

## Our Speakers



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# Stanford MEDICINE

## Building AI-Enabled Systems for Patient Care at Stanford

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Margaret Smith, MBA & Ron Li, MD

# GOALS FOR TODAY'S LECTURE

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

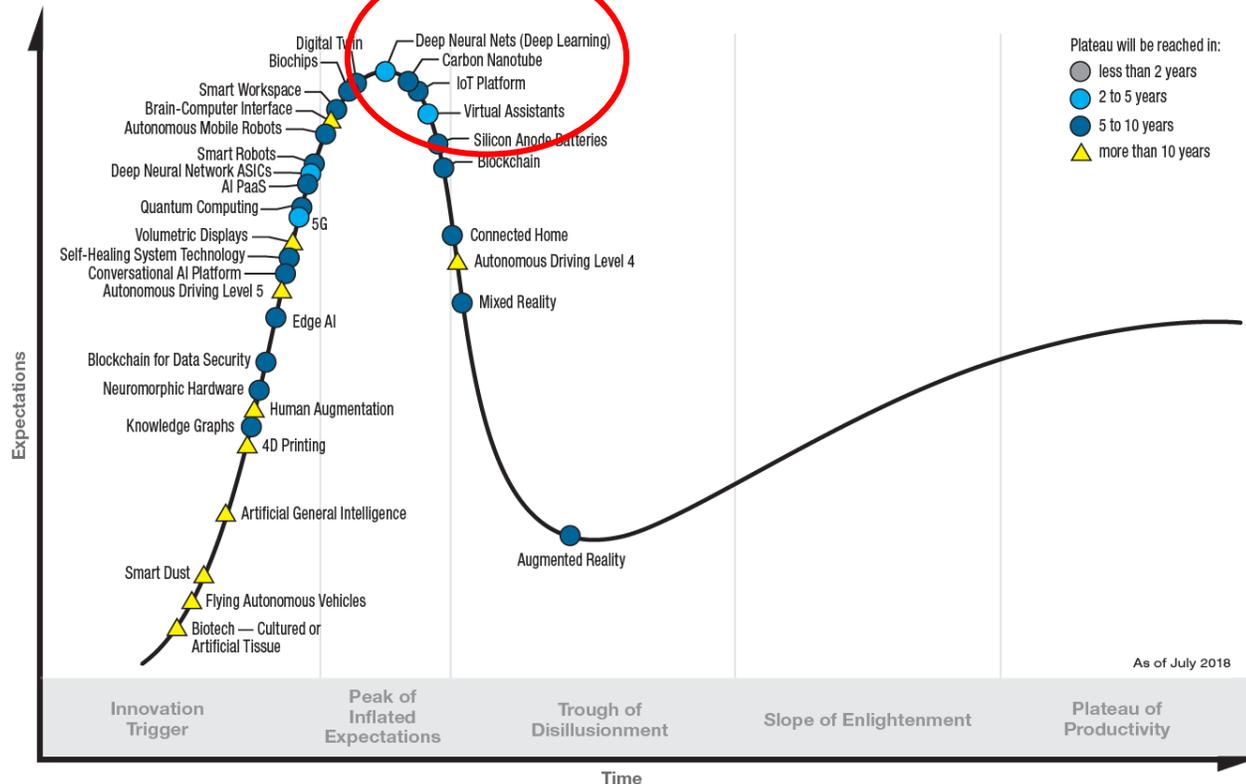
## **Our goal today is to:**

- 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



# AI is at a critical inflection point

## Hype Cycle for Emerging Technologies, 2018



“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.”

[gartner.com/SmarterWithGartner](https://gartner.com/SmarterWithGartner)

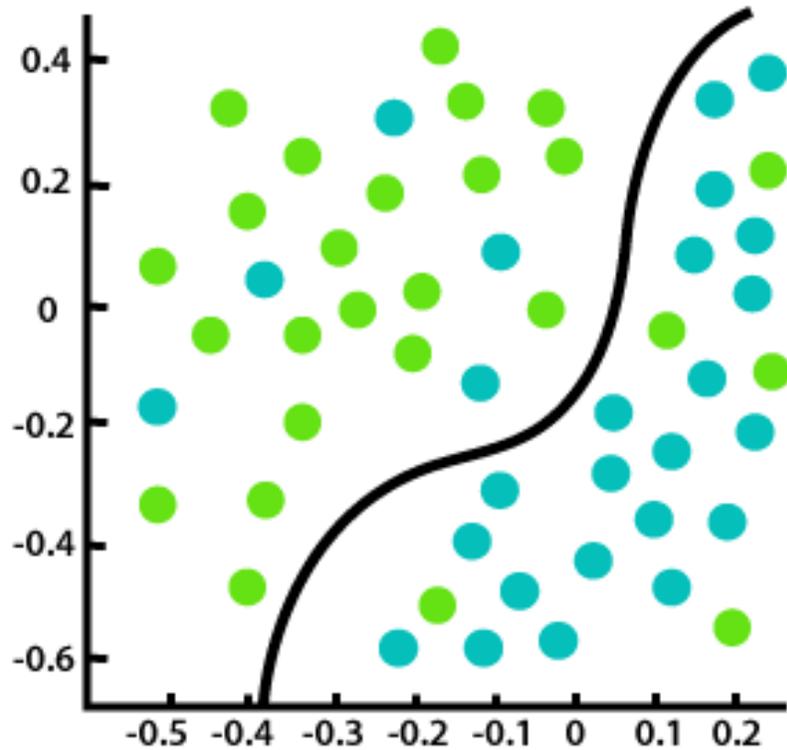
Source: Gartner (August 2018)  
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**Gartner**

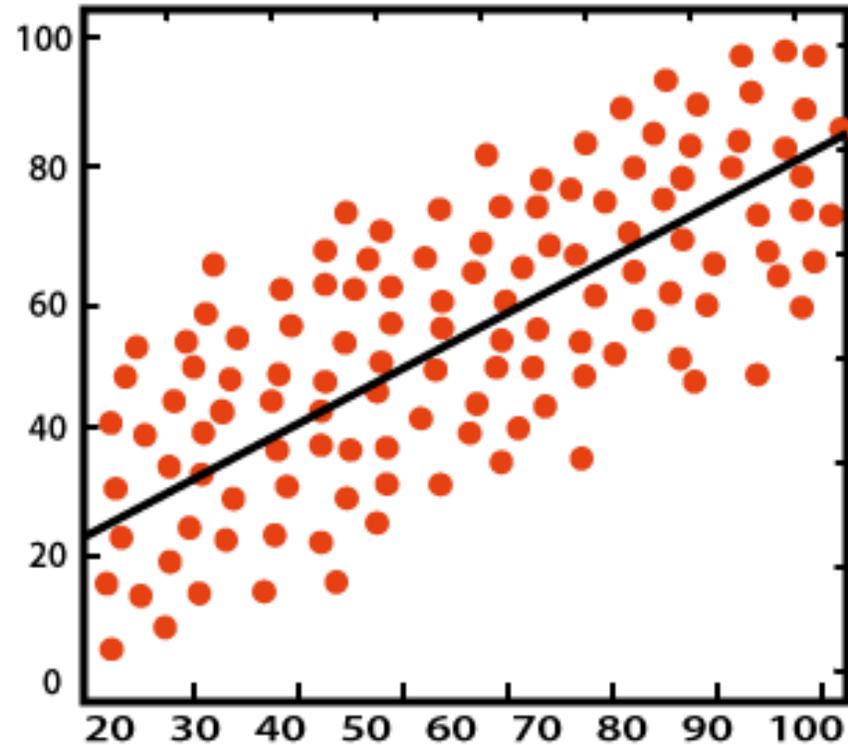
Chen, J. H. & Asch, S. M. Machine Learning and Prediction in Medicine — Beyond the Peak of Inflated Expectations. *N. Engl. J. Med.* **376**, 2507–2509 (2017).

# What are tasks that AI can perform?

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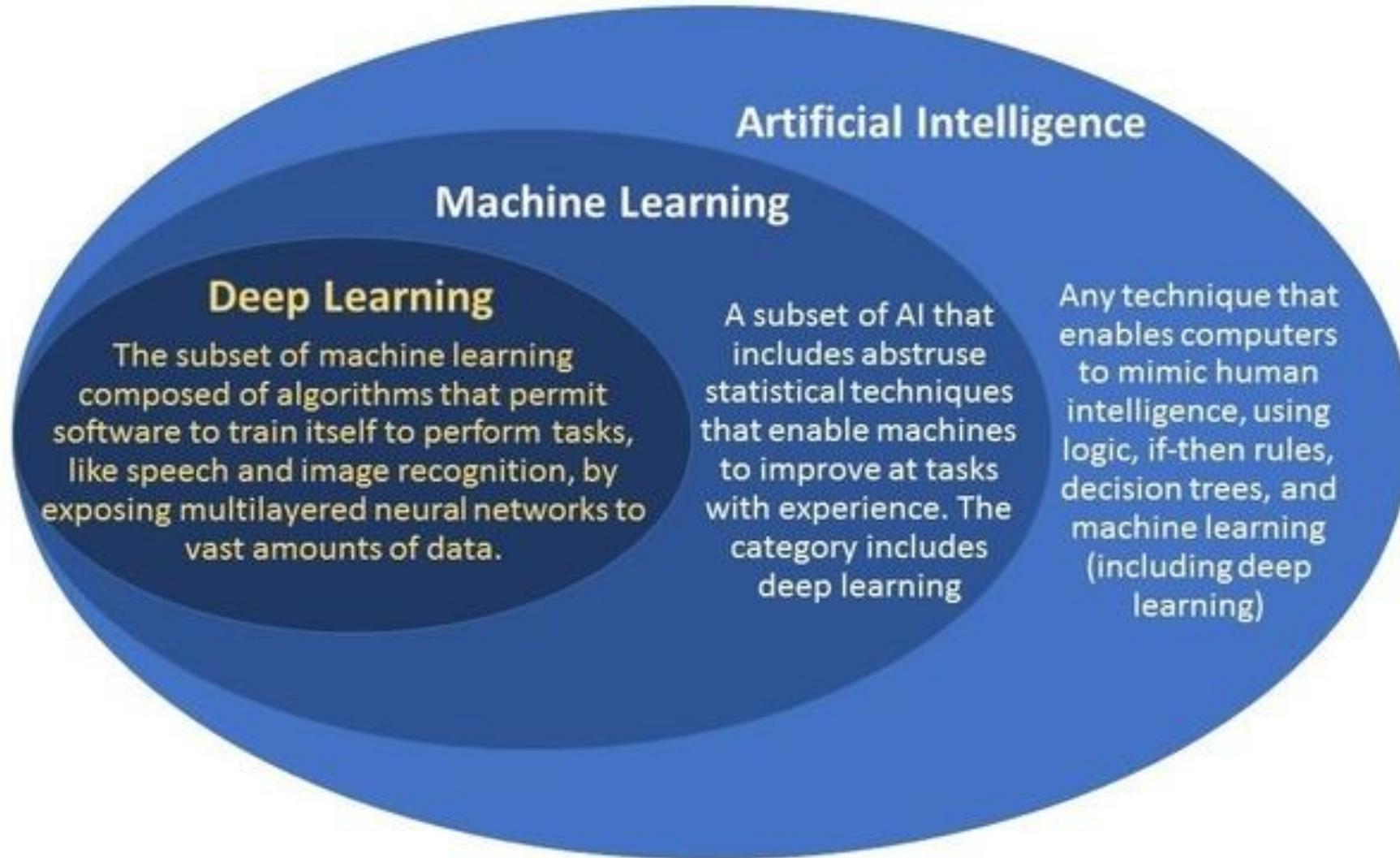
Classification



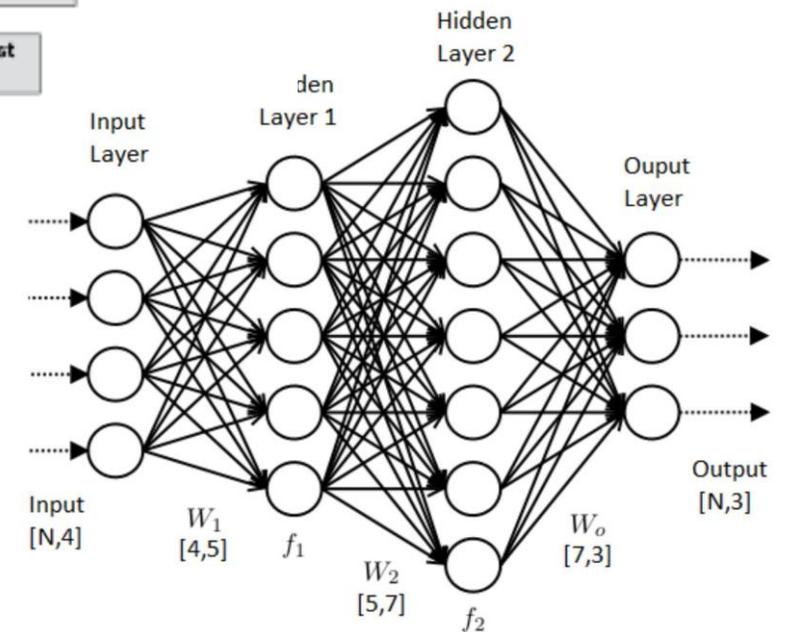
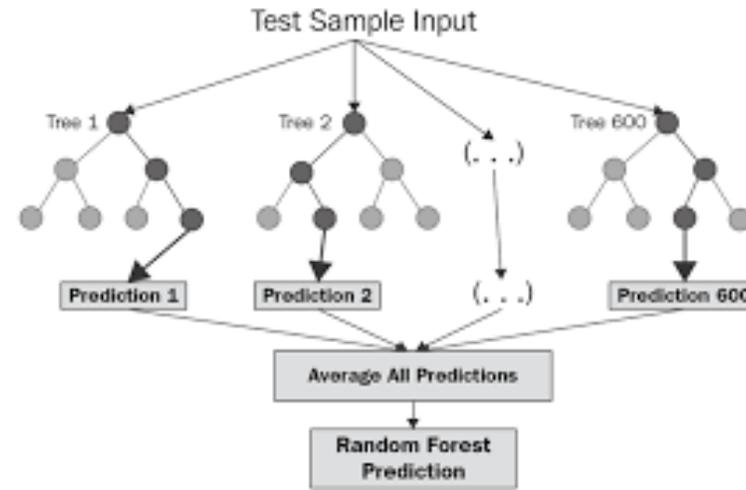
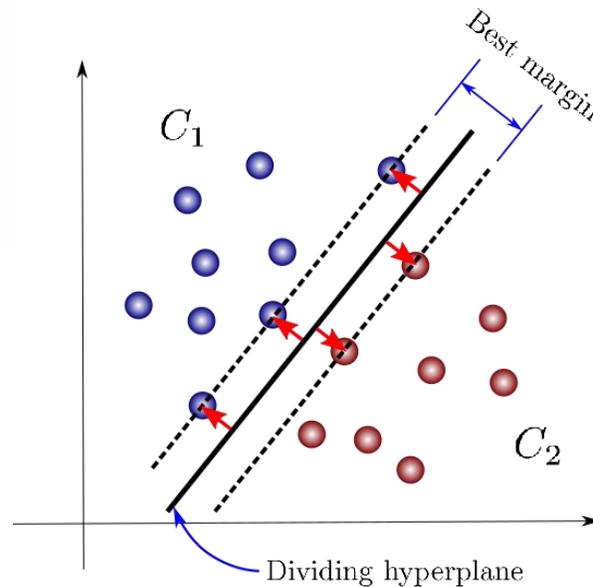
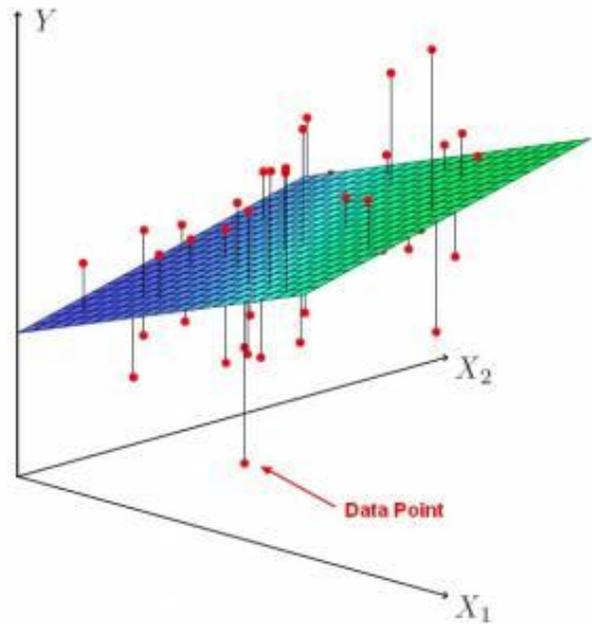
Regression

# What is the difference between AI and machine learning?

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



# Prediction models are not new to medicine

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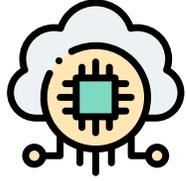
Example:

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

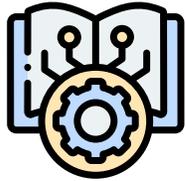
$$MELD = 3.8 * \log_e(\text{serum bilirubin [mg/dL]}) + 11.2 * \log_e(INR) + 9.6 * \log_e(\text{serum creatinine [mg/dL]}) + 6.4$$

# Then why all the hype now?

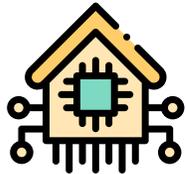
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1. More data and computing power available



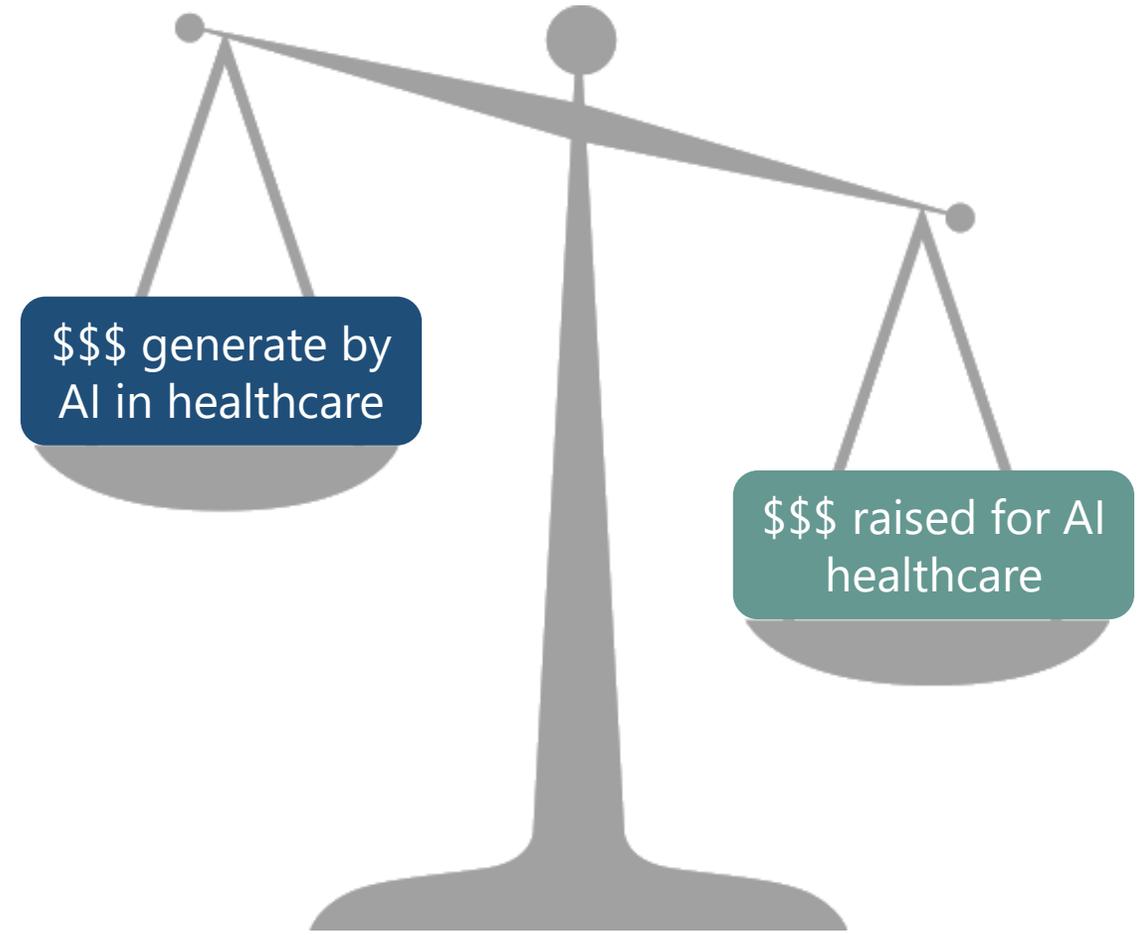
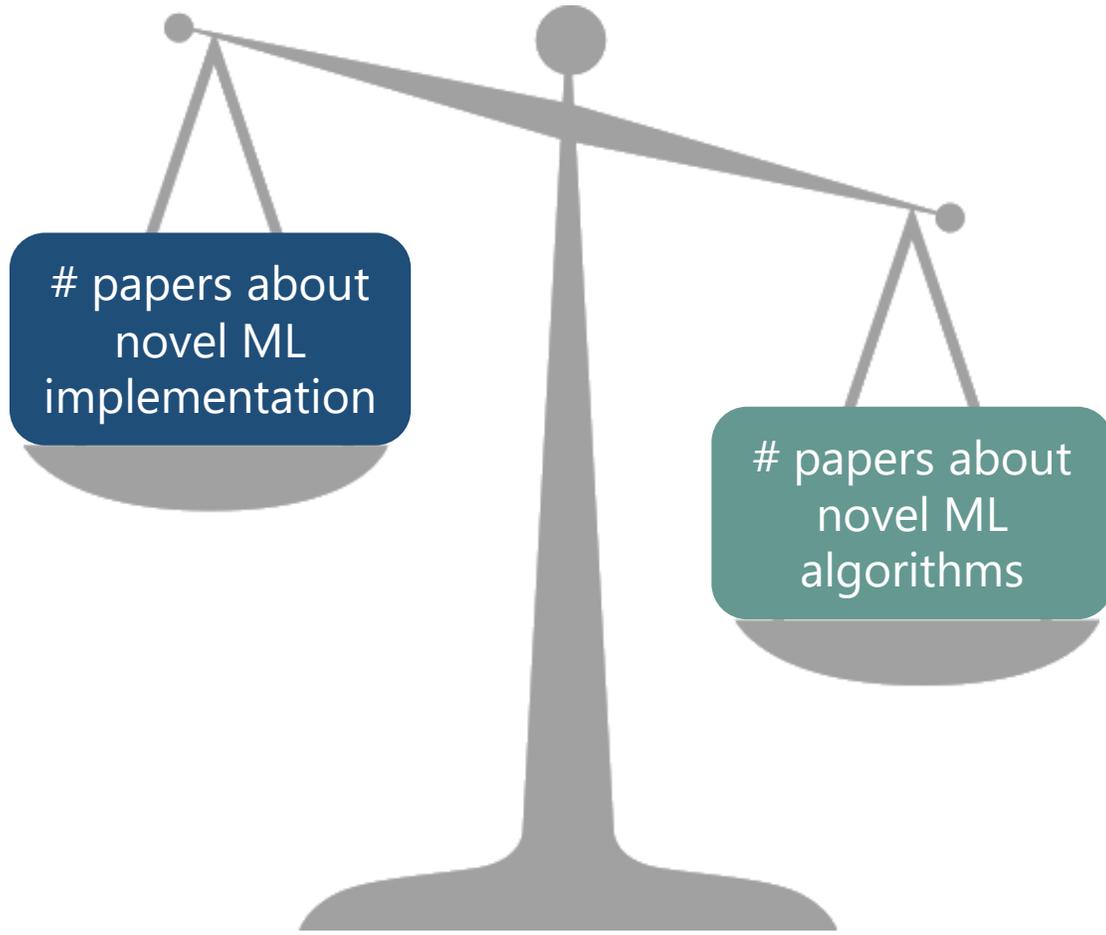
2. Learning algorithms enable the creation of more accurate models



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

# Then, why are we not seeing the impact?

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# Paradigm Shift

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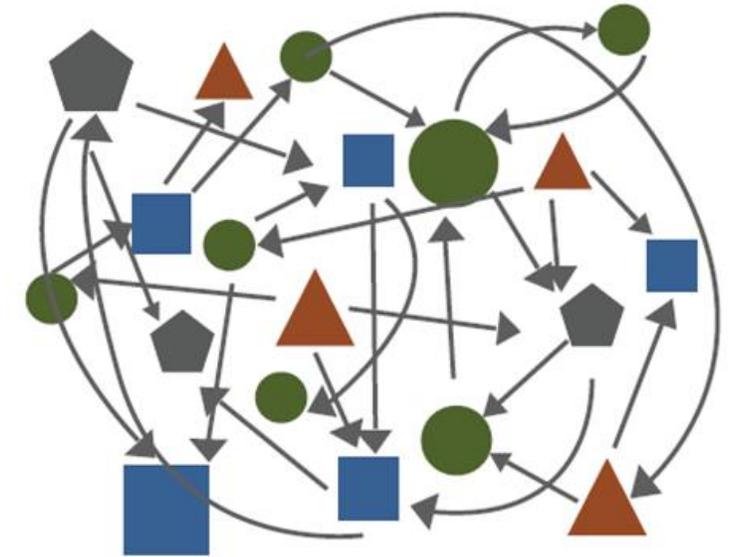
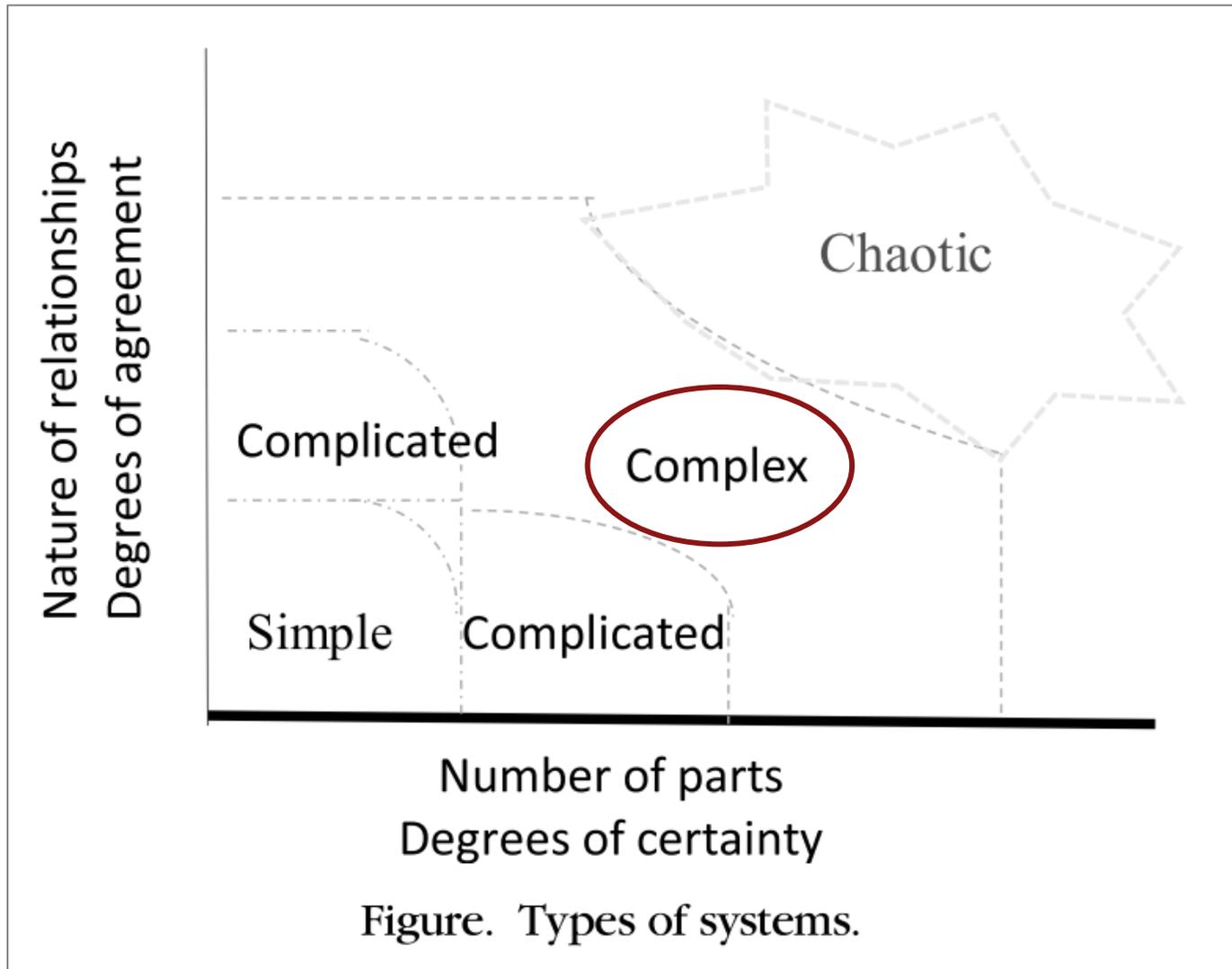
## **From...**

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...



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

# 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.

COMMENT OPEN



# Developing a delivery science for artificial intelligence in healthcare

Ron C. Li <sup>1,2</sup>✉, Steven M. Asch <sup>3,4</sup> and Nigam H. Shah<sup>2</sup>

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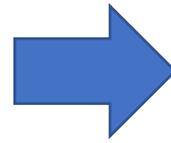
“To address how AI can be leveraged at scale, we need to both broaden and deepen our thinking around **how AI fits into the complexities of healthcare delivery.**”

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

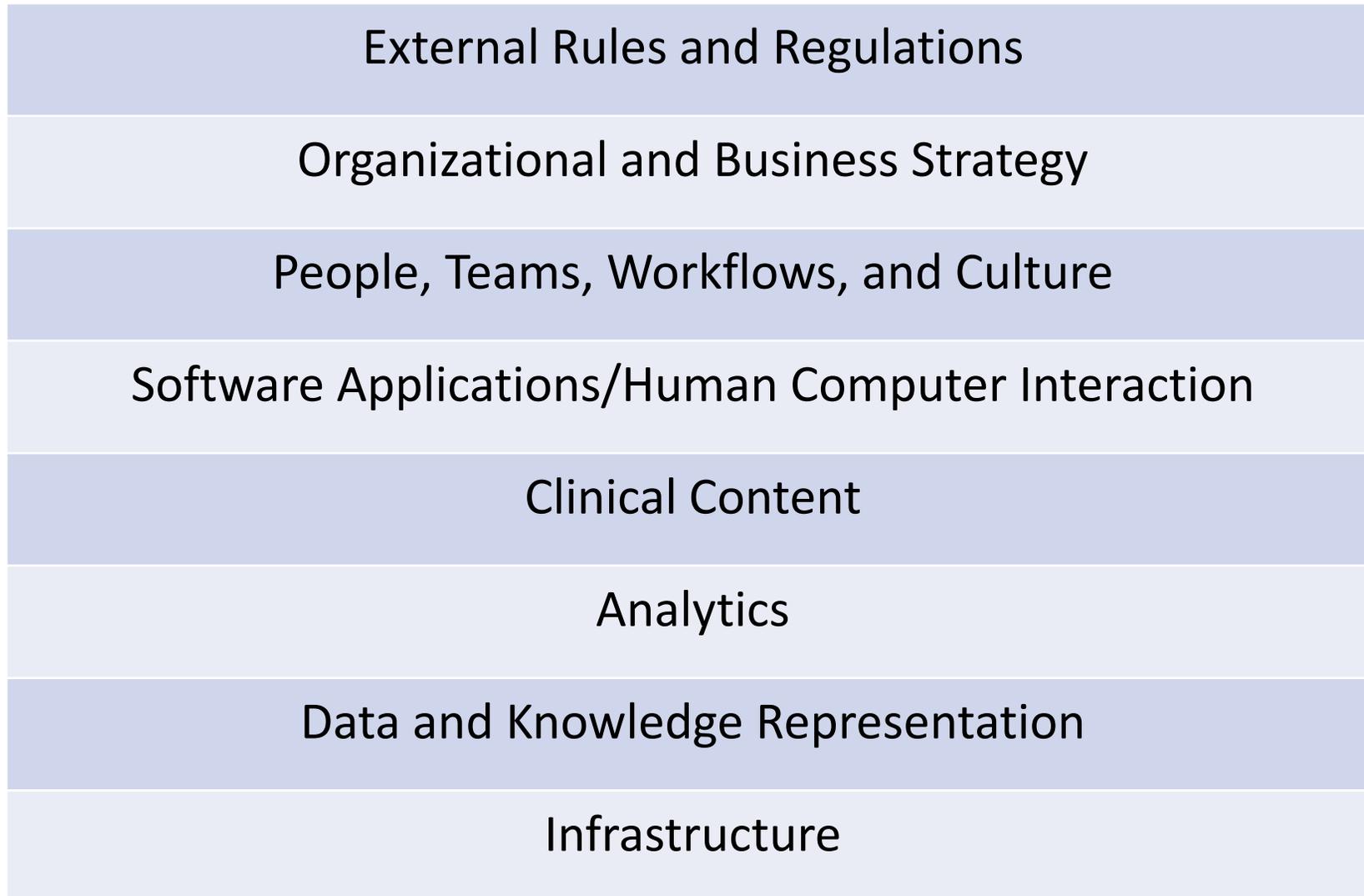
# Create systems enabled by AI

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Machine learning model(s)



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

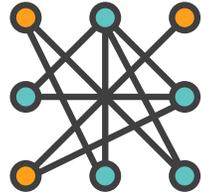


**Building and implementing AI systems require the synthesis of multiple disciplines**

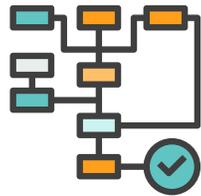
Adapted from Sittig and Dean et al and Nguyen "Health IT Stack"

# How can we create systems enabled by AI?

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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

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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

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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

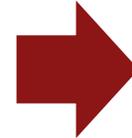
# AI Enabled Clinical Deterioration Prevention



How does AI enable the solution?

Model is looking at 20+ clinical indicators in EPIC

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)

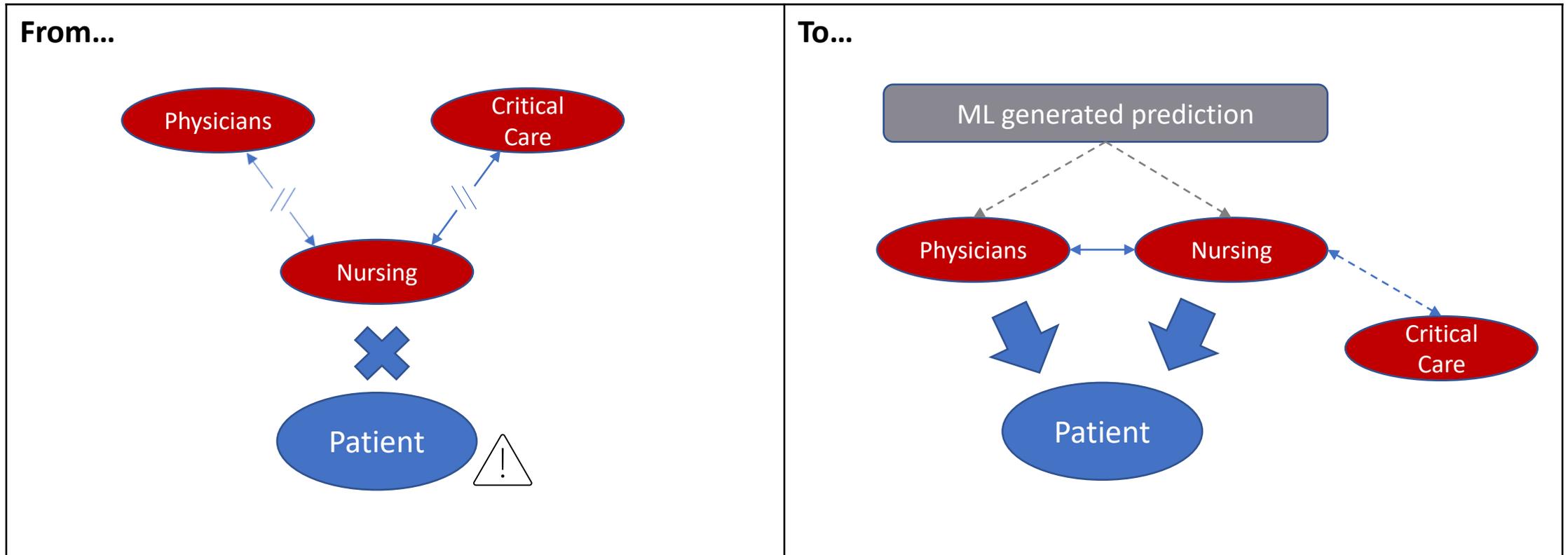


**Flags patients with a 1/5 chance of ICU Escalation, RRT or Code in the next 6-18 hours.**

*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**



# AI Enabled Advanced Care Planning

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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

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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

A screenshot of an Outlook email interface. The browser address bar shows a URL from outlook.office.com. The email header indicates it is a secure message titled "ACP List (Team D) 03-22-20" from "AI-Enabled Advance Care Planning <ai-acp@cs.stanford.edu>". The body of the email addresses "Dr. Li" and provides a list of patients for discussion. The patient list is a table with columns for Name, MRN, Age, Admit Date, Unit, and Bed. The content of the table is redacted with black bars. The email concludes with instructions to fill out an "Advance Care Planning Smartform" in Epic and a thank you from the AI-Enabled ACP Team. A footer note states the message was encrypted in transit via the Stanford Secure Email service.

Secure: ACP List (Team D) 03-22-20

**A** AI-Enabled Advance Care Planning <ai-acp@cs.stanford.edu>  
Sun 3/22/2020 7:05 AM  
To: Ron Li

Dear Dr. Li,

Please consider discussing prognosis with the following patients on C3 and M7:

Name	MRN	Age	Admit Date	Unit	Bed
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

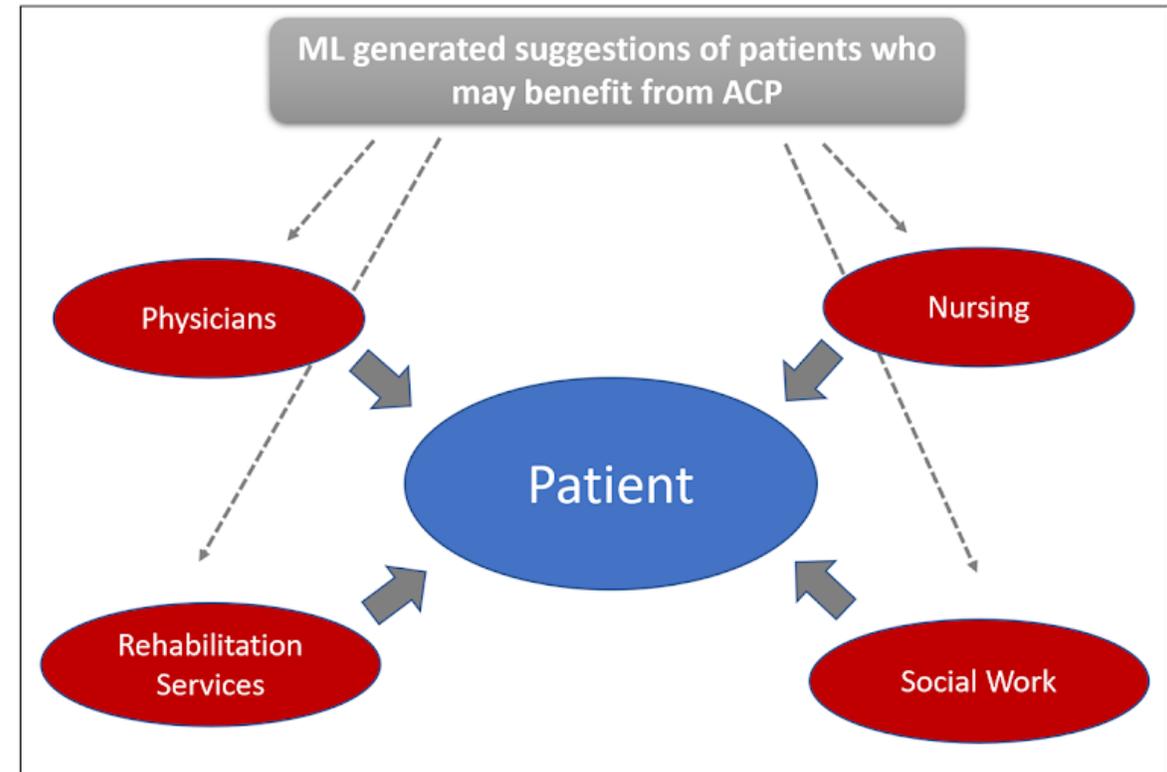
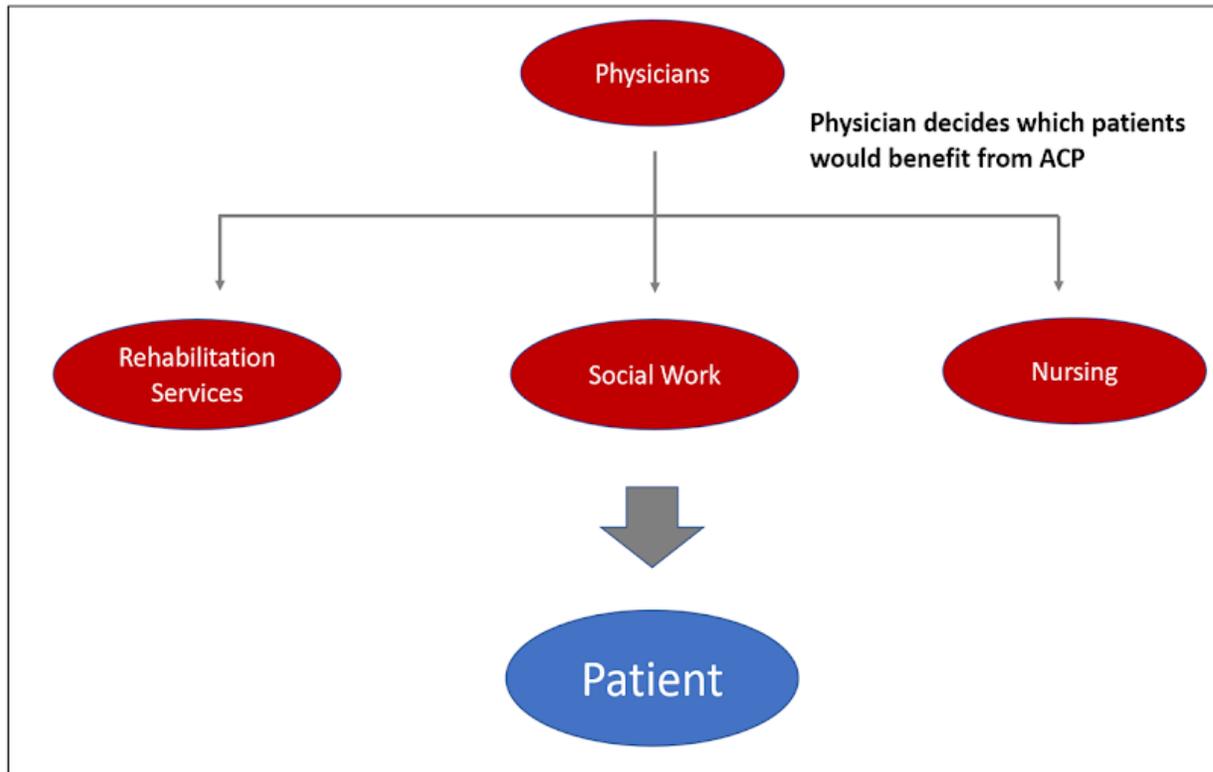
If prognosis is shared, please fill out the "Advance Care Planning Smartform" under the "Goals of Care" tab in Epic. Nursing, Social Work, and PT/OT will be available to help continue an advance care planning discussion.

Thank you,  
AI-Enabled ACP Team.

This message was encrypted in transit via the Stanford Secure Email service.

# 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?

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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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