# Our Speakers

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Stanford MEDICINE | Center for Improvement

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# Building AI-Enabled Systems for Patient Care at Stanford

Margaret Smith, MBA & Ron Li, MD

# GOALS FOR TODAY'S LECTURE

HEA$_3$RT
Stanford Healthcare AI Applied Research Team

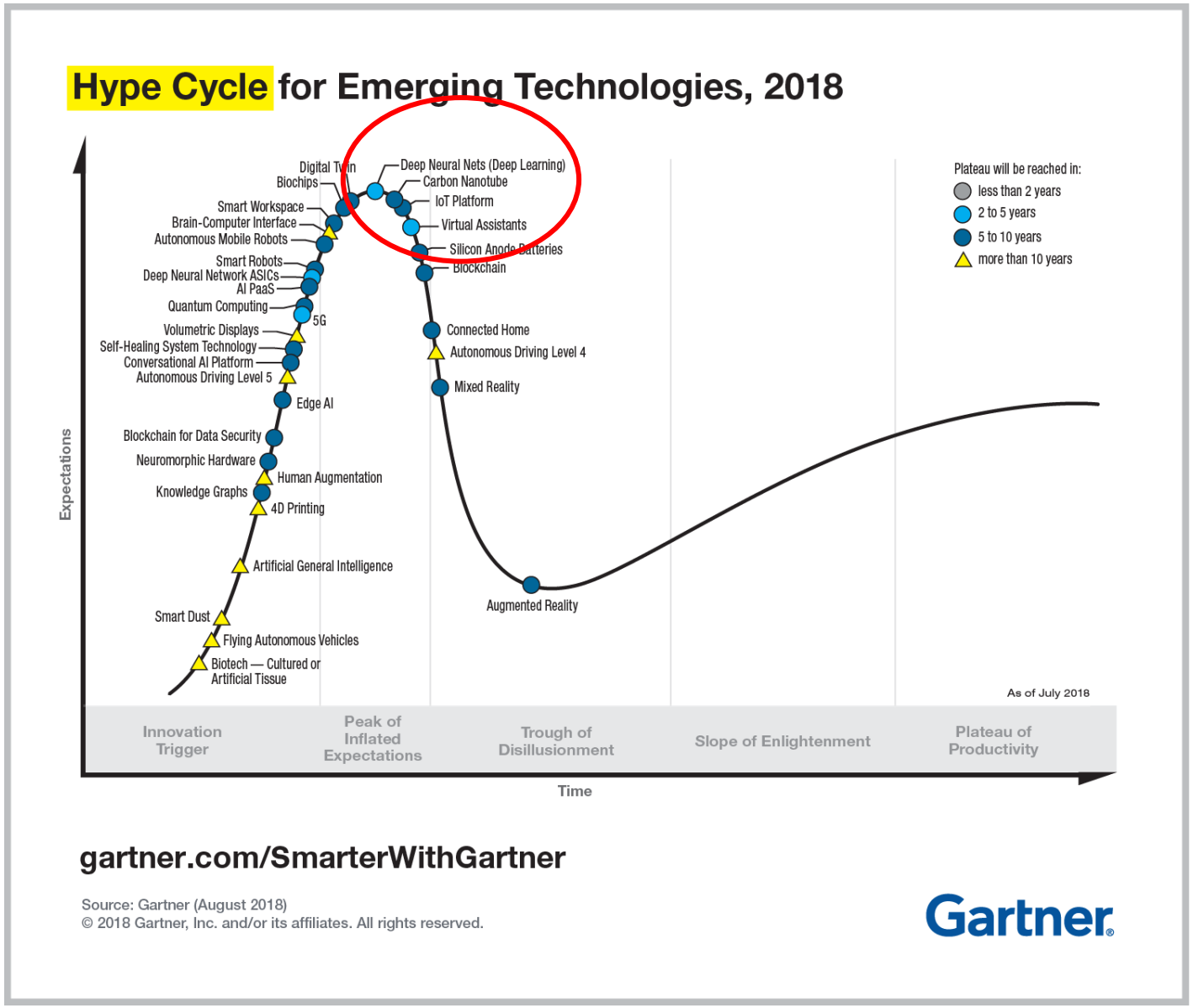
Over the last year, we have collaborated on two projects implementing AI-enabled solutions at Stanford Health Care.

**Our goal today is to:**

- share what we have learned thus far from our experiences on these projects
- discuss how those learnings can be applied more broadly
- reflect on what is necessary to increase the capacity for AI development and integration at Stanford

BMIR
Stanford Center for Biomedical Informatics Research
CONNECTING DATA TO HEALTH

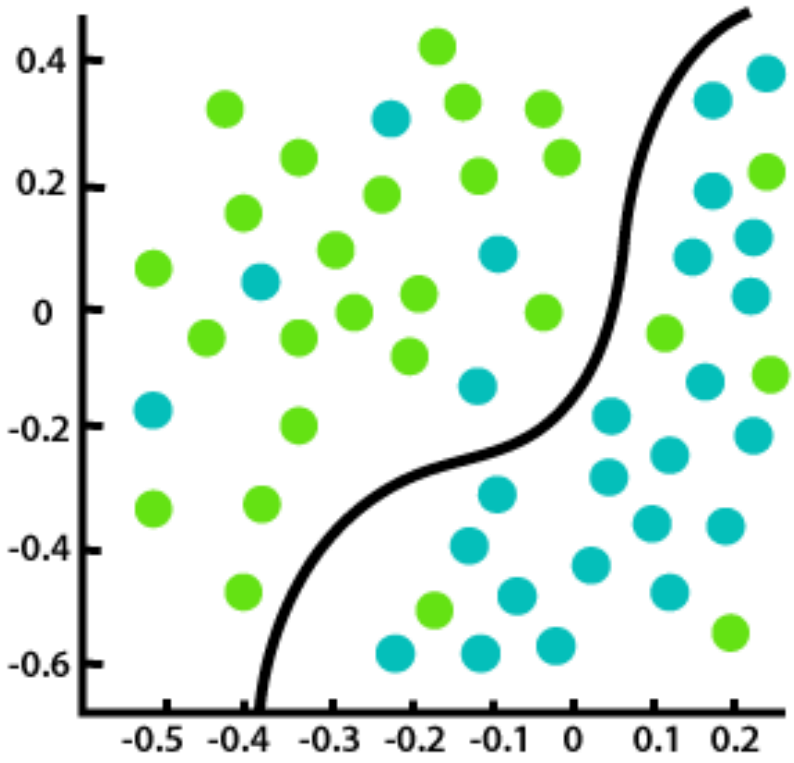
# AI is at a critical inflection point



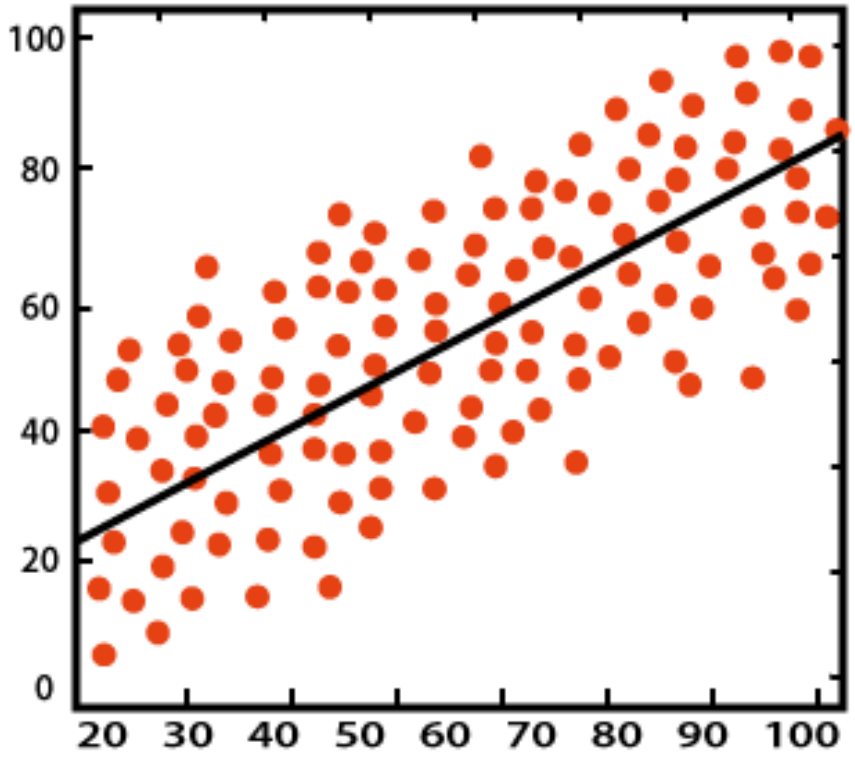

"With machine learning situated at the **peak of inflated expectations**, we can soften a subsequent crash into a "trough of disillusionment" by fostering a stronger appreciation of the technology's capabilities and limitations."

Chen, J. H. & Asch, S. M. Machine Learning and Prediction in Medicine — Beyond the Peak of Inflated Expectations. *N. Engl. J. Med.* **376,** 2507–2509 (2017).

# What are tasks that AI can perform?

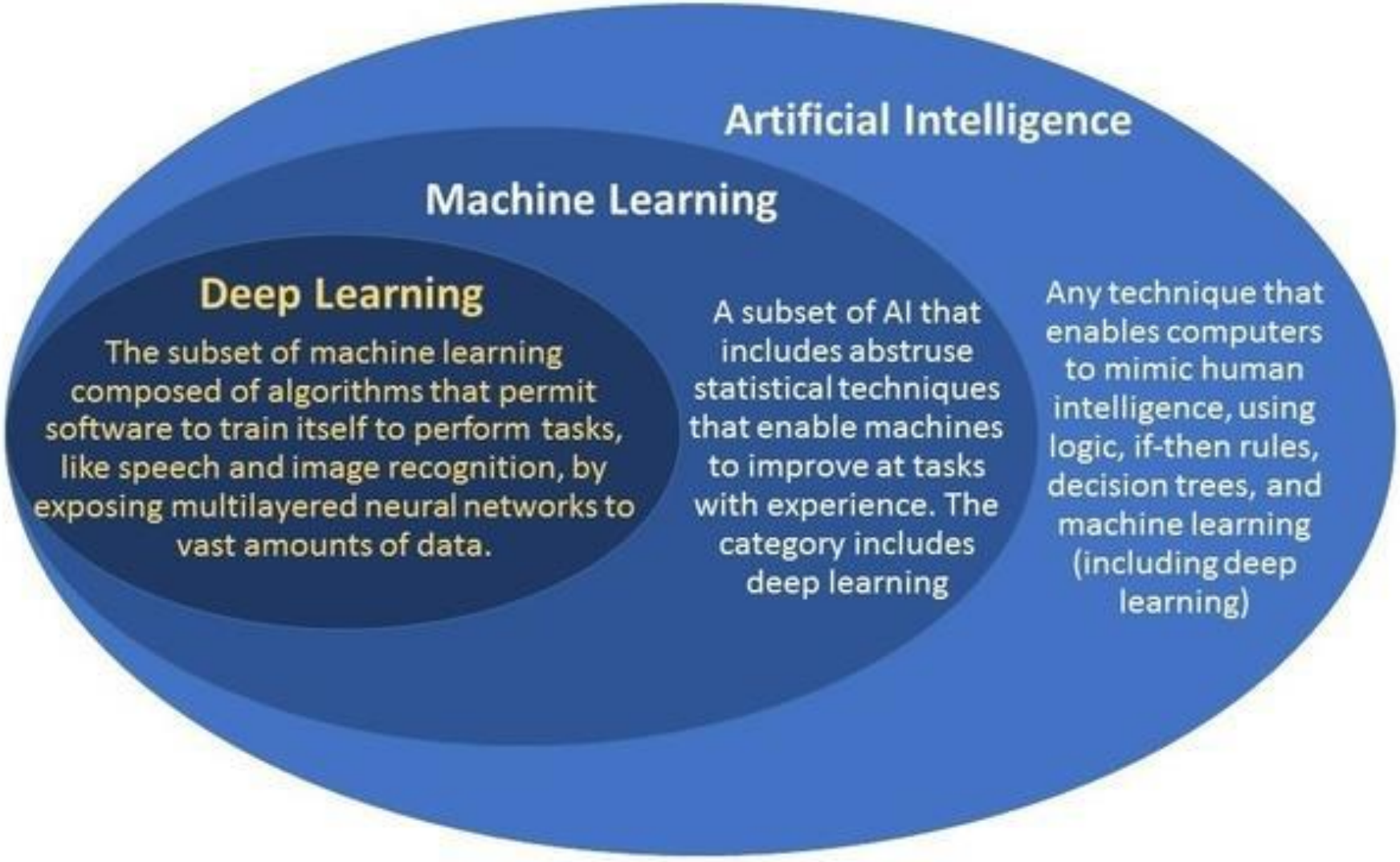



Classification

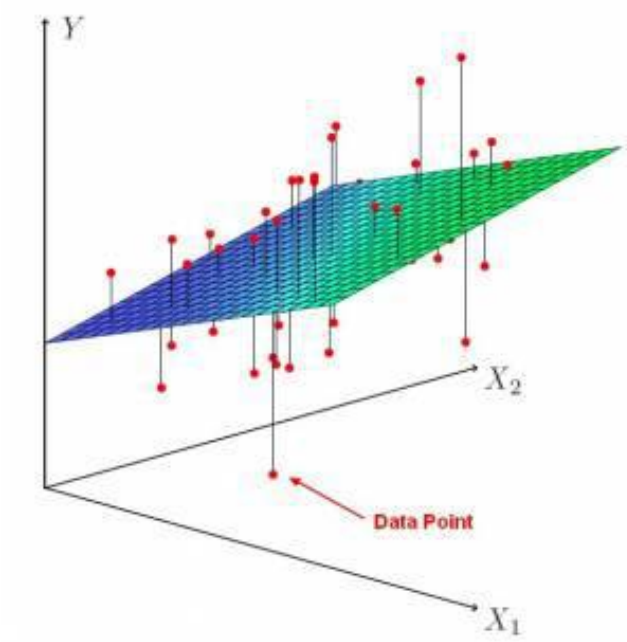


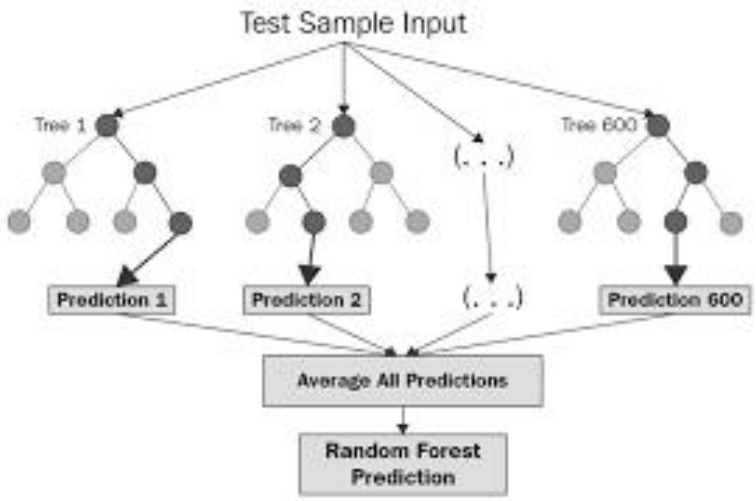

Regression

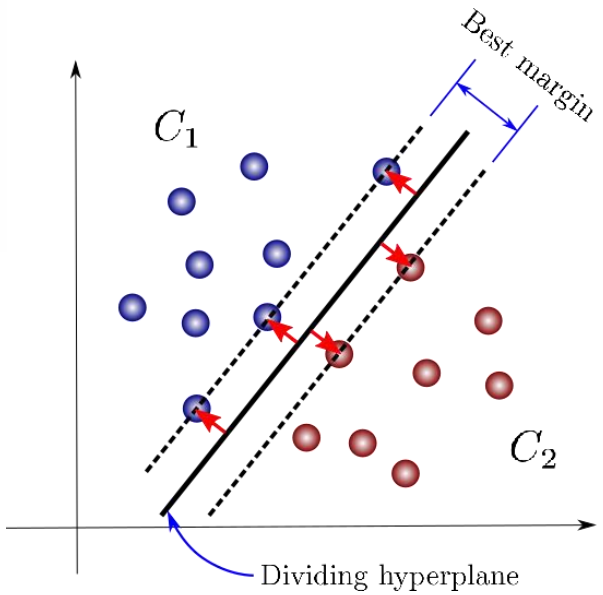
# What is the difference between AI and machine learning?

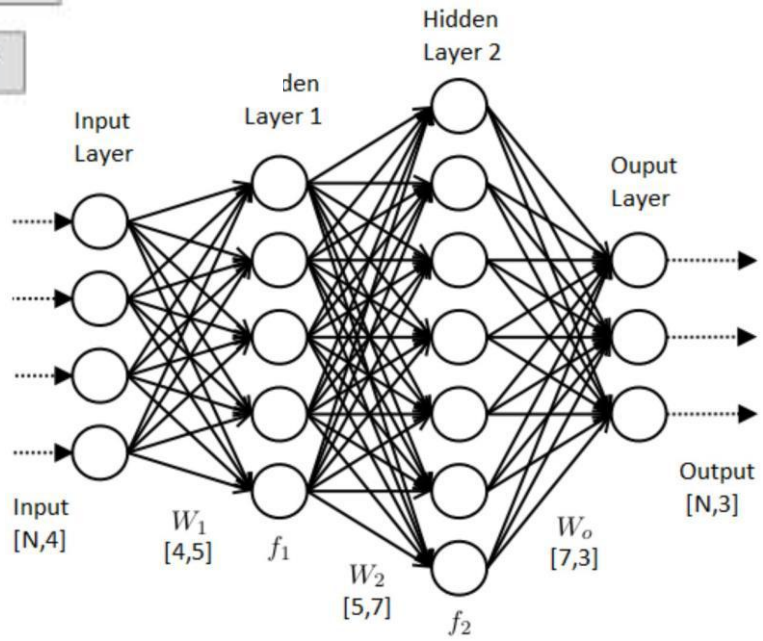


# Machine learning algorithms are used to build models that classify and predict at high accuracy



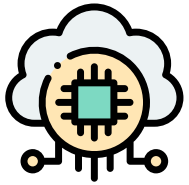
# Prediction models are not new to medicine

Example:

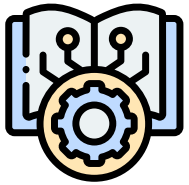
Model for End Stage Liver Disease (MELD) score developed in 2002 to help prioritize liver transplant recipients:

$$MELD = 3.8*\log_e(\text{serum bilirubin [mg/dL]}) + 11.2*\log_e(INR) + 9.6*\log_e(\text{serum creatinine [mg/dL]}) + 6.4$$

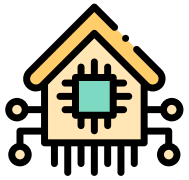
# Then why all the hype now?



1. More data and computing power available

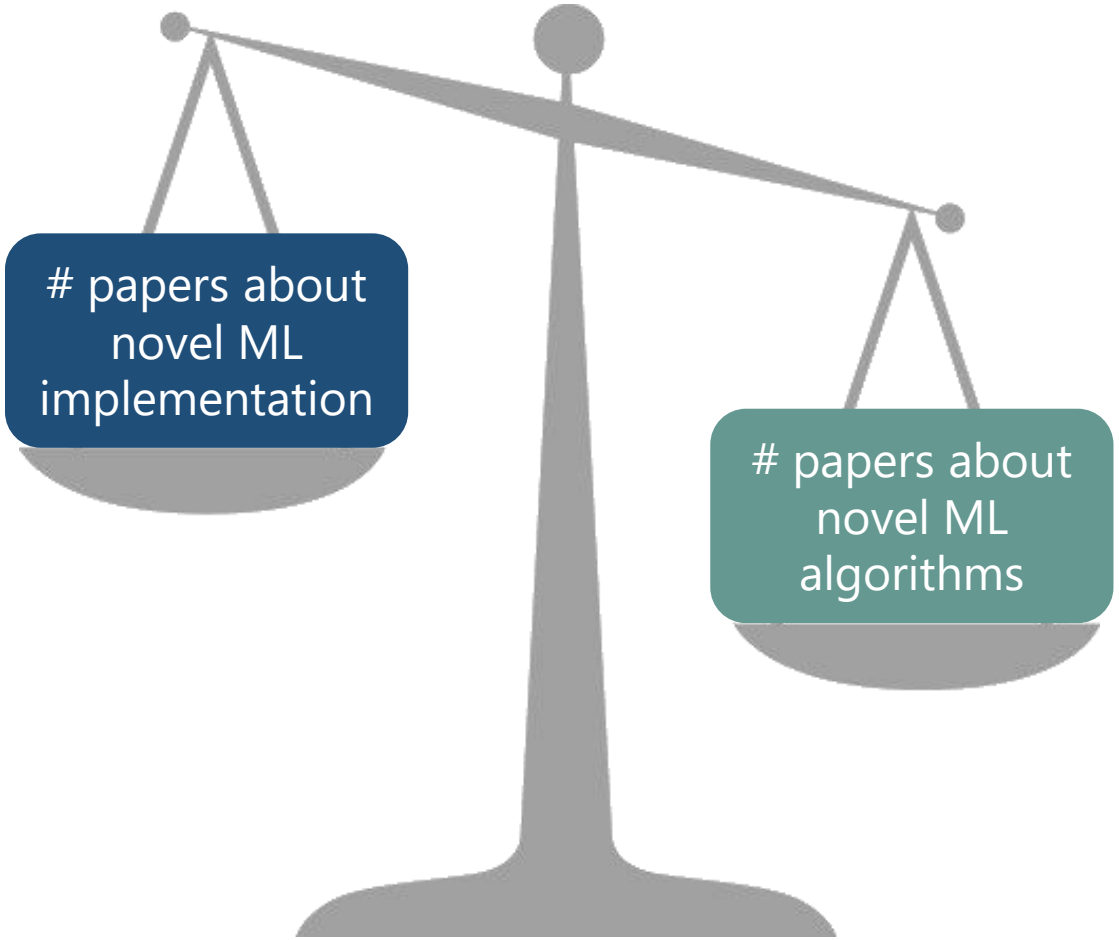


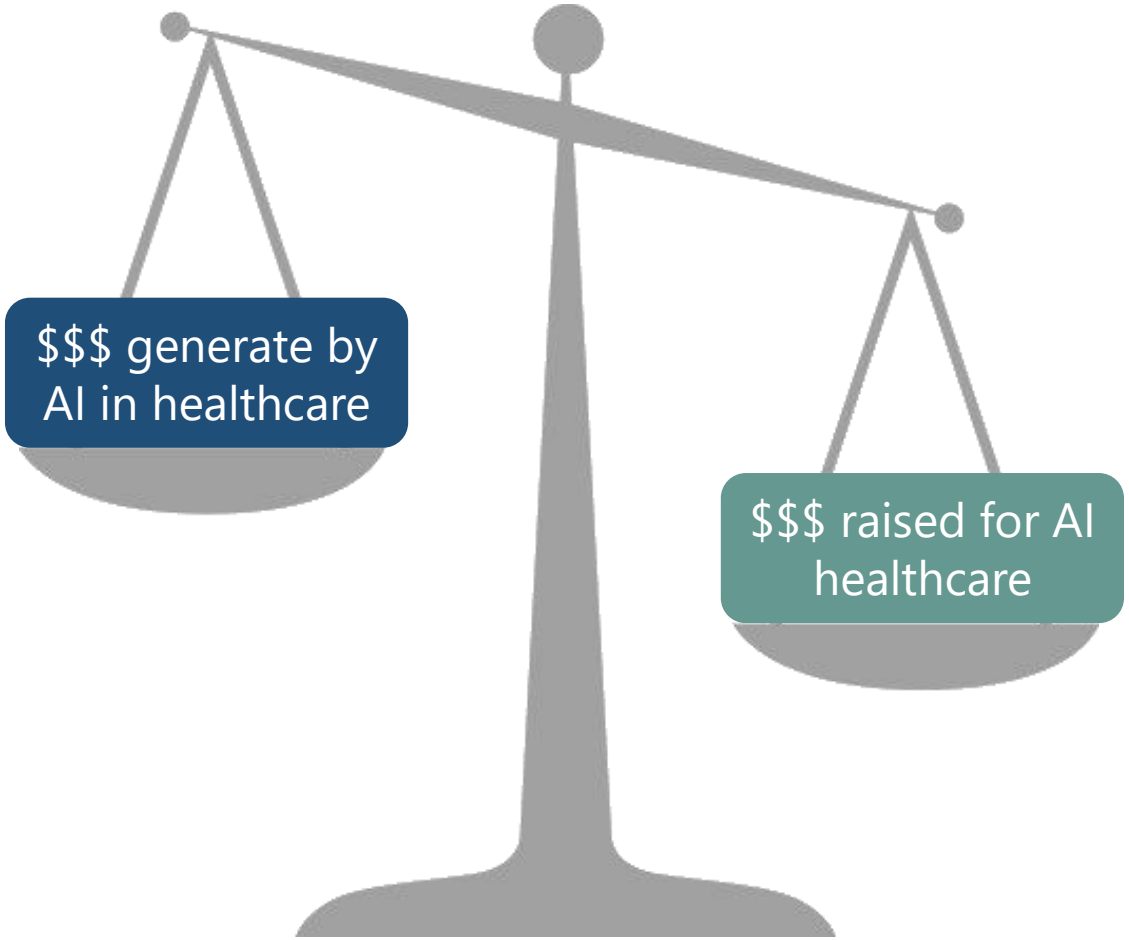
2. Learning algorithms enable the creation of more accurate models



3. Hospitals and clinics more “wired” and capable of using advanced analytics in real time

# Then, why are we not seeing the impact?



# Paradigm Shift

**From…**

Ok, I have a machine learning model…now what?

**To…**

Ok, I have this problem I need to solve…how could machine learning enable the solution?

# Healthcare is a Complex System…

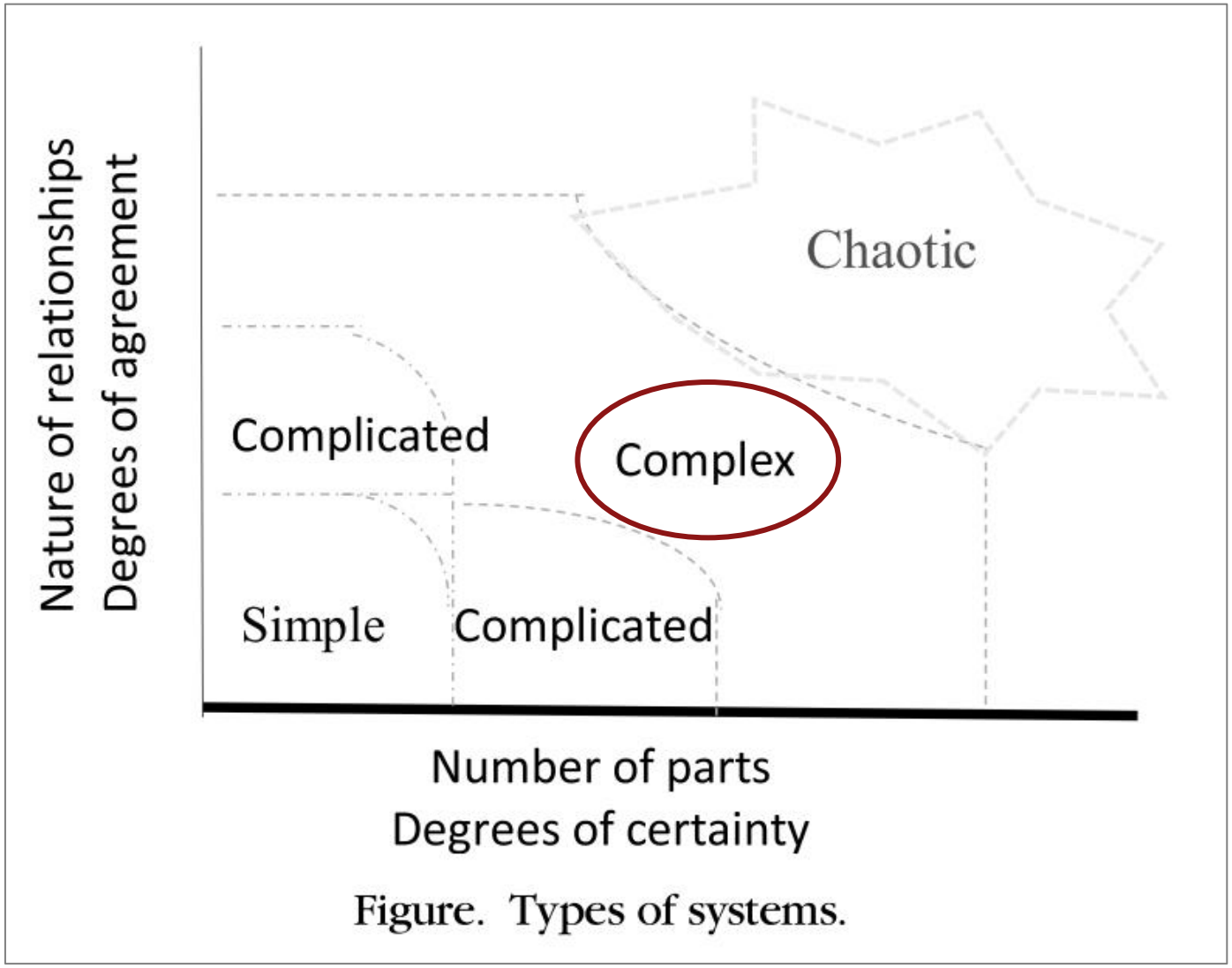
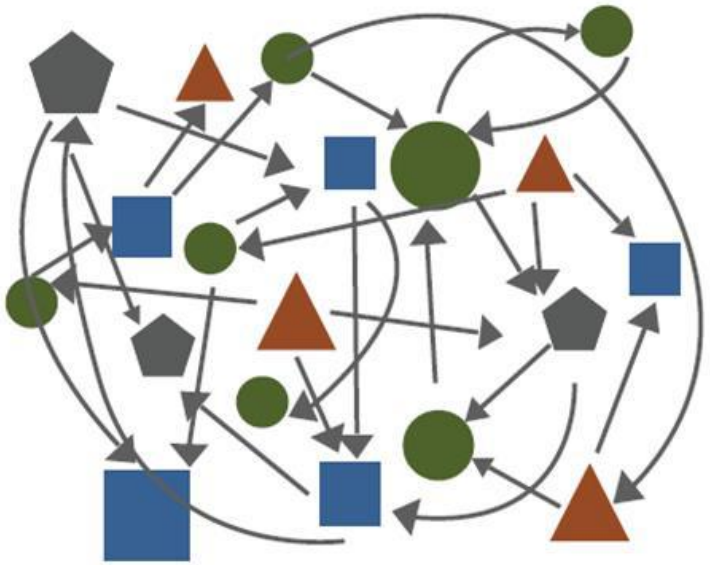


Figure. Types of systems.



**System:** a set of individual agents interacting with each other and forming **structures, processes, and patterns**

Ratnapalan S, Lang D. Health Care Organizations as Complex Adaptive Systems. *Health Care Manag (Frederick)*. 2020;39(1):18-23

# Medication Administration System in Hospital

## Structure

Pharmacy
Nursing units
Elevators
Committees
Info systems
Individual roles
Etc.

## Process

Ordering
Transcribing
Entering
Dispensing
Etc.

## Pattern

Prescribing practices
Types of errors
Feelings & values
Supportive behavior
Blaming
Fear
# of errors reported
Etc.

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COMMENT OPEN

Check for updates

# Developing a delivery science for artificial intelligence in healthcare

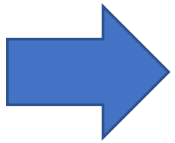
Ron C. Li[1,2]✉, Steven M. Asch[3,4] and Nigam H. Shah[2]

"To address how AI can be leveraged at scale, we need to both broaden and deepen our thinking around **how AI fits into the complexities of healthcare delivery**."

https://www-nature-com.stanford.idm.oclc.org/articles/s41746-020-00318-y

# Create systems enabled by AI

Machine learning model(s)



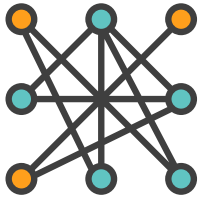
Intelligent care delivery system

*(New work structures and processes for delivering care **enabled** by ML models)*

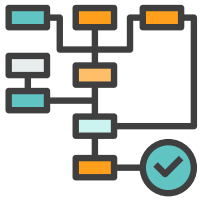

**Building and implementing AI systems require the synthesis of multiple disciplines**

Adapted from Sittig and Dean et al and Nguyen “Health IT Stack”

# How can we create systems enabled by AI?



1. Leverage existing proven methods for complex problem solving and implementation
    - Quality Improvement
    - Human Factors Engineering
    - Quality by Design
    - Design Thinking
    - Implementation Science

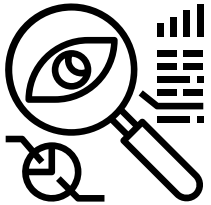


2. Add prediction and classification to the current constructs for improving processes
    - Reduce waste
    - Minimize variation
    - Minimize hand-offs
    - One-piece flow
    - Pull systems
    - Work cells
    - **Prediction and classification**

# A tale of two projects

## AI Enabled Clinical Deterioration Prevention

What's the problem?



AI task identified?

How does AI enable the solution?

## AI Enabled Advance Care Planning

What's the problem?

AI task identified?

How does AI enable the solution?

# AI Enabled Clinical Deterioration Prevention

What's the problem?

Unexpected deterioration events (RRT, Code, escalation to ICU) with some leading to death in the inpatient setting.

Early signs of clinical deterioration missed:

Why:

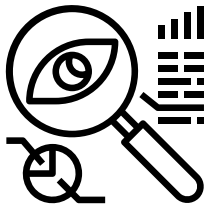
- Information overload
- Continuity > shift change
- No shared definition of severity of illness

Signs identified, but not acted on:

Why:

- Friction amongst team members
  - No shared definition of severity of illness

# AI Enabled Clinical Deterioration Prevention



AI task identified?

Key Drivers Derived from Root Cause Analysis

**Continuous** clinical status monitoring

**Objective** shared mental model for **early** risk of deterioration **detection**

**Standardized initial response** and intervention

Agreed upon workflows **after initial response**

**Role clarity** throughout the process

# AI Enabled Clinical Deterioration Prevention

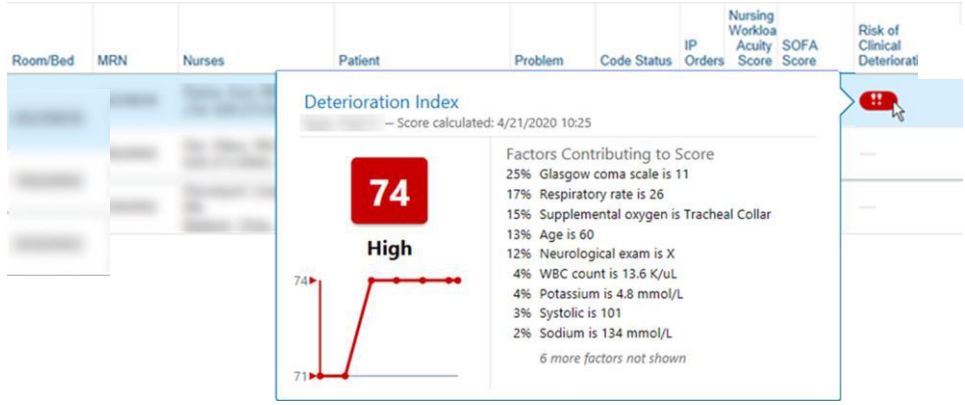
How does AI enable the solution?

## Model is looking at 20+ clinical indicators in EPIC

Inputs | DETERIORATION INDEX Breakdown

| Input | Display Name | Gathered Value | Input Value |
|---|---|---|---|
| Respirations | Respiratory rate | 22 | 22 |
| Pulse Oximetry | Pulse oximetry | 100 % | 100 % |
| Glasgow Coma Scale | Glasgow coma scale | 7 | 7 |
| Neurological Exam | Neurological exam | X | X |
| Hematocrit | Hematocrit | 30.6 | 30.6 |
| WBC Count | WBC count | 15.8 | 15.8 |
| Potassium | Potassium | 3.7 | 3.7 |
| Sodium | Sodium | 153 | 153 |
| Blood pH | Blood pH | 7.39 | 7.39 |
| Cardiac Rhythm | Cardiac rhythm | SR | SR |
| Supplemental Oxygen | Supplemental oxygen | ET Tube;Invasive Ventil... | ET Tube;Invasive Ventil... |
| Platelet Count | Platelet count | 142 | 142 |
| BUN | BUN | 14 | 14 |
| Risk from Age | Risk from Age | | 1 |
| Risk from Systolic | Risk from Systolic | | 0.01882 |
| Risk from Temperature | Risk from Temperature | | 0.03741 |

## Risk of Deterioration Column Flag (in production)



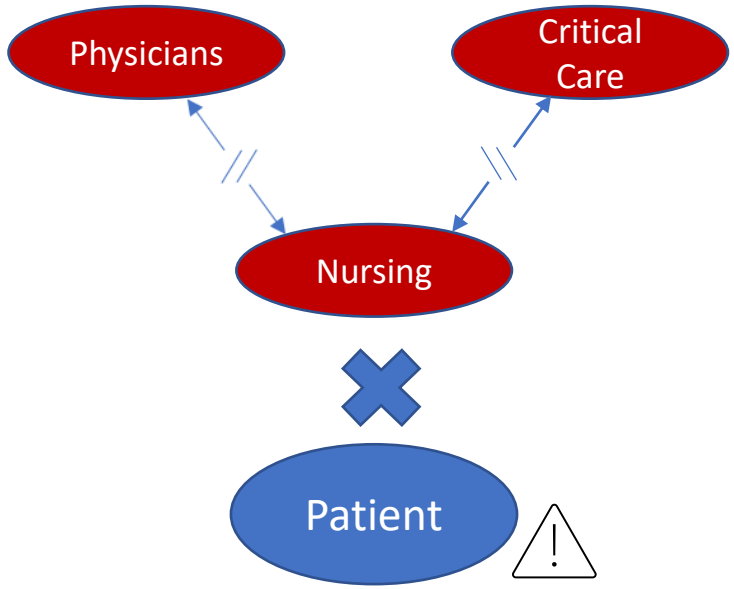

**Flags patients with a 1/5 chance of ICU Escalation, RRT or Code in the next 6-18 hours.**

*Automatically updates every 15 minutes*

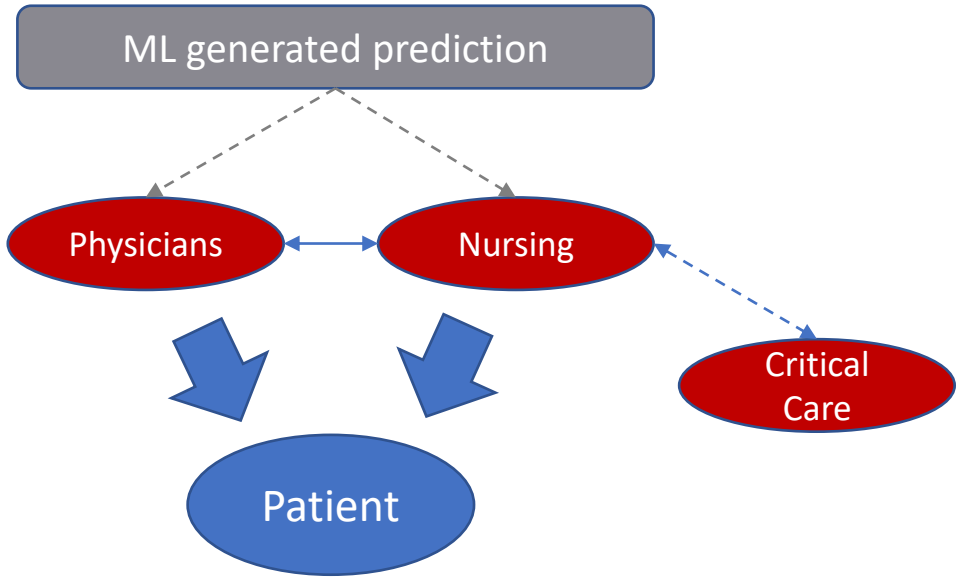
# AI Enabled Clinical Deterioration Prevention

**AI can enable a shared definition for risk and standardized workflows, alleviating cognitive burden and friction**

**From…**




**To…**



# AI Enabled Advanced Care Planning

What's the problem?

Low and late frequency of documented advance care planning conversations for patients with terminal illnesses in the inpatient setting, contributing to end of life care that is not concordant with patient goals, moral distress for providers, and ineffective and inefficient utilization of health system resources.

Selection of appropriate patients:

Why:

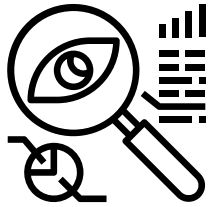
- Difficulties estimating and agreeing on prognosis
- No shared definition of Advance Care Planning

Limited capacity and coordination challenges:

Why:

- Assumption that this is an MD only conversation
- Silo'd documentation
- Little to no outpatient continuity

# AI Enabled Advanced Care Planning



AI task identified?

Key Drivers Derived from Root Cause Analysis

**Consistent identification** of patients that need ACP leveraging a **shared mental model for prognosis**

**Shared definition of** advance care planning

**Decentralization of responsibility** to have iterative **ACP conversations**

**Ability to easily share ACP updates/info** to and from any member of the team

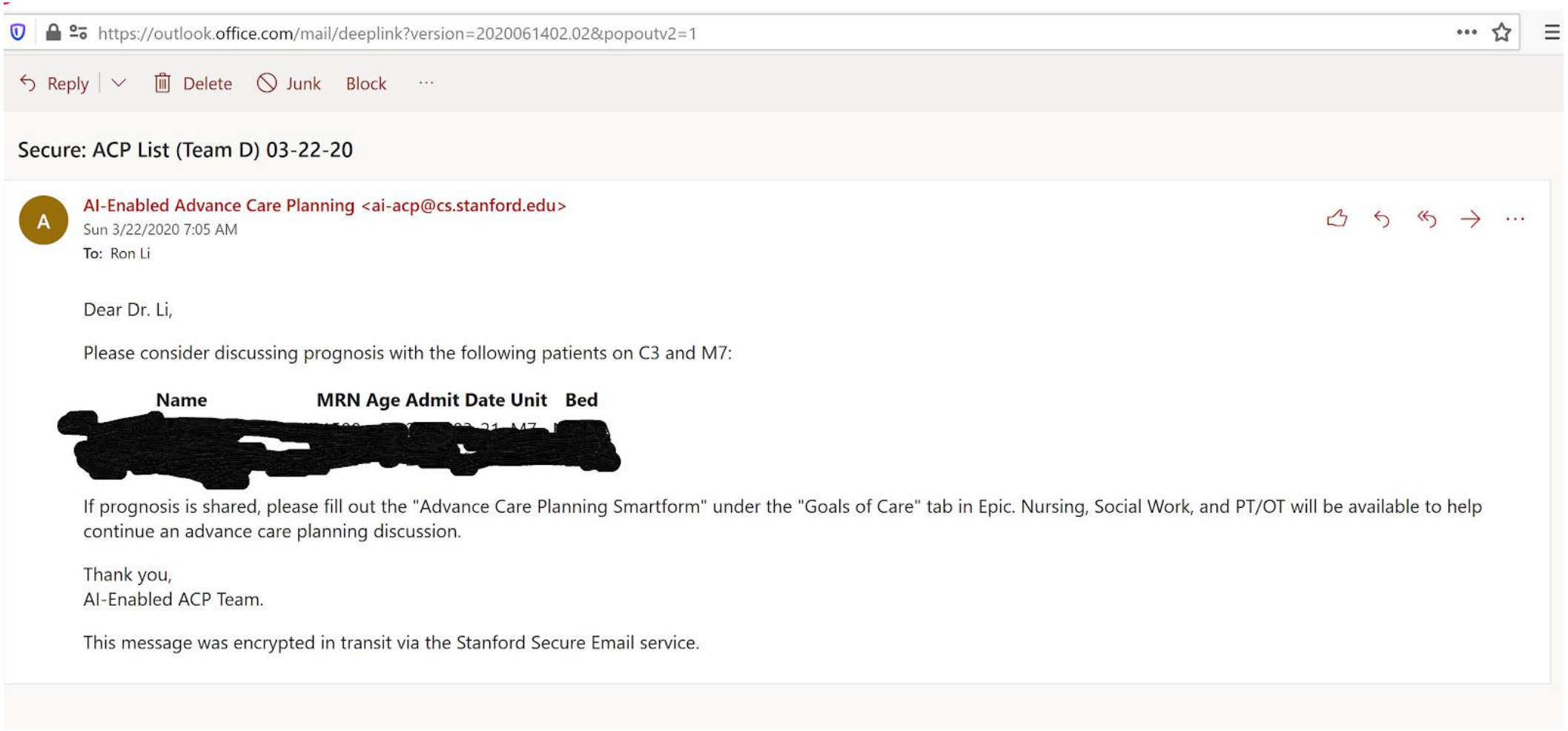
**Providers and have tools and skills** to feel confident to ACP with patients/families

**Continuity with outpatient** primary care providers

# AI Enabled Advanced Care Planning

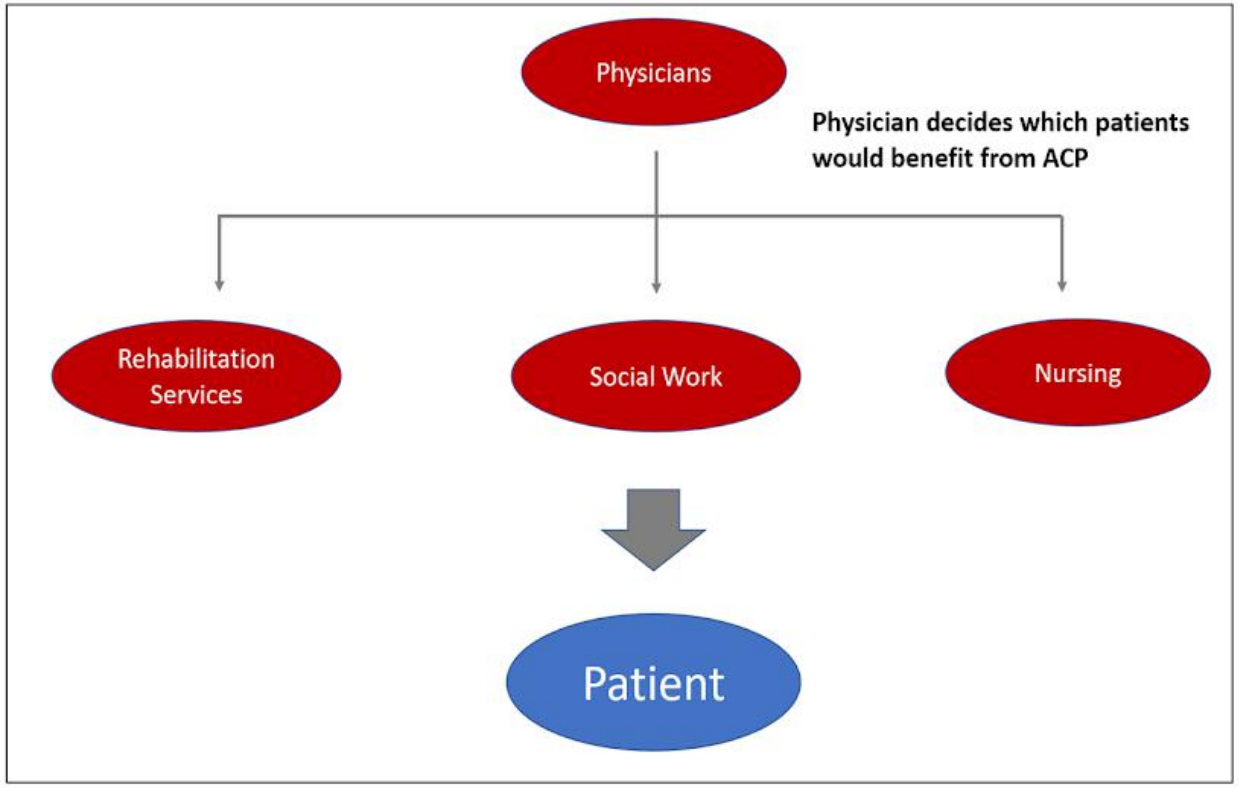
How does AI enable the solution?

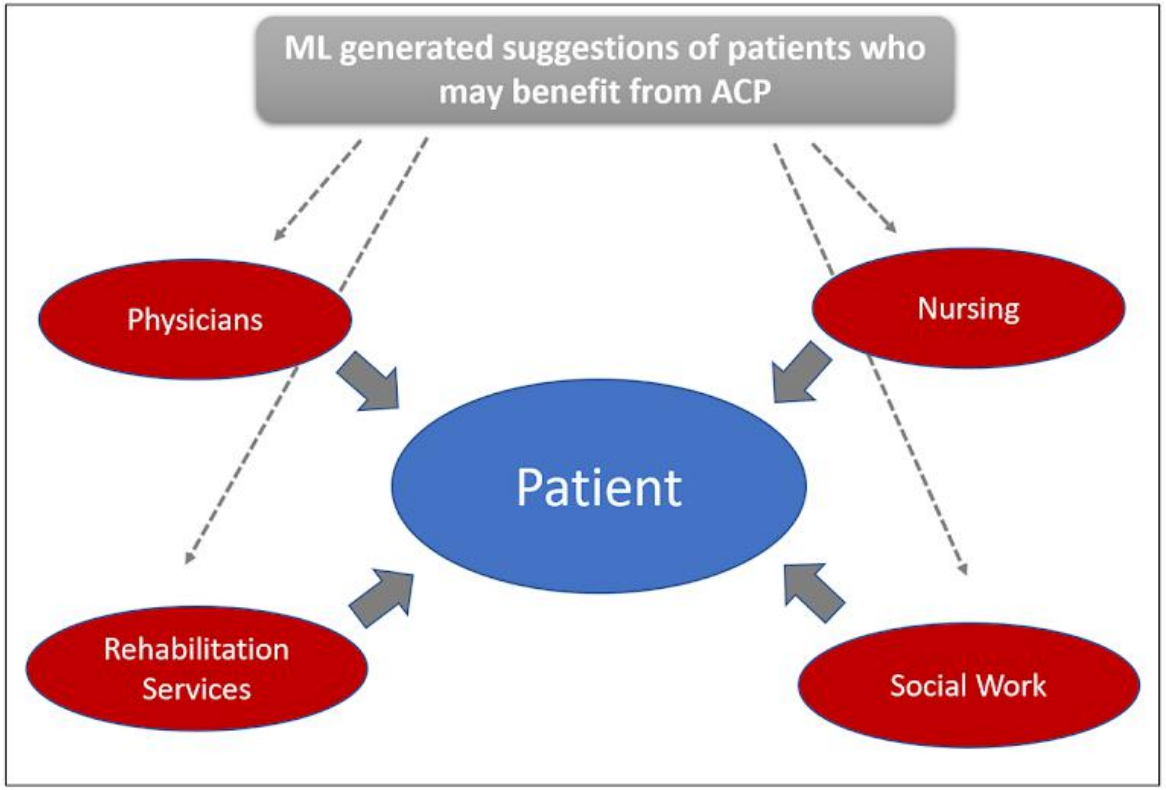
Automated list of ACP candidates generated by a ML model predicting 12-month mortality on all admitted patients



# AI Enabled Advanced Care Planning

**AI can enable new workflows and structures for ACP to be multidisciplinary**



# How do we build our capacity to create AI enabled systems?

1. Stop thinking of AI as the solution but rather an enabler of an intelligent care delivery system

2. Expand our improvement lens on all quality improvement projects to include prediction and classification

3. Streamline the model selection, validation and integration process so that it can occur iteratively in parallel with problem solving and workflow design activities

# THANK YOU

QUESTIONS?

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