Stanford MEDICINE | Emergency Medicine

What Artificial Intelligence and Machine Learning Can Do for Your ED

Maame Yaa "Maya" A. B. Yiadom, MD, MPH, MSCI
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Illinois College of Emergency Physicians

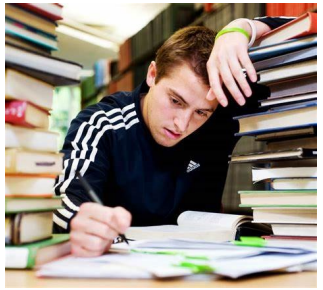
Disclosures

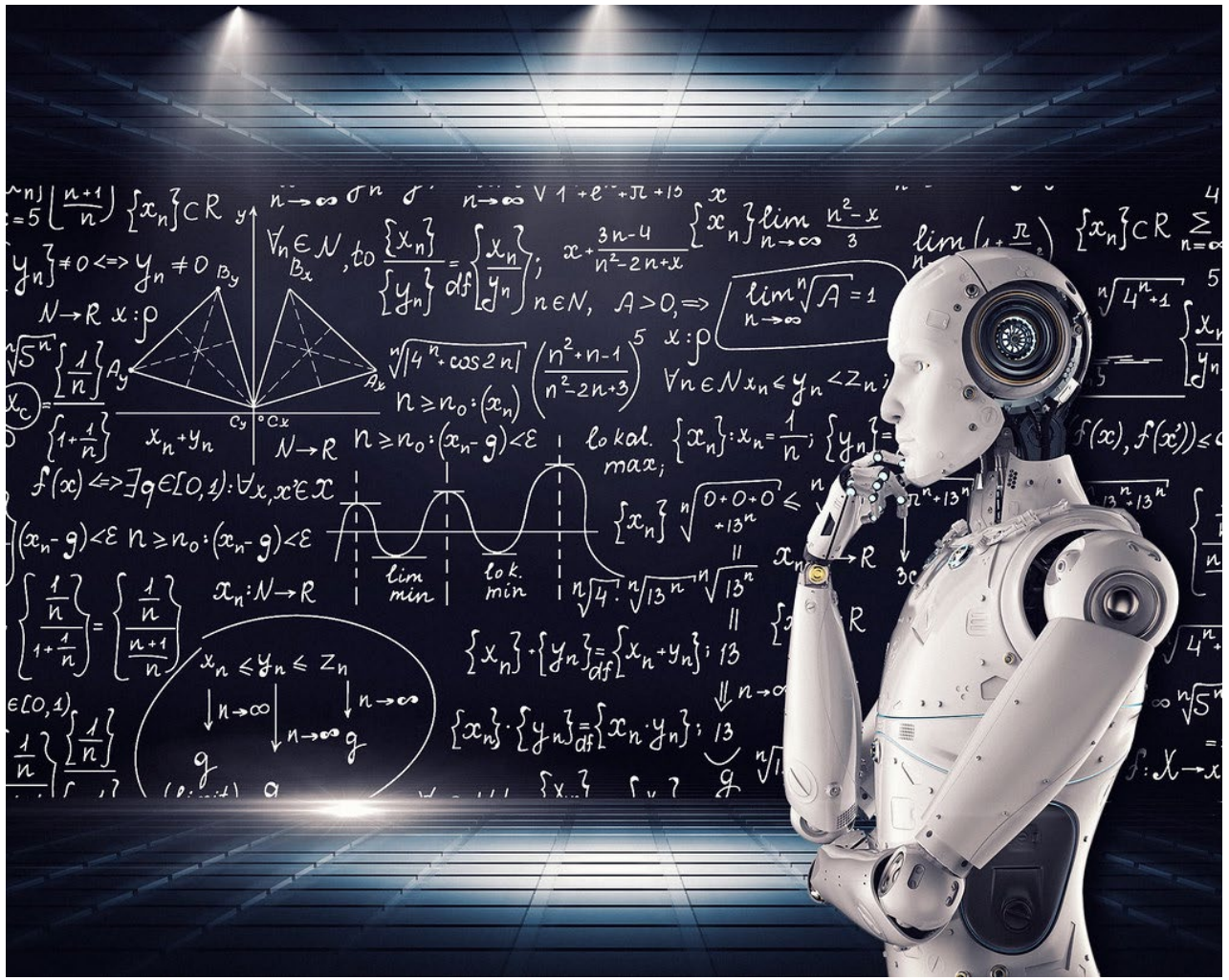
I do not have any significant financial relationships to report

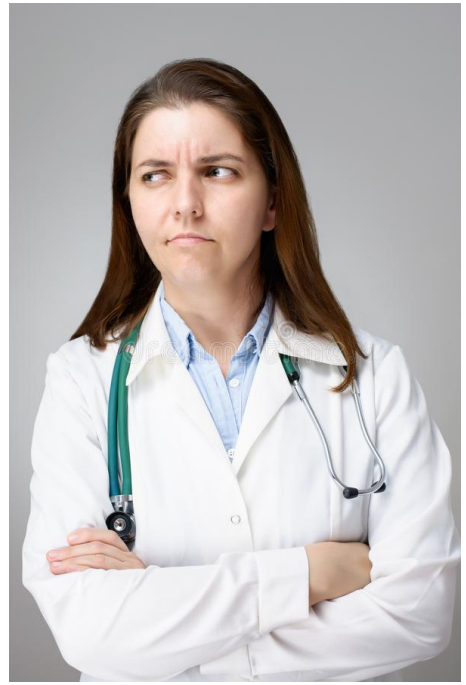
My Journey to AI

- Recognizing clinical operations process patterns from working in over 11 EDs
- Administrative process comparisons across EDs via 2 national data sharing organizations
- Clinical operations research to identify gaps in care
- Identifying the right electronic health record data available at the right time to enhance timely decision making within electronic health record systems
- Developing decision support tools that
  - Replicate physician decision-making when a physician is not available
  - Enhance patient outcomes by automating activities prone to human error

AI in Medicine?







Ample Opportunities for AI in EM

- Does not compete with physician expertise
- Off loads the mental load of consistently replicating a decision
- Can introduce complex “physician-like” decision making into phases of care where physician involvement isn’t optimal

Framework for AI in EM

Use of computer systems to perform tasks that normally require human thinking, calculation and action

Understand the **Decision**

Logic Model or algorithm that replicates the "thinking" used to make a decision using available **Data**

Computer that can use the data to make a Decision Using the logic model

Computer can **initiate action** based on the decision outcome

Evidence Based Medicine

Decision Rules
Clinical Pathways

Decision Rule Calculators

The Next Frontier

Care they are not likely to leave the emergency department without…

CC: Chest Pain in a Patient with a history of CAD or MI

- Labs
- Imaging
- EKG
- Bed type

CC: Vaginal Bleeding in a Female of Reproductive Age

- Labs
- Bed type
- Room type

Nursing Protocol Orders

What if future patients that looked like them didn't have to wait for a physician to put in orders?

What if we looked at all patients with certain presentations and examined what initial labs and tests they received to start care?

What if the role of triage nursing was to discontinue or modify automated orders? Rather than initiate orders?

Understanding the Decision

- Evidence based medicine
- Process mapping
- Understanding activity at each step
- Understanding the agents for the activities occurring

Door-to-ECG in 10 minutes

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Understanding the Decision

Door-to-ECG in 10 minutes

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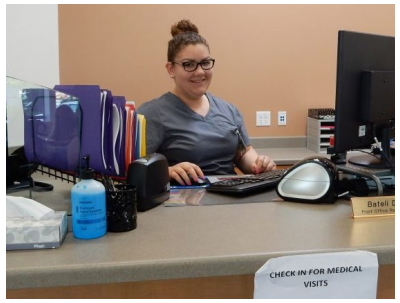
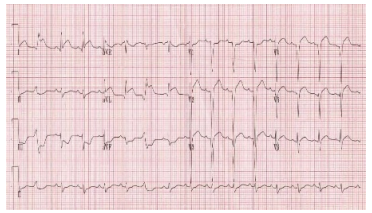
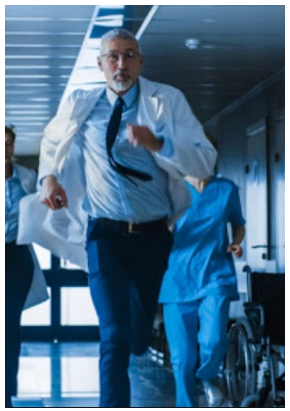
Established Practice Standard

- National guideline for over 30 years
- Hospital quality metric for over 20
- Training physician and nurses for triage
- Decades of research on
  - Risk factors for ACS and
  - Presenting symptom for ED patient found to have STEMI or NSTEMI-ACS

The Process







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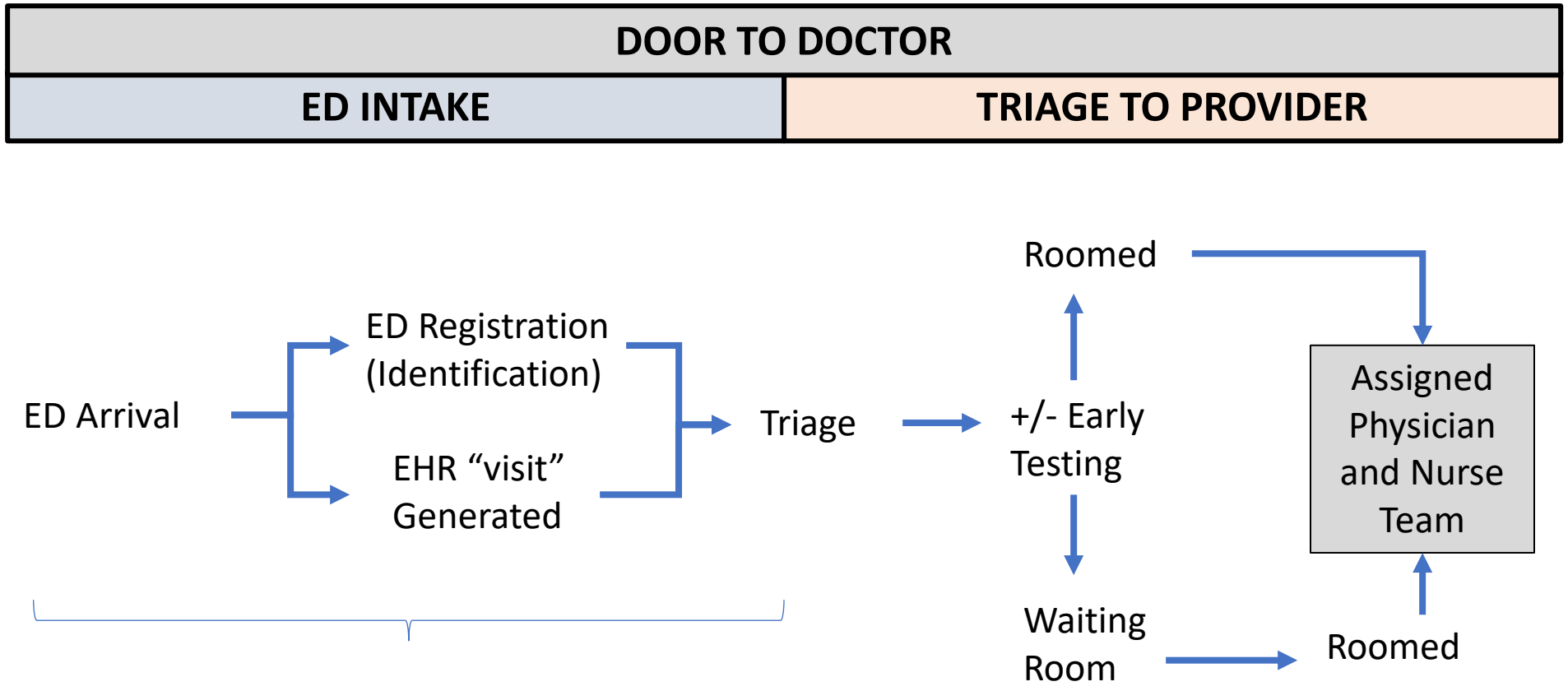
10

90

The Process


DOOR TO DOCTOR
ED INTAKE
TRIAGE TO PROVIDER
ED Arrival
ED Registration (Identification)
EHR "visit" Generated
Triage
+/- Early Testing
Roomed
Waiting Room
Roomed
Assigned Physician and Nurse Team
First 10 minutes of an ED Stay

Data

- Brigham and Women's
- Columbia
- NYU
- University of Pennsylvania
- Vanderbilt
- University of Wisconsin
- Cleveland Clinic Foundation
- UTSW – Parkland
- Oregon Health & Sciences U
- UC Davis

Chief Complaint	Total
1. Chest pain	71.9%
2. Shortness of breath	6.5%
3. Syncope	3.6%
4. Cardiac arrest	2.7%
5. Weakness	2.4%
6. Abdominal pain	2.1%
7. Dizziness	2.1%
8. Shoulder pain	1.5%
9. Back pain	1.2%
10. Bleeding	0.9%
11. Nausea	0.6%
12. Vomiting	0.6%
13. Arm pain	0.6%
14. Diaphoresis	0.6%
15. Unresponsive	0.6%
Total	100.0%

Data

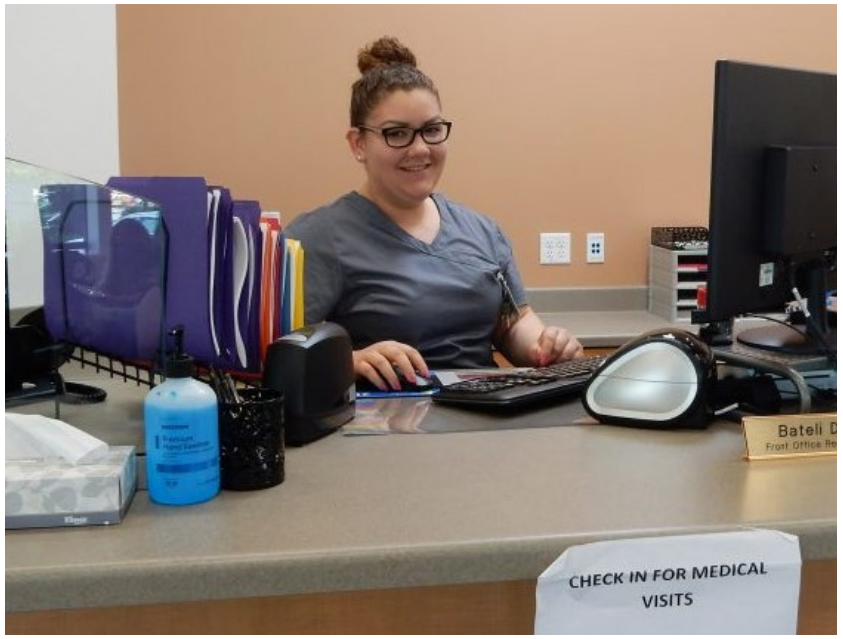
ED Intake
STEMI Screening
Criteria

Immediate ECG for any patient who presents to the ED that is:

1. Greater than 30 years of age with any of the following
   - Chest Pain
   - Shortness of breath
   - Non-traumatic arm pain
   - Non-traumatic shoulder pain
   - Non-traumatic jaw pain
   - Dizziness
   - Syncope/Passing Out (almost or actual)
   - Palpitations
2. Greater than 50 years of age with any of the following
   - Nausea
   - Vomiting
   - Upper abdominal pain
   - Weakness

Must have an immediate ECG performed and handed to an ED attending.

***Chest Discomfort** may be described as pressure, aching, tightness, heaviness, burning, sharp, stabbing, worse with breathing



Current Practice Performance

ED Intake
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How Are We Doing?

		Truth: STEMI (+)	Truth: STEMI (-)	
Test (Screening Criteria)	Screen (+)	60	13,092	13,152
	Screen (-)	25	55,444	55,469
		85	68,536	68,621

Sensitivity (1-ß) **71%**

Specificity (1-ß) **81%**

Precision = Positive Predictive Value = **0.456%**

(True Positives/All Positives = 60/13,152)

Current Practice Performance

Variable Emergency Department (ED) STEMI Screening

Performance and **Patient Impact?**

JAHA: Journal of the American Heart Association

Performance of Emergency Department Screening Criteria for an Early ECG to Identify ST-Segment Elevation Myocardial Infarction

Maame Yaa A. B. Yiadom MD MPH, Christopher W. Baugh MD MBA, Conor M. McWade MPH, Xulei Lu MSc, Kyoung Jun Song MD, Brian Patterson MD MPH, Cathy Jenkins MSc, Mary Tanski MD MBA, Gilberto Salazar MD, Thomas J. Wang MD, Robert S. Dittus MD MPH, Dandan Liu PhD, Alan B. Storrow MD

March 2017

12.8% (Range 3.4-32.6%) Missed at Screening

Patients missed by initial ED screening experience
14-80 minutes of additional myocardial ischemia time*

Current Practice Performance

SAEM Academic Emergency Medicine
Official Journal of the Society for Academic Emergency Medicine

Acute Coronary Syndrome Screening and Diagnostic Practice Variation

Maame Yaa A. B. Yiadom MD MPH, Xiulei Liu MSc, Conor M. McWade MPH, Dandan Liu PhD, **Alan B. Storrow, MD**
The ED Operations Study Group

March 2017

62 Emergency Departments

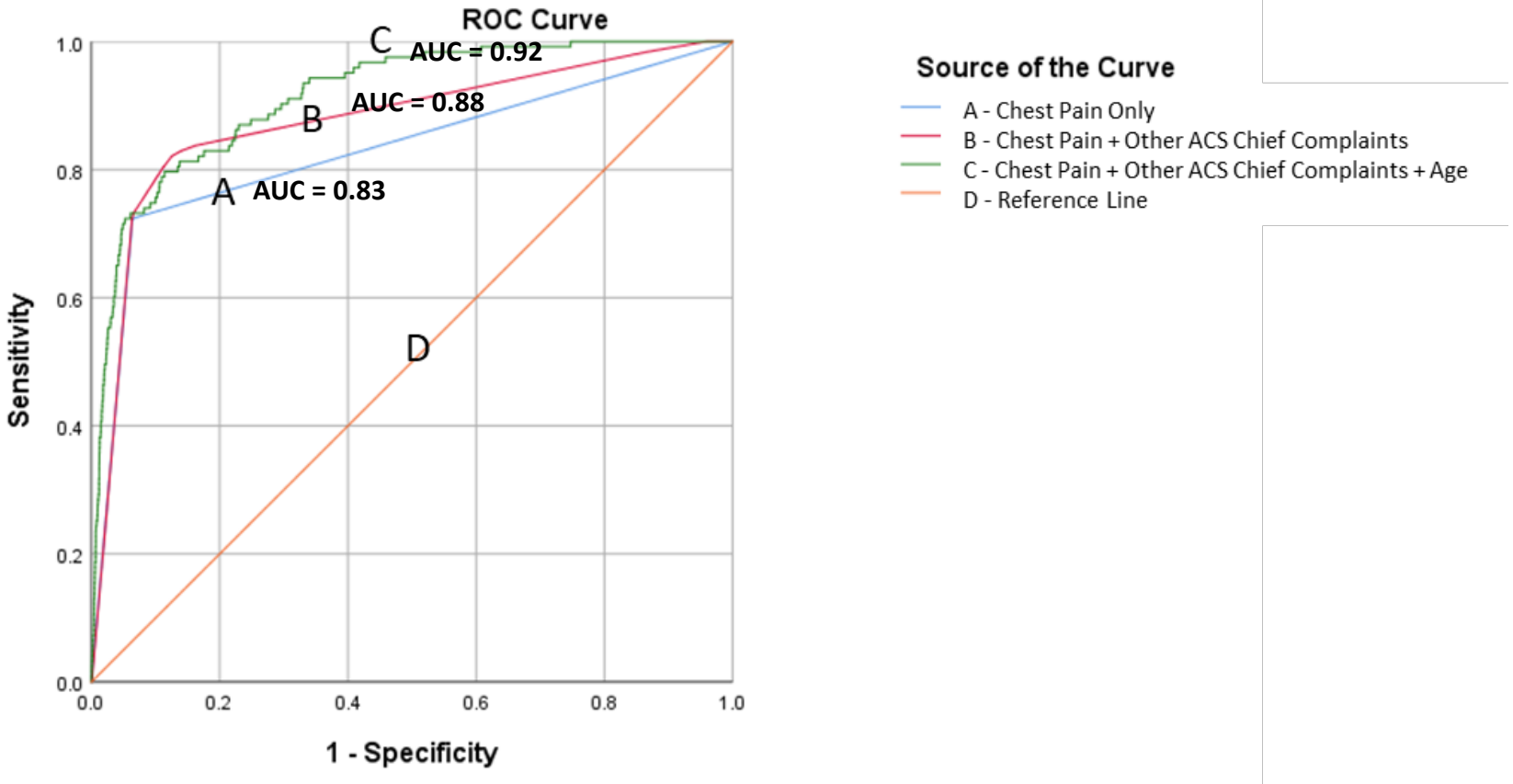
THE EMERGENCY DEPARTMENT OPERATIONS STUDY GROUP

- 15% do not have formal STEMI screening
- 14% use “chest pain” as the sole criteria

Suggests nearly 30% have inadequate screening

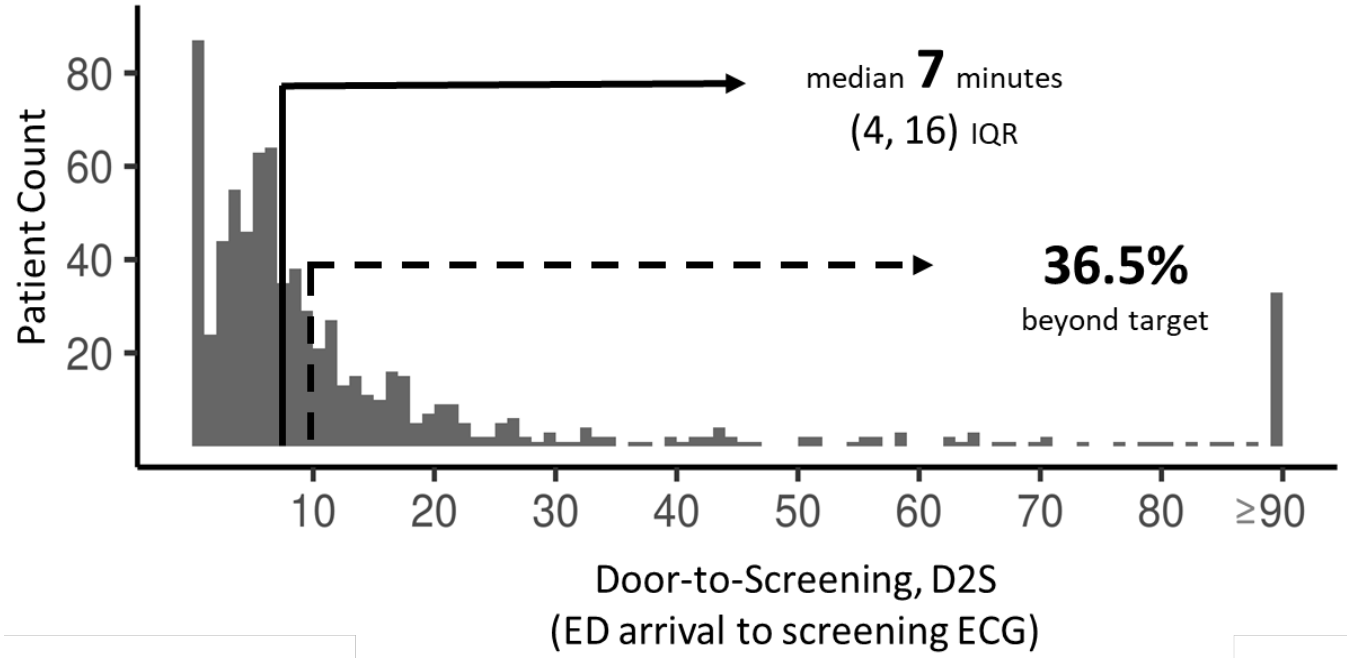
Current Practice Performance

Model		Sensitivity	Specificity	Positive Predictive Value (PPV)	AUC (CI)	95% CI
A	Chest Pain Only	72.4%	93.6%	1.0%	0.83	0.78-0.88
B	Chest Pain + Other ACS Chief Complaints (CC)	98.4%	13.4%	0.1%	0.88	0.84-0.91
C	Chest Pain + Other ACS-CC + Age	82.9%	81.0%	0.4%	0.92	0.89-0.94



Current Practice Performance

Door-to-Screening ECG Time for Undifferentiated STEMI Patients in 10 EDs



IQR, interquartile range. Door is ED arrival time. Screening ECG is the first ECG performed. Most extreme D2S values were 695 and 1407 minutes.

Demographic Differences

Timely and Untimely Care

Circulation:
Cardiovascular Quality and Outcomes

Outcome Differences Associated With STEMI Diagnostic Delay: Disparities on the Frontlines of STEMI Care

Maame Y Yiadom, Christopher Baugh, Cathy A Jenkins, Mary Tanski, Bryn E. Mumma, Timothy J Vogus, Karen F Miller, Brittney E Jackson, Christoph U Lehmann, Stephen C Dorner, Jennifer L West, Olayemi O Olubowale, Thomas J Wang, Sean P Collins, Robert S Dittus, Gordon R Bernard, Alan B Storrow, Dandan Liu.
Originally published. 2018;11:A185

Patients who did not receive an ECG within 10 minutes were

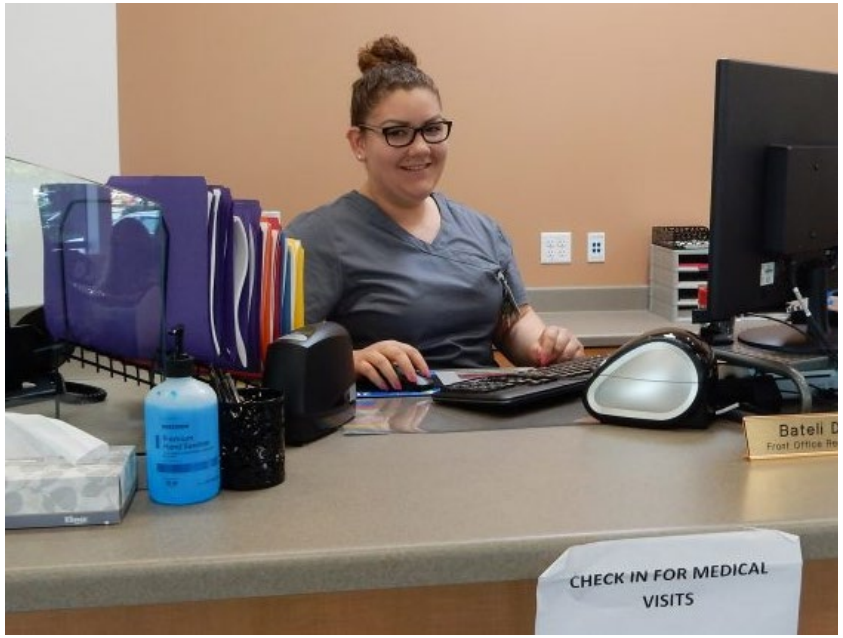
More commonly

- **Female** (55% vs. 19%, p=0.001)
- **non-white** (87% vs. 65%, p =0.028)
- Reported **chest pain** or **shortness of breath less frequently** (55% vs. 94%, p<0.001).

Experienced longer

- Median door-to-cathlab-arrival (159 vs. 50 minutes, p=0.004)
- Median door-to-balloon time (207 vs. 93 minutes, p=0.048).

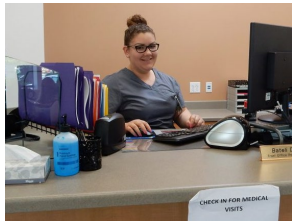
Current Practice Performance

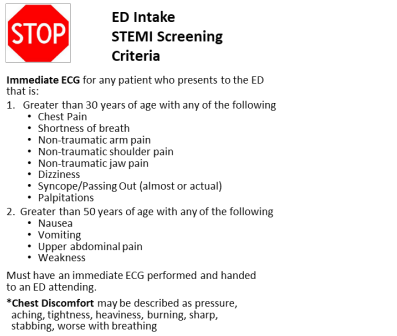


- Chief Complaint
- Date of Birth
- Gender
- Race
- Language
- Registration Scenario

Opportunity for AI

- Process target for a physician **Decision**





- **Logic Model** + improvement on current model
- Capturing **Data** ideal for decision making in a computer (electronic health record)

- Clinical decision support tools that can be programmed to use the available data to help **computer (the EHR) to make the decision** reliably
- Which **actions** are we willing to let it initiate?

Opportunity for AI

- Chief Complaint
- Date of Birth
- Gender
- Race
- Language
- Registration Scenario

EHR predictive model for STEMI triggering an early ECG

Alert

Page

Physician Order for ECG

Opportunity for AI

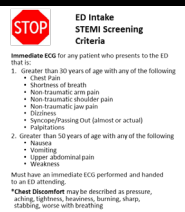
The Decision

Logic Model

Computer

Action

Screen Alert
Page Tech
Order ECG



Natural Language Processing

Machine Learning

Electronic Health Record
Clinical Decision Support

Early ECG

Risk for STEMI?

Waiting Room

Opportunity for AI

- Logic Model

  ECG for patient with a chief complaint of

  - Chest pain

  - Shortness of breath with age >30 and a history of CAD or MI

Natural Language Processing

Involves programming computer algorithms to process and analyze large amounts of data to find valuable concepts or text that can be used for analysis

Opportunity for AI

- NLP requires coding desired concept into likely form within the EHR

History of CAD or MI:

- CAD or MI ICD-10 code in a diagnosis field within medical record

- “Coronary artery disease,” “ischemic cardiomyopathy,” “myocardial infarction,” “NSTEMI,” “STEMI,” “unstable angina,” “coronary occlusion” within an ED, clinic or in-hospital note diagnosis field.

Opportunity for AI

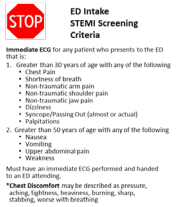
The Decision

Logic Model

Computer

Action

Page Tech
Order ECG



Natural Language Processing

Machine Learning

Electronic Health Record
Clinical Decision Support

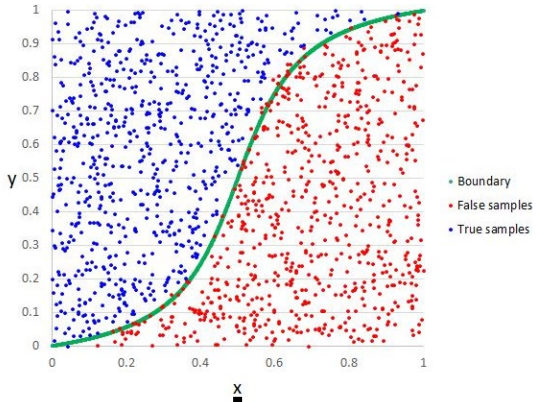
Early ECG

Risk for ACS?

Waiting Room

Opportunity for AI

Statistical Inference
Regression Modeling



Machine
Learning

Electronic Health Record
Clinical Decision Support

Early ECG

Risk for ACS?

Waiting Room

Opportunity for AI

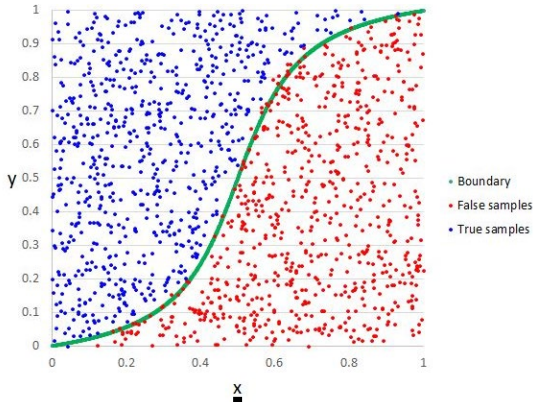
We use our experience to decide what is likely to be predictive of our target outcome

The mathematical "model"

Tells us how well we did
- X sensitivity
- Y specificity

PREDICTIVE ANALYTICS

Statistical Inference
Regression Modeling



Machine Learning

Electronic Health Record
Clinical Decision Support

Action

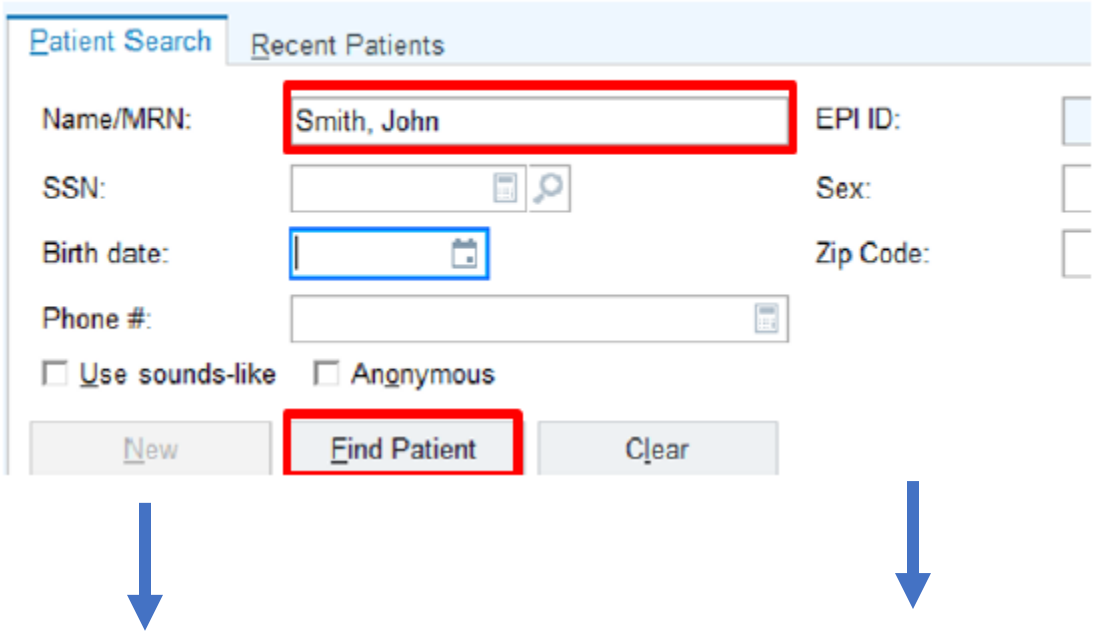
You tell the model how well to perform
- 95% sensitivity
- 90% specificity

It maps the target outcome calculating mathematical relationship in data about patients

Finds what is predictive

Opportunity for AI

60-75% of ED Patients have an existing electronic medical record



New ED Encounter within Existing Medical Record

Demographics Form to Generate a New Encounter

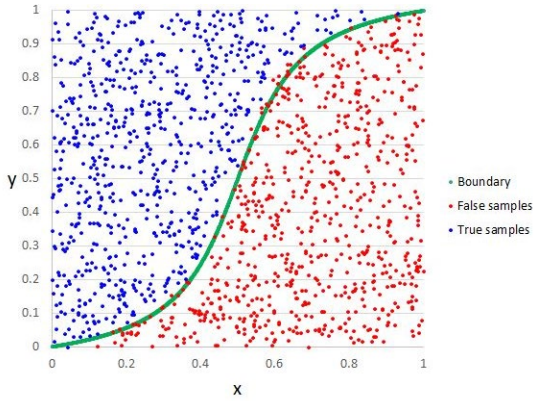
Opportunity for AI

- 2-tier risk prediction
  - Live Care Data (C_1)
  - Historical Data (C_2)

$$C = \alpha C_1 + \beta C_2$$

Opportunity for AI

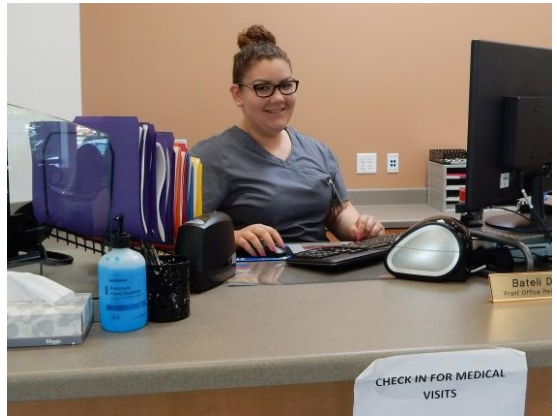
Statistical Inference
Regression Modeling



Machine
Learning

- Head to head comparison of performance
- Optimization of final model using knowledge gained from both models and their variables/features

Precision-Oriented Risk Prediction Approach to Aid Early STEMI Diagnosis in the ED

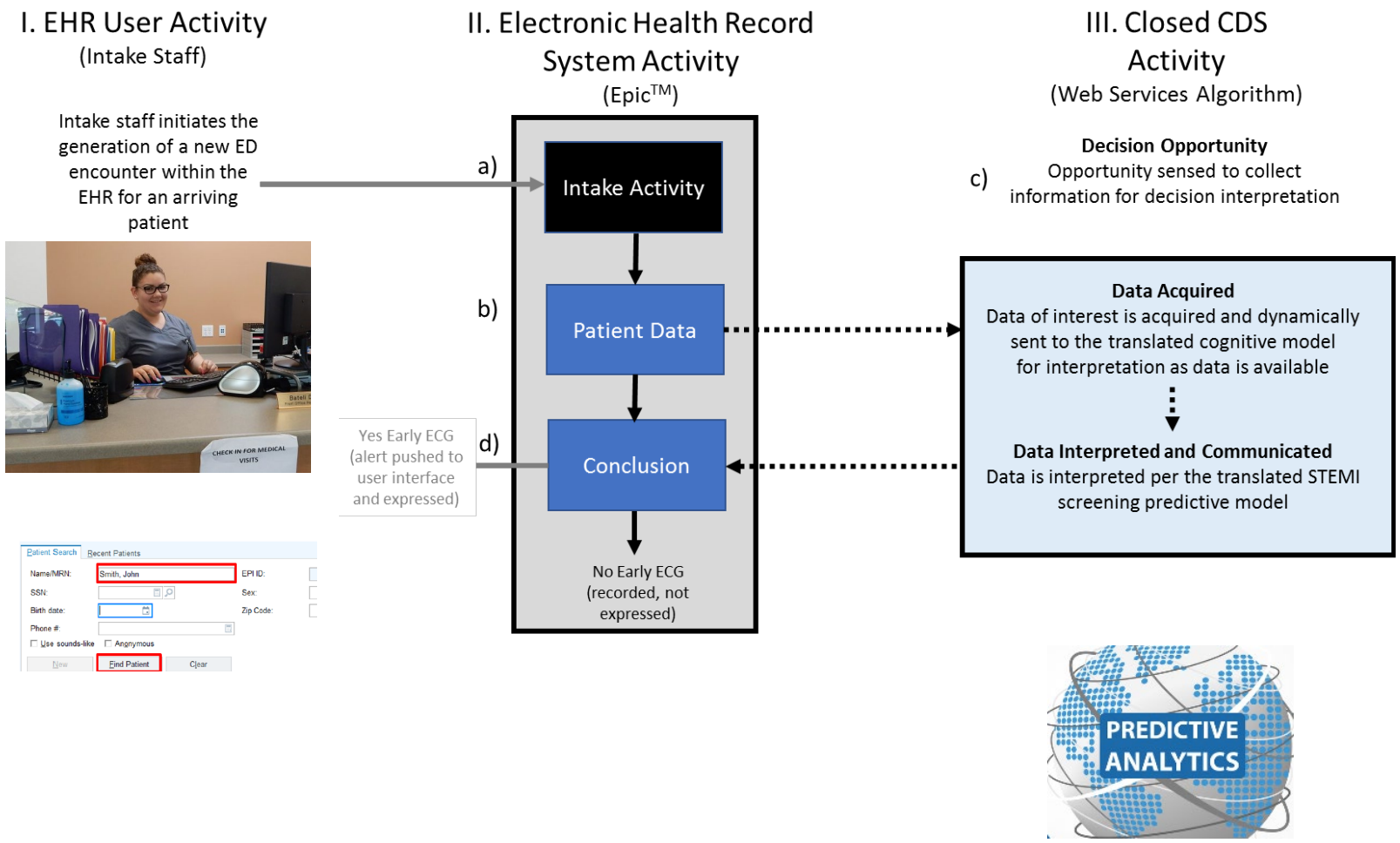


Precision-Oriented Risk Prediction Approach to Aid Early STEMI Diagnosis in the ED

- Predictive Modeling Analytics
  - Statistical Inference
  - Machine Learning

- **Clinical Decision Support**
  - Model Translation Fidelity
  - Efficacy and Safety

Predictive Model → Clinical Decision Support



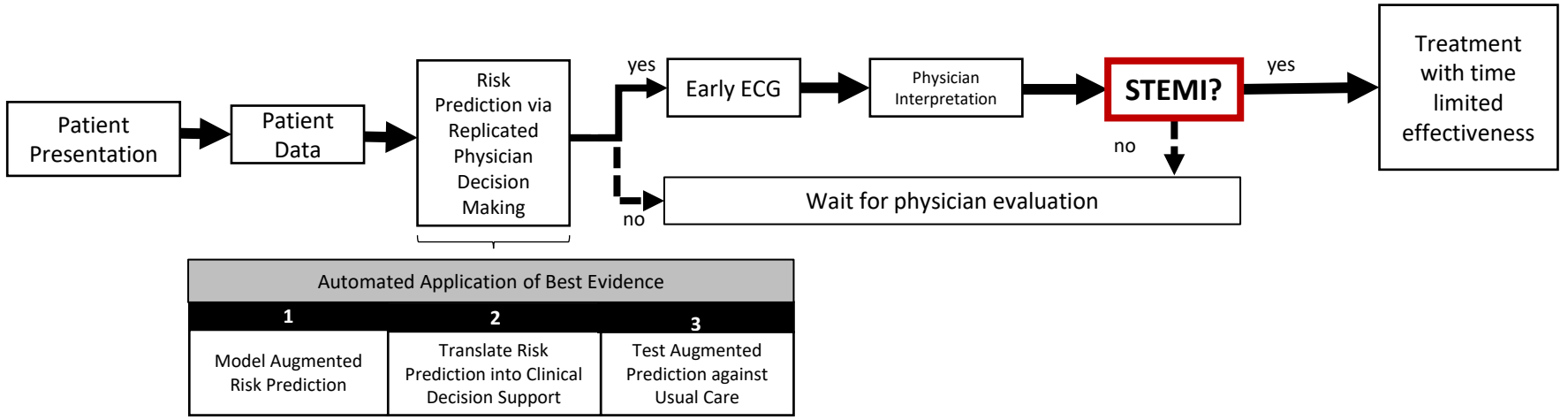
Predictive Model → Clinical Decision Support

Prospective Cohort, but CDS decision will not effect care

- Fidelity Testing: 1:1?
  - Predictive Model vs CDS Identification

- Efficacy and Safety
  - Observed Care vs CDS Identification
  - Discordance Analysis for Safety

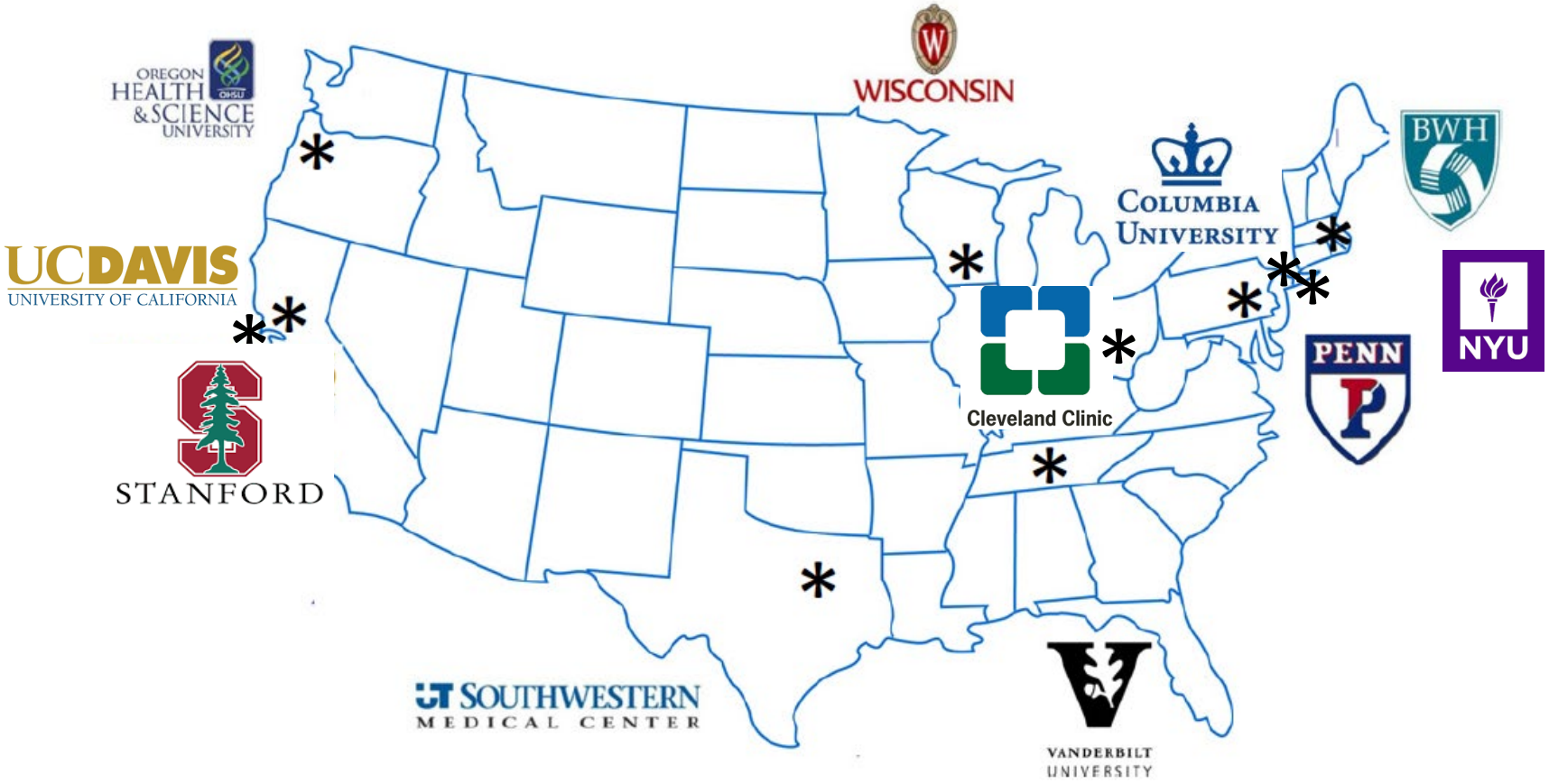
Summary



Right Care, Right Time, Right Patient

Next Steps

Randomized Controlled or Step-Wedge Clinical Trial of EHR-Predictive Model Supported STEMI Screening



Emerging Emergency Medicine Applications

Interdisciplinary partnerships with biomedical informatics specialists and the growing community of applied clinical informaticists is elevating our ability to explore applications of AI in emergency care.

- Identifying the rare patient that has a STEMI using past medical records, registration demographic and chief complaint
- Analyzing variation in radiologic imaging to identify abnormal findings (pulmonary embolism and cancer)
- Predicting elderly patients with features predictive of a traumatic fall.

Artificial Intelligence is Here and Is Your Friend:

What it can do for you in your ED

Maame Yaa “Maya” A. B. Yiadom, MD, MPH, MSCI
Associate Professor, Emergency Medicine, Stanford University
Director, Emergency Care Health Services Research Data Coordinating Center (HSR-DCC)

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Evaluation & CME

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icep.org/evaluation2021

Complete the online form at the conclusion of the program or by Monday, March 1st