Artificial Intelligence in Healthcare: Separating the Reality from the Hype

Robert M. Wachter, MD
Professor and Chair, Department of Medicine
University of California, San Francisco
Author, *The Digital Doctor: Hope, Hype & Harm at the Dawn of Medicine's Computer Age*
*@bob_Wachter / robert.wachter@ucsf.edu*

Disclosures

| Company	Relationship	Company	Relationship
Accuity Medical	Board of Directors	Doctors Company	Board of Directors
Teledoc	Advisory Board	Amino.com	Advisory Board
PatientSafe Solutions	Advisory Board	EarlySense	Advisory Board
Commure	Consultant	Forward Medical	Consultant
Nuance, GE, Health Catalyst, AvaCare	Honoraria for speaking	Smart Patients	Investor

Why I Decided to Explore Health IT
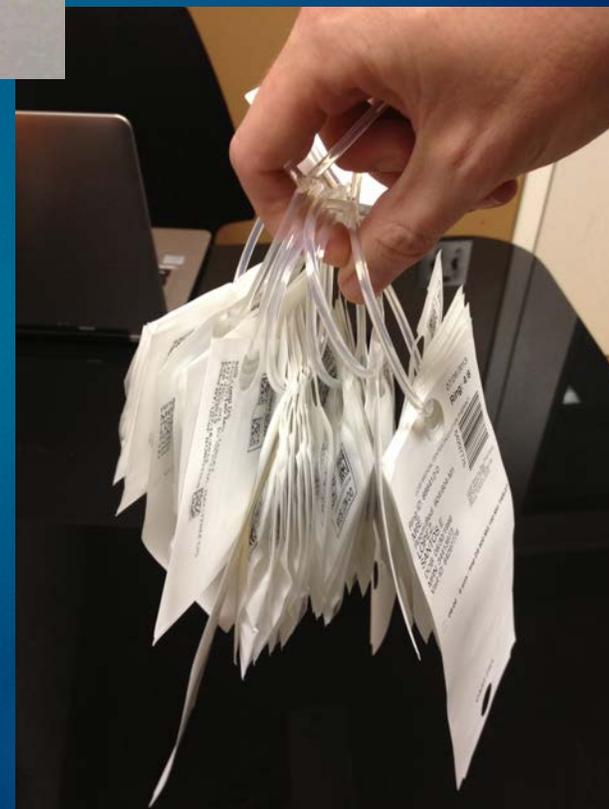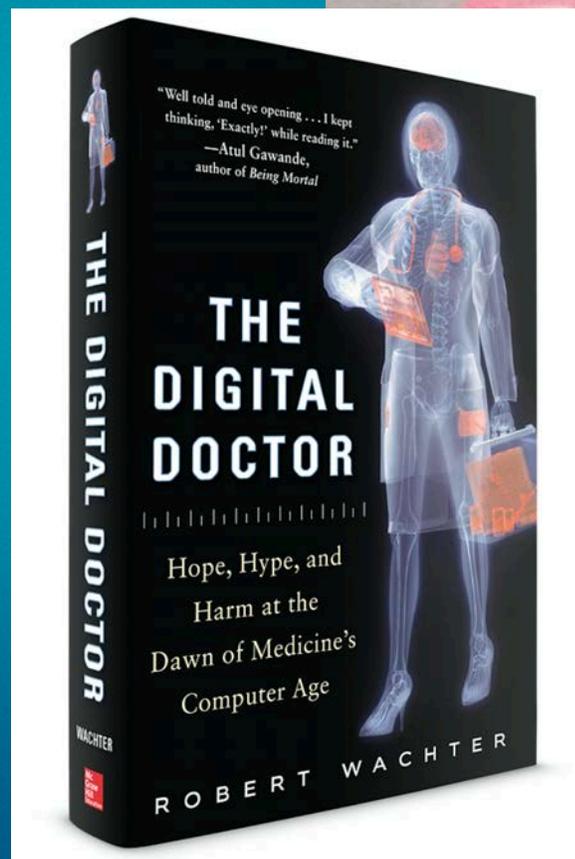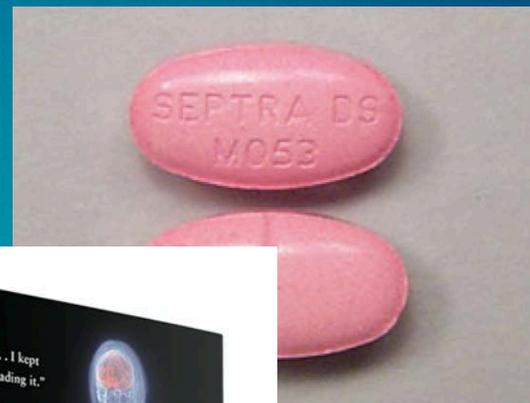
Road Map

- What the EHR years taught us about healthcare and digital
- What you (really) need to know about AI
- Some specific areas in which AI is likely to make a difference
- Speed bumps and unanticipated consequences to anticipate
- Bottom line

EHRs in U.S. Hospitals, 2008-17

EHR ADOPTION FOR NONFEDERAL ACUTE CARE HOSPITALS

96%

$30 billion

2008 — 2017
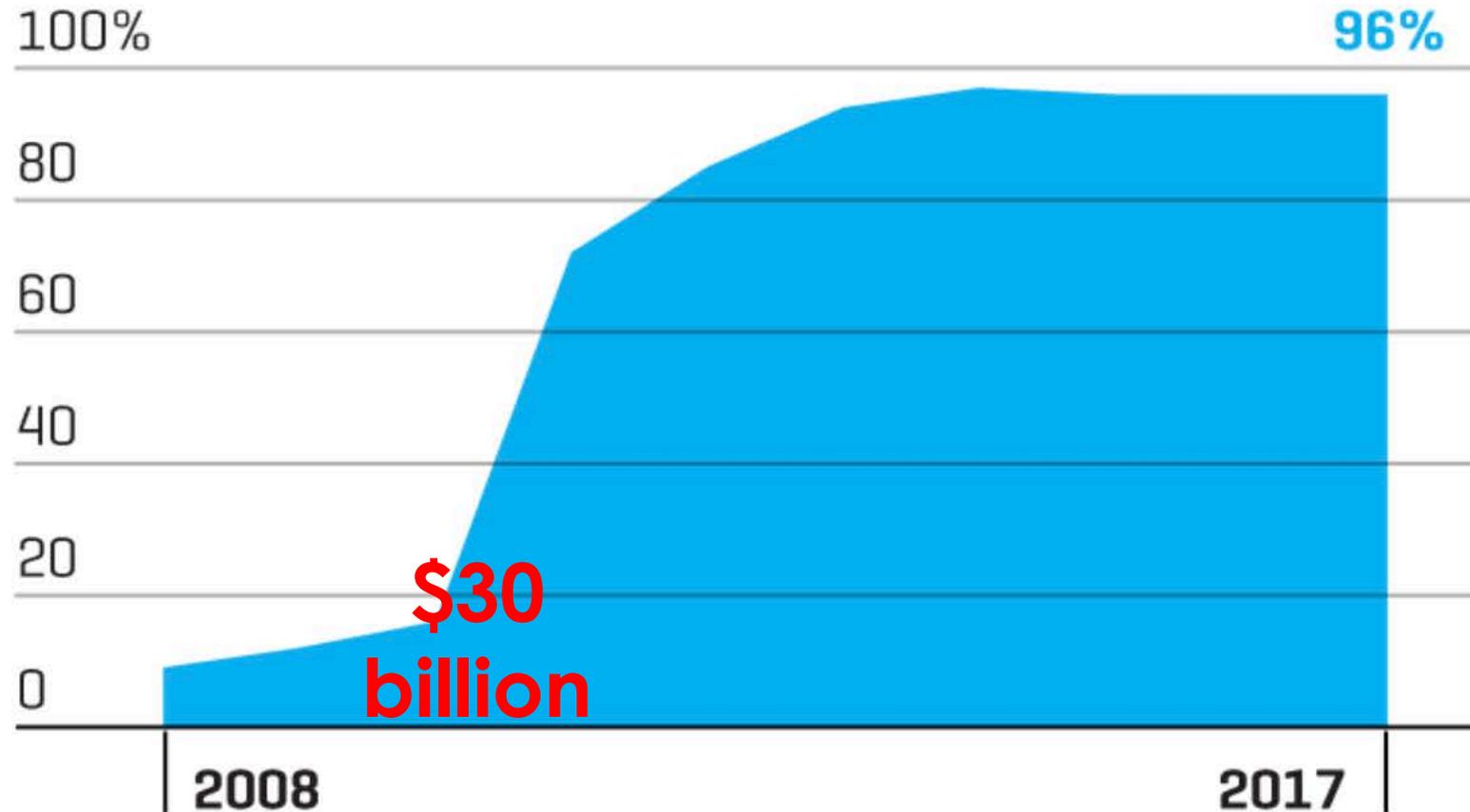
DIGITAL HEALTH FUNDING
2011-2018

ROCK HEAL+H

TOTAL VENTURE FUNDING

OF DEALS

| Year	Total Venture Funding	# of Deals	Average Deal Size
2011	$1.1B	92	$12.0M
2012	$1.5B	143	$10.5M
2013	$2.1B	198	$10.7M
2014	$4.1B	291	$14.2M
2015	$4.7B	320	$14.7M
2016	$4.5B	334	$13.6M
2017	$5.7B	359	$15.9M
2018	$8.1B	368	$21.9M

AVERAGE DEAL SIZE

Source: Rock Health Funding Database
Note: Only includes U.S. deals >$2M

90+ Healthcare AI Startups To Watch

Imaging & Diagnostics

ablacon · aidence · aidoc · Healthy.io · PathAI · RadiomicsAI
Aillis · EXO MEDICAL IMAGING FOR EVERYONE · 深睿医疗 deepwise · 推想科技 inferVISION · sight
enlitic · EXAMIZARDS · freenome · JLK INSPECTION · zebra MEDICAL VISION
BUTTERFLY Network, Inc. · IBEX · IDx · SIG TUPLE · 数坤科技
ULTROMICS
PAIGE · VUNO · VoxelCloud · Lunit · VIZ

Drug Discovery

Accutar Biotech · BenevolentAI · DIP 深度智耀 · FINCH THERAPEUTICS
APEIRON · BlackThorn THERAPEUTICS · Frontier MEDICINES · insitro
Atomwise Better medicines faster. · Exscientia DRIVEN BY KNOWLEDGE · engine BIOSCIENCES · JUVENESCENCE
Notable Labs · OWKIN · RECURSION Pharmaceuticals · 药研社
Standigm · XtalPi · twoXAR · SPRING DISCOVERY

Predictive Analytics & Risk Scoring

BenchSci · lu · 森亿智能 SYNYI·AI · saama
GNS HEALTHCARE · Medial EarlySign · TEMPUS
ikioo · medopad · Welltok · nference

Genomics

DECIPHER BIOSCIENCES · SOPHIA GENETICS · Syntekabio · WuXiNextCODE

Fitness

FiNC · Vi

Virtual Assistant

babylon · Curai · mfine · notable
buoy · K · Suki

Hospital Decision Support

binaryfountain · Cardinal Analytx Solutions · Qventus
gauss · OM1
KenSci · Olive · LeanTaaS
Medical INFORMATICS · NextHealth TECHNOLOGIES

Clinical Trials

deep lens · HEALTH [at] SCALE TECHNOLOGIES · teckro.

Nutrition

NURITAS LIFE-CHANGING INGREDIENTS · WHOLE BIOME

Compliance

DATAVANT · PROTENUS

Mental Health

mindstrong

Remote Monitoring

biofourmis · ContinUse Biometrics · DENTAL MONITORING Connected orthodontics

(Re) Enter the Digital Giants….

November 08, 2018 12:00 AM

Google hires Geisinger CEO Dr. David Feinberg

RACHEL Z. ARNDT

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BRIEFING • ARTIFICIAL INTELLIGENCE

Here's How Microsoft Plans To Modernize Healthcare

By Erin Corbett   February 7, 2019

Amazon's joint health-care venture finally has a name: Haven

PUBLISHED WED, MAR 6 2019 • 4:05 PM EST | UPDATED WED, MAR 6 2019 • 5:09 PM EST

Angelica LaVito   Christina Farr   Hugh Son
@ANGELICALAVITO   @CHRISSYFARR   @HUGH_SON

Understand how your patients can use health features on Apple Watch.

See how heart rate notifications, irregular rhythm notifications, and the ECG app on Apple Watch can help give your patients an early warning sign that further evaluation may be warranted.

Learn more about health features on Apple Watch ›

68 BPM   10:09

22 sec
Apple Watch cannot check for signs of a heart attack.
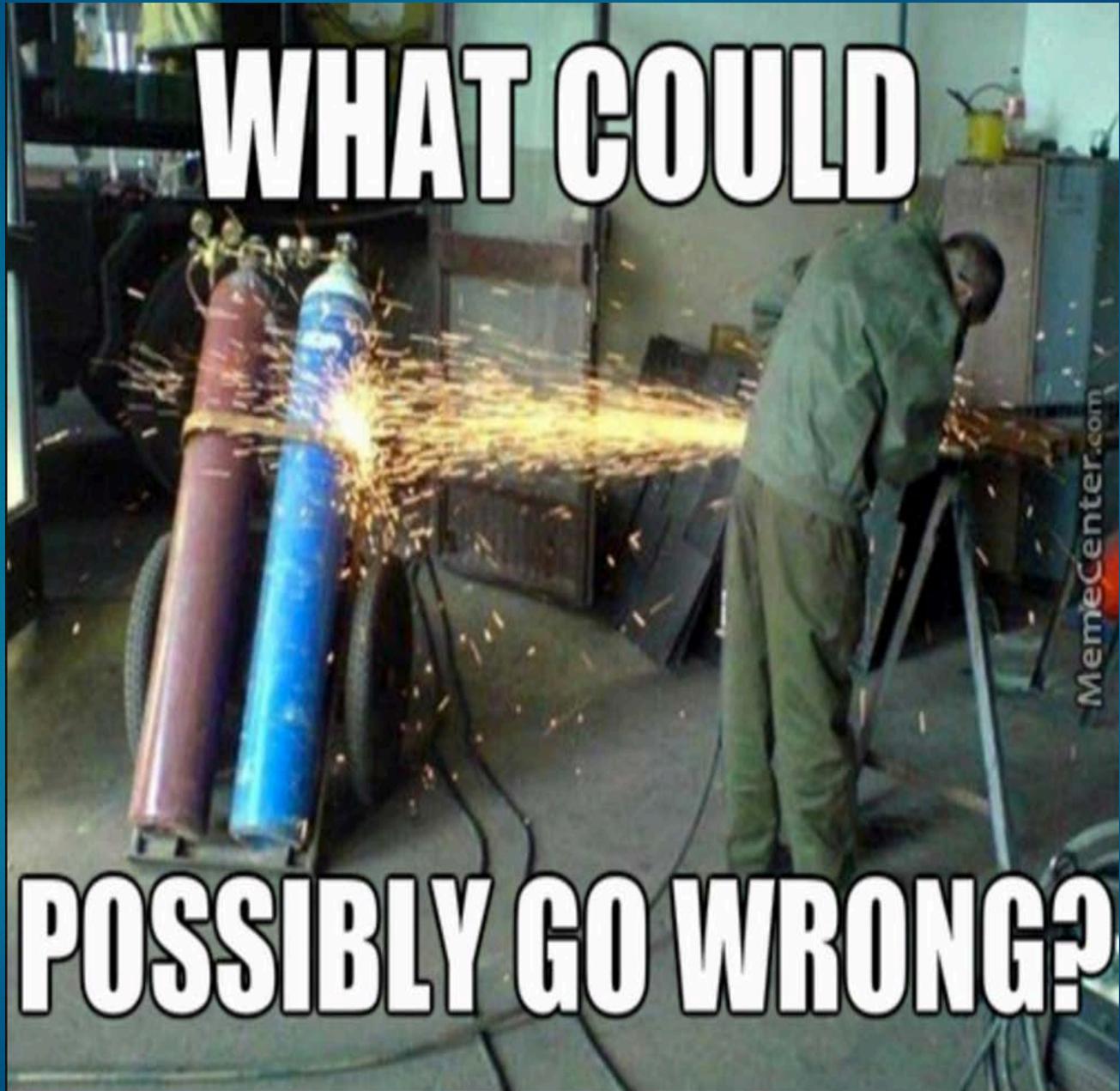
7-year-old Girl's Recollection of her Visit to the Doctor

Advertisement For Arizona ER Job

Arizona General Hospital will be coming to The Grand Canyon State later this year!! Located in a suburb of Phoenix, **Arizona General Hospital** is a 40,000 square-foot boutique general hospital.

Services offered include:

• Emergency Room

• Radiology Suite inc. CT, X-Ray, and Fluoroscopy

• Two State-Of-The-Art Operating Rooms

• Outpatient Surgery

• 16 Inpatient Rooms

• **NO ELECTRONIC MEDICAL RECORD**

From the EHR era of Health IT...

The Four Stages of Health IT

1. Digitizing the record
2. Connecting the parts

   a. PCPs to Hospitals, Hospitals to Hospitals, etc.

   b. Patient-facing systems to enterprise systems, and to one another

3. Gleaning meaningful insights from the data
4. Converting these insights into action that improves value

Health IT: The Mother of all Adaptive Problems

"... problems that require people themselves to change. In adaptive problems, the people are the problem and the people are the solution. And leadership then is about mobilizing and engaging the people with the problem rather than trying to anesthetize them so that you can just go off and solve it on your own."

― Ronald Heifetz, Kennedy School of Government

Bottom line re: Health IT: Much harder than it looks....
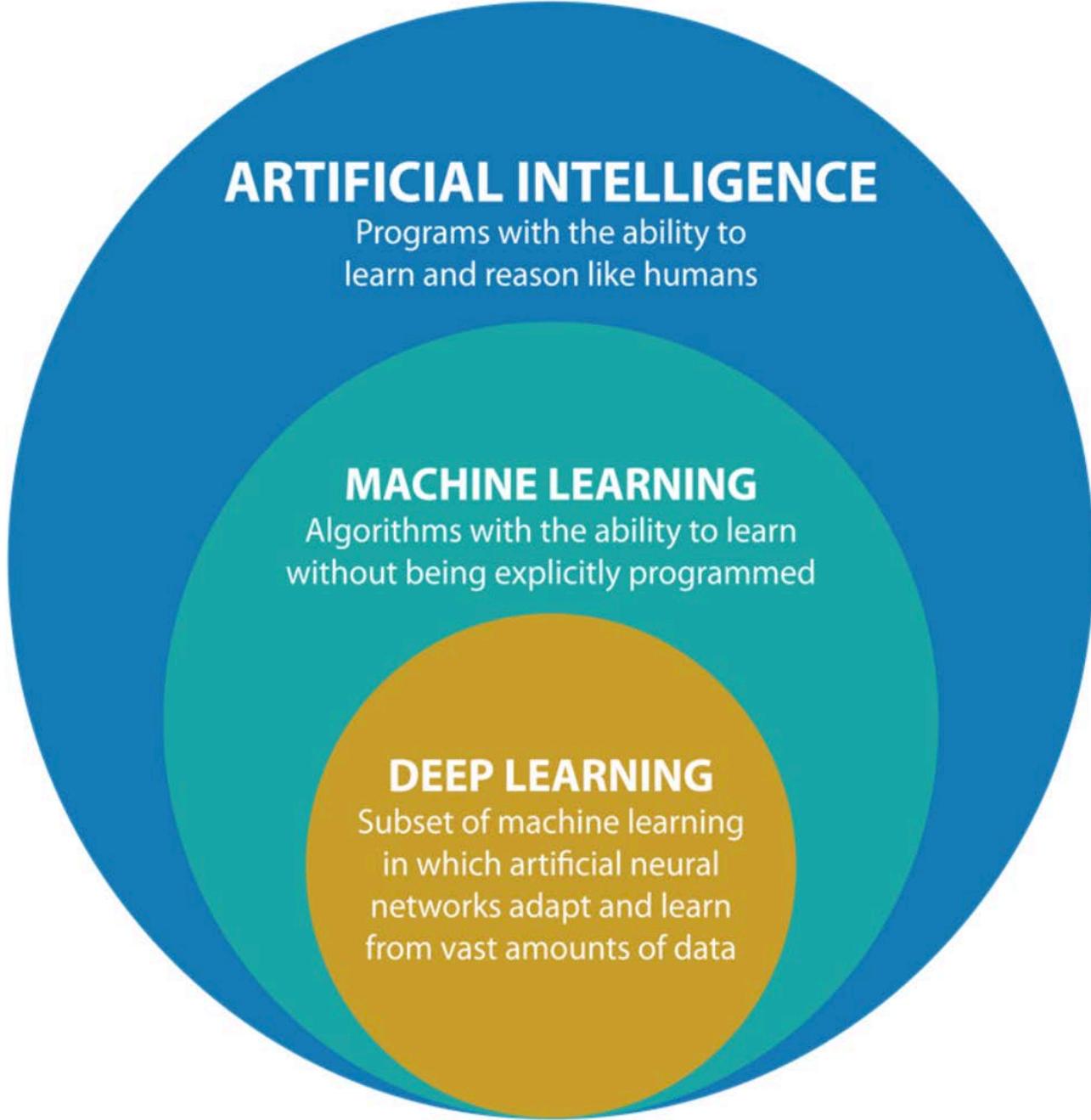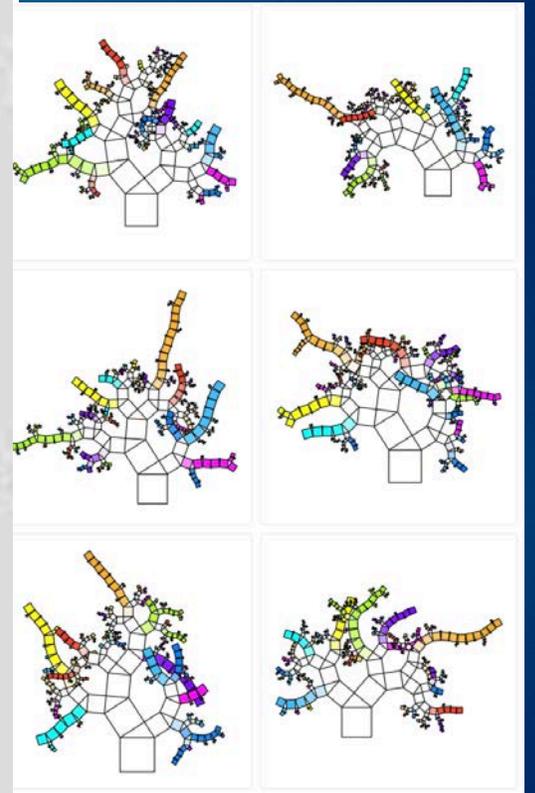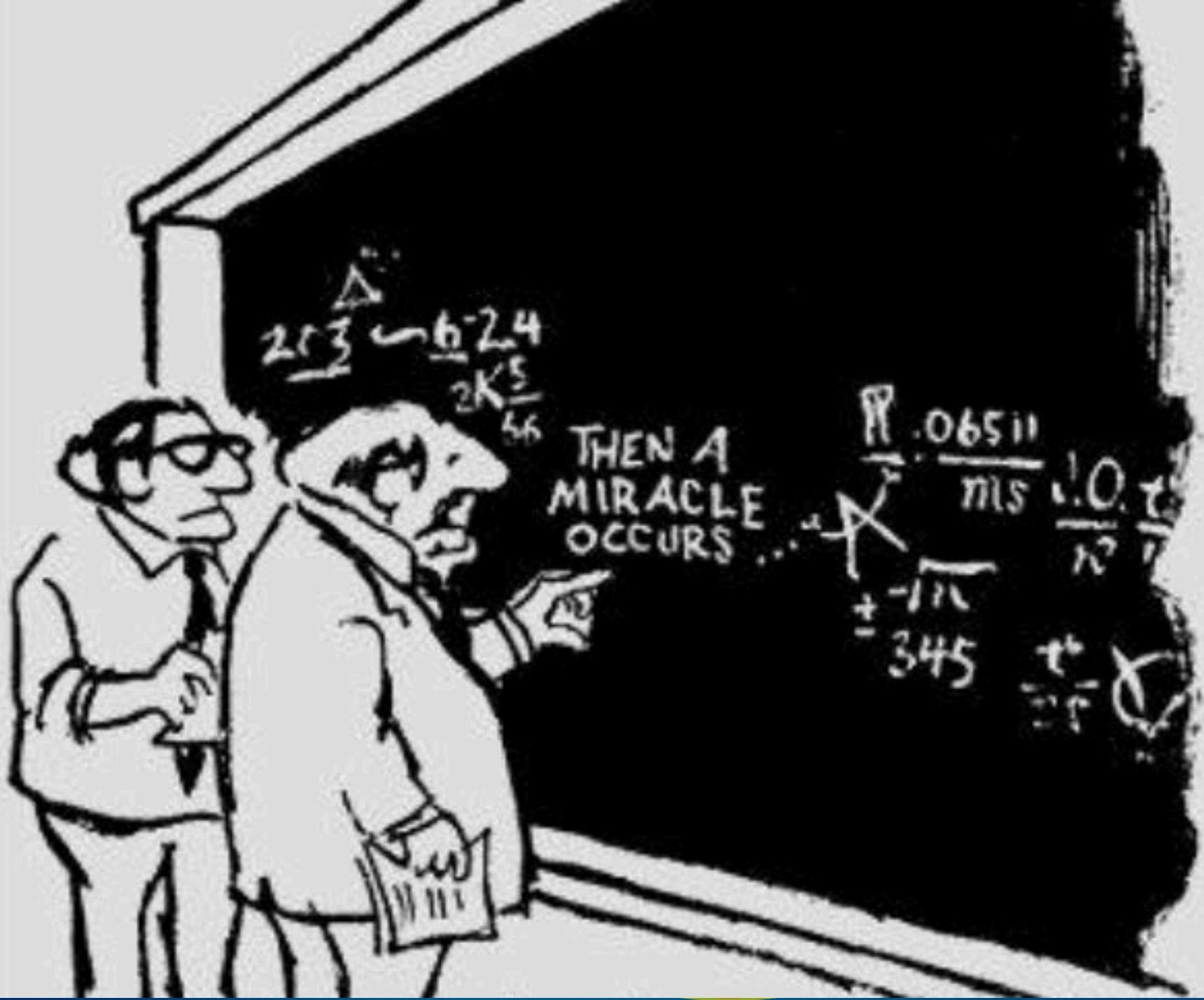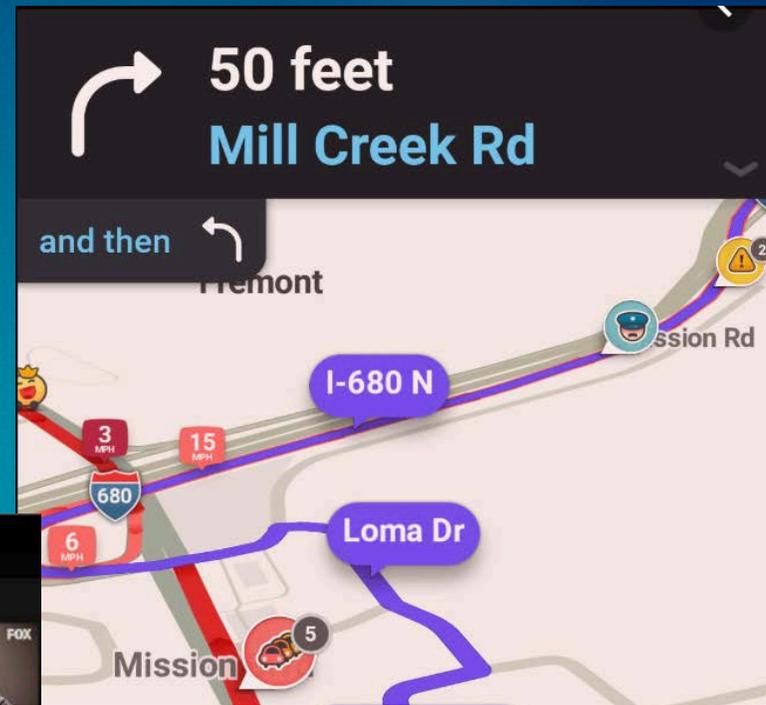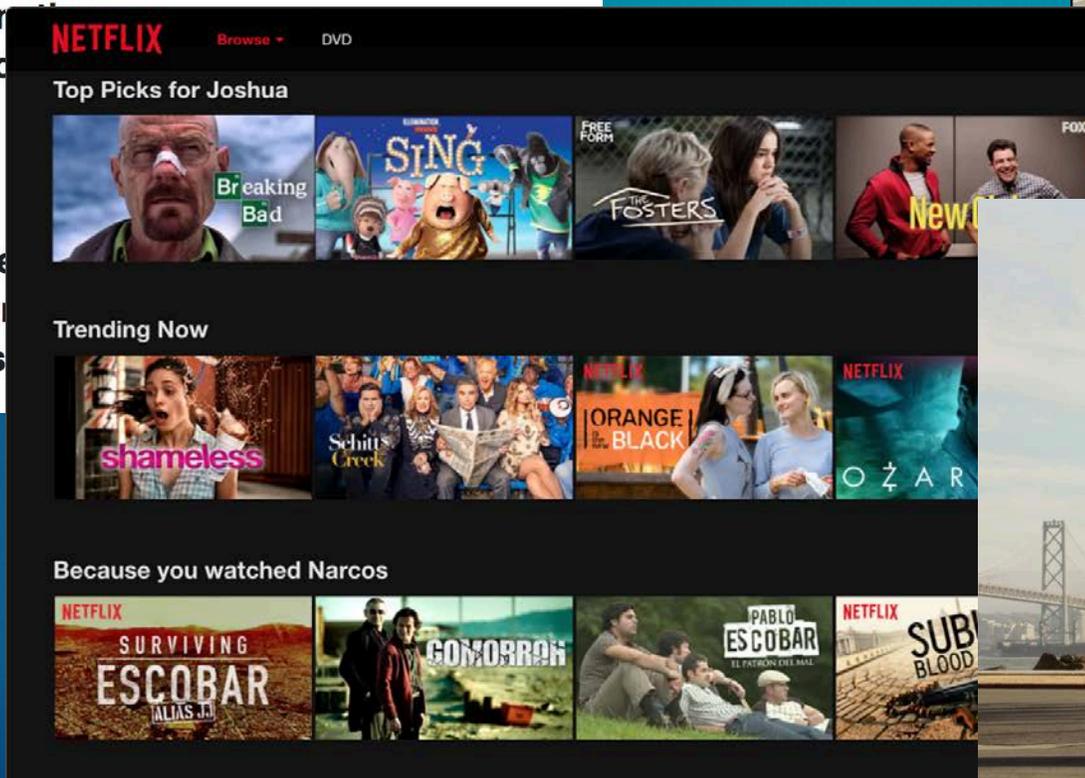
Examples of AI Applications in Healthcare

| Embryo selection for IVF | Genome interpretation sick newborns | Voice medical coach via a smart speaker (like Alexa) | K^+ | Mental health | Paramedic dx of heart attack, stroke | Assist reading of scans, slides, lesions | Prevent blindness | Classify cancer, identify mutations | Promote patient safety | Predict death in-hospital |
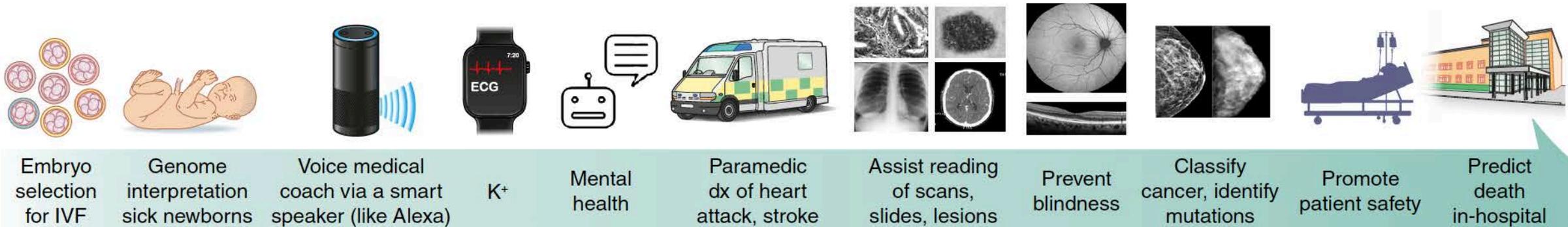
From Topol E. High performance medicine: the convergence of human and artificial intelligence *Nature Medicine* 2019

Early Efforts at Computerized Diagnosis (circa 1970s-80s)

Healthcare questions that will be answered or tasks addressed via AI & Big Data

▶ Diagnose a condition

▶ ...ntify cases of lung cancer from path slides

▶ ...ing a disease or outcome

▶ ...osis mortality based on EHR data

▶ ...onse

▶ ...e to treatment of hypertension or cancer based on genetic data ("precision medicine")

▶ Improve practice

▶ Predict clinic demand or no-shows

▶ Help MD complete EHR note based on prior examples
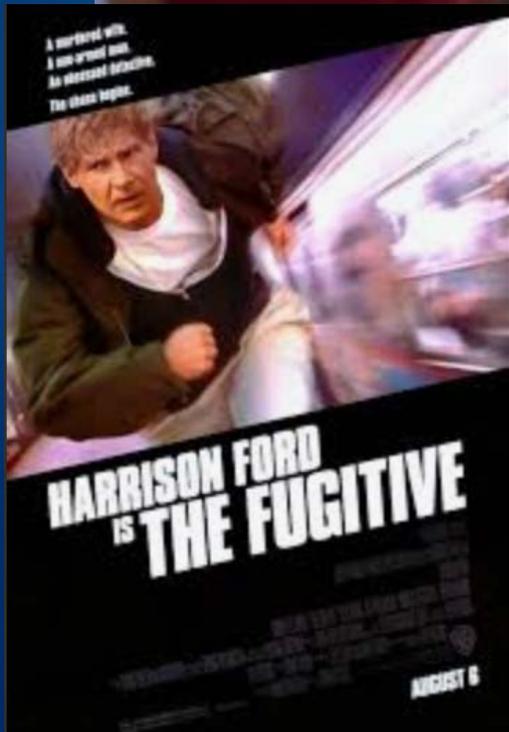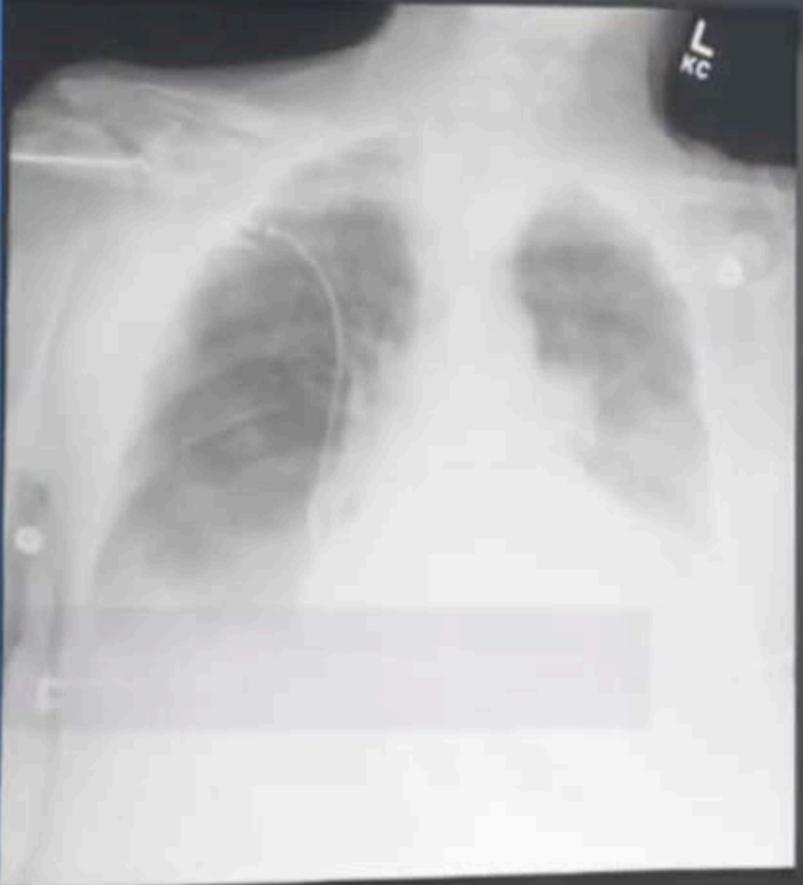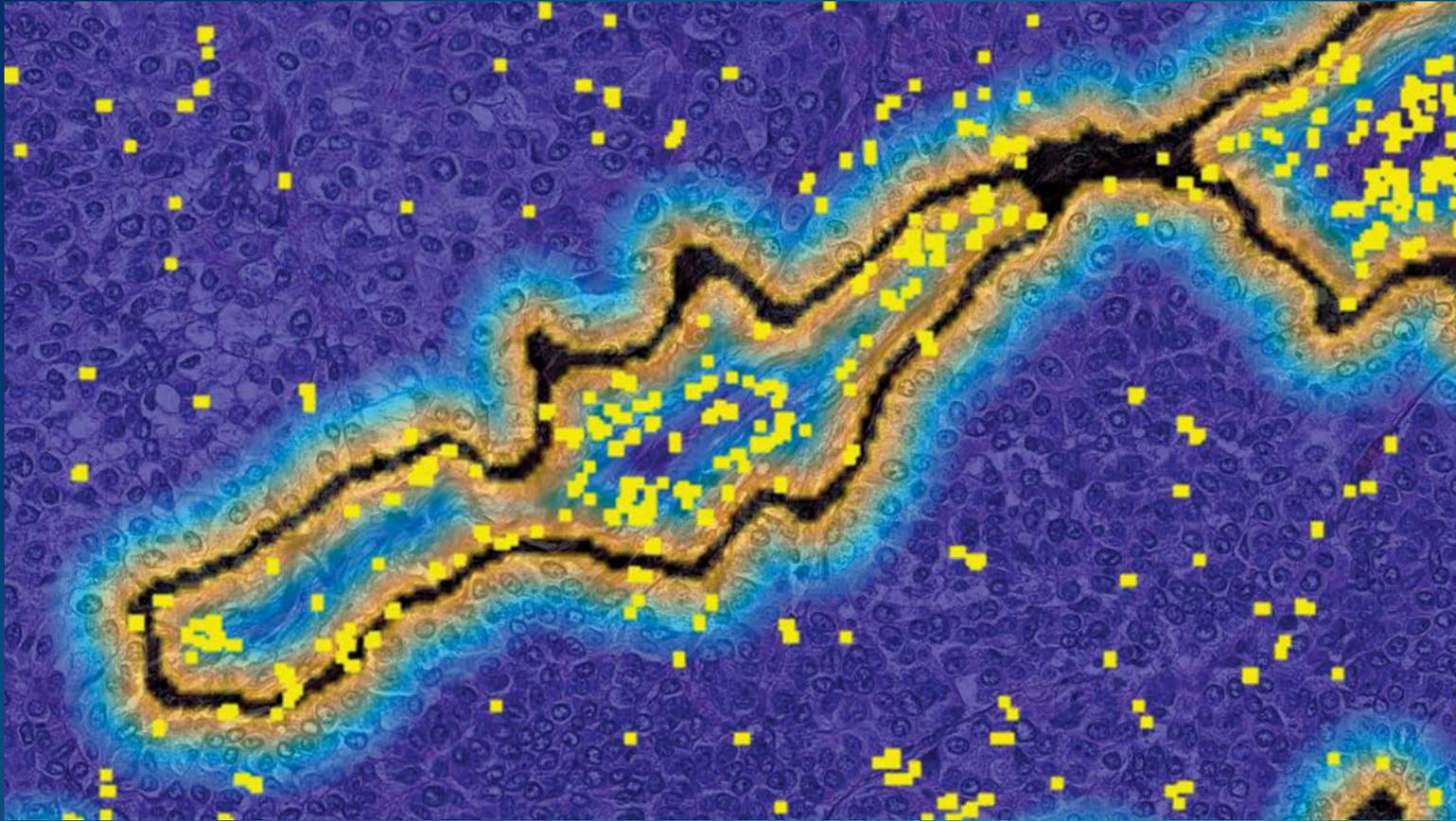
PathAI Secures $60M in Series B Funding

Computational Pathology Leader Plans to Accelerate Industry Impact
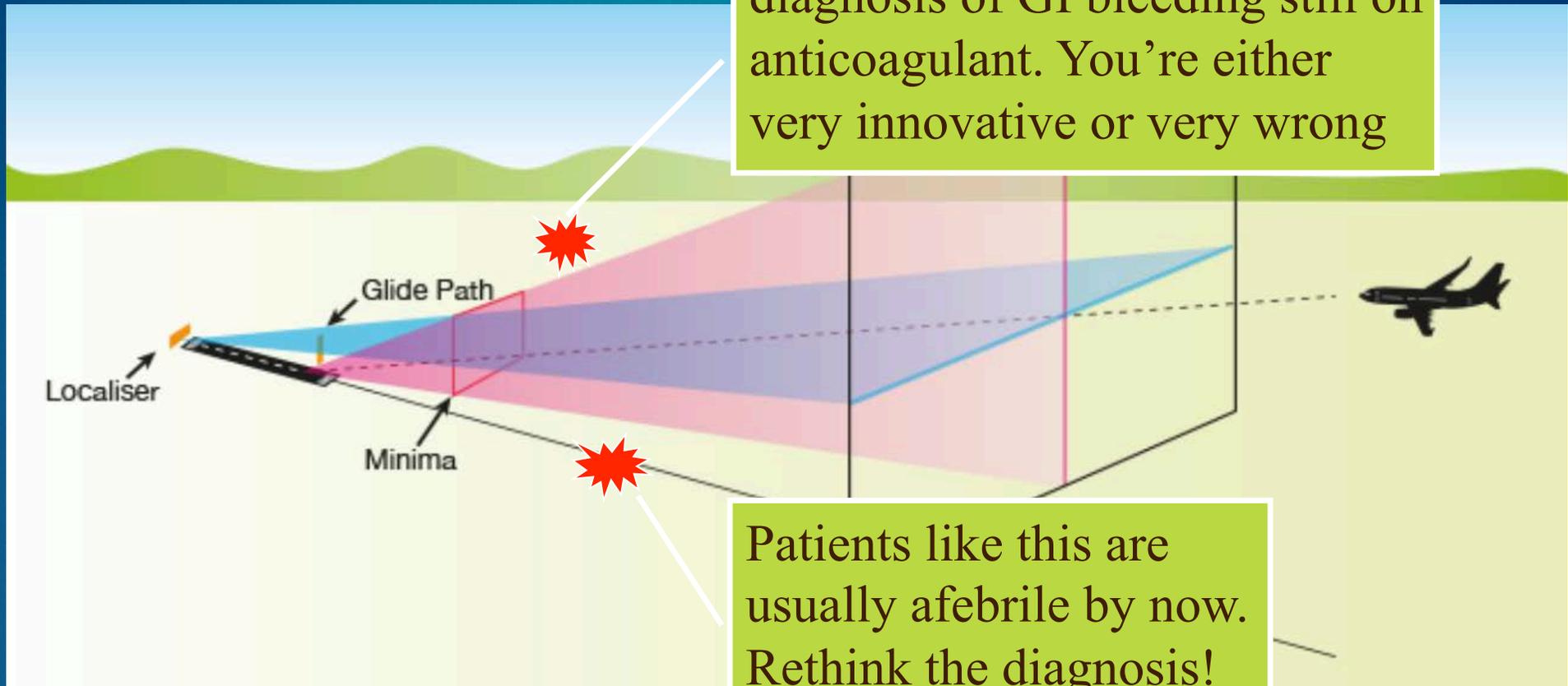
Let's assume AI gets everything right (diagnosis, prediction, outliers, EHR note)... Then what?

Sundar Pinchai, CEO, Google
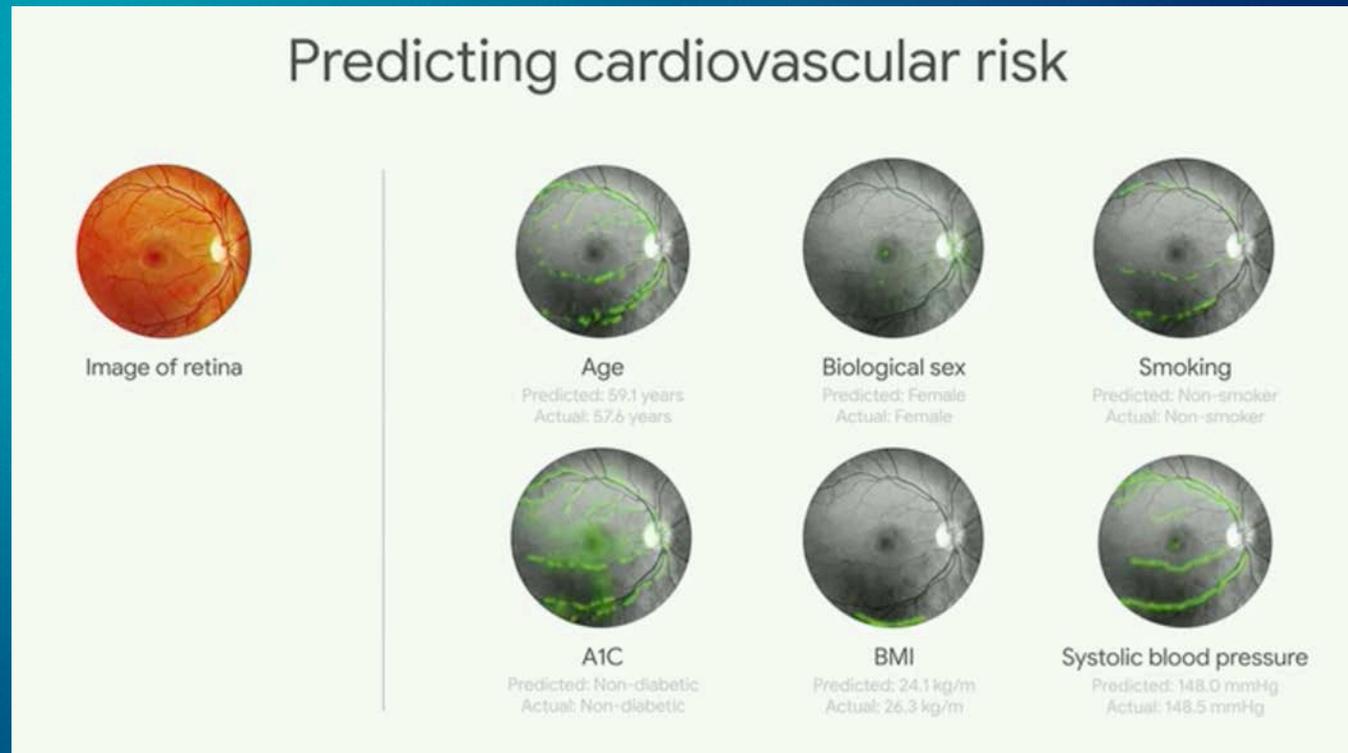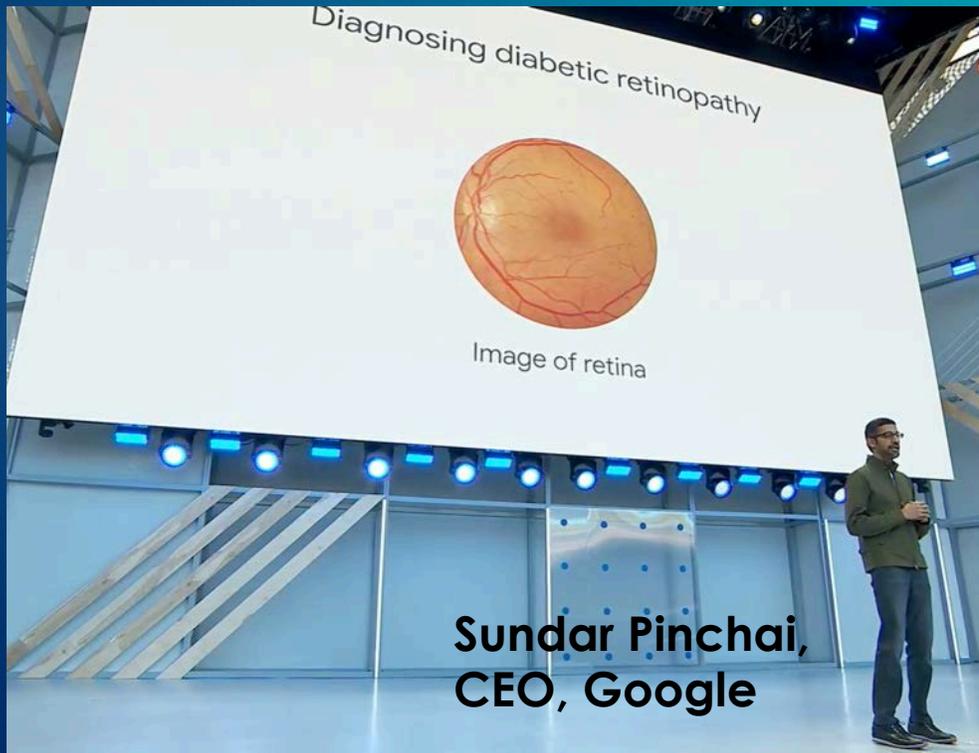
The Traditional Concerns About AI

▶ Black box

- ▶ Will clinicians follow predictions/recommendations whose derivation they don't understand or that have no biologic plausibility?

▶ Garbage In-Garbage Out (GIGO)

- ▶ E.g., much EHR data fed into AI generators is from billing data of questionable accuracy

▶ Bias

- ▶ Might appear that African-American patients with fractures require less pain meds, and build that into algorithm; melanoma detection less accurate in darker skin people

▶ Wacky and confounded results

- ▶ BMJ study found that 4am CBC (*even if normal) was* top predictor of mortality

▶ Promoting healthcare disparities

- ▶ If much of AI is served up via iPhone, there will be haves and have-nots

▶ Privacy and security issues

- ▶ Requires huge data to be amalgamated & often combined; can algorithms be hacked?

Riffs on 4 Other Areas Likely to Be Associated with Speedbumps

- How is this actually going to work?
  - Integration and interoperability
  - The need for a new layer that connects patients to the system
  - Will better predictions actually change behavior
  - The AI version of alert fatigue
- Deskilling
- How good is good enough (AKA, the Tesla Problem)
- The politics of AI
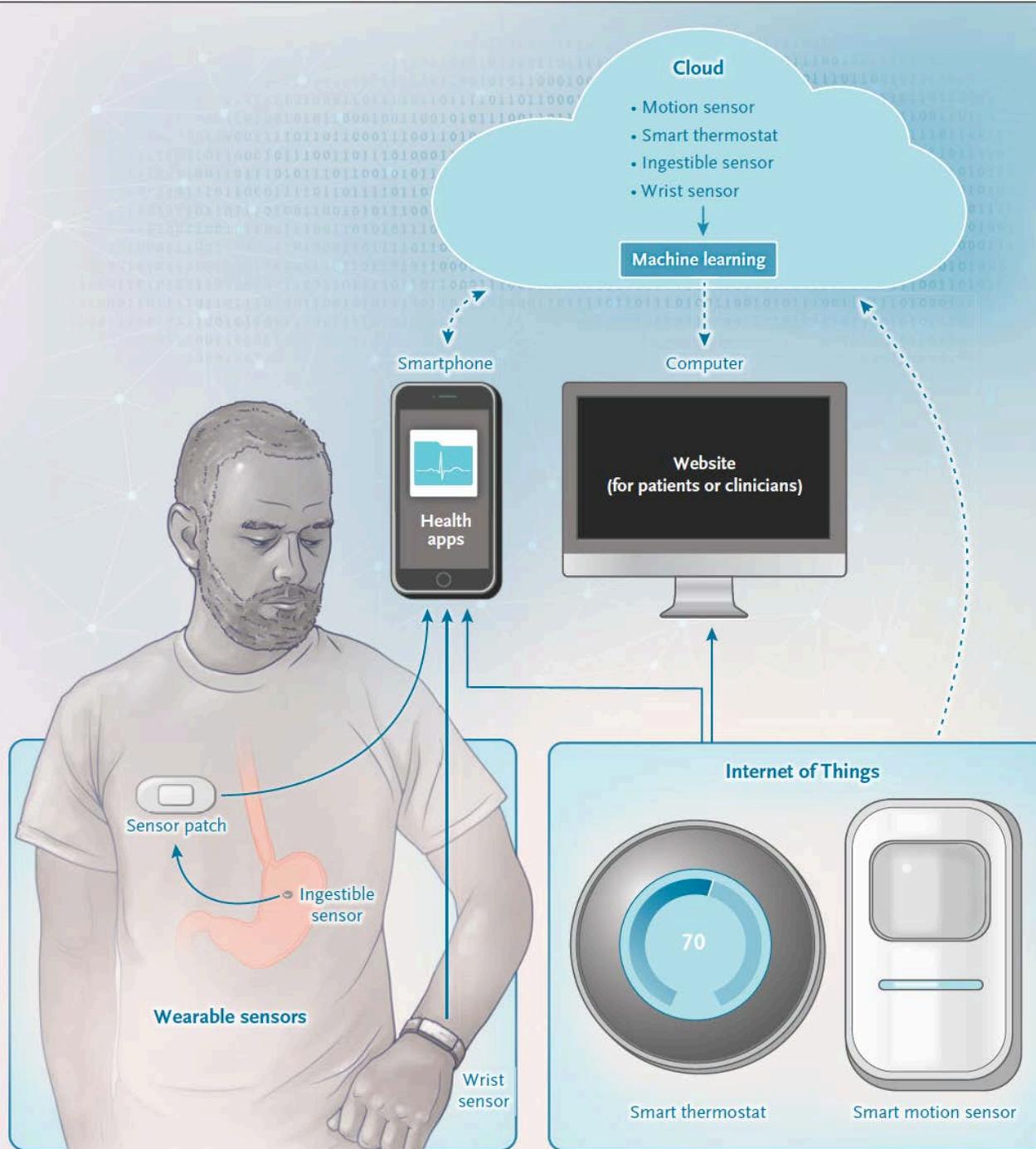
Ida Sim, *NEJM* 2019

The Care Traffic Controllers

Artificial Intelligence in Health Care
Will the Value Match the Hype?

Ezekiel J. Emanuel, MD, PhD[1,2]; Robert M. Wachter, MD[3]

The gurus of data seem to assume that once something is identified and known, it is solved. That might be true in the tech world, where the aim is to hound consumers with electronic ads until they click on a link and buy a product. But in the health care system the goal is often changing an ingrained habit such as eating processed foods, smoking, not exercising, or skipping daily medications. There are no data to suggest that changing the precision of a prediction—such as, for example, explaining to a patient that "there's a very good chance your smoking will cause cancer or heart disease," compared with "there's a 27.6% chance your smoking will cause cancer or heart disease"—will succeed in changing behavior. The issue is the same when considering giving physicians more accurate predictions about the risk of readmission or sepsis.

One More Problem: Alert Fatigue

- One month in UCSF ICUs (70 beds)
  - 2,558,760 alerts
    - Audible alert every 7 minutes
    - What would get a nurse scared?
- Experience with other alerts is similarly underwhelming

⚠ **This is a hypotension alert.**

This is a *sepsis alert*. EPIC has detected this patient is **hypotensive** and carries a **high risk** of severe sepsis.

Severe sepsis is defined as a suspected infection, 2 or more SIRS criteria, and *any* sign of acute organ dysfunction.

Feds Say Tes   to Blame for
a 2018 Crash

Tesla doesn't stop
hitting the trailer a
traveling under i

BETWEEN 2012–2017
NEARLY 20,000
PEOPLE DIED
IN CRASHES INVOLVING
A DISTRACTED DRIVER.

NHTSA   U DRIVE. U TEXT. U PAY

The New York Times | Source: Florida traffic crash report

The Digital Squeeze on Physicians
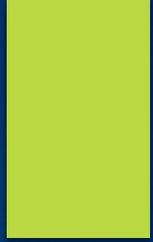
Central/ Corporate Control

Democratization, Questioning of Expertise

Deskilling in the Face of Automation

The New York Times Magazine

What Really Brought Down the Boeing 737 Max?

By William Langewiesche

*Referring to the Lion Air copilot….*

his experience with flying was scripted, bounded by checklists and cockpit mandates and dependent on autopilots. He had some rote knowledge of cockpit procedures as handed down from the big manufacturers, but he was weak in an essential quality known as airmanship. Sadly, his captain turned out to be weak in it, too.

"Airmanship" is an anachronistic word, but it is applied without prejudice to women as well as men. Its full meaning is difficult to convey. It includes a visceral sense of navigation, an operational understanding of weather and weather information, the ability to form mental maps of traffic flows, fluency in the nuance of radio communications and, especially, a deep appreciation for the interplay between energy, inertia and wings. Airplanes are living things. The best pilots do not sit in cockpits so much as strap them on.

The Phenomenon of "Deskilling"

"How do you measure the expense of an erosion of effort and engagement, or a waning of agency and autonomy, or a subtle deterioration of skill? You can't. Those are the kinds of shadowy, intangible things that we rarely appreciate until after they're gone."
-- *Nicholas Carr*

THE GLASS CAGE

AUTOMATION AND US

NICHOLAS CARR

New York Times best-selling author of THE SHALLOWS
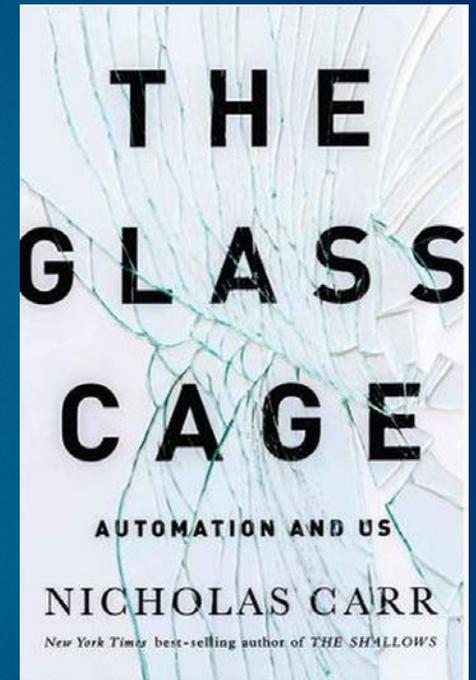
The political-economics of healthcare AI

- Pressure for value, competitive market will push care down to tech-enabled solutions: Specialists>Generalists>Non-MD Clinicians>Coaches>Families> Pts
- How much people will be willing to pay for higher priced, more personal entities will be determined empirically (See: concierge medicine, travel agents, tax preparers)
  - This includes the value that people place on "human touch" and empathy
- May be some tasks that incumbents are happy to lose (menial, rote, poorly paid), esp. if there is more interesting & equally (or more) lucrative replacement work
- When there isn't, expect a dogfight from incumbents
  - MDs are a better guild than taxi-drivers (nurses are too, and they're unionized)
  - Much depends on who is at risk for costs (& quality?)
  - The liability landscape will also have a say
- If machine is ultimately better and cheaper (or cheaper and not demonstrably worse), it will win as standard of practice
  - With ability to buy up to "business class"

Research to date often supports the Centaur idea. But when you hear the warm, fuzzy answer ("man + machine is better than either alone")....
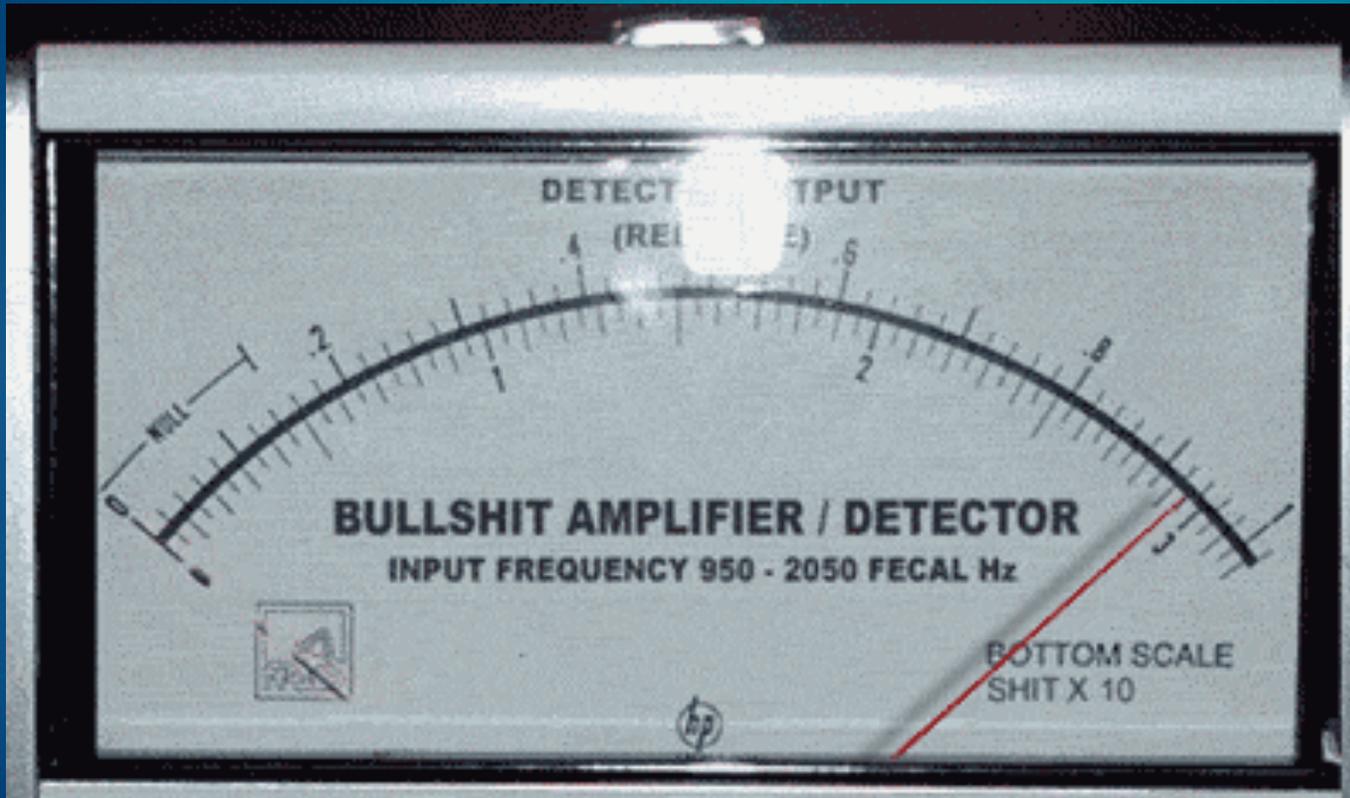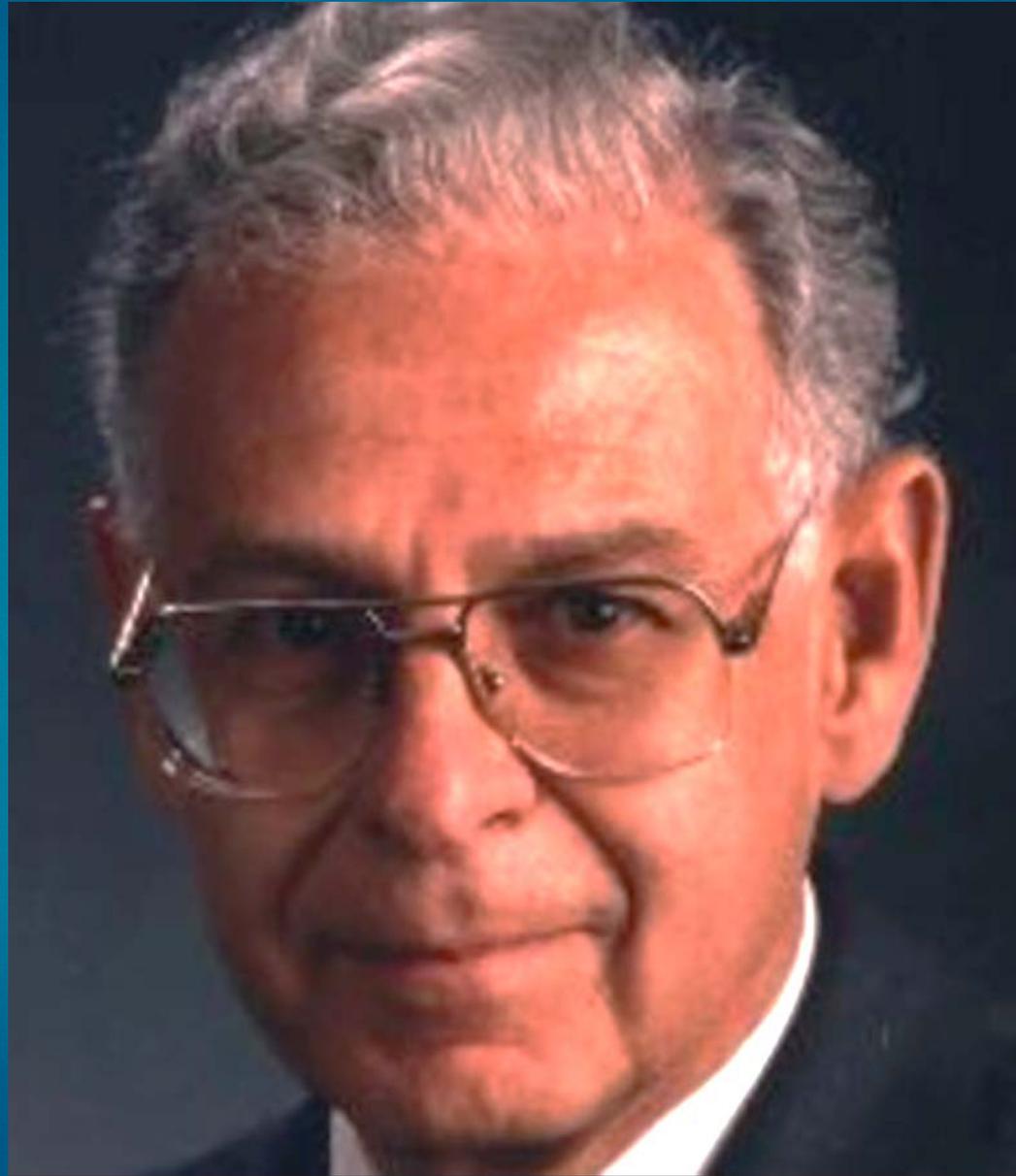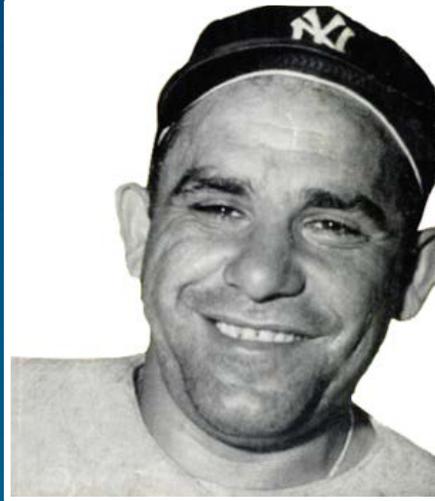
"In theory there is no difference between theory and practice. In practice there is."

\- Yogi Berra (maybe)

Additional Slides If Needed

02 Apr 2019 | 15:00 GMT

How IBM Watson Overpromised and Underdelivered on AI Health Care

After its triumph on Jeopardy!, IBM's AI seemed poised to revolutionize medicine. Doctors are still waiting

By Eliza Strickland
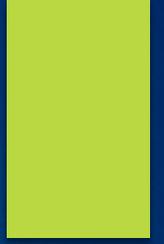
Here's How IBM Wa
Transforming the Heal

As Watson Health hits its one-year anniversary, here's a

By Laura Lorenzetti

April 5, 2016

In 2014, IBM opened swanky new headquarters for its artificial intelligence division, known as IBM Watson. Inside the glassy tower in lower Manhattan, IBMers can bring prospective clients and visiting journalists into the "immersion room," which resembles a miniature planetarium. There, in the darkened space, visitors sit on swiveling stools

$300,000 $1,000,000 $200,000

ken   WATSON   BRAD

AI reverses traditional healthcare predicting/reasoning

▶ The traditional deductive process (predictors -> test)

  ▶ Based on biological plausibility and prior research, hypothesize (for example) predictors for readmission, sepsis, stroke, death…

  ▶ Test, through a variety of clinical research methods, whether these predictors are in fact associated with the outcome we care about

▶ The new inductive process (test -> predictors)

  ▶ Feed the machine data on thousands/millions of patients with all sorts of possible predictor data

  ▶ Computer looks at who had the outcome (eg, sepsis, lung cancer, readmission), works backwards to find the variables that predicted the outcome, and then creates a model that optimizes the predictions

Thanks to Ziad Obermeyer, UC Berkeley

The New Digital Triad

Remote Sensing

Consumer-facing Personal Tech

Artificial Intelligence
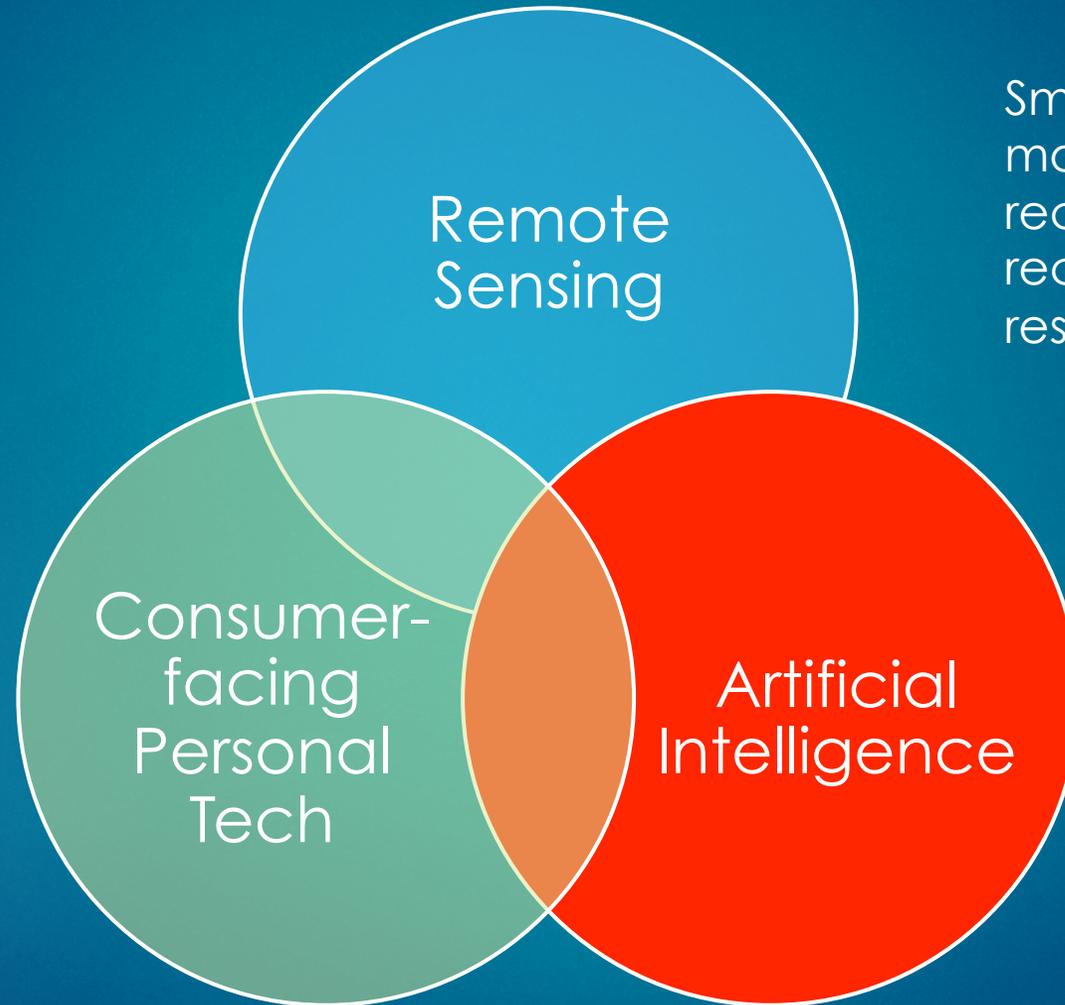
Smartphones can sense motion & position, record vital signs & falls, record survey responses…

81% of North Americans own a smartphone

Sim I. Mobile devices and health. *NEJM* 2019

Table 1 | Peer-reviewed publications of AI algorithms compared with doctors

Specialty	Images	Publication
Radiology/neurology	CT head, acute neurological events	Titano et al. [27]
	CT head for brain hemorrhage	Arbabshirani et al. [19]
	CT head for trauma	Chilamkurthy et al. [20]
	CXR for metastatic lung nodules	Nam et al. [8]
	CXR for multiple findings	Singh et al. [7]
	Mammography for breast density	Lehman et al. [26]
	Wrist X-ray*	Lindsey et al. [9]
Pathology	Breast cancer	Ehteshami Bejnordi et al. [41]
	Lung cancer (+driver mutation)	Coudray et al. [33]
	Brain tumors (+methylation)	Capper et al. [45]
	Breast cancer metastases*	Steiner et al. [35]
	Breast cancer metastases	Liu et al. [34]
Dermatology	Skin cancers	Esteva et al. [47]
	Melanoma	Haenssle et al. [48]
	Skin lesions	Han et al. [49]
Ophthalmology	Diabetic retinopathy	Gulshan et al. [51]
	Diabetic retinopathy*	Abramoff et al. [31]
	Diabetic retinopathy*	Kanagasingam et al. [32]
	Congenital cataracts	Long et al. [38]
	Retinal diseases (OCT)	De Fauw et al. [56]
	Macular degeneration	Burlina et al. [52]
	Retinopathy of prematurity	Brown et al. [60]
	AMD and diabetic retinopathy	Kermany et al. [53]
Gastroenterology	Polyps at colonoscopy*	Mori et al. [36]
	Polyps at colonoscopy	Wang et al. [37]
Cardiology	Echocardiography	Madani et al. [23]
	Echocardiography	Zhang et al. [24]

Prospective studies are denoted with an asterisk.

"The Challenge That Will Dominate Your Career..."