Leveraging Electronic Data in “Real-Time”

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Outline

1. Background
2. What is real-time?
3. Tracking the essentials - “Air Traffic Control”
4. Identifying patterns – “Weather Forecasting”
5. Some final thoughts

Background

- Learning Health Systems Researcher
  - NICHD K23: “A Learning Health Systems Approach to Precision Sedation and Analgesia for Critically Ill Children”
  - NINDS R01: “A Biodigital Rapid Alert for Identifying Neuromorbidity in Critically Ill Children”
- Operations Informatics
  - UPMC Department of Critical Care Medicine
    - >40 Adult and Pediatric ICUs
    - Cerner x2, Epic x2, Allscripts, Medtech
- Embedded Clinical Trials
  - EHR to support traditional EDC
  - Workflow integration

What is “Real-Time”?

On-demand data or information with essentially no delay

Cerner

- Discern explorer
- Tap into a recovery server
- Analytic instance
- ETL data for specific use cases

Epic

- Clarity reporting DB
- Cognitive computing platform
- Slicer Dicer

Informatica

- Multiple data sources
- ‘Real-time’ ETL at a cadence of the slowest refresh

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Tracking the essentials -“Air Traffic Control”

Tracking the essentials -"Air Traffic Control"

System Capacity – *Can I accept this patient?*

Patient Transfers and Triage – *Where do I put this patient?*

Tracking Staffing/Personnel – *Who is going to care for this patient?*

Supply Chain Management – *Do we have what we need to provide care?*

Strategic Stockpile Management – *How long can we last?*

'Real-time' Patient Identification and Enrollment – *Where is the patient?*

The UPMC REMAP-COVID Group, on behalf of the REMAP-CAP Investigators *Trials* (2021) 22:100
https://doi.org/10.1186/s13063-020-04997-6

Trials

METHODOLOGY Open Access

Implementation of the Randomized Embedded Multifactorial Adaptive Platform for COVID-19 (REMAP-COVID) trial in a US health system—lessons learned and recommendations

The UPMC REMAP-COVID Group, on behalf of the REMAP-CAP Investigators[1]

Advantages 1, 2 and 3

1) Patient Identification

UPMC COVID-19 Intake Form FIN: 123456789

Symptoms

What symptoms were present prior to or at the time of presentation? (Check all that apply)

- ☐ **Abdominal Pain**
- ☐ **Body Aches / Myalgias**
- ☐ **Chills**
- ☐ **Confusion**
- ☐ **Cough**
- ☐ **Diarrhea** (>/= 3 loose/looser than normal stools/24 hr period)
- ☐ **Fever** (Temperature >=38°C / 100°F) **or subjective fever**
- ☐ **Headache**
- ☐ **Malaise / Fatigue / Lethargy**
- ☐ **Nausea or Vomiting**
- ☐ **Shortne**
- ☐ **Sputum**
- ☐ **None**

How many days since the onset of symptoms? (The numb… recognized by the patient)

Anticipated Treatment

Please read the following to the patient or their representative and record their response:

"There are few known treatments for COVID-19. Would the patient like to hear about potential additional therapies and studies?" She or he will only be contacted if potentially eligible.

○ Yes ○ No ○ Unknown

(Please only click if the patient or representative is unable to respond. An unknown response will delay potential additional therapies and studies.)

Fig. 1 UPMC REMAP-COVID Intake Form. This form is embedded into a patient's electronic health record, solicits basic clinical information, and requests providers to ask the patient or legally authorized representative if s/he is interested in potential additional therapies for COVID-19. The intake form represents the singular route of entry into the REMAP-COVID trial at UPMC

2) Trial Data Collection

3) Deploy Interventions

Discern: (1 of 1)

Cerner

COVID-19 Vitamin C

COVID-19 Vitamin C

This patient has been randomized to receive Vitamin C for the treatment of COVID-19. This should NOT be ordered if the patient:

- Has received more than 24 hours of a vasoactive infusion, positive pressure ventilation (invasive or noninvasive), or HFNC ≥ 30 L/min and FiO2 ≥ 0.4
- Has received supplemental Vitamin C during this hospitalization (not including Vitamin C administered in parenteral nutrition)
- Has a history of glucose-6-phosphatase dehydrogenase deficiency (G6PD)
- Is allergic to Vitamin C
- Has a history of symptomatic kidney stones in the past 1 year
- If the treating clinician does not think Vitamin C is in the patient's best interest

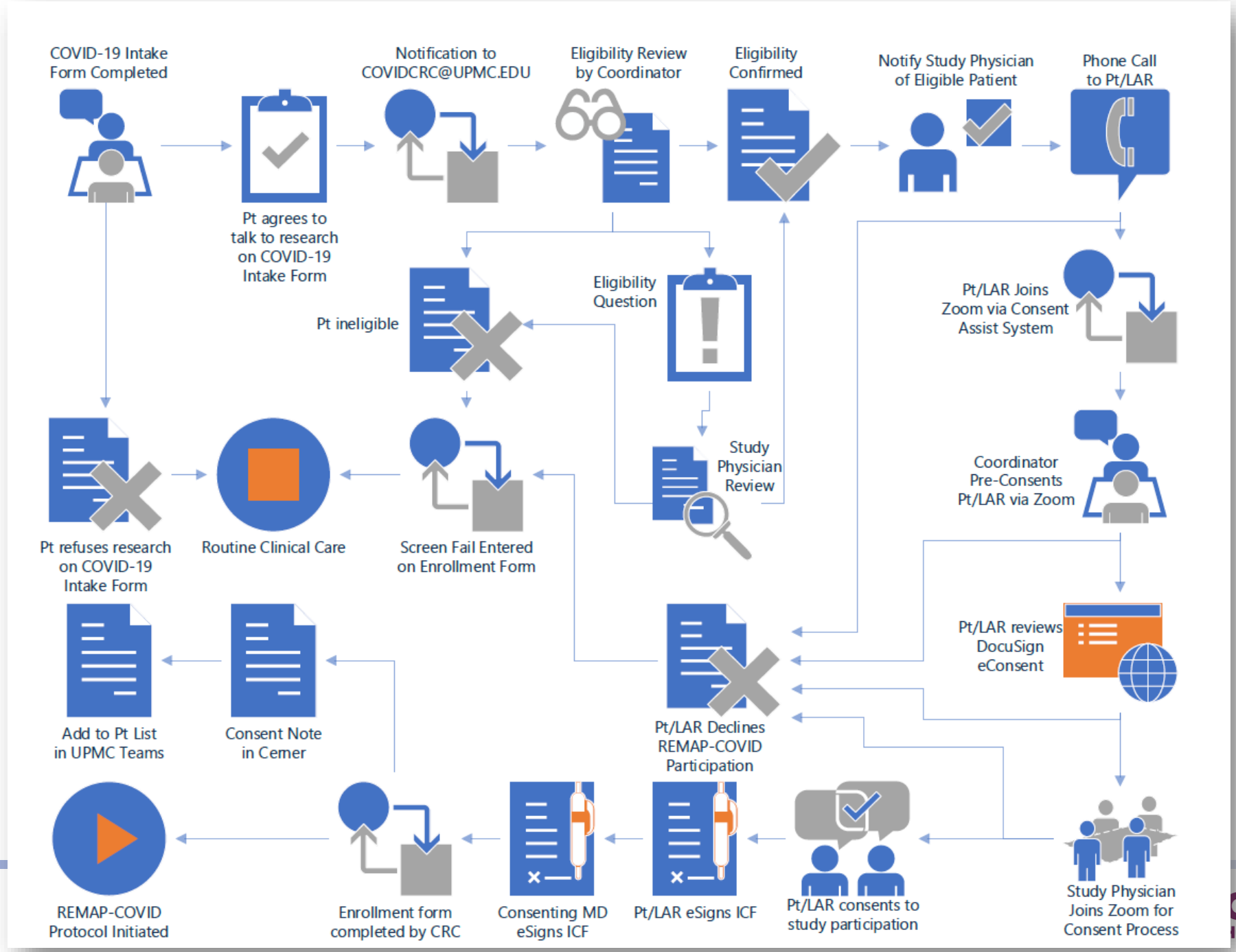
Intravenous Vitamin C may cause falsely elevated glucose readings by point-of-care glucometers and blood gas/stat lab devices. Glucose measurements made using a central core laboratory are not affected by Vitamin C.

Add Orders for

☑ Vitamin C (REMAP COVID-19 Trial) -> 50mg/kg, IV, Q6H, Drug Form: Amp, Duration: 16 Dose(s)/Time(s)
☐ Patient no longer participating in REMAP COVID

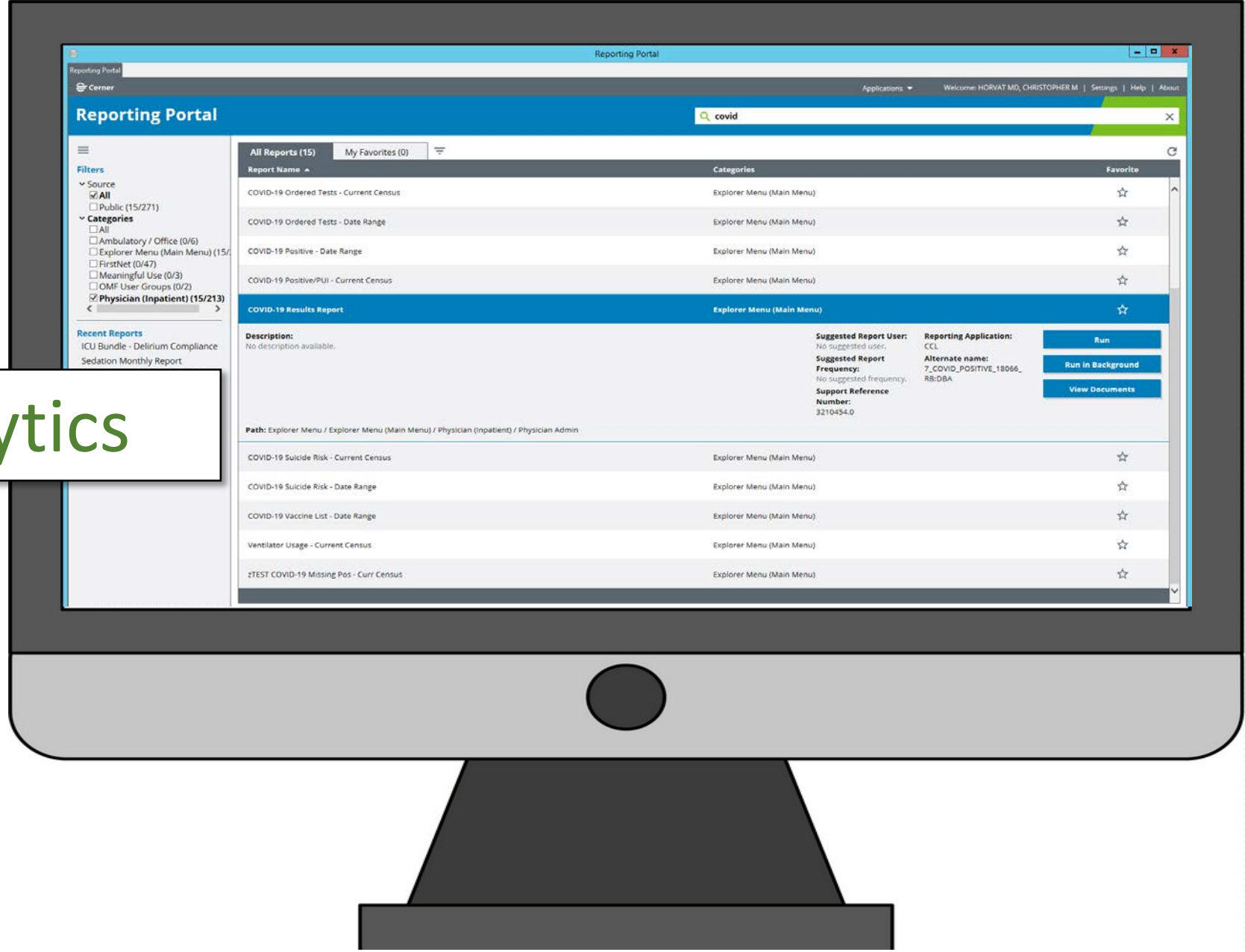
Continue

Fig. 2 Example of an embedded order alert. This order alert displays the randomization status of the patient and asks the treating clinician to approve the order for the randomized investigational treatment unless deemed to be not in the patient's best interest


COVID-19 Intake Form Completed
Pt agrees to talk to research on COVID-19 Intake Form
Notification to COVIDCRC@UPMC.EDU
Eligibility Review by Coordinator
Eligibility Confirmed
Notify Study Physician of Eligible Patient
Phone Call to Pt/LAR
Pt ineligible
Eligibility Question
Pt/LAR Joins Zoom via Consent Assist System
Pt refuses research on COVID-19 Intake Form
Routine Clinical Care
Screen Fail Entered on Enrollment Form
Study Physician Review
Coordinator Pre-Consents Pt/LAR via Zoom
Add to Pt List in UPMC Teams
Consent Note in Cerner
Pt/LAR Declines REMAP-COVID Participation
Pt/LAR reviews DocuSign eConsent
REMAP-COVID Protocol Initiated
Enrollment form completed by CRC
Consenting MD eSigns ICF
Pt/LAR eSigns ICF
Pt/LAR consents to study participation
Study Physician Joins Zoom for Consent Process

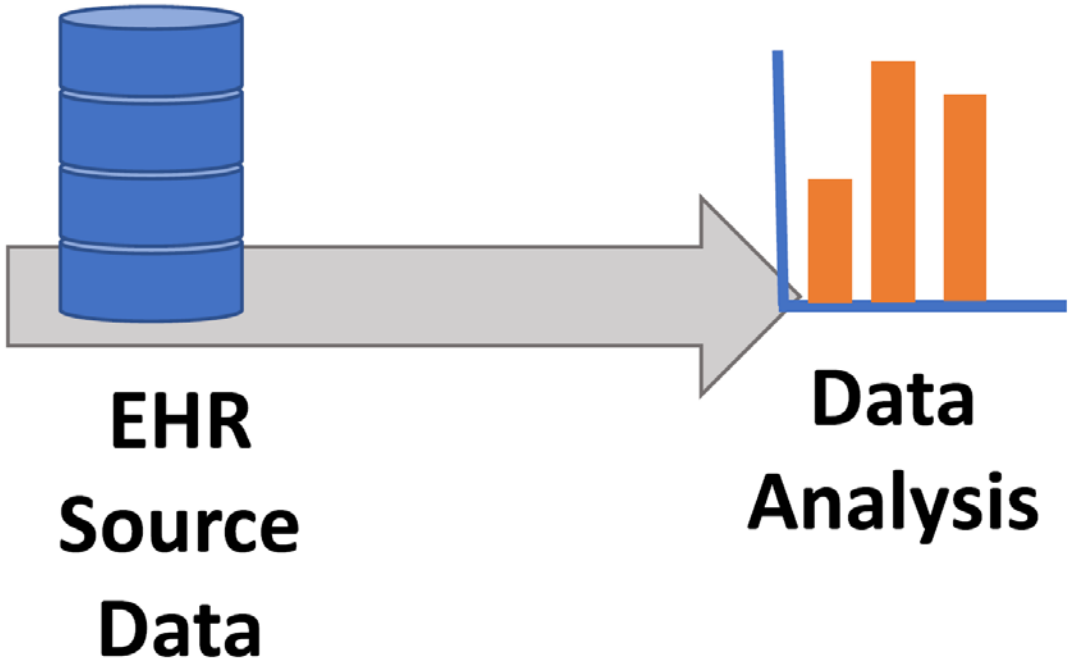
Advantage 4

4) EHR-based Analytics



Advantage 5

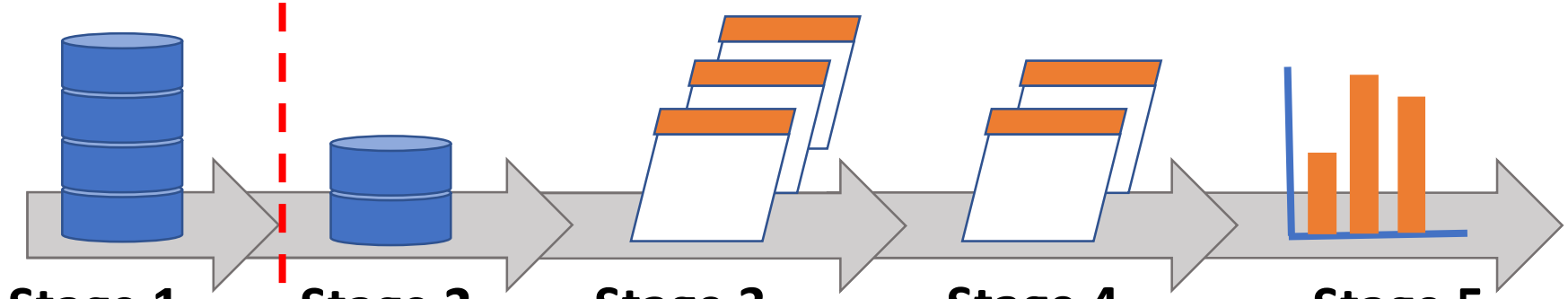
5) Deriving all trial data from the EHR



Challenge 1

Local access barriers

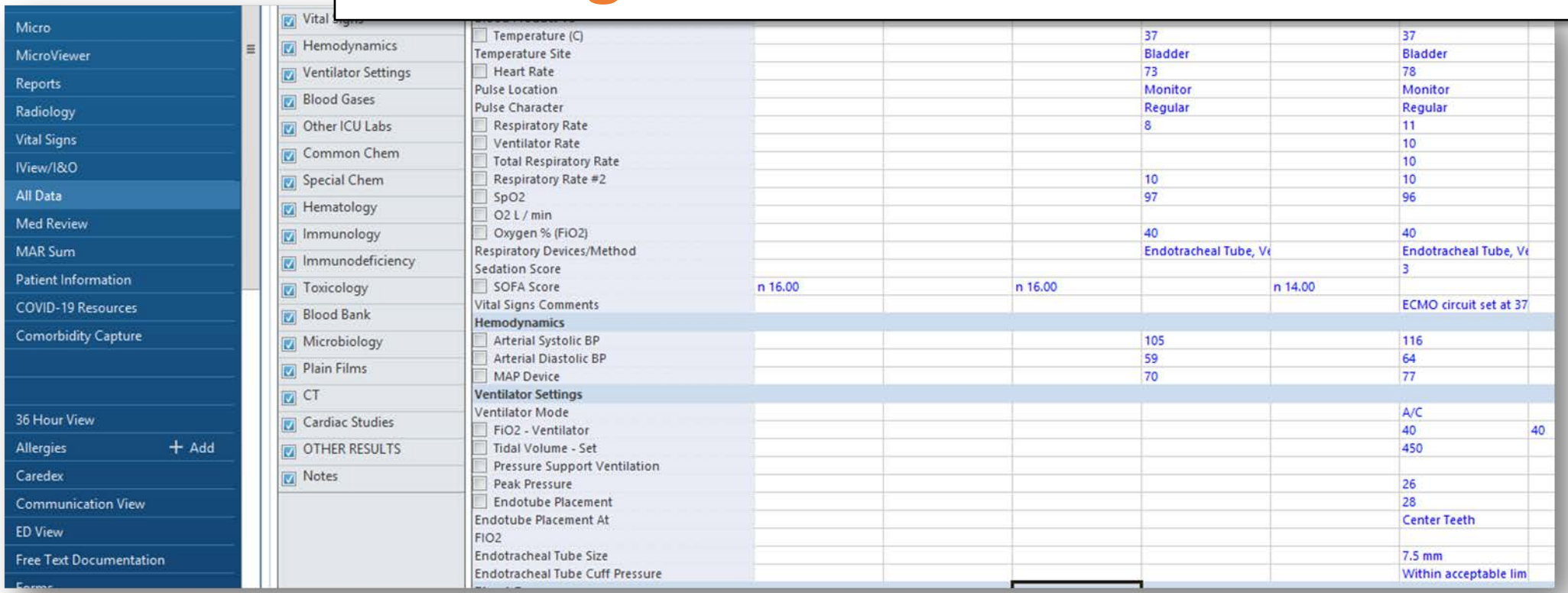
Deriving all trial data from the EHR



Stage 1 Source Data | **Stage 2 Collected Data** | **Stage 3 Curated Data** | **Stage 4 Transformed Data** | **Stage 5 Analyzed Data**

Resource Intensive

Deriving all trial data from the EHR



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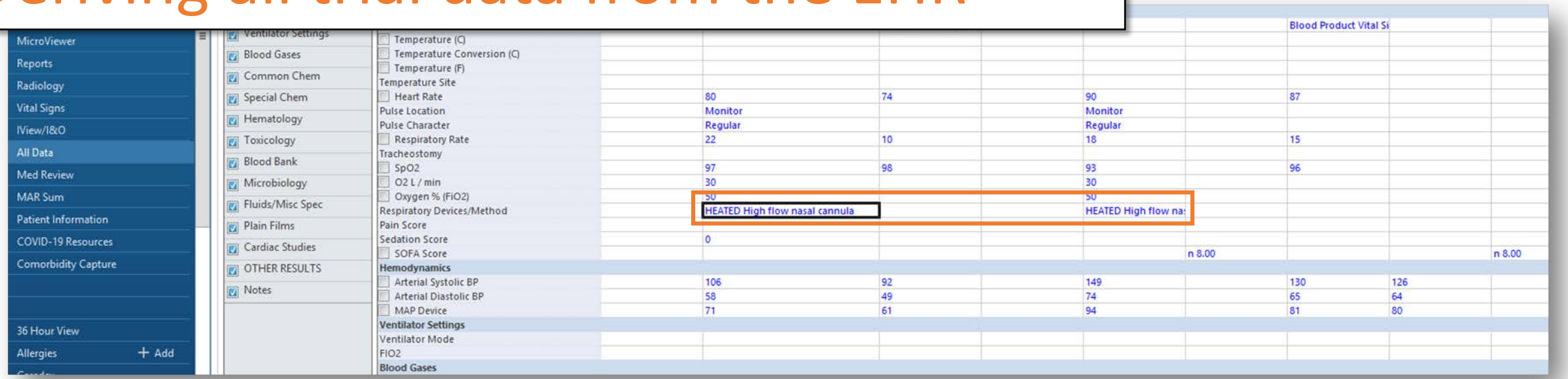
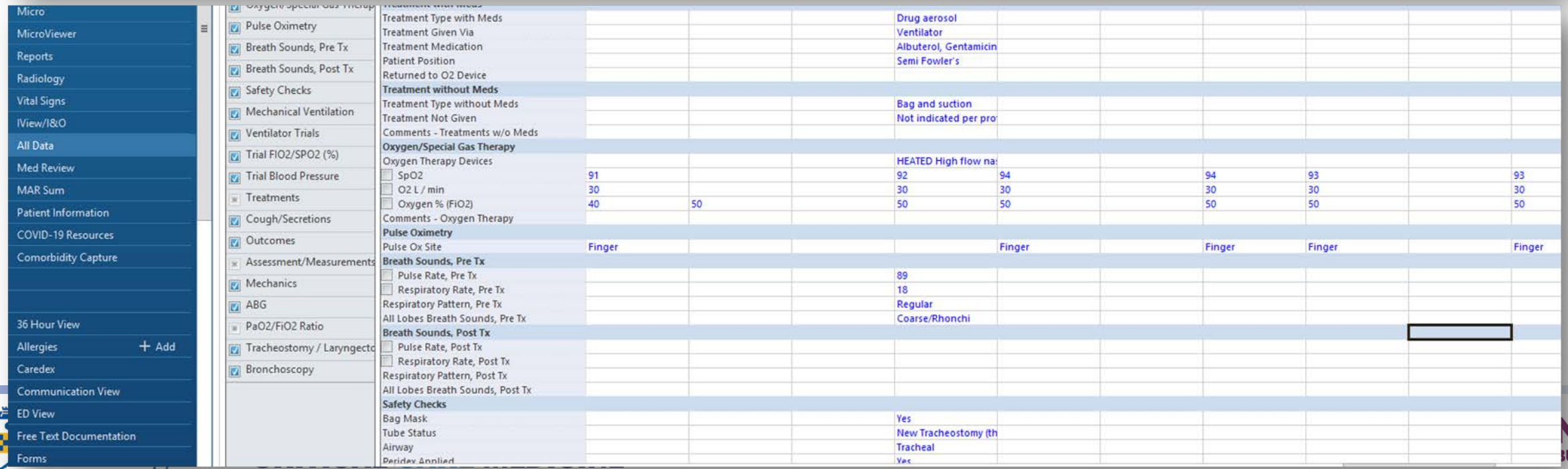
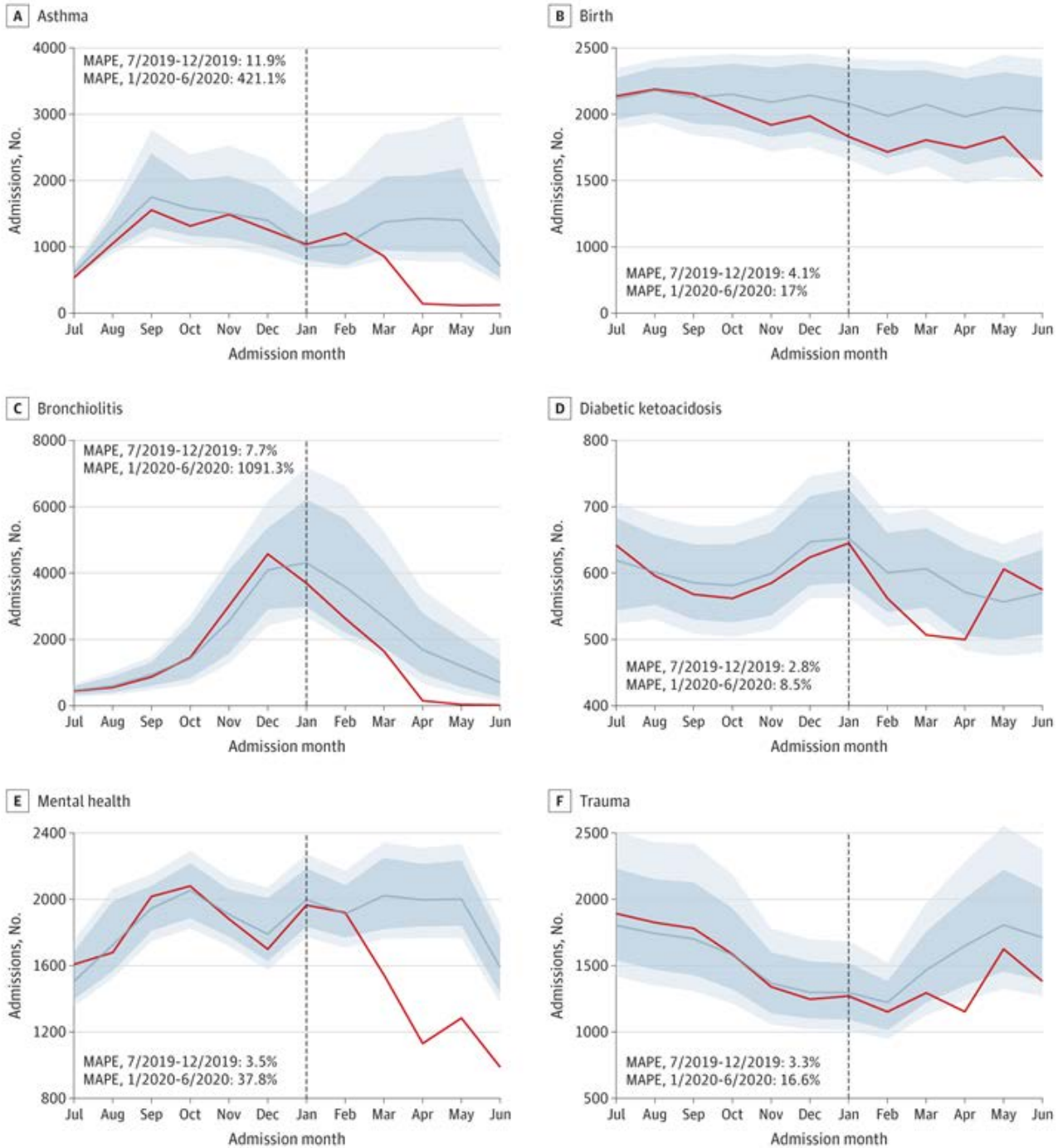




Identifying Patterns – “Weather Forecasting”



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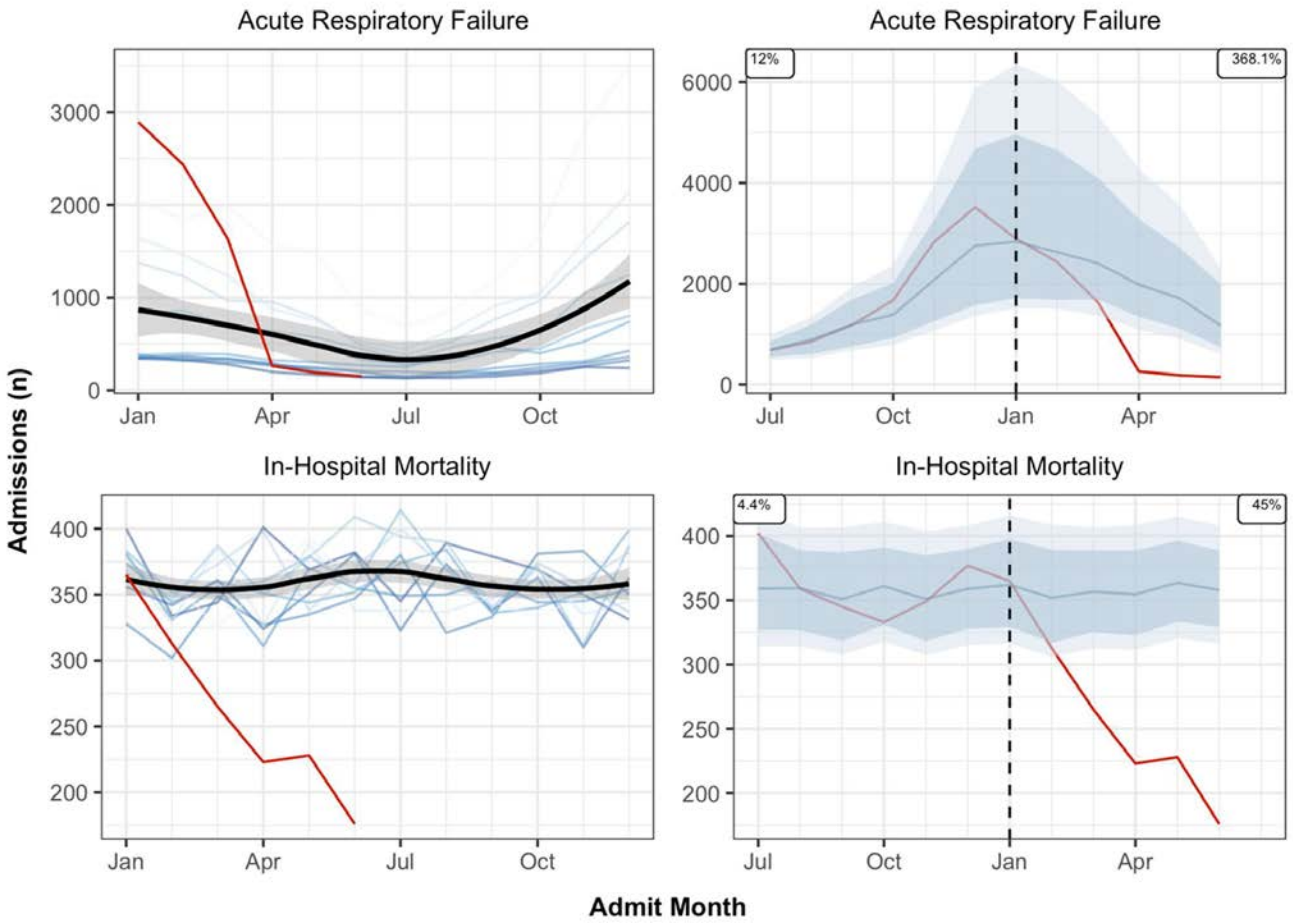
Acute Respiratory Failure
Acute Respiratory Failure
12%
368.1%
In-Hospital Mortality
In-Hospital Mortality
4.4%
45%
Admissions (n)
Admit Month
Jan
Apr
Jul
Oct
Jan
Apr
Jul
Oct

"…we're all just gambling with probabilities."
– Henry Fonda, *12 Angry Men*

The origin of “evidence-based medicine”

“The evidence presented shows that physicians do not manage uncertainty very well, that many physicians make major errors in probabilistic reasoning, and that these errors threaten the quality of medical care.”

- David Eddy, MD PhD

https://www.cambridge.org/core/books/judgment-under-uncertainty/prob
problems-and-opportunities/661E12D1ECD669EDB5B410407A4BB570

Table 1. *Accuracy of mammography in diagnosing benign and malignant lesions*

Results of X ray	Malignant lesion (cancer)	Benign lesion (no cancer)
Positive	.792	.096
Negative	.208	.904

Source: The numbers are from Snyder (1966).

Bayes' formula can be applied to assess the probability. This formula tells us that

$$P(\text{ca}\,|\,\text{pos}) = \frac{P(\text{pos}\,|\,\text{ca})\,P(\text{ca})}{P(\text{pos}\,|\,\text{ca})\,P(\text{ca}) + P(\text{pos}\,|\,\text{benign})\,P(\text{benign})}$$

where

$P(\text{ca}\,|\,\text{pos})$ is the probability that the patient has cancer, given that she has a positive X-ray report (the posterior probability)

$P(\text{pos}\,|\,\text{ca})$ is the probability that, if the patient has cancer, the radiologist will correctly diagnose it (the true-positive rate, or sensitivity)

$P(\text{ca})$ is the probability that the patient has cancer (prior probability)

$P(\text{benign})$ is the prior probability that the patient has benign disease [$P(\text{benign}) = 1 - P(\text{ca})$]

$P(\text{pos}\,|\,\text{benign})$ is the probability that, if the patient has a benign lesion, the radiologist will incorrectly diagnose it as cancer (the false-positive rate)

Table 1 summarizes the numbers given by Snyder. The entries in the cells are the appropriate probabilities (e.g., $P(\text{pos}\,|\,\text{ca}) = .792$).

Using 1% as the physician's estimate of the prior probability that the mass is malignant and taking into account the new information provided by the test, we obtain

$$P(\text{ca}\,|\,\text{pos}) = \frac{(0.792)\,(0.01)}{(0.792)\,(0.01) + (0.096)\,(0.99)} = 0.077$$

Thus, the physician should estimate that there is approximately an 8% chance that the patient has cancer.

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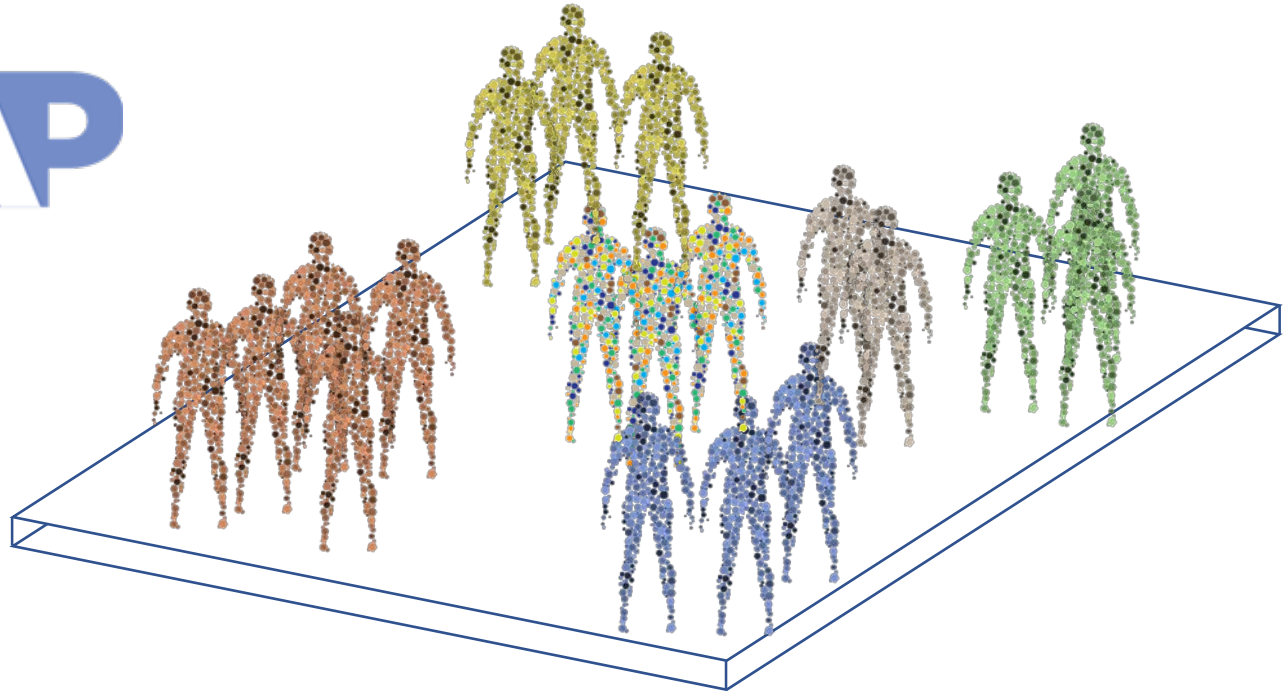
REMAP

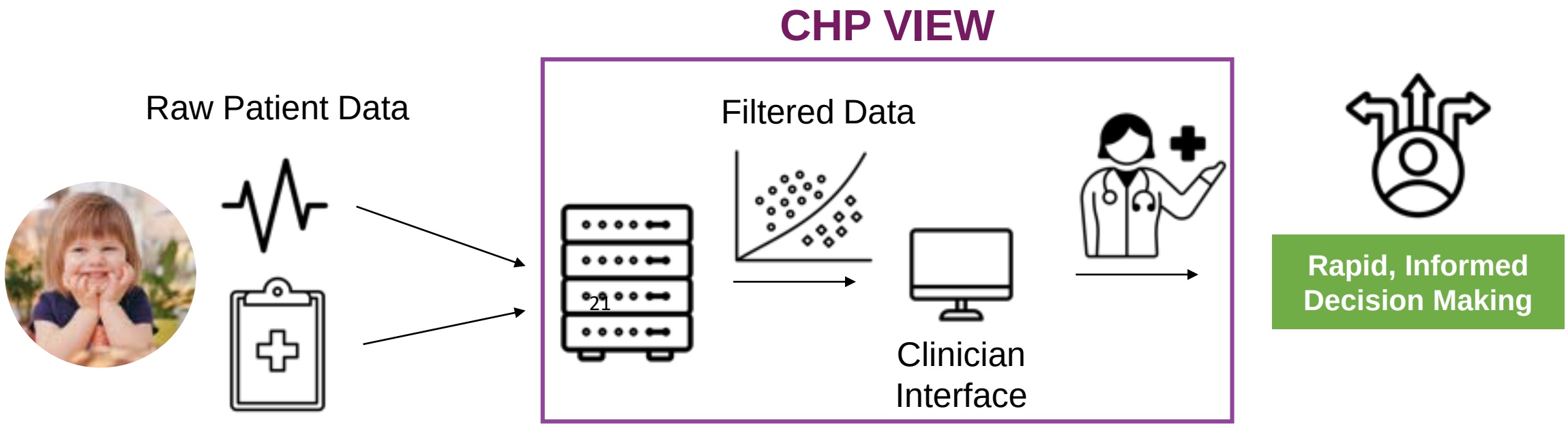


$$\log\left(\frac{\pi}{1-\pi}\right) = \sum_{R=1}^{R} \nu_R + \sum_{k=1}^{K}\sum_{s=1}^{S} \alpha_{s,g_k} + \sum_{age=1}^{AGE} \lambda_{age} + \sum_{T=1}^{T} \theta_T + \sum_{d=1}^{D}\sum_{j=1}^{J_d} \beta_{d_j}$$

$$+ \sum_{k=1}^{K}\sum_{d=1}^{D}\sum_{j=1}^{J_d} I(g_k = 2)\gamma_{kd_j} + \sum_{d=1}^{D}\sum_{j=1}^{J_d}\sum_{d'=d+1}^{D}\sum_{j'=1}^{J'_{d'}} \delta_{d_j d'_{j'}}$$

Unified Statistical Analysis Plan

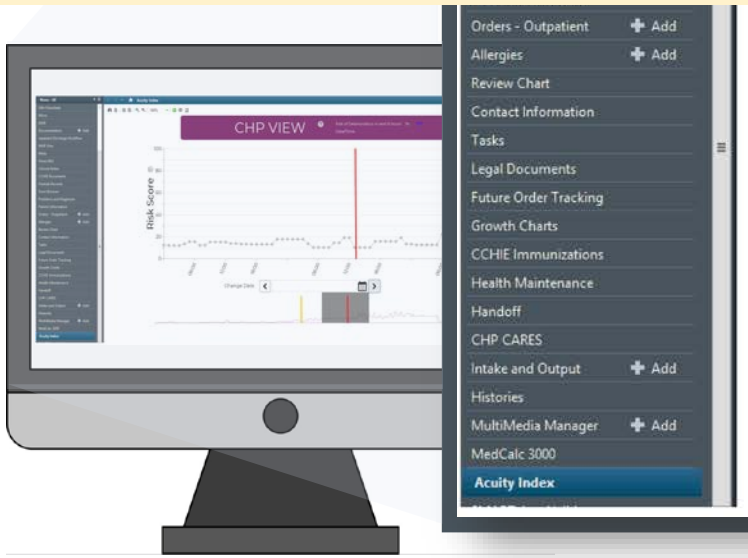
Intelligence Augmentation (IA)

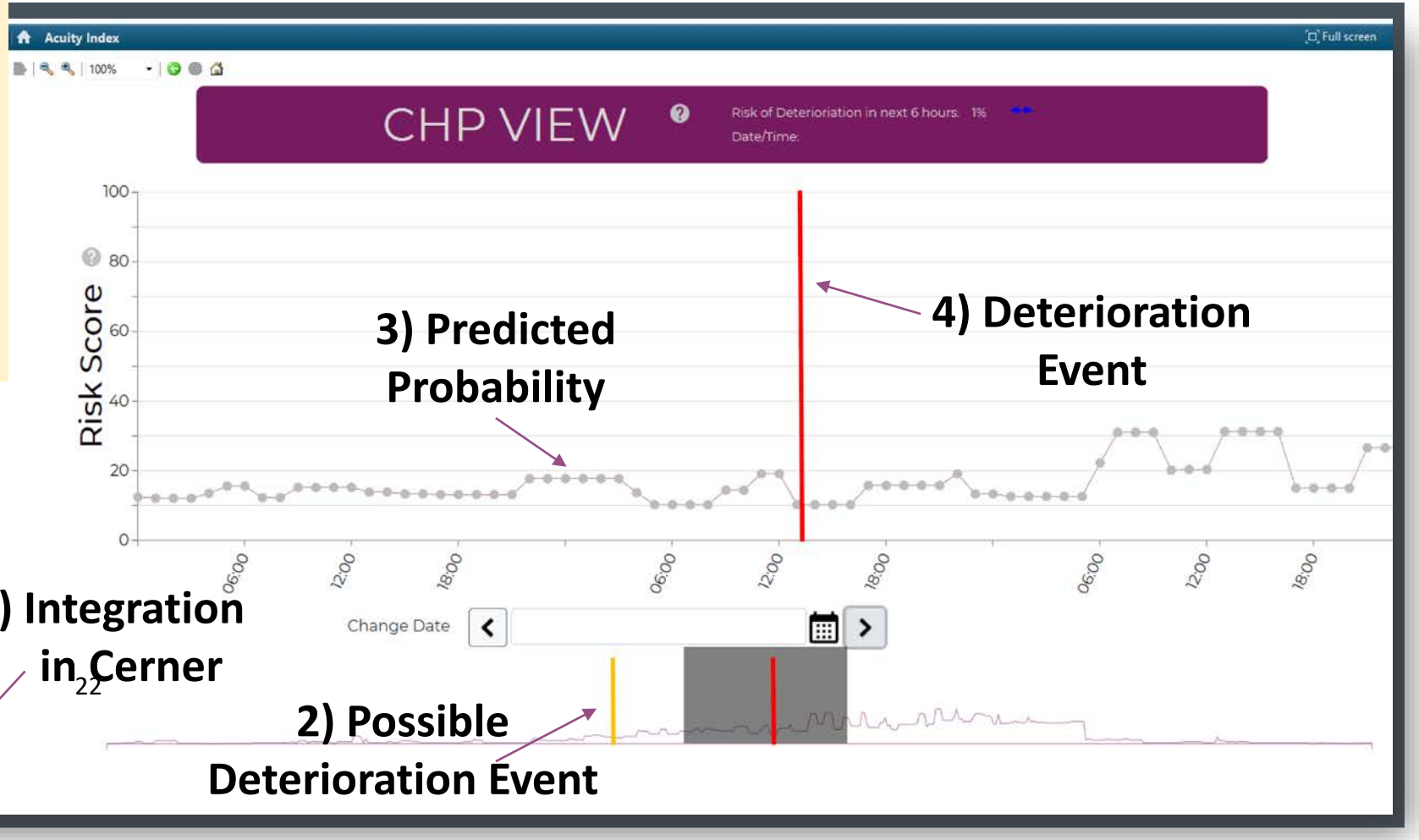


Human Centered Design

Probability of **deterioration in the next 6 hours** defined by any one of the following:

- CPR
- Condition A or C
- Multiple Blood Transfusions
- Emergent Transfer to the ICU
  - PPV or vasoactive gtt within 12 hours
- ECMO





Scores >8.5% are considered HIGH RISK

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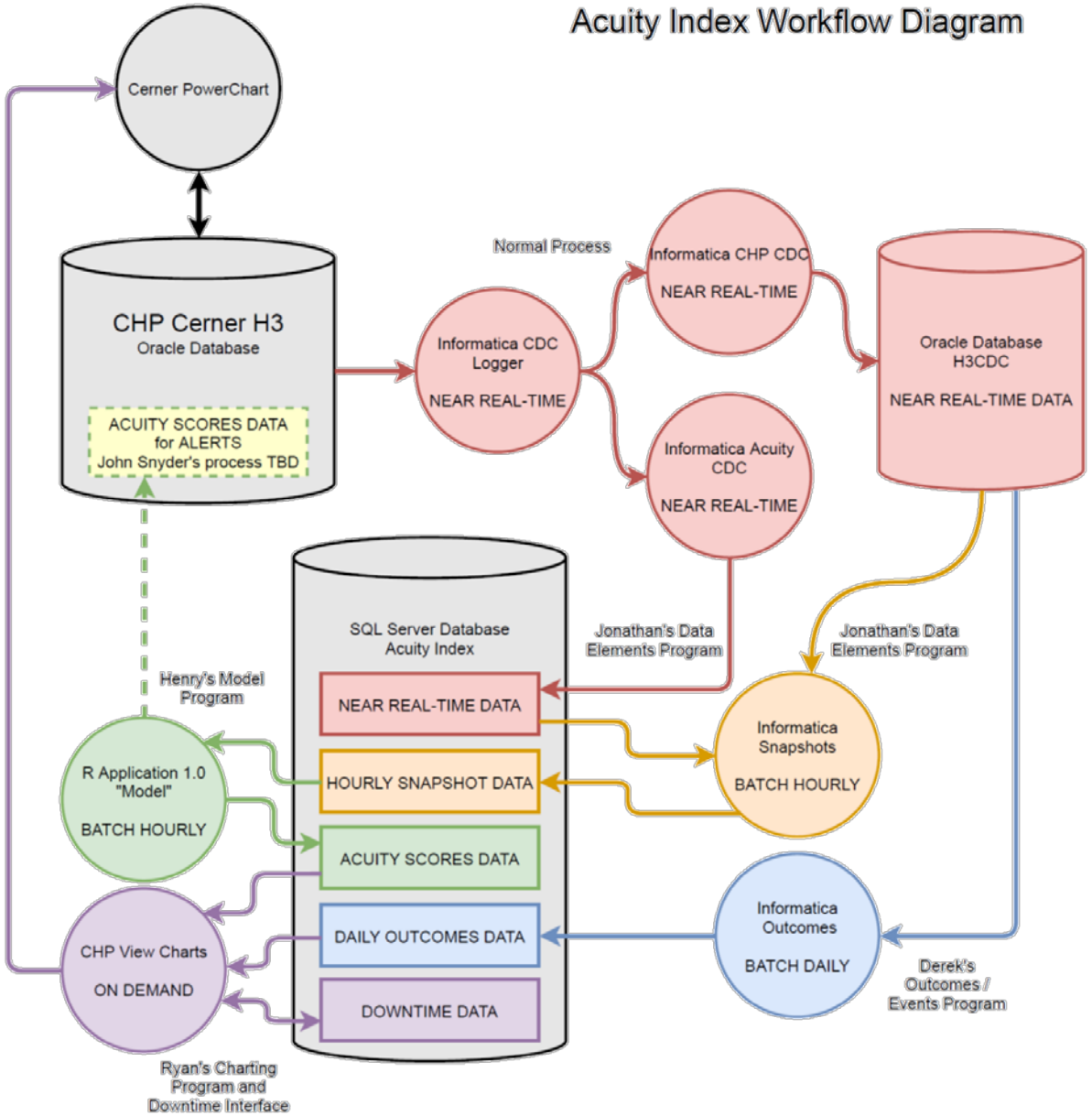
Acuity Index Workflow Diagram



Summary

- ‘Real-time’ can refer to a range of cadences and depends on technical infrastructure
- Tracking the essentials is a major undertaking
- Advanced analytics can augment our current capabilities
- There is no such thing as ‘automation’ – this all requires substantial investment

Thank You

Questions/Discussion

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