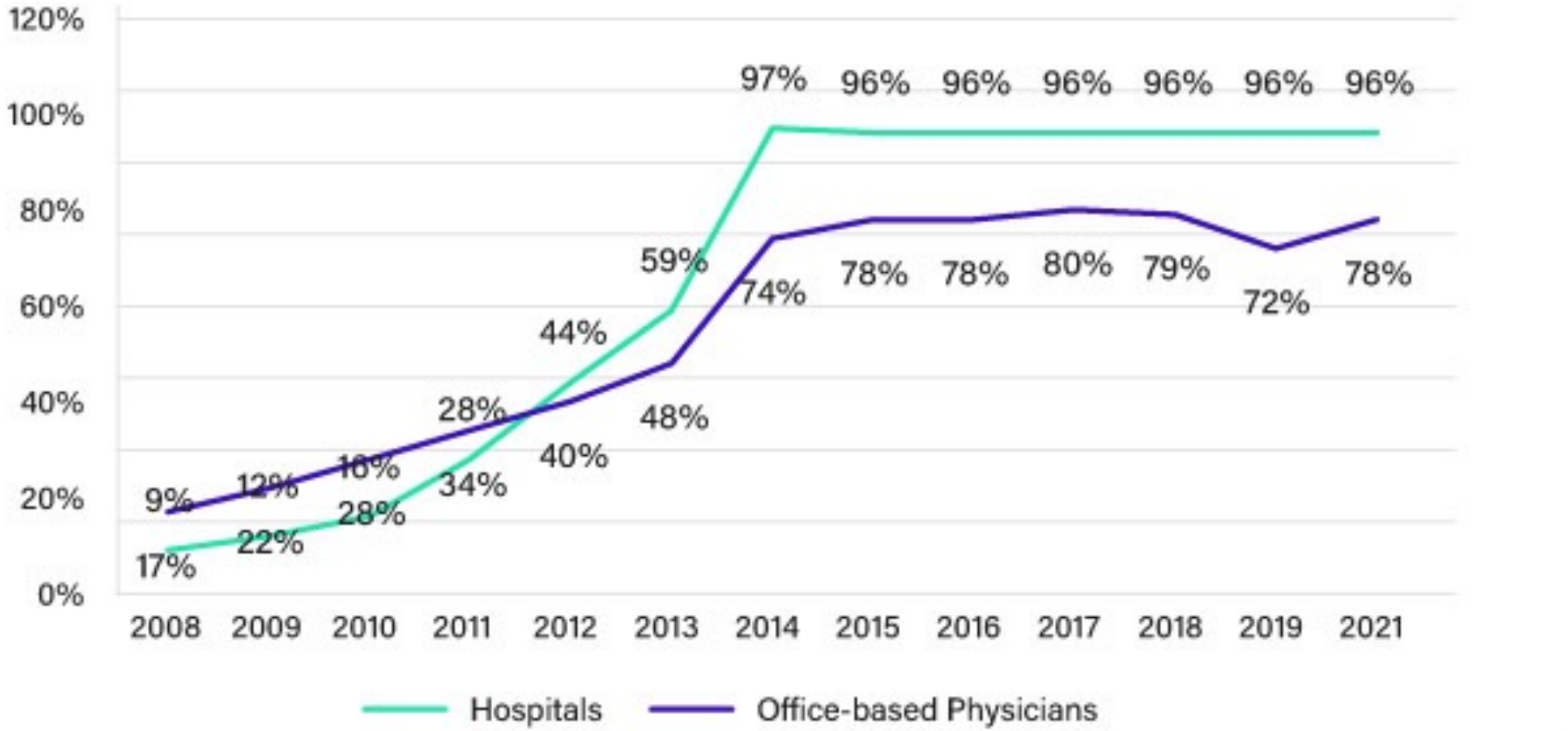
Data 146: Foundations for CPH

Electronic Health Records

Irene Y. Chen

Towards HEALTHCARE

Trend in U.S. Hospitals and Physician EHR Adoption



Source: www.towardshealthcare.com

Outline

- **EHR Adoption** (30 mins)
- **MIMIC Deep Dive** (20 mins)

How can we make Data 146 better for you?

Learning Objective: Understand how EHR data came to be and potential issues

Why did hospitals adopt the electronic health record?

HITECH Act of 2009

HITECH Act

- Health Information Technology for Economic and Clinical Health (HITECH) ACT of 2009

- Of $840 billion stimulus package in 2009, **$30 billion** was allotted for hospitals and medical providers for "**meaningful use**" of certified EHR systems
  - Payments linked to improvements in quality, safety, and efficiency

How would you allocate $30 billion? (Partner discussion)

Health IT Policy Committee

- Created under the HITECH Act as an advisory committee
- Recommend policies and defined "**meaningful use**" of EHRs
- Included federal appointees, representatives from healthcare, technology, academia, and patient advocates
- Included **Judy Faulkner, CEO of Epic**

PROFILE

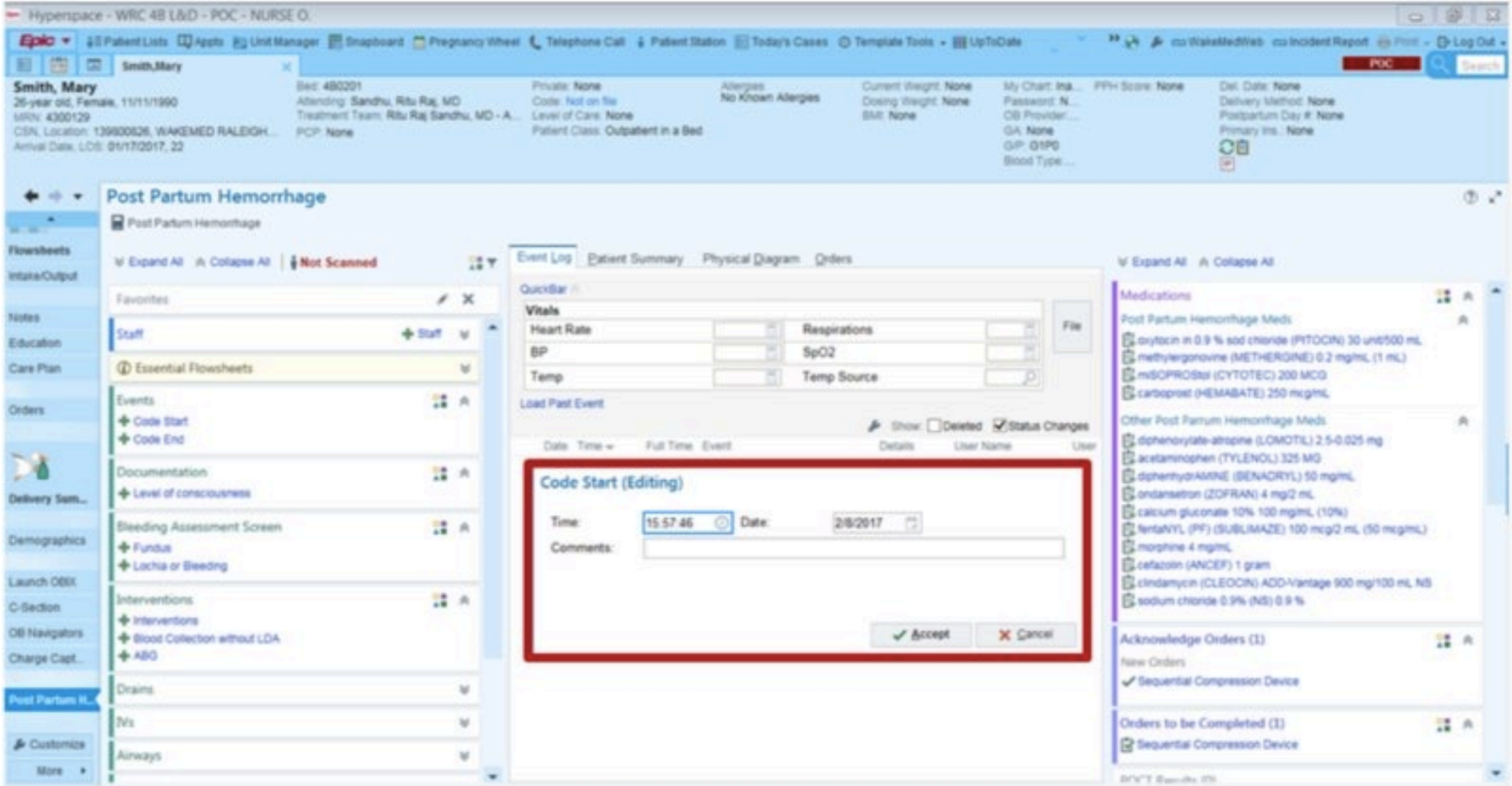
Judy Faulkner

Founder & CEO, Epic Systems

$7.8B **Real Time Net Worth**
as of 10/28/25
#469 in the world today

$7.8B
2025 America's Richest Self-Made Women Net Worth
as of 6/3/25

PHOTO BY COURTESY JUDY FAULKNER


Hyperspace - WRC 4B L&D - POC - NURSE O.
Epic
Patient Lists
Appts
Unit Manager
Snapboard
Pregnancy Wheel
Telephone Call
Patient Station
Today's Cases
Template Tools
UpToDate
Log Out
Smith,Mary
POC
Search
Smith, Mary
26-year old, Female, 11/11/1990
MRN: 4300129
CSN, Location: 139800826, WAKEMED RALEIGH...
Arrival Date, LOS: 01/17/2017, 22
Bed: 4B0201
Attending: Sandhu, Ritu Raj, MD
Treatment Team: Ritu Raj Sandhu, MD - A...
PCP: None
Private: None
Code: Not on file
Level of Care: None
Patient Class: Outpatient in a Bed
Allergies
No Known Allergies
Current Weight: None
Dosing Weight: None
BMI: None
My Chart: Ina...
Password: N...
OB Provider:...
GA: None
G/P: G1P0
Blood Type:...
PPH Score: None
Del. Date: None
Delivery Method: None
Postpartum Day #: None
Primary Ins.: None
Post Partum Hemorrhage
Post Partum Hemorrhage
Flowsheets
Intake/Output
Notes
Education
Care Plan
Orders
Delivery Sum...
Demographics
Launch OBIX
C-Section
OB Navigators
Charge Capt...
Post Partum H...
Customize
More
Expand All
Collapse All
Not Scanned
Favorites
Staff
Staff
Essential Flowsheets
Events
Code Start
Code End
Documentation
Level of consciousness
Bleeding Assessment Screen
Fundus
Lochia or Bleeding
Interventions
Interventions
Blood Collection without LDA
ABG
Drains
IVs
Airways
Event Log
Patient Summary
Physical Diagram
Orders
QuickBar
Vitals
Heart Rate
Respirations
BP
SpO2
Temp
Temp Source
File
Load Past Event
Show:
Deleted
Status Changes
Date
Time
Full Time
Event
Details
User Name
User
Code Start (Editing)
Time:
15:57:46
Date:
2/8/2017
Comments:
Accept
Cancel
Expand All
Collapse All
Medications
Post Partum Hemorrhage Meds
oxytocin in 0.9 % sod chloride (PITOCIN) 30 unit/500 mL
methylergonovine (METHERGINE) 0.2 mg/mL (1 mL)
misOPROStol (CYTOTEC) 200 MCG
carboprost (HEMABATE) 250 mcg/mL
Other Post Partum Hemorrhage Meds
diphenoxylate-atropine (LOMOTIL) 2.5-0.025 mg
acetaminophen (TYLENOL) 325 MG
diphenhydrAMINE (BENADRYL) 50 mg/mL
ondansetron (ZOFRAN) 4 mg/2 mL
calcium gluconate 10% 100 mg/mL (10%)
fentaNYL (PF) (SUBLIMAZE) 100 mcg/2 mL (50 mcg/mL)
morphine 4 mg/mL
cefazolin (ANCEF) 1 gram
clindamycin (CLEOCIN) ADD-Vantage 900 mg/100 mL NS
sodium chloride 0.9% (NS) 0.9 %
Acknowledge Orders (1)
New Orders
Sequential Compression Device
Orders to be Completed (1)
Sequential Compression Device

What is “meaningful use”?

- Data capture and sharing
- Hospital had to demonstrate basic capabilities about data entry and clinical quality measures
- Record demographics, problem lists, medications, lab results, electronic prescribing

What is missing here?
(Partner discussion)

Problems with original recommendations

- **Limited data exchange**: No need to share data or facilitate exchange with patients or other hospitals
- **Vendor lock-in**: Each EHR vendor has its own data format. No cross-vendor interoperability means vendors are incentivized to silo in hospitals and have high switching costs
- **Improved clinical outcomes**: More documentation could slow down clinical workflows. How do you incentivize structures that actually improve clinical care?
- **Patient rights**: Hospitals control all of the data and nothing is written with the patient in mind.

PERSPECTIVE

Escaping the EHR Trap — The Future of Health IT

Authors: Kenneth D. Mandl, M.D., M.P.H., and Isaac S. Kohane, M.D., Ph.D. Author Info & Affiliations

Published June 14, 2012 | N Engl J Med 2012;366:2240-2242 | DOI: 10.1056/NEJMp1203102

VOL. 366 NO. 24 | Copyright © 2012

"In reality, diverse functionality needn't reside within single EHR systems, and there's a clear path toward better, safer, cheaper, and nimbler tools for managing health care's complex tasks."

21st Century Cures Act

- Merged and replaced previous committees with one that focuses on **interoperability, privacy, and patient empowerment**
- Explicitly prohibited “information blocking”, meaning EHR vendors or health systems that prevent data sharing
- Required development for standardized APIs (like FHIR) to allow patients and third party apps to securely access and exchanged health data

In 2015, lots of open EHR datasets

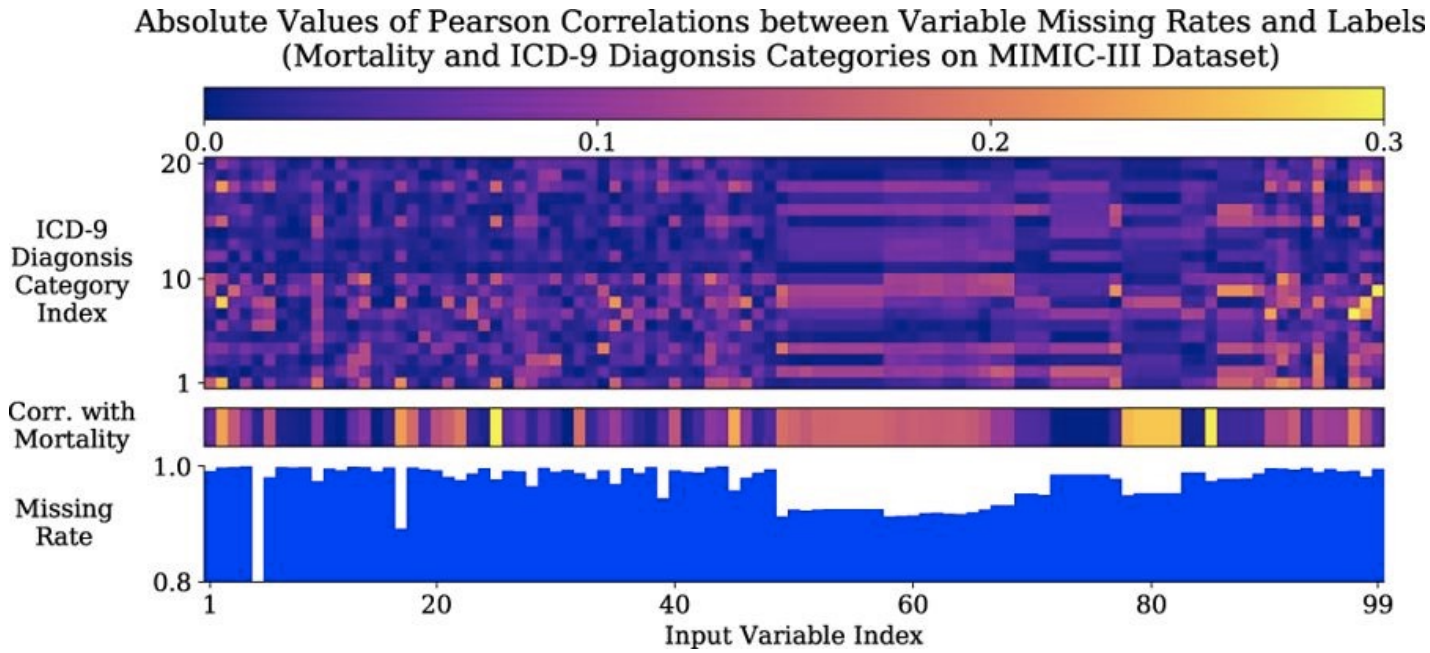
- **MIMIC-IV**: 65k patients intensive care unit (ICU) and emergency department (ED) data from Beth Israel Deaconess Medical Center in Boston
- **All of Us** research program: 200k patients including EHR, genomics, wearables, and patient surveys in standardized (OMOP) format from NIH
- **EHRSHOT**: 6k patients and 900k visits from Stanford

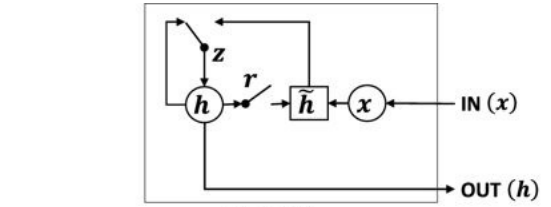
What is MIMIC?

- Largest open dataset for clinical healthcare (for authorized researchers)
- Dataset of 26 tables (e.g. admissions, patients)
- Maintained by Roger Mark's lab at MIT
- Potential place for **final project ideas**!

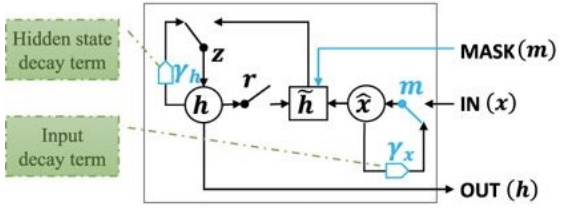
Recurrent Neural Networks for Multivariate Time Series with Missing Values

Che et al, 2018
(Nature Scientific Reports)

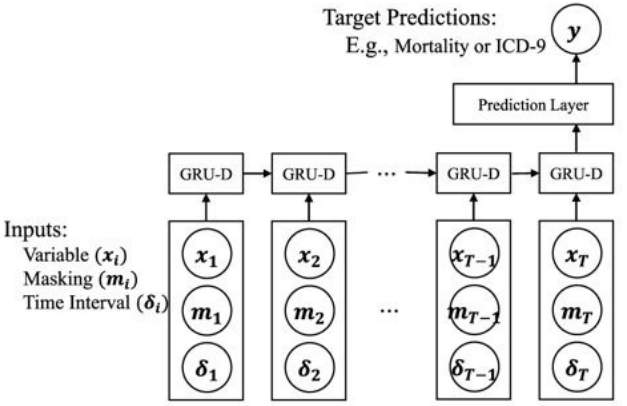




(a) GRU



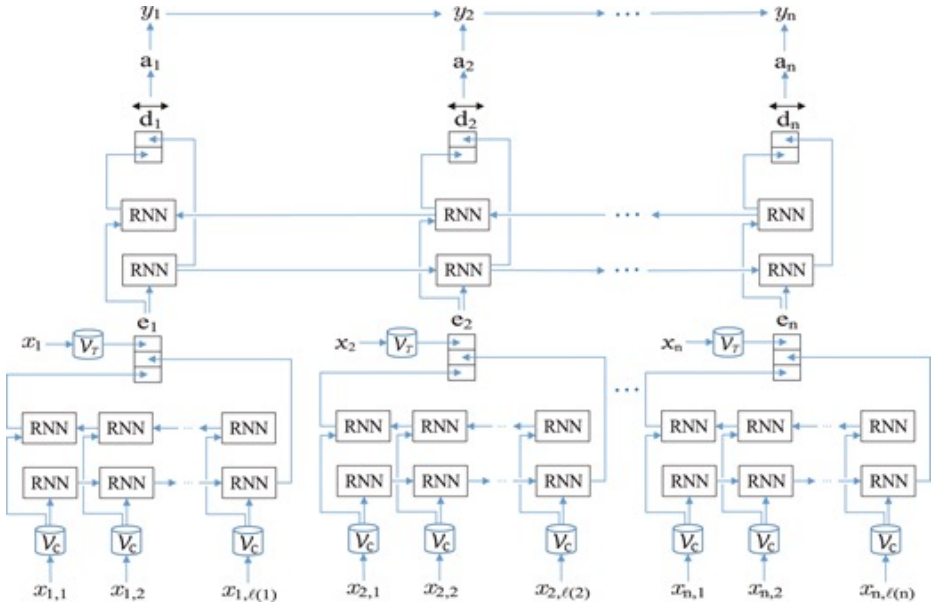
(b) GRU-D (Parts in cyan refer to the modifications.)



(c) Proposed prediction model architecture with GRU-D.

De-identification of patient notes with recurrent neural network

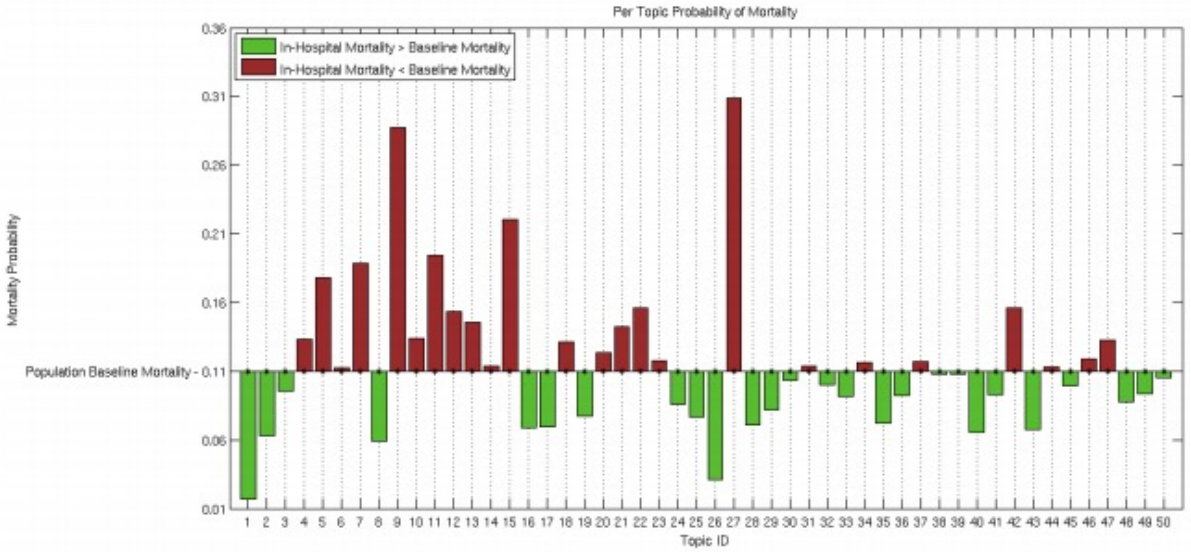
Dernoncourt et al, 2017 (JAMIA)



	i2b2			MIMIC		
Model	**Precision**	**Recall**	**F1**	**Precision**	**Recall**	**F1**
Nottingham	**99.000**	96.400	97.680	–	–	–
MIST	91.445	92.745	92.090	95.867	98.346	97.091
CRF	98.560	96.528	97.533	99.060	98.987	99.023
ANN	98.320	97.380	97.848	**99.208**	99.251	**99.229**
CRF + ANN	97.920	**97.835**	**97.877**	98.820	**99.398**	99.108

Unfolding Physiological State: Mortality Modeling in Intensive Care Units

Ghassemi et al, 2014 (KDD)

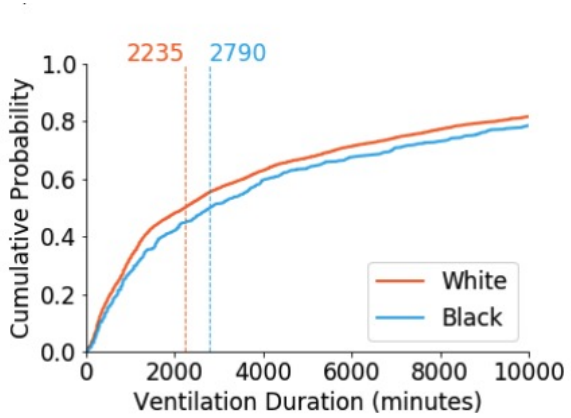


	Topic	Top Ten Words	Possible Topic
In-hospital Mortality	27	name, family, neuro, care, noted, status, plan, stitle, dr, remains	Discussion of end-of-life care
	15	intubated, vent, ett, secretions, propofol, abg, respiratory, resp, care, sedated	Respiratory failure
	7	thick, secretions, vent, trach, resp, tf, tube, coarse, cont, suctioned	Respiratory infection
	5	liver, renal, hepatic, ascites, dialysis, failure, flow, transplant, portal, ultrasound	Renal Failure

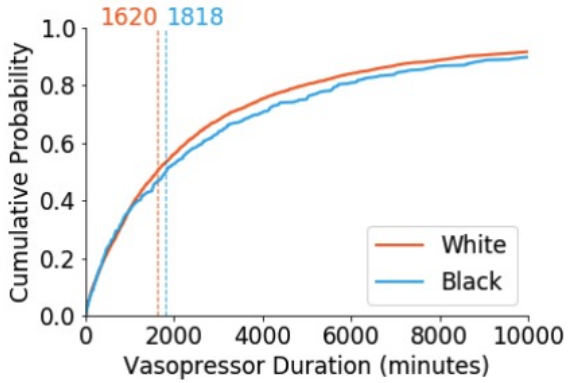
Racial Disparities and Mistrust in End-of-Life Care

Social: Pt refused to sign ICU consent and expressed wishes to be DNR/DNI, seemingly very frustrated and mistrusting of healthcare system in relation to [redacted]. Also, w/ hx of poor medication compliance and follow-up

Boag et al, 2018 (MLHC)



(a) CDF of ventilation duration by race ($p = .005$).



(b) CDF of vasopressor duration by race ($p = 0.12$).

Reproducibility in critical care: a mortality prediction case study

Johnson et al, 2017 (MLHC)

We reproduced datasets for 38 experiments corresponding to 28 published studies using MIMIC. In half of the experiments, the sample size we acquired was 25% greater or smaller than the sample size reported. The highest discrepancy was 11,767 patients. While accurate reproduction of each study cannot be guaranteed, we believe that these results highlight the need for more consistent reporting of model design and methodology to allow performance improvements to be compared. We discuss the challenges in reproducing the cohorts used in the studies, highlighting the importance of clearly reported methods (e.g. data cleansing, variable selection, cohort selection) and the need for open code and publicly available benchmarks.

Study	Window, W (hours)	Inclusion criteria
Caballero Barajas and Akella (2015)	24	Age>18, Random fixed size subsample
Caballero Barajas and Akella (2015)	48	Age>18, Random fixed size subsample
Caballero Barajas and Akella (2015)	72	Age>18, Random fixed size subsample
Calvert et al. (2016b)	5*	Age>18, In MICU, >1 obs. for all features, LOS $\geq$ 17hr, ICD-9 codes indicating alcohol withdrawal
Calvert et al. (2016a)	5*	Age>18, In MICU, >1 obs. for all features, 500hr $\geq$ LOS $\geq$ 17hr
Celi et al. (2012)	72	ICD-9 code 584.9
Celi et al. (2012)	24	ICD-9 code 430 or 852
Che et al. (2016) (b)	48	PhysioNet 2012 Challenge dataset
Ding et al. (2016)	48	PhysioNet 2012 Challenge dataset
Ghassemi et al. (2014)	12	Age>18, >100 words across all notes
Ghassemi et al. (2014)	24	Age>18, >100 words across all notes
Ghassemi et al. (2015)	24	Age>18, >100 words across all notes, >6 notes

EHR Safari: Data is Contextual

William Boag WBOAG@MIT.EDU
MIT CSAIL
Cambride, MA, USA

Mercy Oladipo MOLADIPO@MIT.EDU
MIT CSAIL
Cambride, MA, USA

Peter Szolovits PSZ@MIT.EDU
MIT CSAIL
Cambride, MA, USA

"we demonstrate numerous examples where a non-clinician's intuition may lead to incorrect – and potentially harmful – modeling assumptions"

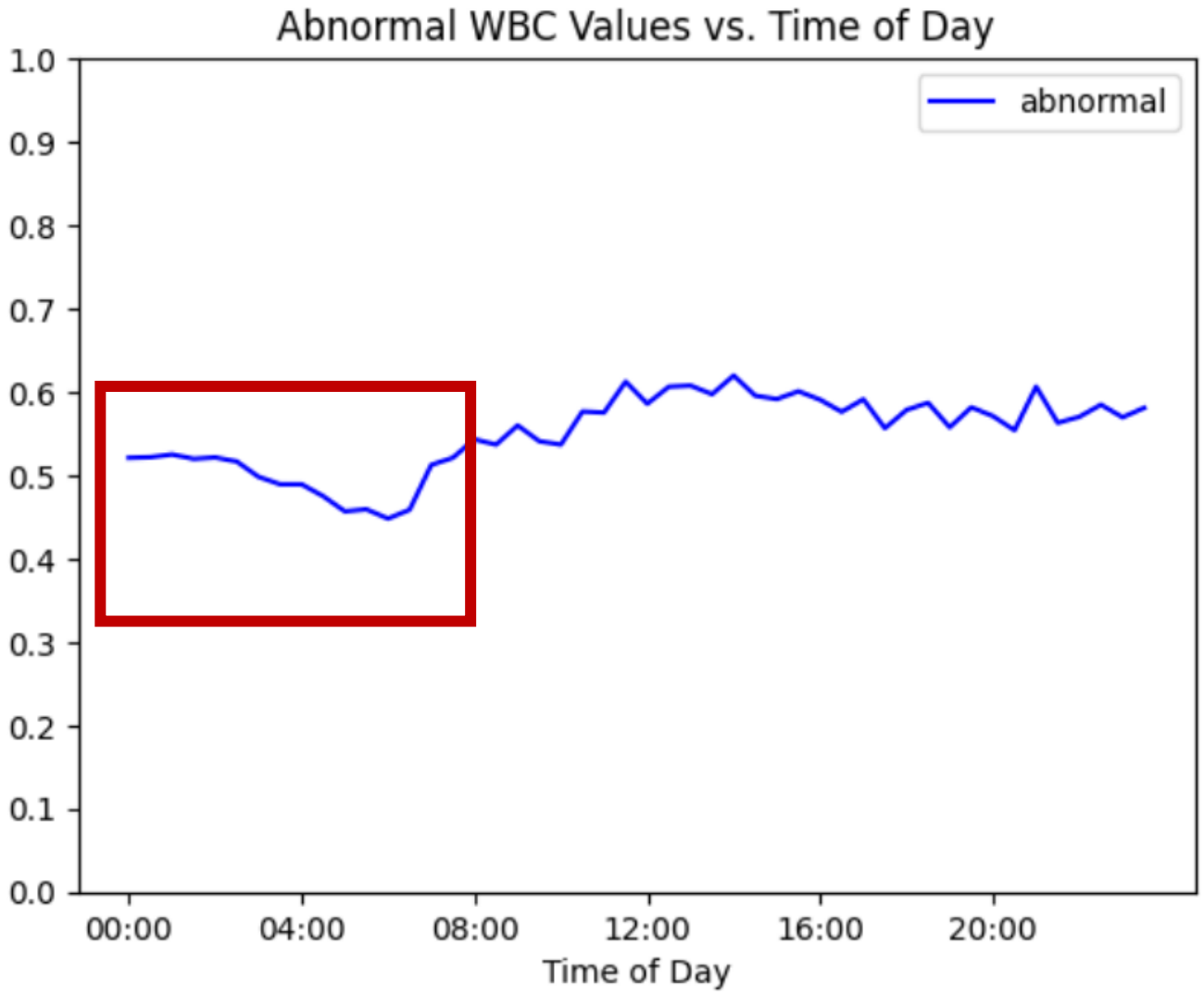
Problems with MIMIC

1. Inconsistent timestamps
2. Lab values vary by time of day
3. Multiple copies of provider notes
4. Missing death date collection

Inconsistent time stamps

- We want time stamps that show:
  - hospital admission time (admittime) ≤
  - patient enters ICU (intime) ≤
  - patient leaves ICU (outtime) ≤
  - patient discharged from hospital (dischtime)
- BUT, of 57k ICU stays, this ordering only holds **79% of the time**
  - Because hospital and ICU staff have their own paperwork, things can get filed out of sync

Lab values vary by time of day

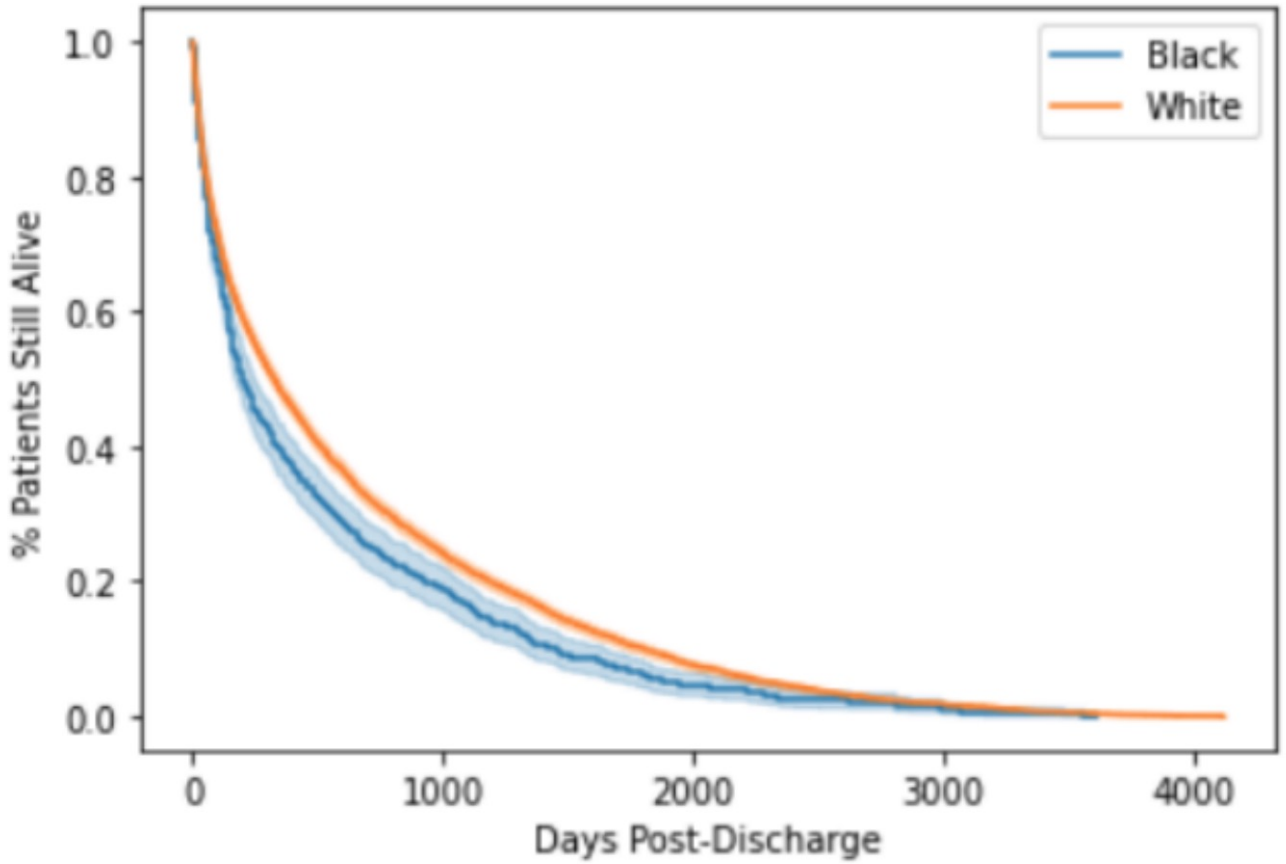


Multiple copies of provider notes

- NLP techniques use clinical notes to predict clinical outcomes
- MIMIC contains all note drafts that EHR autosaves
  - Disconnect between the chart time (completed) and the store time (partially written)

Missing death date collection

- Higher rate of mortality for white patients than black patients??
- Because 2013 legislative change forbid SSN collection from state records, this led to 40% change in capture of death information



More reading

- Caldwell, "We've Spent Billions to Fix Our Medical Records and They're Still a Mess", November 2015

- Boag et al, "EHR Safari: Data is Contextual", MLHC 2022.

Mother Jones

Smart, Fearless Journalism Donate

POLITICS ENVIRONMENT CRIMINAL JUSTICE GUNS RACE GENDER FOOD PODCAST VIDEO MAGAZINE

We've Spent Billions to Fix Our Medical Records, and They're Still a Mess. Here's Why.

Digitizing America's medical records was supposed to help patients and save money. Why hasn't that happened?

PATRICK CALDWELL NOVEMBER/DECEMBER 2015 ISSUE

EHR Safari: Data is Contextual

William Boag WBOAG@MIT.EDU
MIT CSAIL
Cambride, MA, USA

Mercy Oladipo MOLADIPO@MIT.EDU
MIT CSAIL
Cambride, MA, USA

Peter Szolovits PSZ@MIT.EDU
MIT CSAIL
Cambride, MA, USA

Summary

- ✓ **Creation of the modern EHR** (30 mins)
- ✓ **Deep dive into MIMIC** (20 mins)

How can we make Data 146 better for you?

Next Class: Other health datasets and where to find them