

# Advancing Artificial Intelligence and Machine Learning for the Future of Primary Care and Population Health



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Section Chief, General Primary Care

Vice Chief, Technology Innovation

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Division of Primary Care and Population Health

Stanford University School of Medicine





# What is Missing in Healthcare AI/ML Today?

Only 3% of FDA approved AI/ML tools is intended for primary care, and 1% of AI/ML research funding goes to primary care

90% of AI/ML models never make it to production, and 97% of FDA approved AI/ML tools never undergo prospective evaluation

AI/ML activity is concentrated in a short list of affluent academic centers, and community engagement is little to non-existent



# How can a Research Team Address These Gaps?

Develop effective  
cross-sectoral  
collaborations

Engage in the  
implementation  
science of AI/ML

Partner in AI/ML  
policy and health  
equity work



# Stanford Healthcare AI Applied Research Team

## Staff



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Director of Operations



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Research Associate



**Trevor Crowell**  
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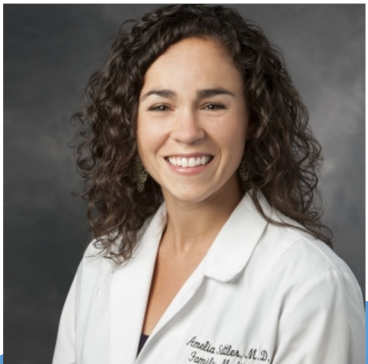


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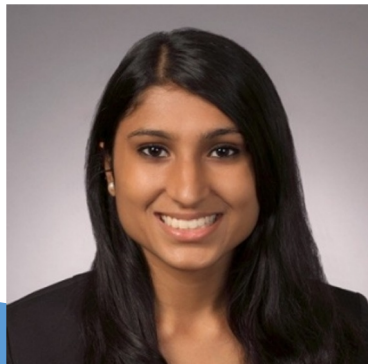


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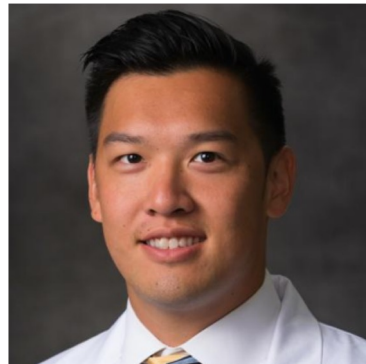
## Faculty



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**Julie Lee**  
Clinical Informatics

# HEART

Stanford Healthcare AI Applied Research Team

## Clinical Decision Making

Dermatology in Primary Care      Autoimmune Disease      Behavioral Health

## Population Health Management

Remote Patient Monitoring      Hypertension & Heart Failure      Stress Sensing

## Value Based Care

Predicting ED/Hospitalizations      Digital Care Coordinator      Care Gap Voice Assistant

## Transitions of Care

Predicting Clinical Deterioration in Hospitals      Advance Care Planning

## Care Team Burnout

Automating Clinical Documentation      Message Categorization      Message Auto Reply

## Health Policy, Education and Development

Equity & Governance      Advocacy & Education      Research Capacity Building



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Santa Clara Family Health Plan

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BMIR Stanford Center for Biomedical Informatics Research

CONNECTING DATA TO HEALTH

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AAFP SOCIETY OF TEACHERS OF FAMILY MEDICINE

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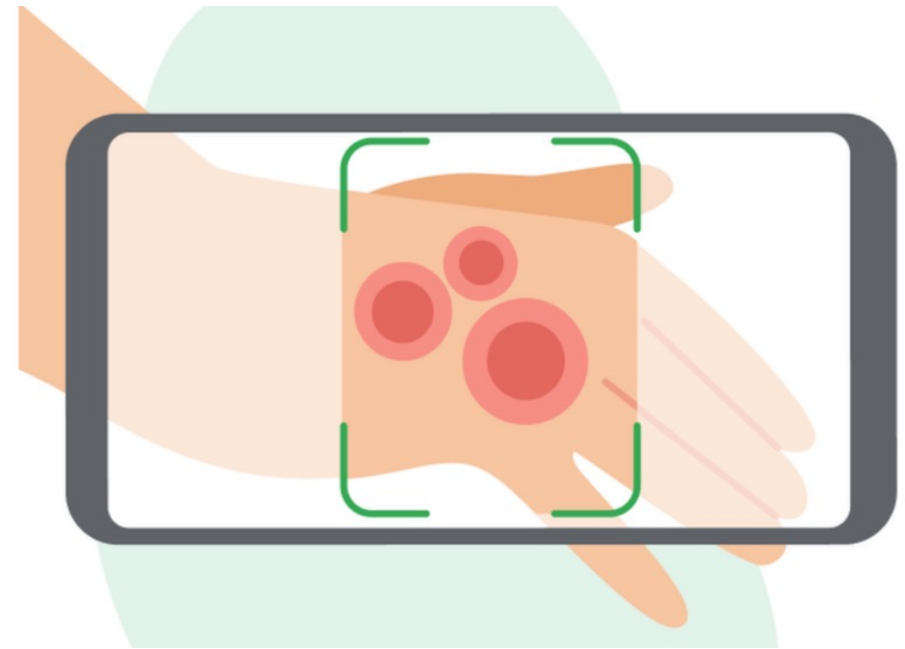

American Board of Family Medicine

GORDON AND BETTY MOORE FOUNDATION

Research Capacity Building

# Improving Access to Skin Disease Diagnosis

- **Problem:** Primary care providers manage 70% of skin cases, and access to dermatology is lacking in many community settings
- **What's been done:** AI is non-inferior to dermatologists, and can improve PCP diagnoses
- **What we're doing:** Testing the AI's feasibility, acceptability, and performance in the community

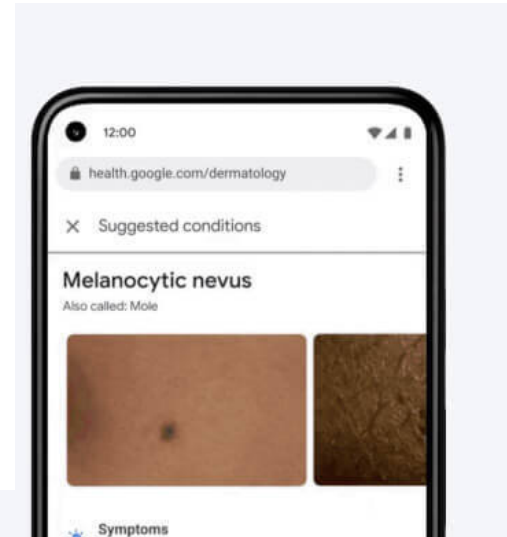






# A deep learning system for differential diagnosis of skin diseases

AI built using 16K cases can distinguish between 419 skin conditions, and is non-inferior to dermatologists and superior to PCPs on 963 validation cases



JAMA Network | **Open**<sup>™</sup>

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Original Investigation | Dermatology

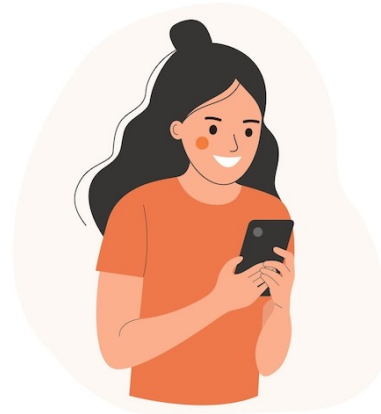
## Development and Assessment of an Artificial Intelligence–Based Tool for Skin Condition Diagnosis by Primary Care Physicians and Nurse Practitioners in Teledermatology Practices

AI was associated with improved PCP diagnoses for 1 in every 8-10 validation cases





Enrolled **110**  
diverse community  
participants across  
4 health fairs



**73%** of participants  
were extremely or  
very satisfied with  
the app



Clinicians: app was  
concordant with their  
own assessments in  
**86%** of cases





Merging **research**, **product development** and **community service** into a single pursuit may help bridge the gap between academia, industry and community in AI/ML science, innovation and equity





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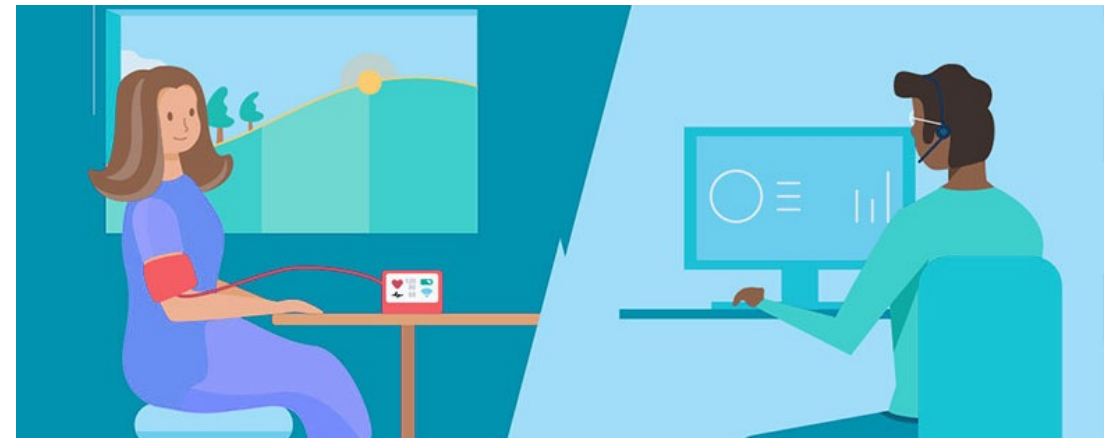

Advocacy & Education




Research Capacity Building

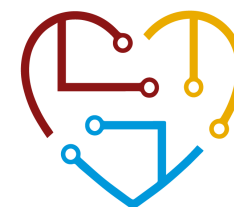
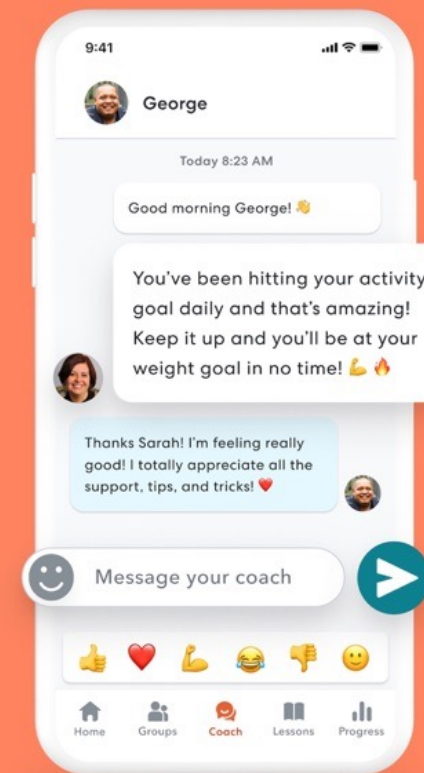
# Improving Chronic Care With Remote Monitoring

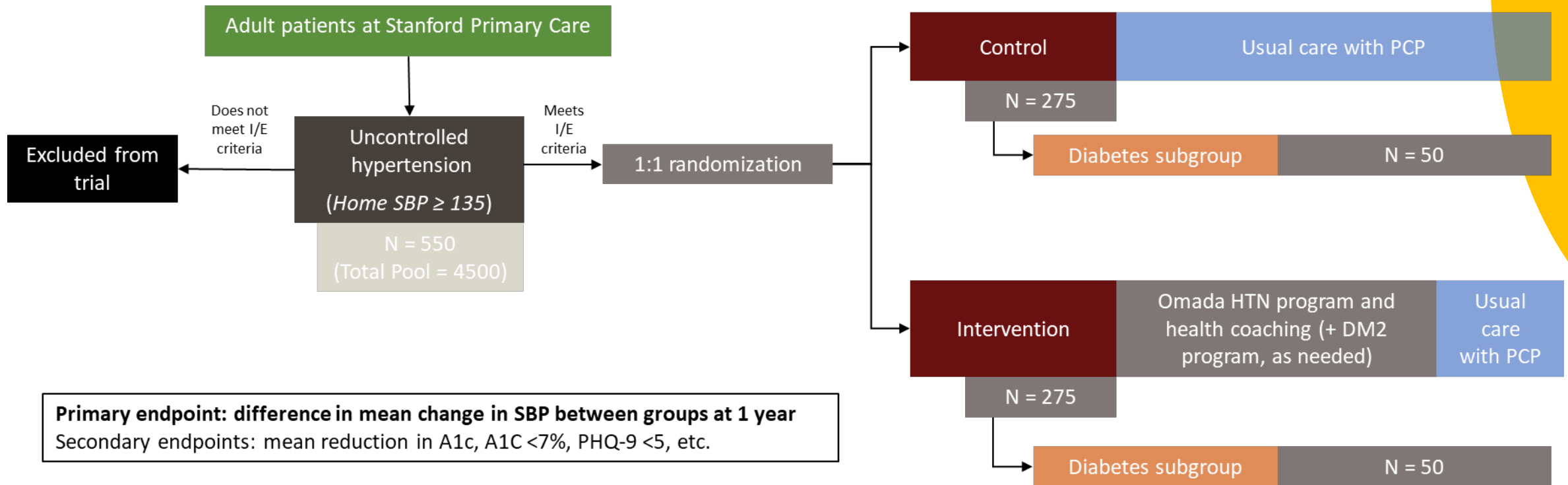
- **Problem:** Episodic visits are not sufficient for controlling chronic diseases at the population level
- **What's been done:** AI-assisted RPM is promising, but evidence is inadequate and RPM vendors operate outside health systems
- **What we're doing:** Testing an AI-assisted RPM program vs usual care for HTN in a pragmatic RCT





Connect with your coach via direct messaging.





- Recruitment integrated into population health outreach
- Completely remote patient enrollment process and trial
- Unique funding, hybrid research-implementation model





Reached out to  
**11,000+** patients  
via patient portal  
and text messages



Collected and  
entered **1,500+**  
BP readings into  
EHR for pop health



Enrolled **250**  
patients in fully  
remote fashion





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# Predicting Preventable ED Visits/Hospitalizations

- **Problem:** Avoidable ED visits and hospitalizations are a serious source of human suffering and economic pain (\$100B per year)
- **What's been done:** AI can predict ambulatory care sensitive and all-cause ED visits/hospitalizations
- **What we're doing:** Testing the AI's feasibility, acceptability, and performance in a VBC program



**Current state** (retrospective, relying largely on claims)



## Predicting Avoidable Health Care Utilization: Practical Considerations for Artificial Intelligence/Machine Learning Models in Population Health

AI built using 7 years of EHR data on 70K unique patients including both inpatient and outpatient encounters with 1600 providers can predict ED visits/hospitalizations for all-cause and 5 ACS conditions



Aggregate risk

Major Diagnoses



Risk evolution

Risk relative to population

Care gaps and recommendations





All Patients

Patients 500

Metrics

High Utilizers (25th Percentile) 125

5 or More Recommendations 45

Less Than 5 Recommendations 80

Not Engaged with Care 60

Metrics

Not Engaged with Care 80

Rising Risk 60

High Utilization 60

Metrics

NL

Not Engaged w

60 All Patients

Schedule Appointment

PATIENT ↑

Margaret Bauch

Dianna Beahan

Terrell Grady

Candice Leuschke

Kirk Marvin

Peter Nienow

Craig Reynolds III

Harold Rippin

Jason Stracke

Brent Thiel

Condition

Heart Failure Diabetes Hypertension

CKD Asthma COPD

ED Visits (1Y)

- 0 47,855
- 1-2 9,852
- 3+ 5,544

PCP Visits (1Y)

- Yes 43,193
- No 20,058

Risk Score

- Top Decile 6,325
- Rising Risk 15,813

Cost

- Top Decile 6,325
- Top Quartile 15,813

Care Gaps

- 0 8,091
- 1-4 28,910
- 5+ 26,520

Payer

Select...

PCP

Select...

Clinic

Select...

Metrics

Patient List

Time Period 1 year prior to October 2019

Total Patients



2,062 ↑ 13% WITH ACSC

3,829 ↑ 15% NO ACSC

ED Visits

TYPE	AMOUNT	TREND
Total Visits	1,434	↑ 21%
With ACSC	875	↑ 23%
Low Acuity	316	↑ 4%
Followed by In-Patient Admission	229	↑ 13%
PCP Follow-Up within 7d	129	↑ 7%

Hospital Admissions

TYPE	AMOUNT	TREND
Total Admissions	463	↑ 25%
With ACSC	387	↑ 19%
No ACSC	76	↑ 4%

TYPE	AMOUNT	TREND
Total Readmissions	168	↑ 25%
Readmissions with ACSC	156	↑ 19%
Readmissions No ACSC	12	↑ 4%

Utilization Metrics

TYPE	AMOUNT	TREND
Specialist Visits	69,165	↑ 4%
PCP Visits	19,802	↑ 2%
Telehealth Visits	18,185	↑ 12%
Messages	4,108	↑ 59.0%
Phone Calls	961	↑ 53%

GDMT Care Gaps

TYPE	AMOUNT
Median Care Gaps per Patient	8
Patients with any Care Gaps	73%
Patients with Studies Care Gaps	9%
Patients with Procedure Care Gaps	9%
Patients with Medication Care Gaps	9%





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# Improving Advance Care Planning Conversations

- **Problem:** Most people say they have wishes regarding end-of-life care, yet only 1 in 3 adults has an advance care plan
- **What's been done:** AI accurately predicts patient mortality
- **What we're doing:** Evaluating an AI-enabled workflow to improve rates of ACP conversations for inpatients and outpatients



A Patient Name/Age/Gender ▲	Recommended for Advance Care Planning
[Blurred Patient Name]	—
[Blurred Patient Name]	
[Blurred Patient Name]	
[Blurred Patient Name]	

**Recommend**

Document Advance Care Planning - double click to complete the Serious Illness Conversation Guide

### Serious Illness Conversation Guide

**SETUP** I'd like to talk about what is ahead with your illness and do some thinking in advance about what is important to you so that I can make sure we provide you with the care you want. **Is that okay?**

**ASSESS** What is your **understanding** now of where you are with your illness?  
How much **information** about what is likely ahead with your illness would you like from me?

**SHARE PROGNOSIS** I want to share with you my **understanding** of where things are with your illness.  
**Uncertain:** It can be difficult to predict what will happen with your illness. I **hope** you will continue to live well for a long time, but I'm worried that you could get sick quickly, and I think it is important to prepare for that possibility.

**OR**  
**Time:** I wish we were not in this situation, but I'm **worried** that time may be as short as \_\_\_\_ (express as a range, e.g. days to weeks, weeks to months, months to a year).

**OR**  
**Function:** I hope that this is not the case, but I'm **worried** that this may be as strong as you will feel, and things are likely to get more difficult.

**EXPLORE** What are your most important **goals** if your health situation worsens?  
What are your biggest **fears and worries** about the future with your health?  
What gives you **strength** as you think about the future with your illness?  
What **abilities** are so critical to your life that you can't imagine living without them?  
If you become sicker, **how much are you willing to go through** for the possibility of gaining more time?  
How much do your **loved ones** know about your priorities and wishes?

**CLOSE** I've heard you say \_\_\_\_\_. Keeping that in mind, and what we know about your illness, I **recommend** that we \_\_\_\_\_. This will help us make sure that your treatment plans reflect what's important to you.  
How does this plan seem to you? **We will do everything we can** to help you through this.

**Handoff** **To colleague:** "I talked with the patient about \_\_\_\_\_. I learned \_\_\_\_\_. I think they would benefit from talking with you about \_\_\_\_\_."

- Implemented for >11K patients admitted to the general medicine inpatient service
- AI flagged patients in the top 25<sup>th</sup> percentile of predicted 12-month mortality
- >2,600 patients flagged by the AI as candidates for ACP (22% of total encounters)







Catalyst

Innovations in Care Delivery

CASE STUDY

# Using AI to Empower Collaborative Team Workflows: Two Implementations for Advance Care Planning and Care Escalation



SMARTER HEALTH



47:21

## Smarter health: The ethics of AI in health care



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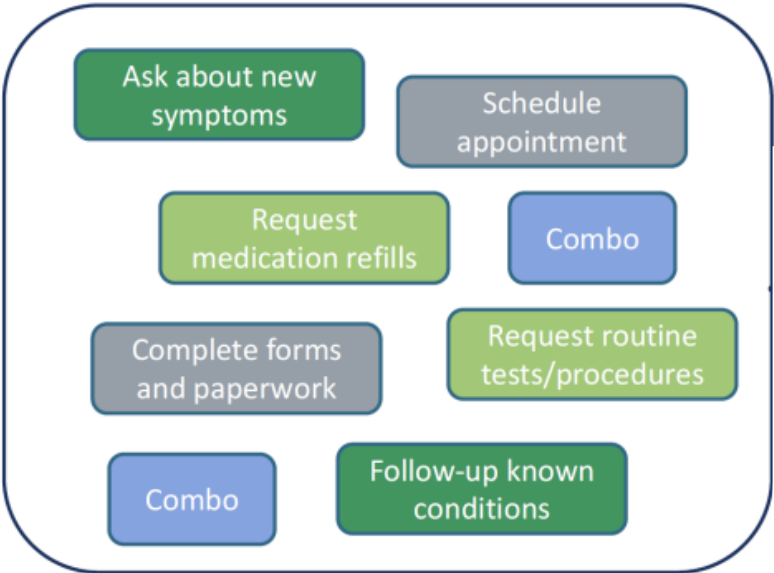
Advocacy & Education

Research Capacity Building

# Reimagining EHR In-Baskets and Patient Messages

- **Problem:** EHR in-basket work by PCPs requires an extra 1-2 hours per day, leading to burnout
- **What's been done:** AI can read patient messages and predict the actions needed to resolve them
- **What we're doing:** Testing the AI's ability to categorize patient messages and automate in-basket tasks to reduce burnout



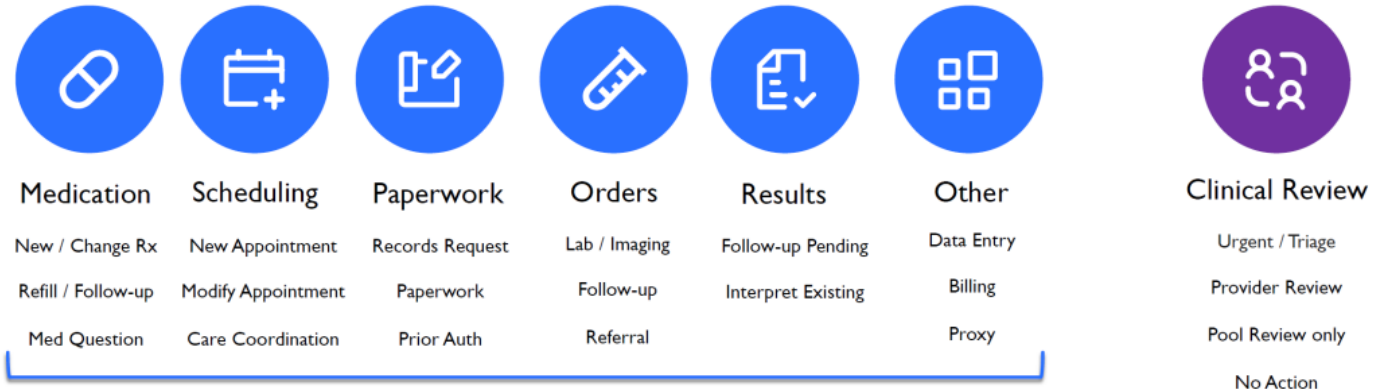


Pool of patient messages, unsorted and untriaged

## AI built on 2M messages

Customized to SHC Patient Population

Performance Tested on 1,500 Messages labeled by SHC Providers



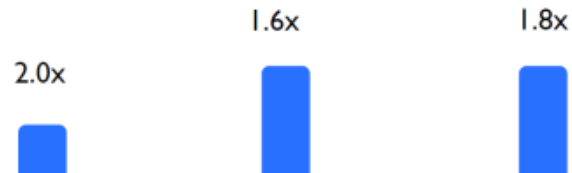
### Work Type

"What actions need to be taken to resolve this message?"

"Clinical Judgement/context is needed to determine the actions to resolve this message"



# AI CATEGORIZATION OUTPERFORMS PATIENT DROP DOWN CATEGORIZATION



AI categorization of patient messages outperforms patient self-categorization and achieves a level of accuracy that enables automation of routing

Clinical Medication Scheduling Resu

% of Messages Routed Correctly  
(Sensitivity)

Categorization	AUC	Sensitivity	Specificity
Clinical Symptom	.93	.86	.86
Medication All	.95	.89	.89
		.89	
		.88	
		.86	
		.78	
		.88	
Orders All (labs, imaging, follow-up)	.90	.84	.83
Paperwork	.90	.82	.86
Referral	.96	.89	.90
Pool All	.93	.88	.89
Pool No Action	.98	.92	.92
Proxy	.99	.97	.97



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# Using AI to Draft Replies to Patient Messages

- **Problem:** COVID-19 hastened the adoption of virtual care resulting in 1.6-fold increase in electronic patient messages
- **What's been done:** AI chatbots can draft replies to messages with human-quality text
- **What we're doing:** Testing a ChatGPT-powered Epic “draft auto-reply” feature with PCPs



✉ Non-urgent Medical Question

Received: Yesterday

Jongus, Junebug → P Sim West Myhealth Clinic Messaging

Phone Number: 555-444-7777

When should I get a COVID-19 booster shot? I just got my first vaccine dose yesterday.

 **Generated Draft Reply**

Pioneering Feature

Dear Junebug Jongus,

I hope you're doing well. It's great to hear that you received your first COVID-19 vaccine dose yesterday. As for the booster shot, the timing depends on which vaccine you received.

If you received the Pfizer-BioNTech or Moderna vaccine, you should get your second dose 3-4 weeks after your first dose. If you received the Johnson & Johnson vaccine, a booster shot is not required at this time.

Please feel free to reach out if you have any further questions or concerns. We're here to help.


Take care and stay safe!

Best regards,

Test Provider  
Stanford Internal Medicine - West  
650-498-9000

 [Learn more](#)

 Start with Draft

 Start Blank Reply

Did you find the draft reply helpful?



This was helpful



This was not helpful





# LLM Draft Replies Pilot Study: A developmental assessment for quality improvement (QI) purposes leveraging the RE-AIM evaluation framework for AI (GPT4) generated draft replies for patient messages

Enrolled 206 users in Primary Care and GI including frontline providers (MDs/APPs), RNs, and clinical pharmacists



Analysis performed on 80 providers for whom we have both pre- and post- surveys



## Patient Messaging Burden Index Score (NASA-TLX) Pre-Post Analysis

Specialty	Role	Pre	Post	P-value	N
Primary Care	Physician + APP	61.5	50.625	0.001	36
	Nurse	58.25	49.75	0.418	5
	Clinical Pharmacist	62.75	37.5	0.035	7
Gastroenterology	Physician + APP	66.875	48.125	0.002	22
	Nurse	64.375	49.5	0.014	10

Statistically significant **reductions in perceived mental workload** were observed across the majority of respondent groups when using the AI-generated draft reply tool to respond to patient messages



## Burnout & Professional Fulfillment Composite Score (PFI) Pre-Post Analysis

Specialty	Role	Pre	Post	P-value	N
Primary Care	Physician + APP	2	1.5	0.006	36
	Clinical Pharmacist	2	1.5	0.249	7
Gastroenterology	Physician + APP	1.75	1.5	0.008	22
	Nurse	1.88	1.42	0.214	10

Statistically significant **reductions in burnout** for physicians and APPs after using the AI-generated draft reply tool



# High expectations met or exceeded across usability domains

Domain	Results	P-value Range
Utility	<b>No significant change</b> across all specialties and roles, before and after use. Stakeholders <b>expressed optimism</b> about the tool's utility before implementation, and this <b>positive perception remained largely unchanged</b> after its use.	0.178 – 1.000
Time Saving	<b>No significant change</b> across all specialties and roles, before and after use. Stakeholders <b>expressed optimism</b> about the tool's ability to decrease the amount of time it takes to respond to patient messages prior to its implementation, and this <b>positive perception remained largely unchanged</b> after its use.	0.178 – 0.693
Quality	<b>Observed a significant change</b> in perception among Primary Care Physicians (PCPs)/APPs and Clinical Pharmacists. PCPs/APPs initially held some skepticism regarding the tool's ability to enhance response quality, but this <b>skepticism shifted toward a positive outlook after use</b> . Conversely, PC Clinical Pharmacists were optimistic before use, and this <b>positive perception further improved</b> .	0.022 – 0.594
Voice/Tone	<b>Observed a significant change</b> in perception among PCPs/APPs only, who initially held some skepticism regarding the tool's ability to use the appropriate voice/tone, but this <b>skepticism shifted toward a positive outlook after use</b> . Otherwise, stakeholders generally expressed neutrality and positivity both before and after use.	0.022 – 0.855
Long-Term Use	<b>Observed a significant change</b> in anticipated long-term use of the tool among <b>Primary Care Physicians/APPs</b> , before and after use. PCPs/APPs initially held some skepticism, but this <b>skepticism shifted toward a positive outlook after use</b> . <b>No significant change</b> was detected across all other groups.	0.019 – 0.856



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# Advancing Equity With Technology Governance

- **Problem:** Current governance fails to address threats to equity from emerging technologies
- **What's been done:** AI “codes of conduct” have been proposed, but are siloed and ungoverned
- **What we're doing:** Developing a unified governance framework for emerging technologies and a foundational AI code of conduct



NATIONAL  
ACADEMY  
*of* MEDICINE



# Committee on Creating a Framework for Emerging Science, Technology, and Innovation in Health and Medicine

## IMPERATIVES

- Broadening participation and sharing responsibility to empower a wider range of stakeholders
- Aligning incentives to encourage equitable decision making
- Determining how inequities develop along technology innovation life cycles and taking responsibility for mitigating them
- Crafting timely guidance for pursuing equitable ends
- Sharpening ongoing, iterative oversight and evaluation along innovation life cycles



- Funding and Research Approvals
- Researching, Developing, & Assembling a Technology
- Licensing, Investment, and Scale-Up
- Ensuring a Technology's Success

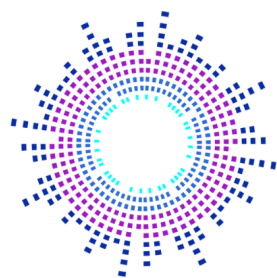
## OUTCOME

### Advancing Equitable Innovation





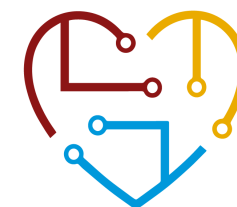




# Health Care Artificial Intelligence Code of Conduct



A 3-year project convening health, tech, research, and bioethics leaders in producing a foundational code of conduct for the development and use of AI in healthcare and health research





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Care Gap Voice Assistant

## Transitions of Care







Predicting Clinical Deterioration in Hospitals



Stanford Center for Biomedical Informatics Research  
CONNECTING DATA TO HEALTH  
Advance Care Planning


## Care Team Burnout

Automating Clinical Documentation



Message Categorization



Message Auto Reply

## Health Policy, Education and Development



Equity & Governance




Advocacy & Education




Research Capacity Building

# Building AI/ML Research Capacity in Primary Care

- **Problem:** Primary care is being left behind in the research and implementation of AI/ML
- **What's been done:** ABFM started a grant program to embed AI/ML scientists within FM departments
- **What we're doing:** Leading this national collaborative of FM departments to advance a shared vision of primary care AI/ML





**Stanford**  
MEDICINE



UNIVERSITY OF  
**HOUSTON**



**UT Health**  
San Antonio



Advancing a shared vision of strengthening  
primary care with AI/ML technologies built  
*by primary care, for primary care*



ANNALS OF  
FAMILY MEDICINE™

## Competencies for the Use of Artificial Intelligence in Primary Care



## Advancing Primary Care With Artificial Intelligence and Machine Learning



### SPECIAL COMMUNICATION

## A Clinician's Guide to Artificial Intelligence (AI): Why and How Primary Care Should Lead the Health Care AI Revolution





American Board of Family Medicine

GORDON AND BETTY MOORE FOUNDATION



# North American Primary Care Research Group 51st Annual Meeting – Pre-Conference Workshop AI & ML Bootcamp

10/30/2023, San Francisco, 8:00am – 4:30pm

## Morning Expert Lecture Series



**Yun Liu, PhD**  
*Research Scientist,  
Google*



**Irene Dankwa-Mullan, MD, MPH**  
*Chief Health Equity Officer and Chief Medical Officer,  
Marti Health*



**Mark Sendak, MD, MPP**  
*Population Health and Data Science,  
Duke Institute for Health Innovation*

## Afternoon Research Pitch Showcase



Multi-disciplinary Panel of Experts



Reacting to 3 Primary Care AI/ML Research Pitches



Clinical Decision  
Making

Population  
Health  
Management

Value Based  
Care

Transitions of  
Care

Care Team  
Burnout

Health Policy,  
Education and  
Development

Develop effective  
cross-sectoral  
collaborations

Engage in the  
implementation  
science of AI/ML

Partner in AI/ML  
policy and health  
equity work



# How can Primary Care Orgs Advance AI/ML?

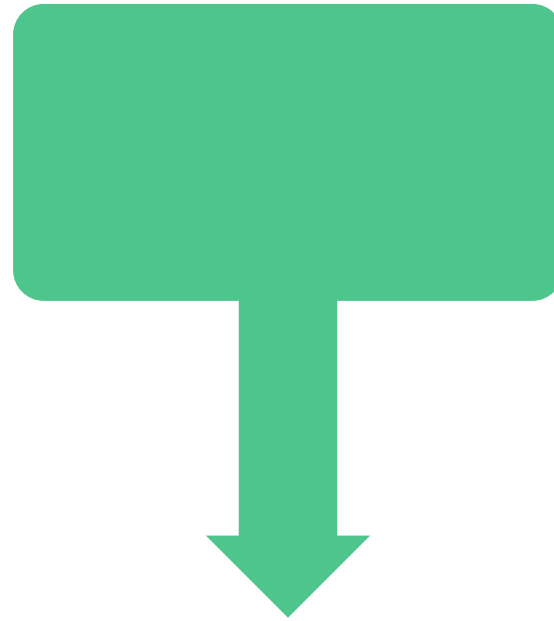
Demystify AI by focusing on use cases that matter to primary care providers/systems

Rebrand primary care as the go-to specialty for trainees who are interested in AI

Partner with the family of primary care organizations to craft a unified AI vision







National Primary Care AI Strategy



ALLIANCE for ACADEMIC INTERNAL MEDICINE



American Board of Internal Medicine®



American Board of Family Medicine



THE CENTER FOR PROFESSIONALISM & VALUE IN HEALTH CARE



NAPCRG



# Thank you! Questions?



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