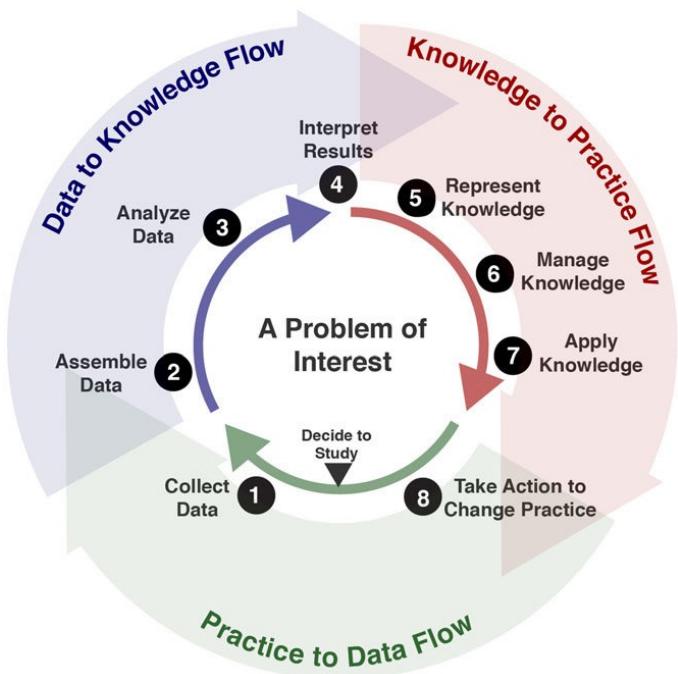


Using Data Science and Clinical Informatics to transform PICU care



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Disclosures/Conflict of Interest

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Roadmap

- ❑ Definitions
- ❑ 6 considerations for using data science in the PICU
- ❑ The road ahead

Definition: Learning health systems



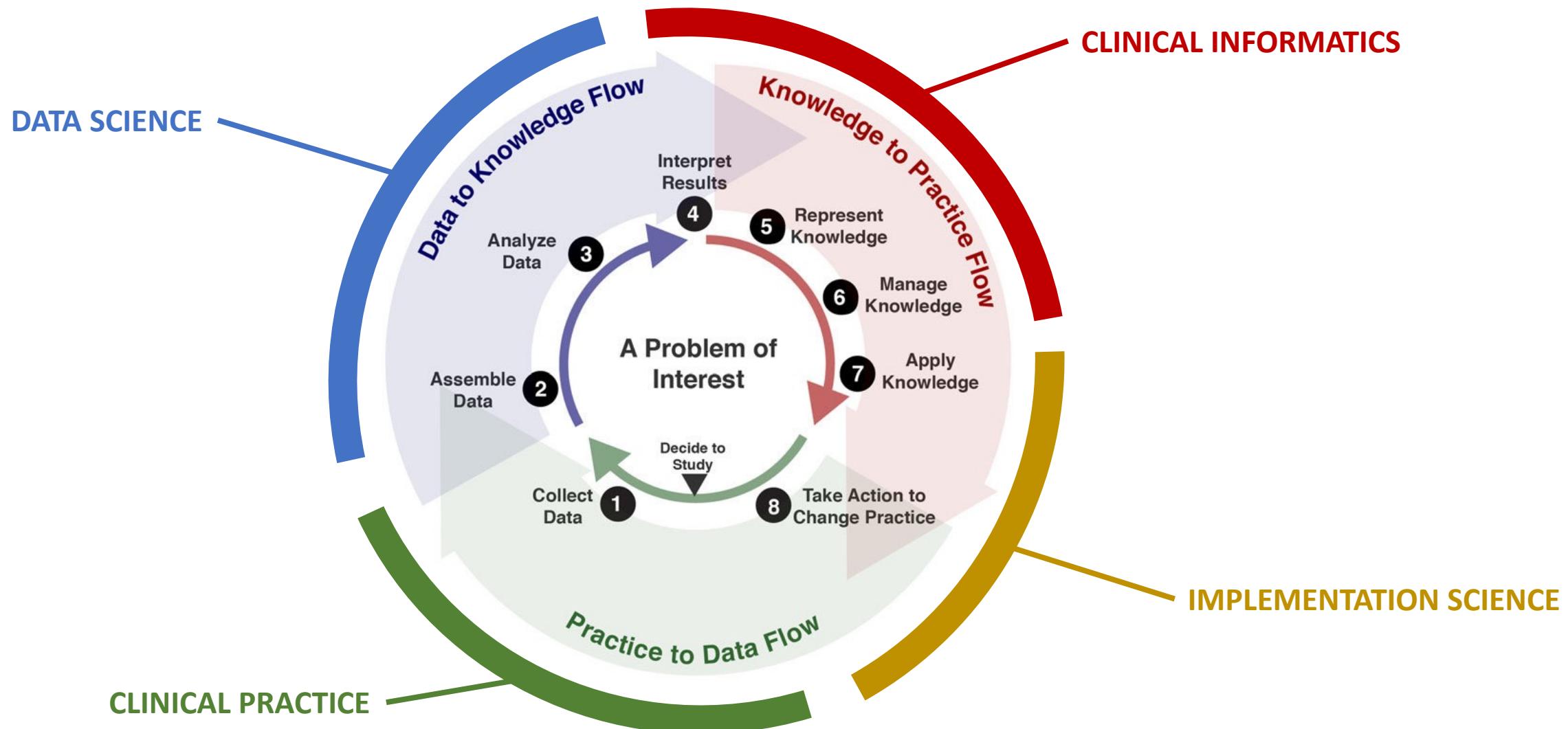
Agency for Healthcare
Research and Quality

“A health system in which **internal data and experience are systematically integrated with external evidence**, and that knowledge is put into practice.

As a result, **patients get higher quality, safer, more efficient care**, and health care delivery organizations become better places to work.”



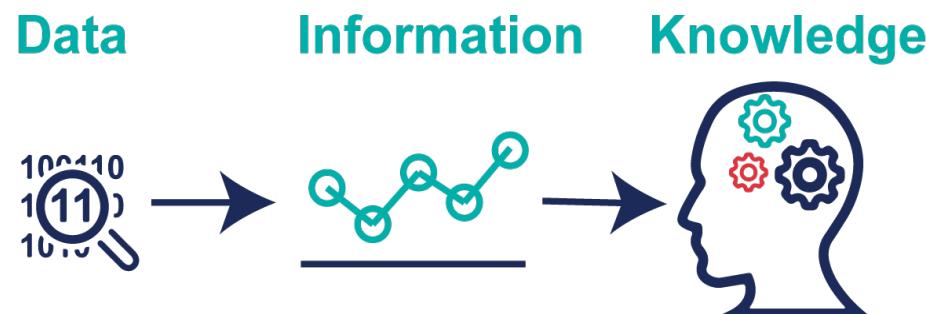
Definition: Learning health systems



Definition: Data science

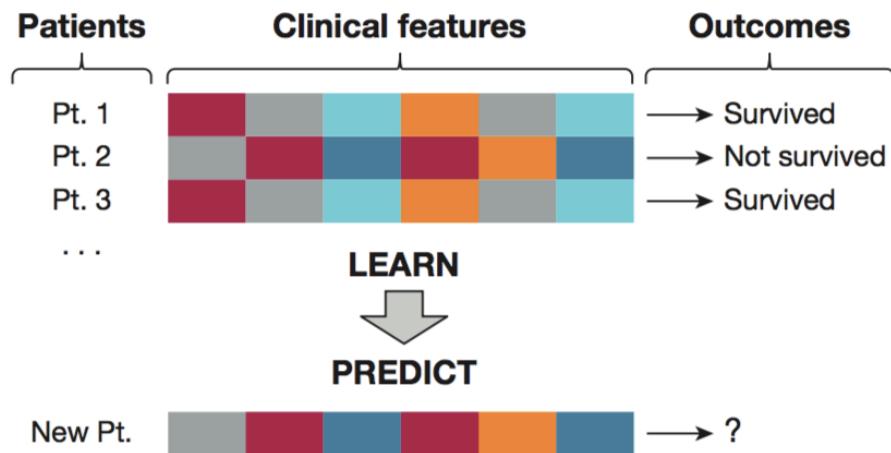


“The field of inquiry in which **quantitative approaches** and processes are developed and used to **extract knowledge** from increasingly complex sets of data.”



Definition: Data science

In data science we use **machine learning algorithms** to learn from the data

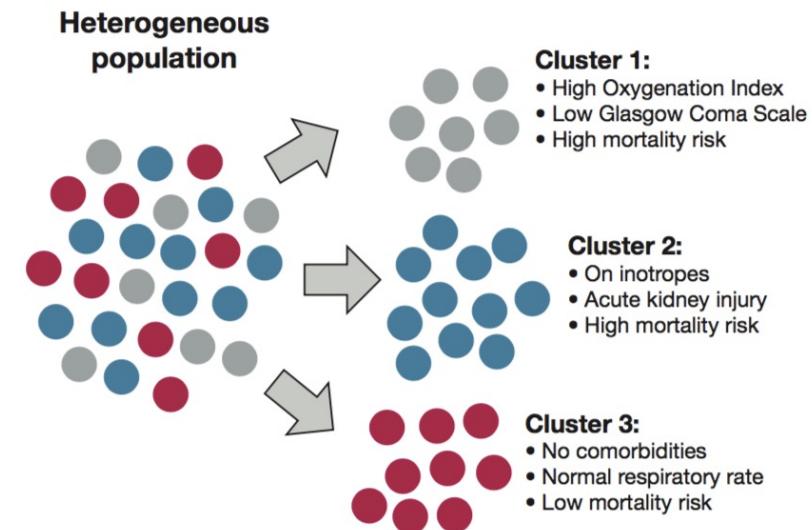


Supervised learning

Goal: To uncover the relationship between a set of variables and an endpoint/event

Types: Regression, random forests, SVM,...

E.g.: Predict clinical deterioration



Unsupervised learning

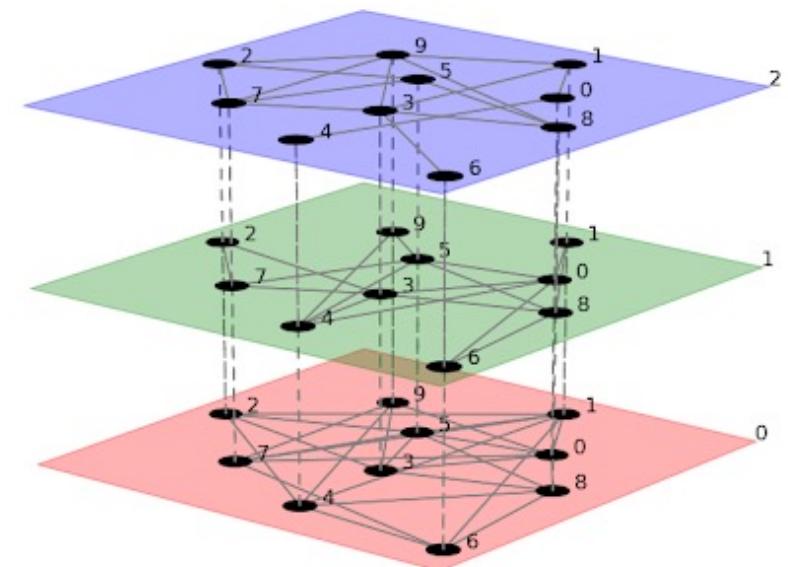
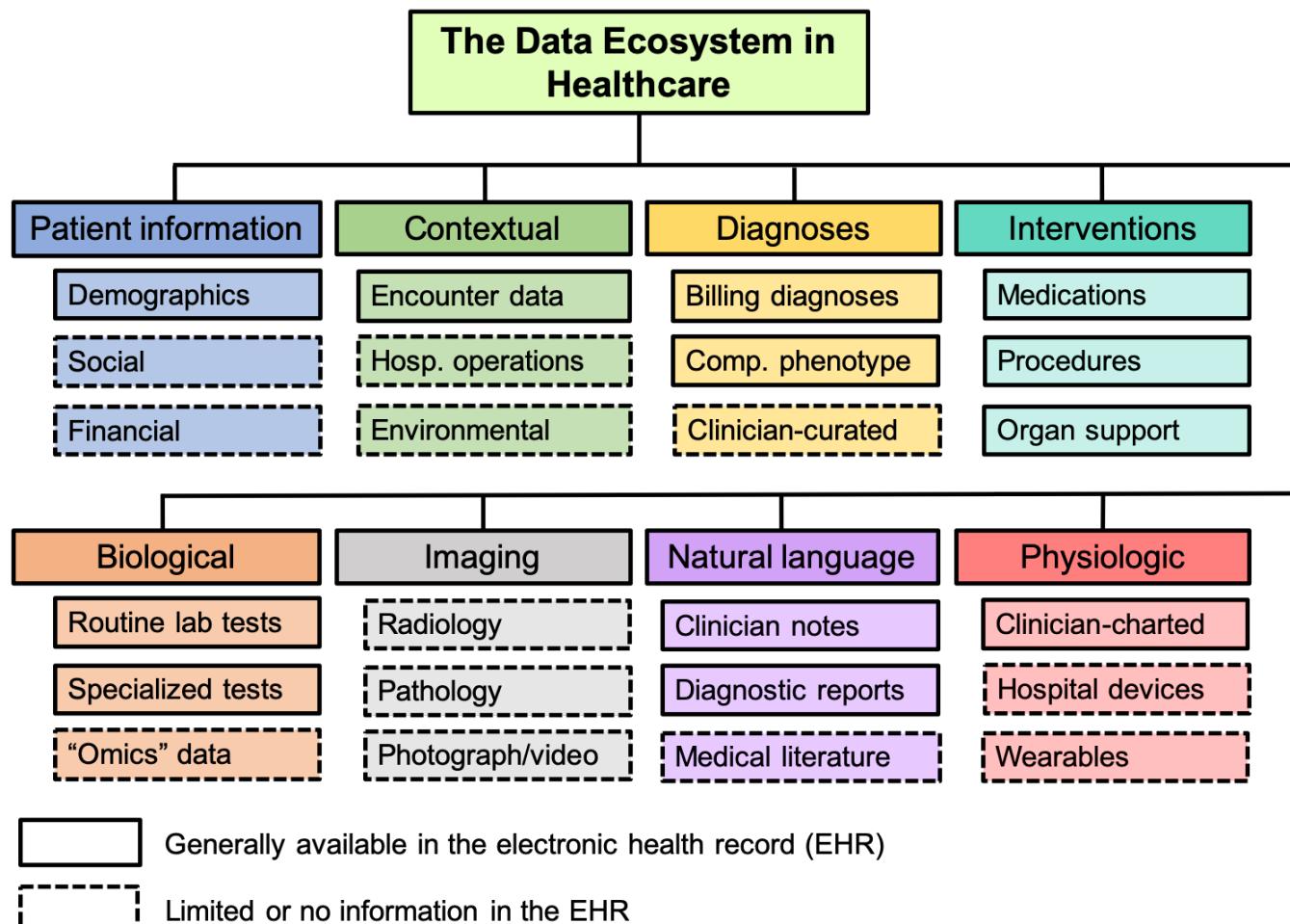
Goal: To uncover naturally occurring patterns or groupings in the data

Types: Clustering analysis, LCA, GBM,...

E.g.: Discover disease subgroups/phenotypes

Definition: Data science

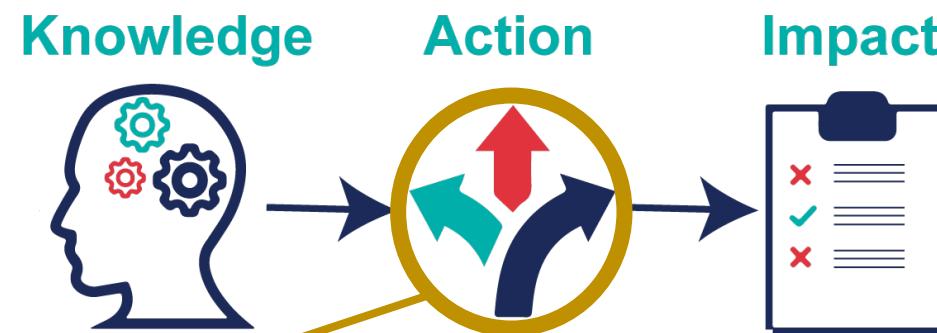
The acute care setting, and especially the ICU, is a data rich environment



Definition: Clinical informatics



“Clinical informatics is the science of **how to use data, information, and knowledge** to improve delivery of health care services.”



Definition: Implementation science

“Implementation science is the scientific study of methods and strategies that facilitate the uptake of evidence-based practice and research into regular use by practitioners. It seeks to systematically **close the gap between what we know and what we do.**”

Roadmap

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1. “The complexity of modern medicine exceeds the inherent limitations of the unaided human mind” - David Eddy

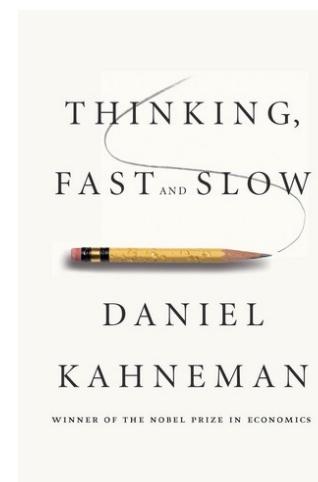
Cognitive load limitations

- 4 vs. 40,000



Cognitive biases

- Anchoring effect
- Availability heuristics
- Confirmation bias



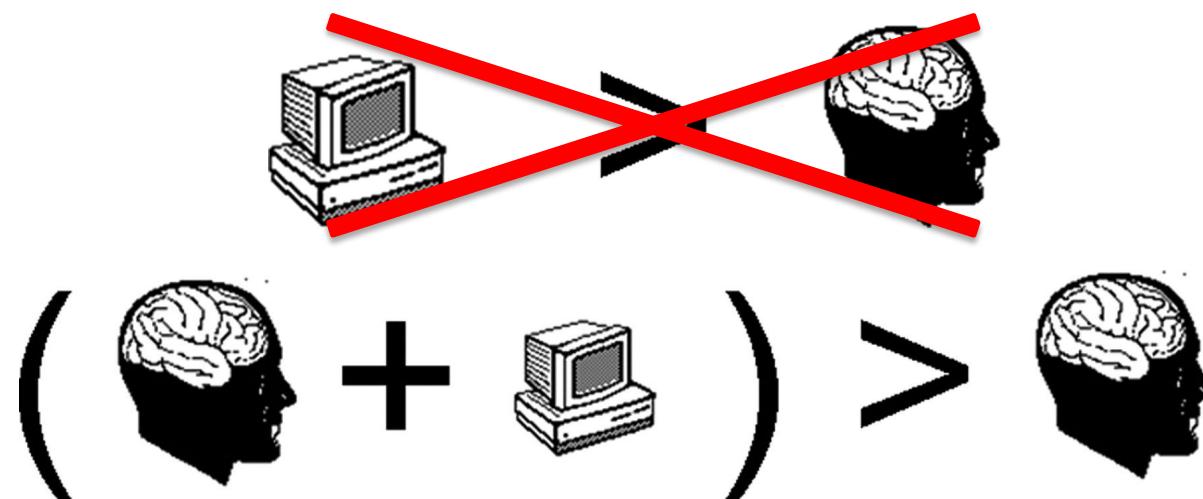
1. “The complexity of modern medicine exceeds the inherent limitations of the unaided human mind”

Viewpoint Paper ■

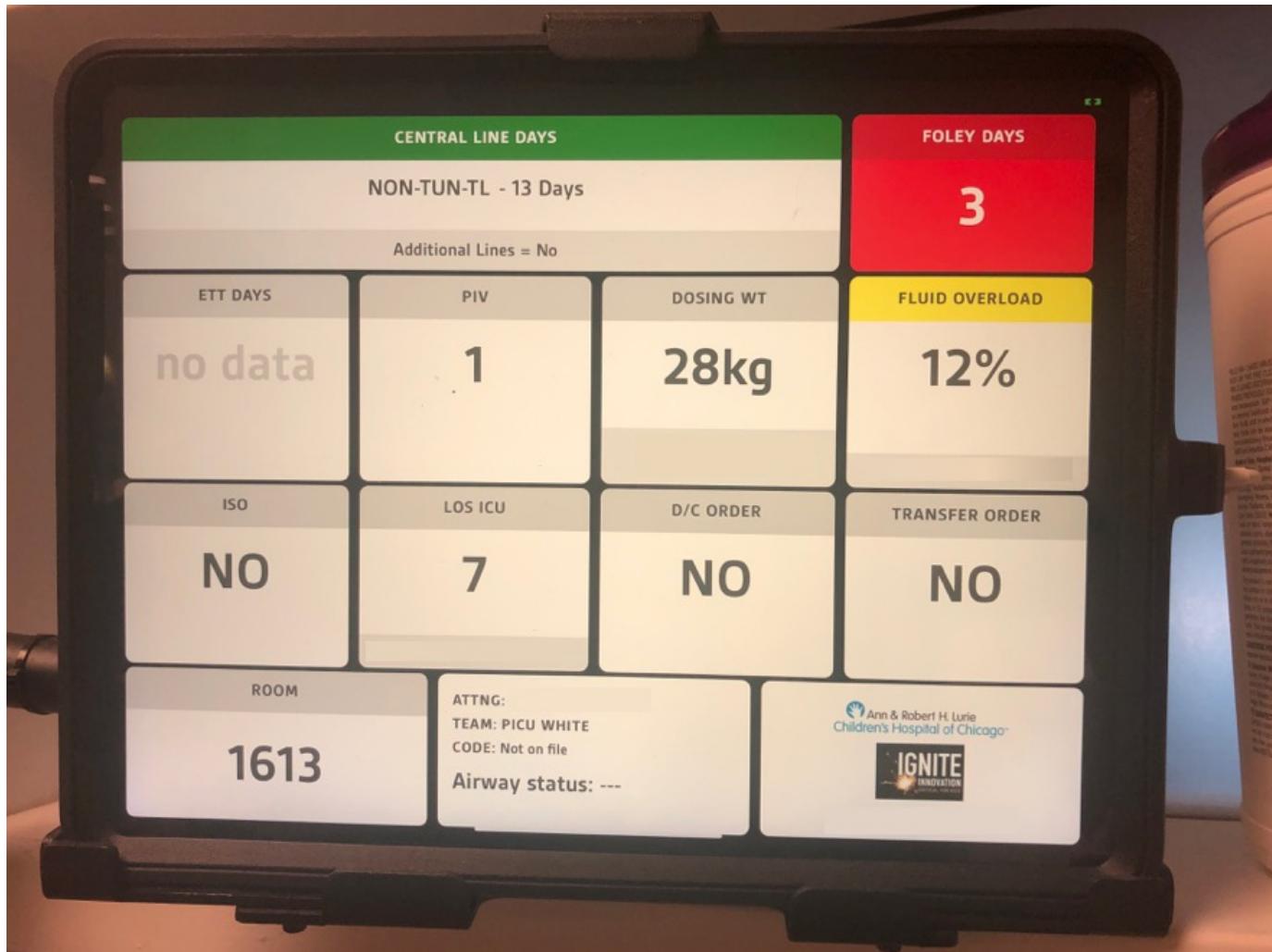
A “Fundamental Theorem” of Biomedical Informatics

CHARLES P. FRIEDMAN, PhD

J Am Med Inform Assoc. 2009;16:169–170. DOI 10.1197/jamia.M3092.



2. “If you don’t measure it, you can’t improve it” - Peter Drucker



2. “If you don’t measure it, you can’t improve it” - Peter Drucker

2.1. We perform thousands of natural experiments every day

Table 3. Therapies Used within the 48-Hour Data Collection Window

| Therapy | Total |
|----------------------------------|----------|
| Vasoactive infusions* | 314 (55) |
| Dopamine† | 102 (32) |
| Dobutamine† | 20 (6) |
| Epinephrine† | 134 (43) |
| Norepinephrine† | 133 (42) |
| Vasopressin† | 31 (10) |
| Phenylephrine† | 2 (<1) |
| Milrinone† | 95 (30) |
| Vasodilator‡‡ | 9 (3) |
| Invasive mechanical ventilation | 421 (74) |
| Corticosteroids | 242 (45) |
| Albumin | 135 (24) |
| Synthetic colloid | 22 (4) |
| Blood products§ | 232 (41) |
| Nutrition, enteral | 331 (58) |
| Nutrition, parenteral | 221 (39) |
| Gastric stress ulcer prophylaxis | 445 (78) |
| Insulin | 57 (10) |
| G/GM-CSF | 23 (4) |
| IVIG | 38 (7) |
| RRT¶¶ | 81 (14) |
| Plasma exchange | 5 (1) |
| ECMO | 30 (5) |

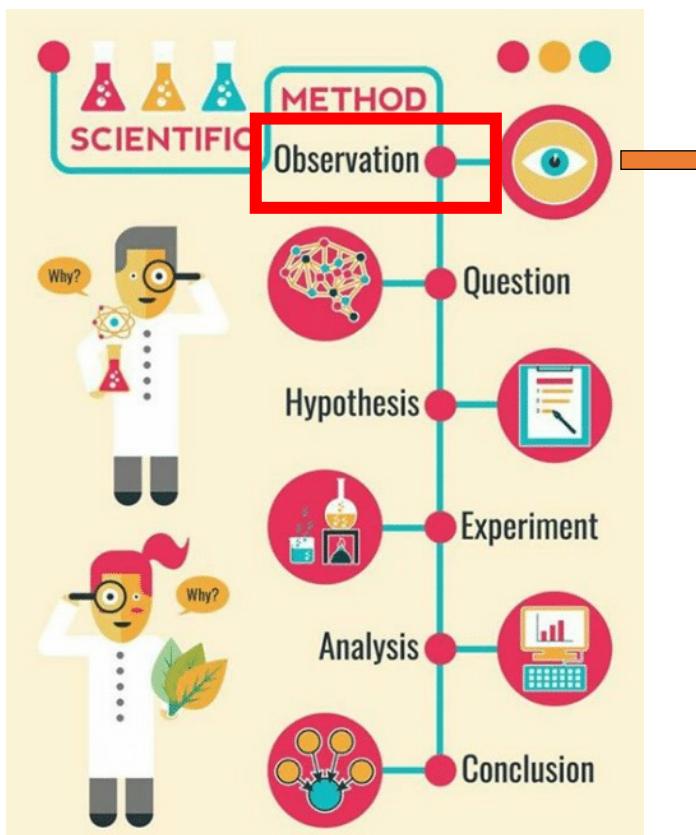
Global Epidemiology of Pediatric Severe Sepsis: The Sepsis Prevalence, Outcomes, and Therapies Study

Scott L. Weiss^{1*}, Julie C. Fitzgerald^{1*}, John Pappachan^{2,3}, Derek Wheeler^{4,5}, Juan C. Jaramillo-Bustamante⁶, Asma Saloo⁷, Sunit C. Singhi⁸, Simon Erickson⁹, Jason A. Roy¹⁰, Jenny L. Bush¹, Vinay M. Nadkarni¹, and Neal J. Thomas^{1,11}; for the Sepsis Prevalence, Outcomes, and Therapies (SPROUT) Study Investigators and the Pediatric Acute Lung Injury and Sepsis Investigators (PALISI) Network

2. “If you don’t measure it, you can’t improve it” - Peter Drucker

2.1. We perform thousands of natural experiments every day

2.2. Most of the data we need is already being collected



- For example, each kid with sepsis generates ~20,000 data points in the EHR.
- Data science becomes a powerful **magnifying glass** with which to observe this big data

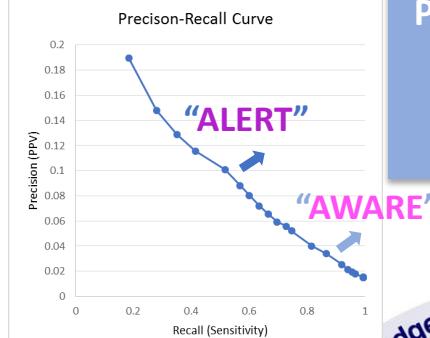
Example: Improving sepsis recognition using EHR data

*Supervised learning

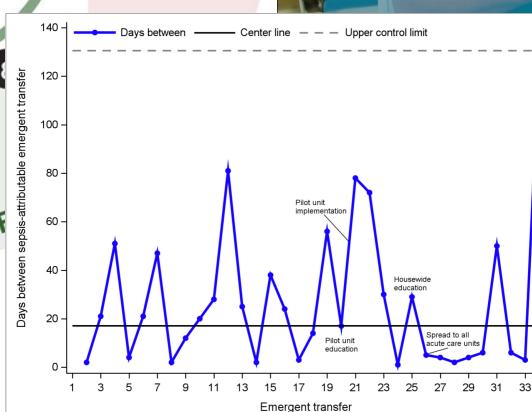
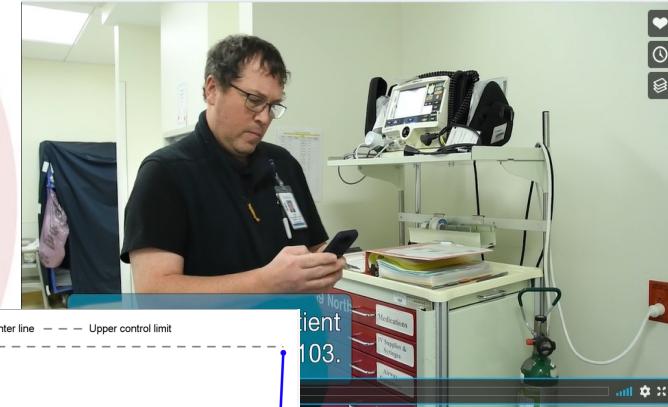
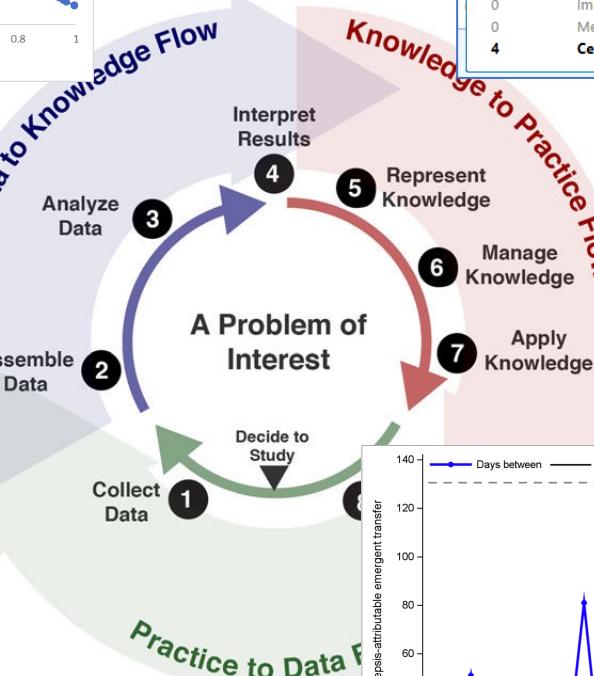


Retrospective dataset from EHR (~47,000 pts)

Problem: Delay in recognition of sepsis in the pediatric ward

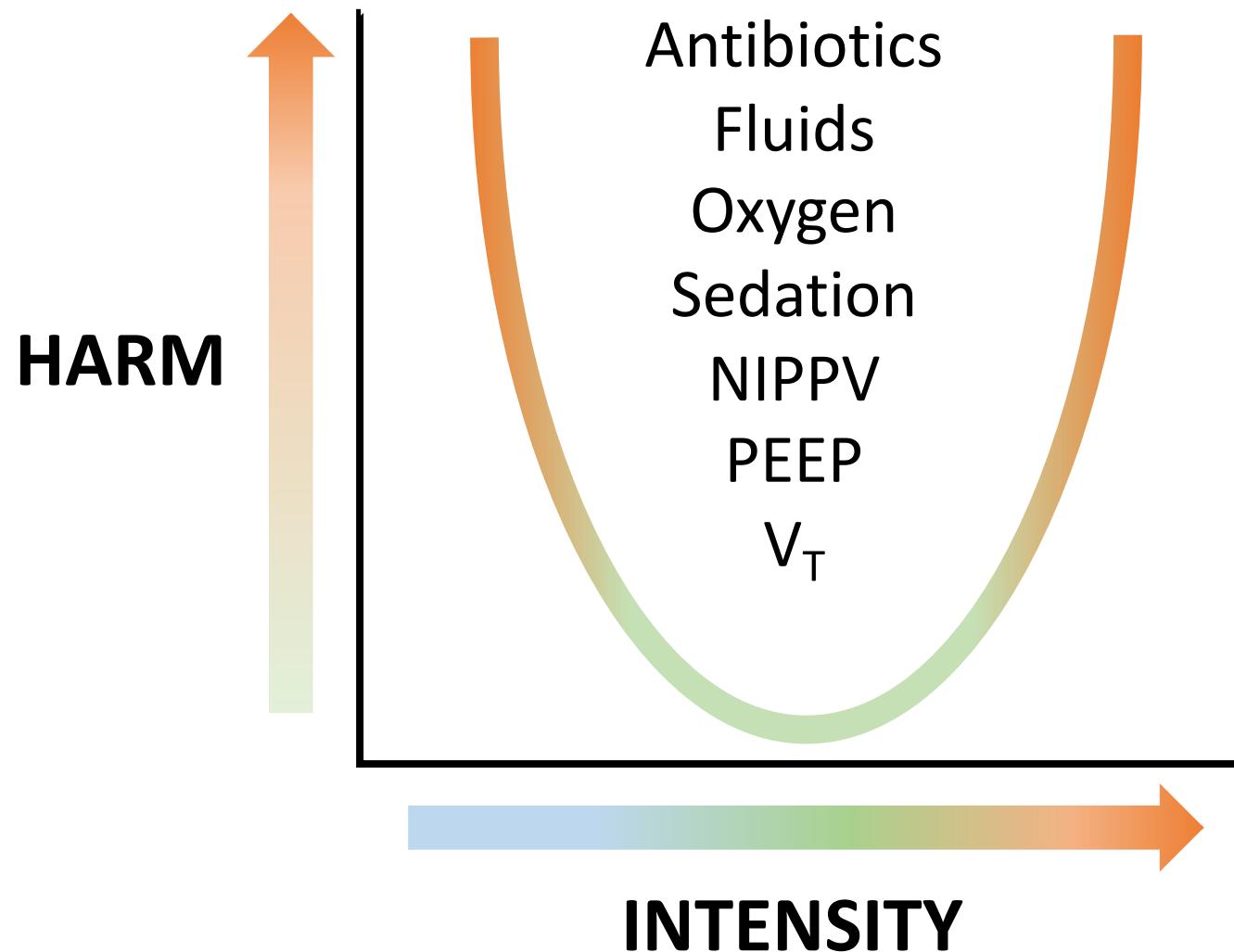


Prospective test in the EHR (~8,600 pts)

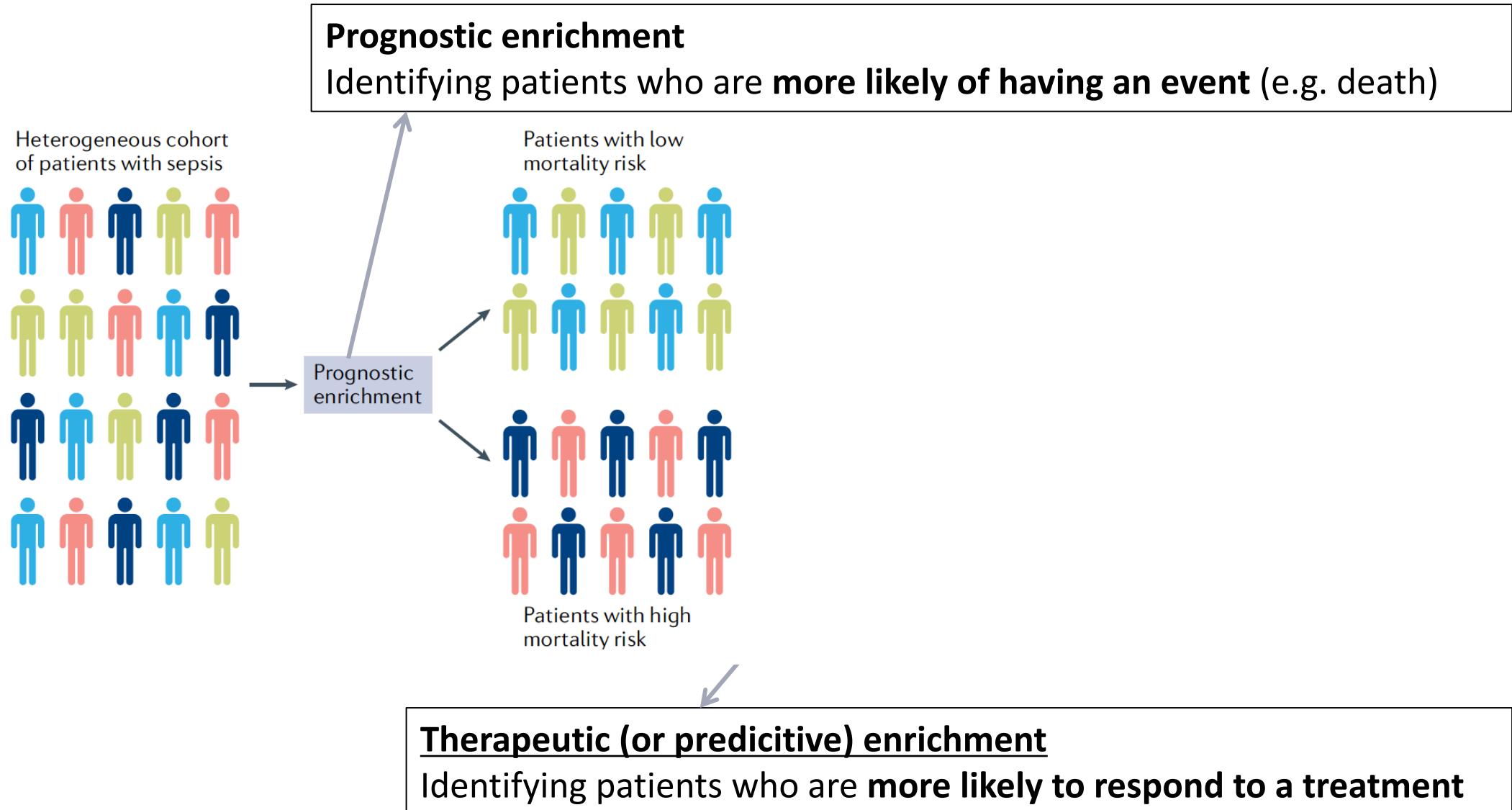


Result: Decrease in emergent transfers to the ICU for sepsis

3. We need to find the “Goldilocks” of care intensity

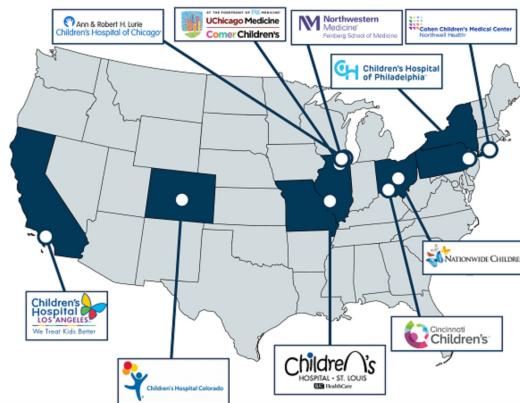


4. One size DOES NOT fit all!



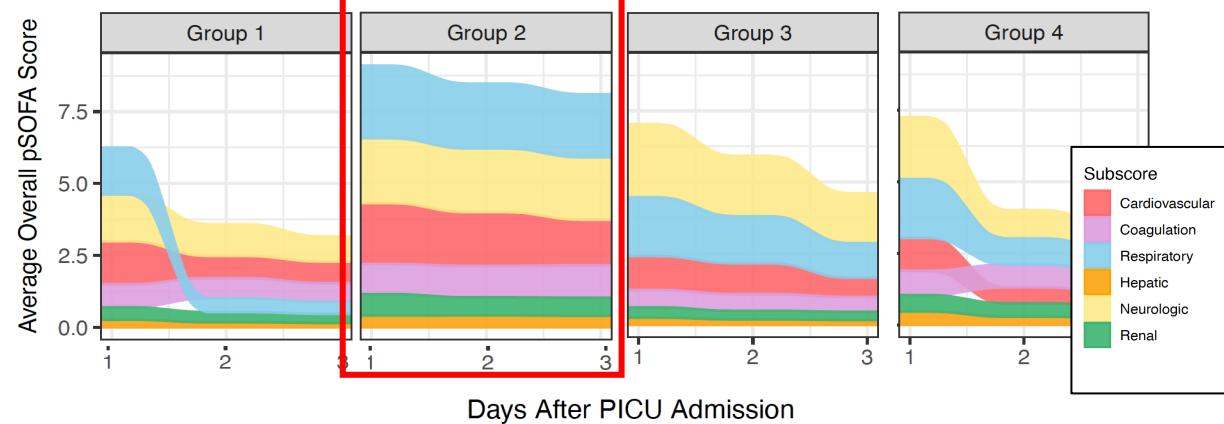
Example: Enrichment strategies in sepsis

Problem: Sepsis is very heterogeneous and presents with different patterns of organ dysfunction



Data from
~15,000 pts with
sepsis-assoc.
MODS from 13
PICUs

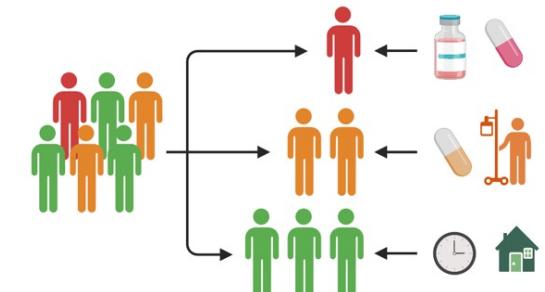
*Unsupervised learning



Persistent hypoxemia, encephalopathy, and shock phenotype

- 4-fold higher mortality after adjusting for confounders
- Higher inflammatory cytokine and endothelial activation
- More likely to respond to hydrocortisone and albumin

Result: We identified a high-risk phenotype with prognostic and therapeutic enrichment

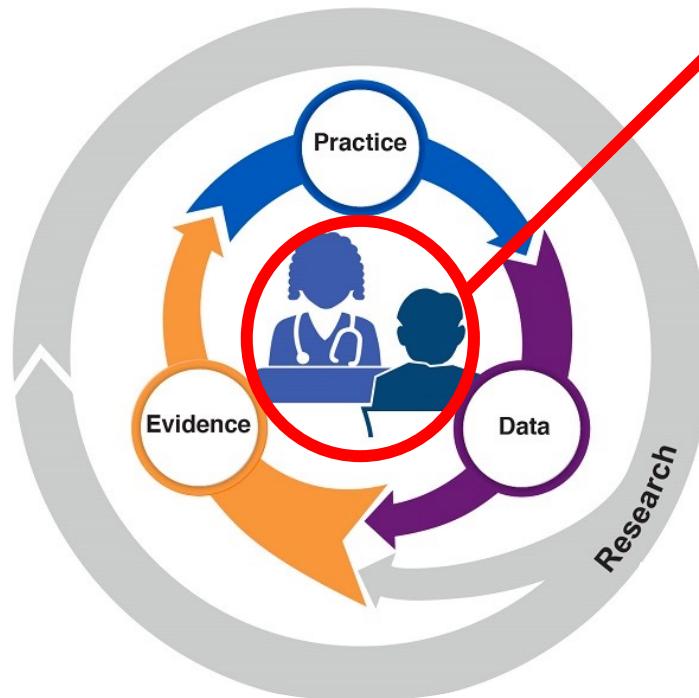


5. Innovation happens when the right “ingredients” are available

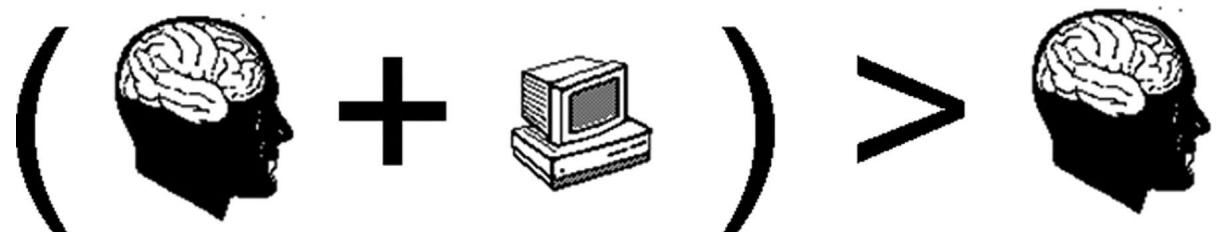
Diversity + collaboration = Innovation



6. It's more about the people than the technology



- Culture of change & continuous improvement
- Diversity of ideas to spark innovation
- Need for widespread buy-in and support



Roadmap

- ❑ Definitions
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- ❑ The road ahead

The road ahead

Consumer IT



1997 (Internet adoption = 25%)

.com

2000 (70%)



2007 (>90%)



NETFLIX

Health IT



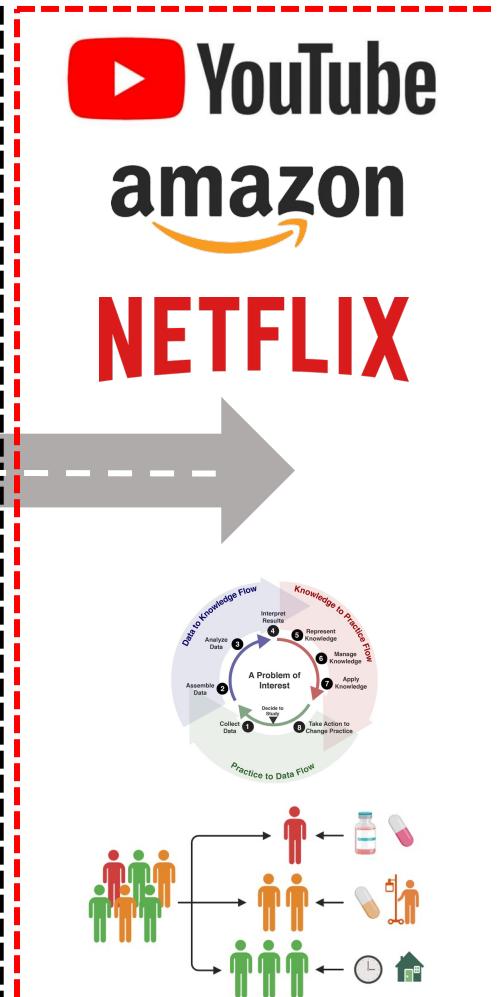
2012 (EHR adoption = 25%)

2015 (70%)



ADOPTION

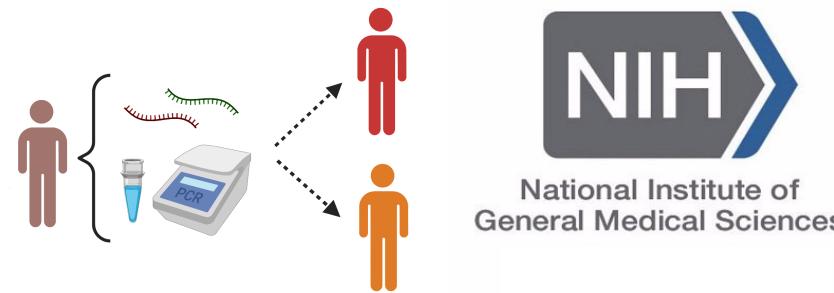
IMPACT



The road ahead

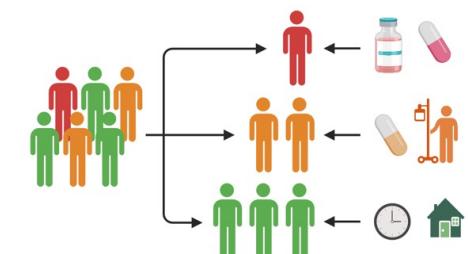
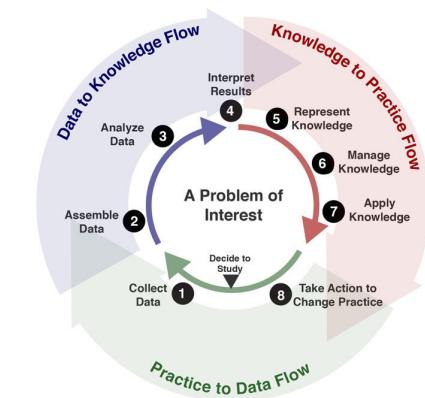
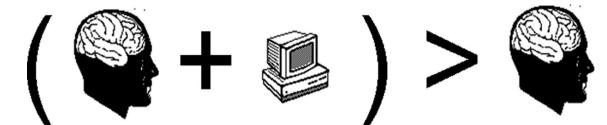
The “ingredients” for the future:

1. Large-scale data collaborations
2. Physiological data utility
3. Multi-omics data integration



Summary

- Learning health systems systematically **integrate internal data with external evidence** and translate that knowledge into practice
- Data science, clinical **informatics**, and **implementation science** are integral parts of a successful learning health systems in pediatrics
- The road ahead is promising, we are **on the verge of realizing the real impact** of healthcare technology



A close-up photograph of a person's hand reaching upwards from the surface of dark blue, rippling water. The hand is positioned vertically, with fingers slightly spread, creating a stark contrast against the dark background.

QUESTIONS?
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