MAYO CLINIC

Mayo Clinic Department of
Cardiovascular Medicine

THE FUTURE OF CARDIOLOGY: FROM ARTIFICIAL INTELLIGENCE TO CARDIAC MONITORING

Suraj Kapa, MD
Mayo Clinic College of Medicine
Kapa.suraj@mayo.edu

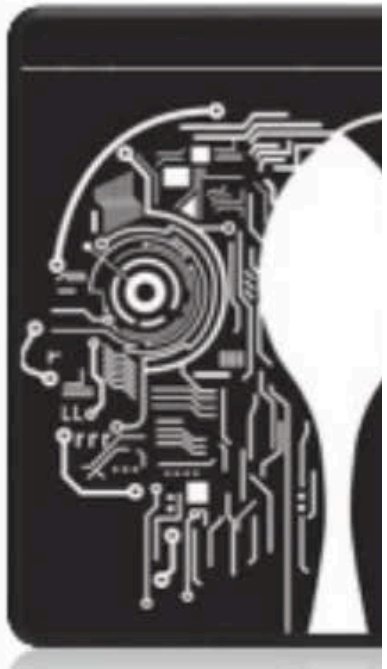
©2019 MFMER | 3868227-1

Outline

- What is AI?
- Examples of how AI may be applied to medical data
- Role of AI in remote monitoring, wearables, and healthcare

©2019 MFMER | 3868227-2

AI and augmented vision



NEW NAVY DEVICE LEARNS BY DOING

Psychologist Shows Embryo of Computer Designed to Read and Grow Wiser

WASHINGTON, July 7 (UPI) —The Navy revealed the embryo of an electronic computer today that it expects will be able to walk, talk, see, write, reproduce itself and be conscious of its existence.

The embryo—the Weather Bureau's $2,000,000 "704" computer—learned to differentiate between right and left after fifty attempts in the Navy's demonstration for newsmen.

The service said it would use this principle to build the first of its Perceptron thinking machines that will be able to read and write. It is expected to be finished in about a year at a cost of $100,000.

Dr. Frank Rosenblatt, designer of the Perceptron, conducted the demonstration. He said the machine would be the first device to think as the human brain. As do human beings, Perceptron will make mistakes at first, but will grow wiser as it gains experience, he said.

Dr. Rosenblatt, a research psychologist at the Cornell Aeronautical Laboratory, Buffalo, said Perceptrons might be fired to the planets as mechanical space explorers.

Without Human Controls

The Navy said the perceptron would be the first non-living mechanism "capable of receiving, recognizing and identifying its surroundings without any human training or control."

The "brain" is designed to remember images and information it has perceived itself. Ordinary computers remember only what is fed into them on punch cards or magnetic tape.

Later Perceptrons will be able to recognize people and call out their names and instantly translate speech in one language to speech or writing in another language, it was predicted.

Mr. Rosenblatt said in principle it would be possible to build brains that could reproduce themselves on an assembly line and which would be conscious of their existence.

1958 New York Times…

In today's demonstration, the "704" was fed two cards, one with squares marked on the left side and the other with squares on the right side.

Learns by Doing

In the first fifty trials, the machine made no distinction between them. It then started registering a "Q" for the left squares and "O" for the right squares.

Dr. Rosenblatt said he could explain why the machine learned only in highly technical terms. But he said the computer had undergone a "self-induced change in the wiring diagram."

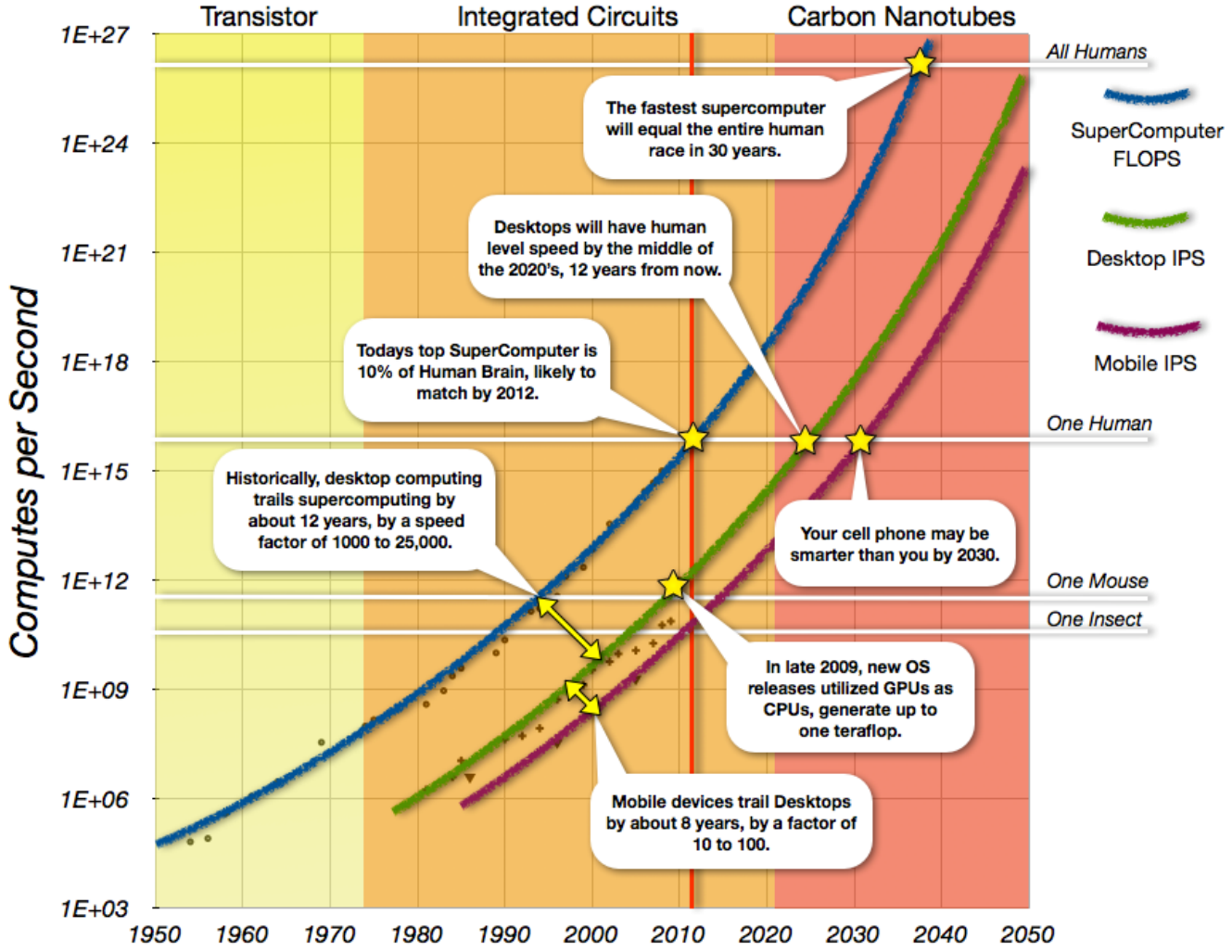
The first Perceptron will have about 1,000 electronic "association cells" receiving electrical impulses from an eye-like scanning device with 400 photo-cells. The human brain has 10,000,000,000 responsive cells, including 100,000,000 connections with the eyes.

…ematician
…landmark
…ting
…ligence" that
…"Can

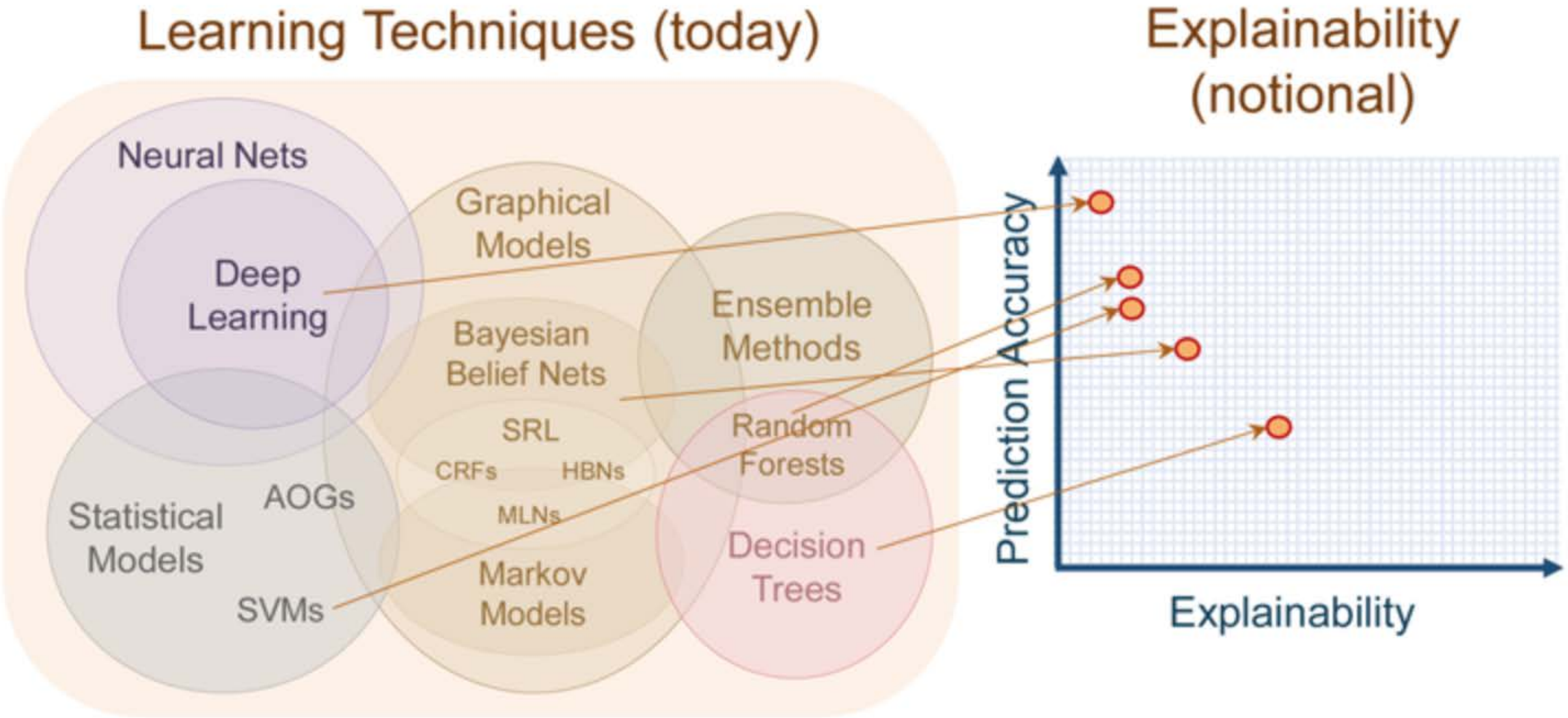
…ut of a 1956
…uth
…McCarthy. In
…t workshop,
…e a "study of
…"

©2019 MFMER | 3868227-3

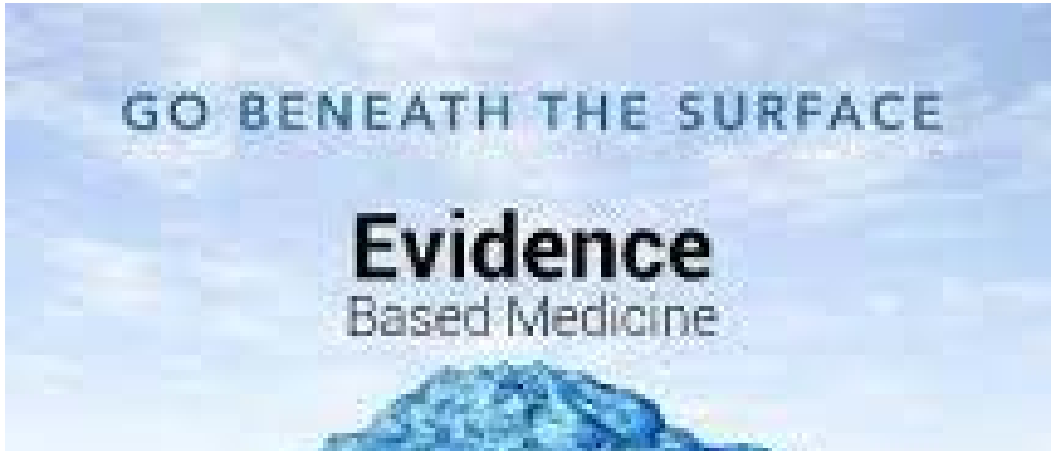
Compute Power



©2019 MFMER | 3868227-4



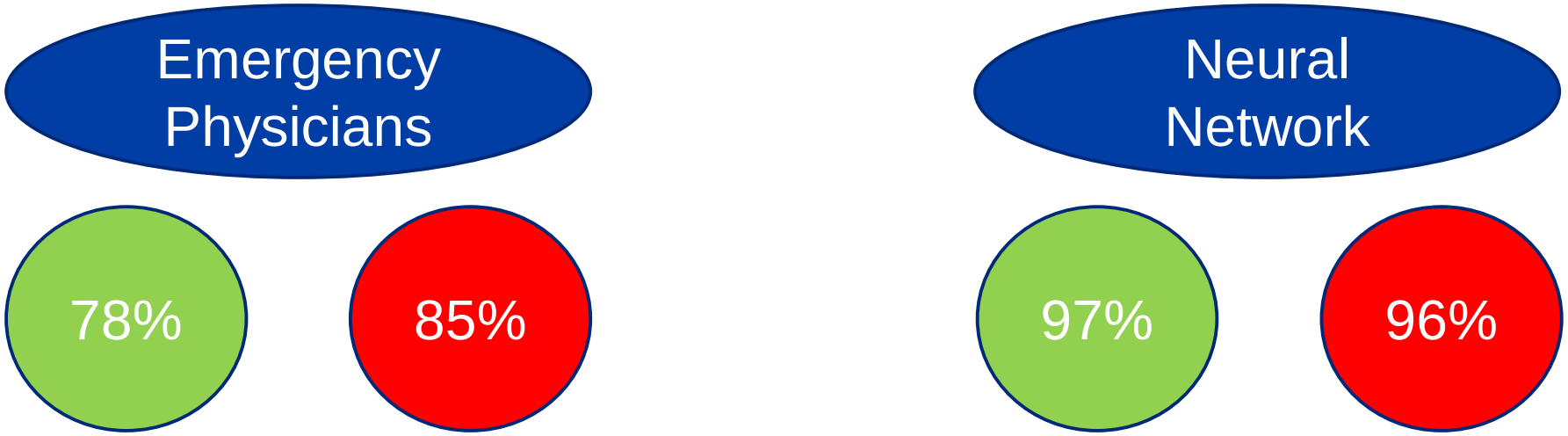
©2019 MFMER | 3868227-5



- Machine intelligence + clinical intelligence = medical intelligence

MAYO CLINIC
©2019 MFMER | 3868227-6

Diagnosis of acute MI in the ED



Baxt, et al. Ann Intern Med. 1991

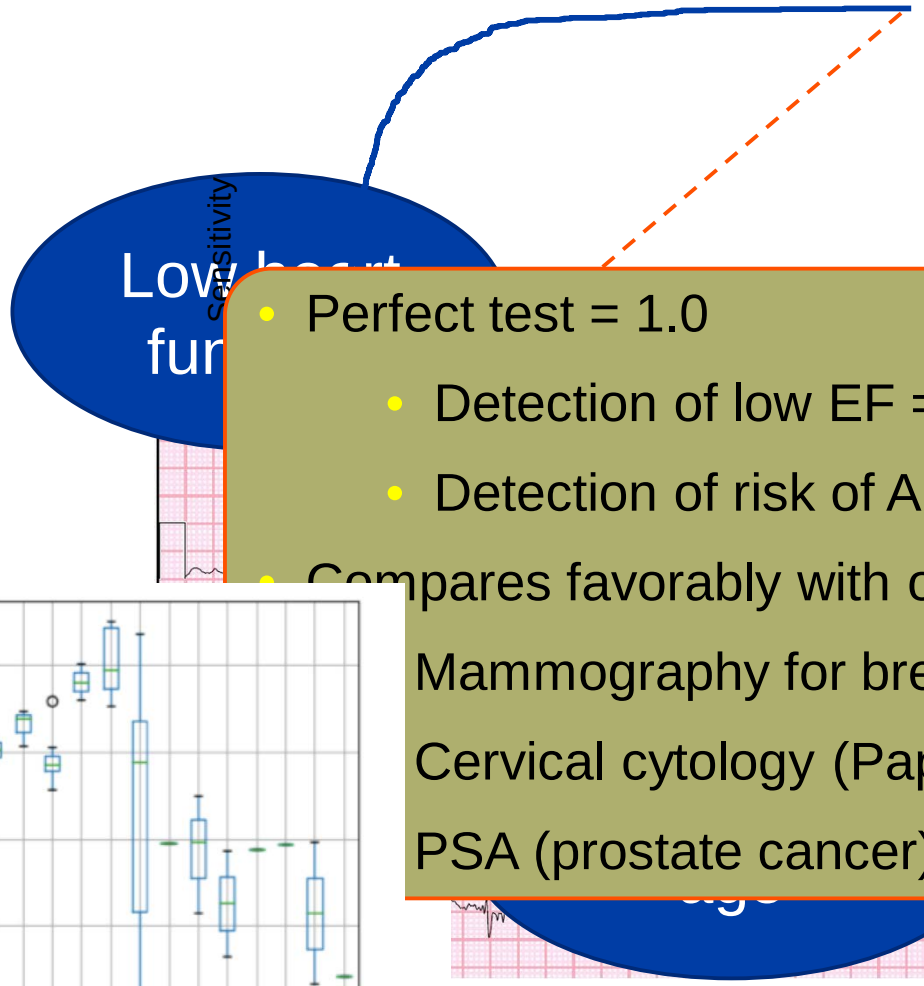
©2019 MFMER | 3868227-7

AI-enhanced ECG interpretation

Streamlining ***human*** capability
- First pass interpretation
- Triage work flow
- Scalability

Beyond ***human*** capability
- Seeing what a clinician cannot
- ‘value-added’ ECG read
- Moving beyond normal/abnormal

©2019 MFMER | 3868227-8

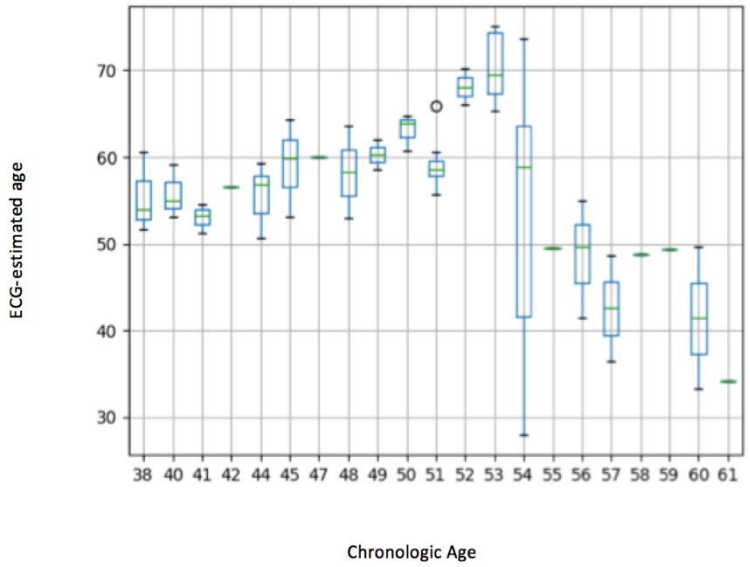


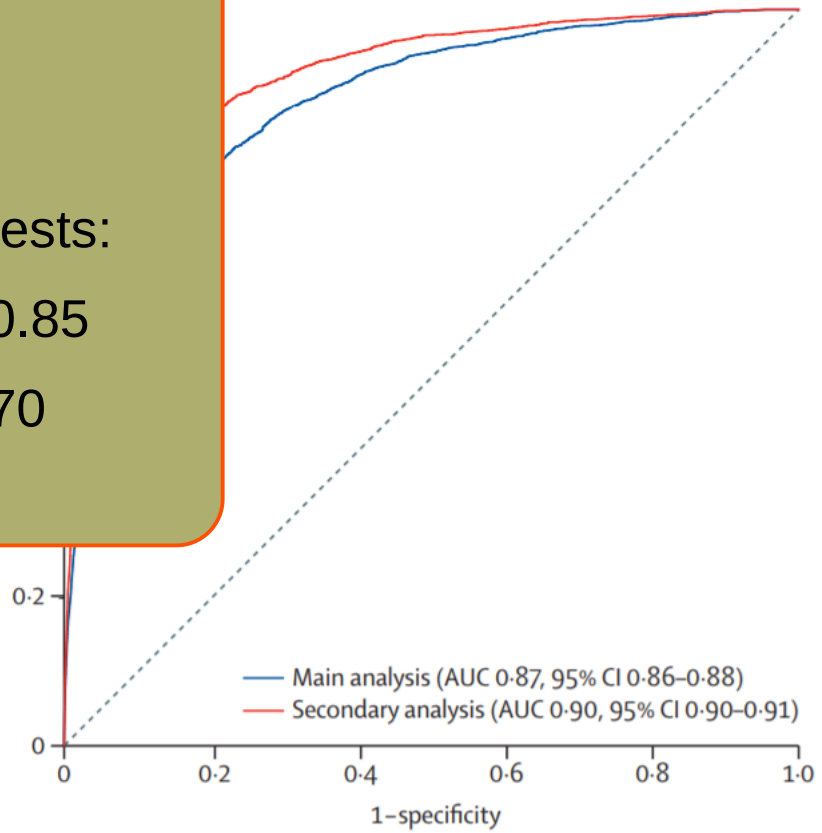
- Perfect test = 1.0
  - Detection of low EF = 0.93
  - Detection of risk of AF = 0.90
- Compares favorably with other medical tests:

Mammography for breast cancer = 0.85

Cervical cytology (Pap smear) = 0.70

PSA (prostate cancer) = 0.92



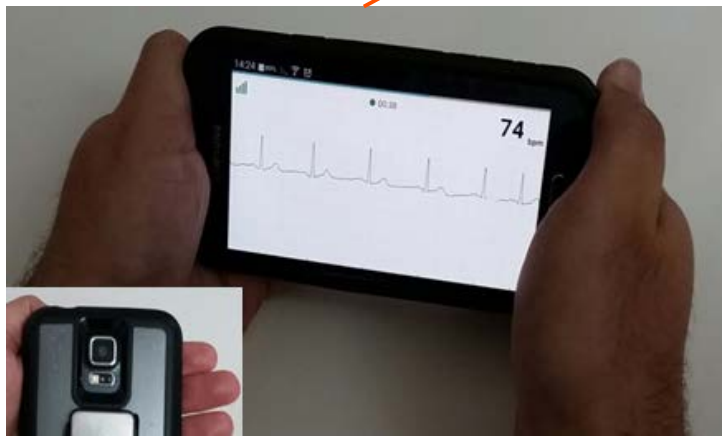


Attia, et al. Nature Medicine 2019

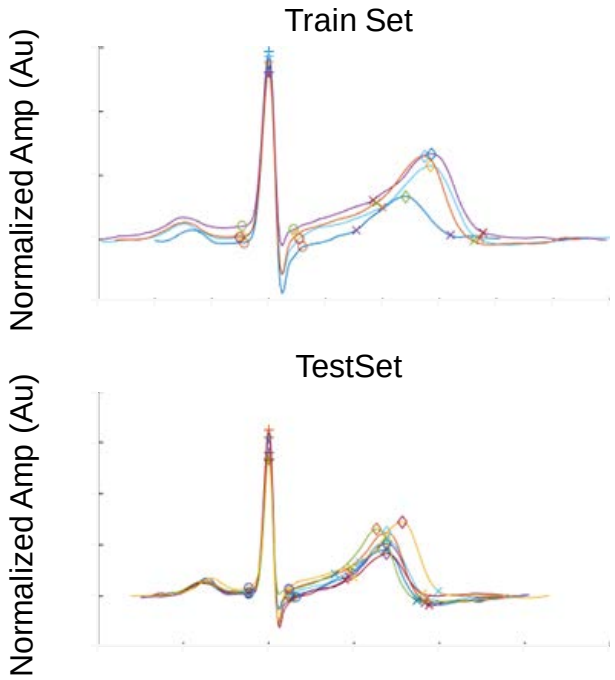
©2019 MFMER | 3868227-9

Can We Do It with a Smartphone?

Secure cloud

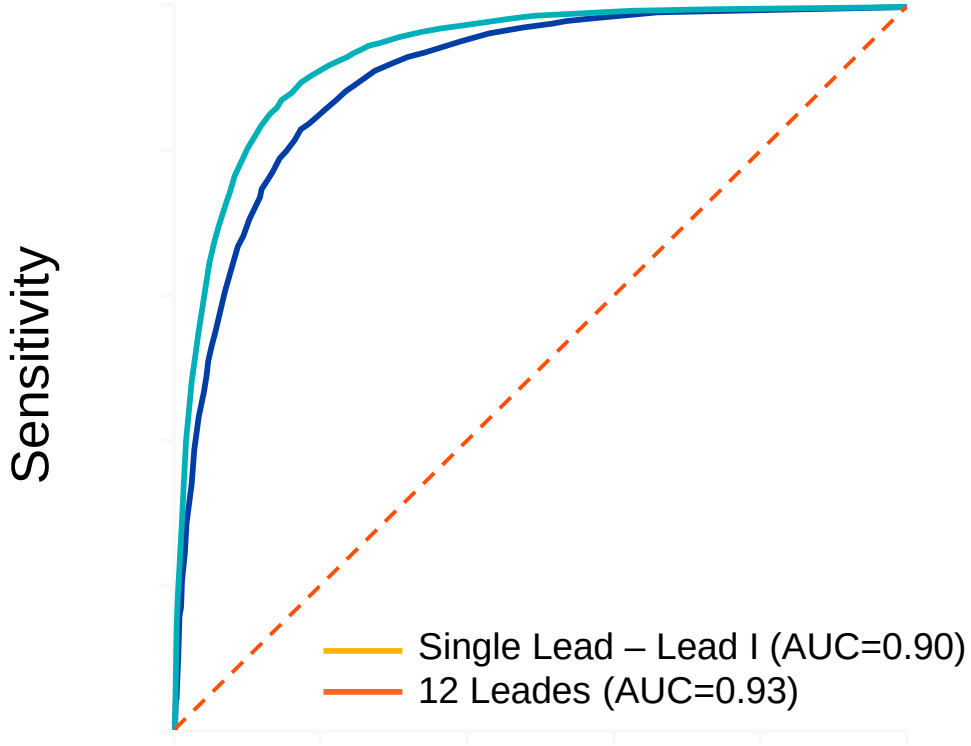


Signal Acquisition



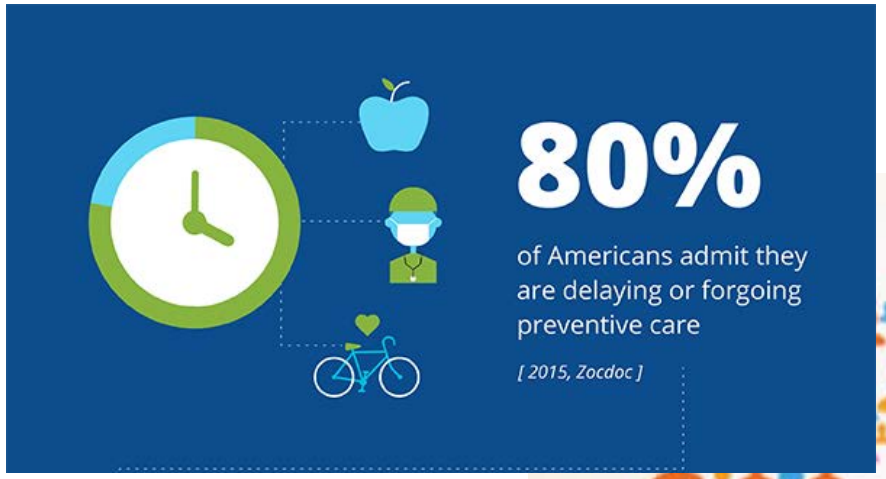
Processes ECG

Receiver Operating Characteristic

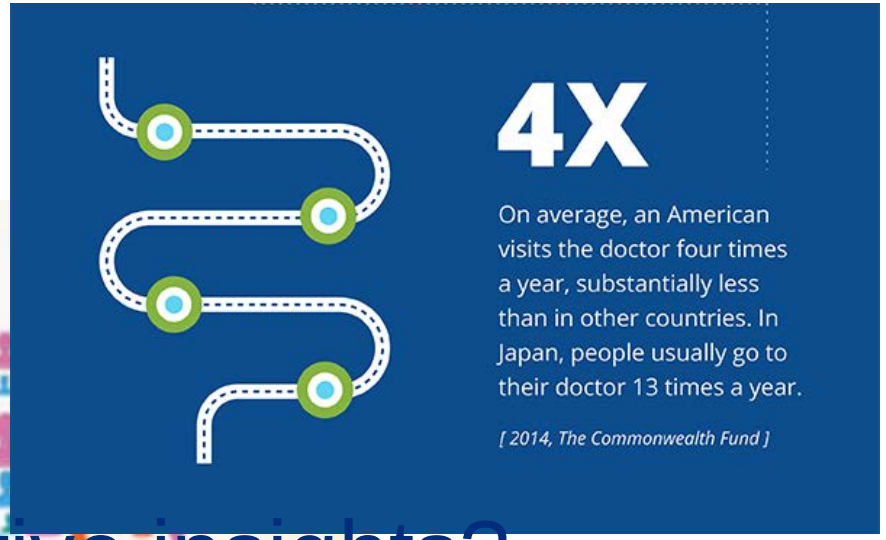


1 – Specificity

©2019 MFMER | 3868227-10



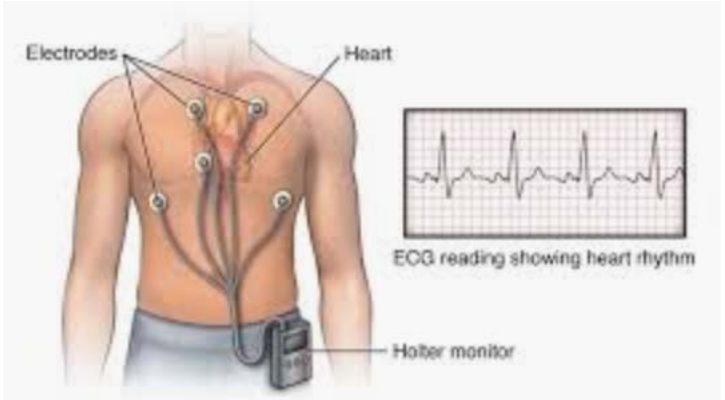
Is this enough?



How do we scale cost effective insights?

©2019 MFMER | 3868227-11

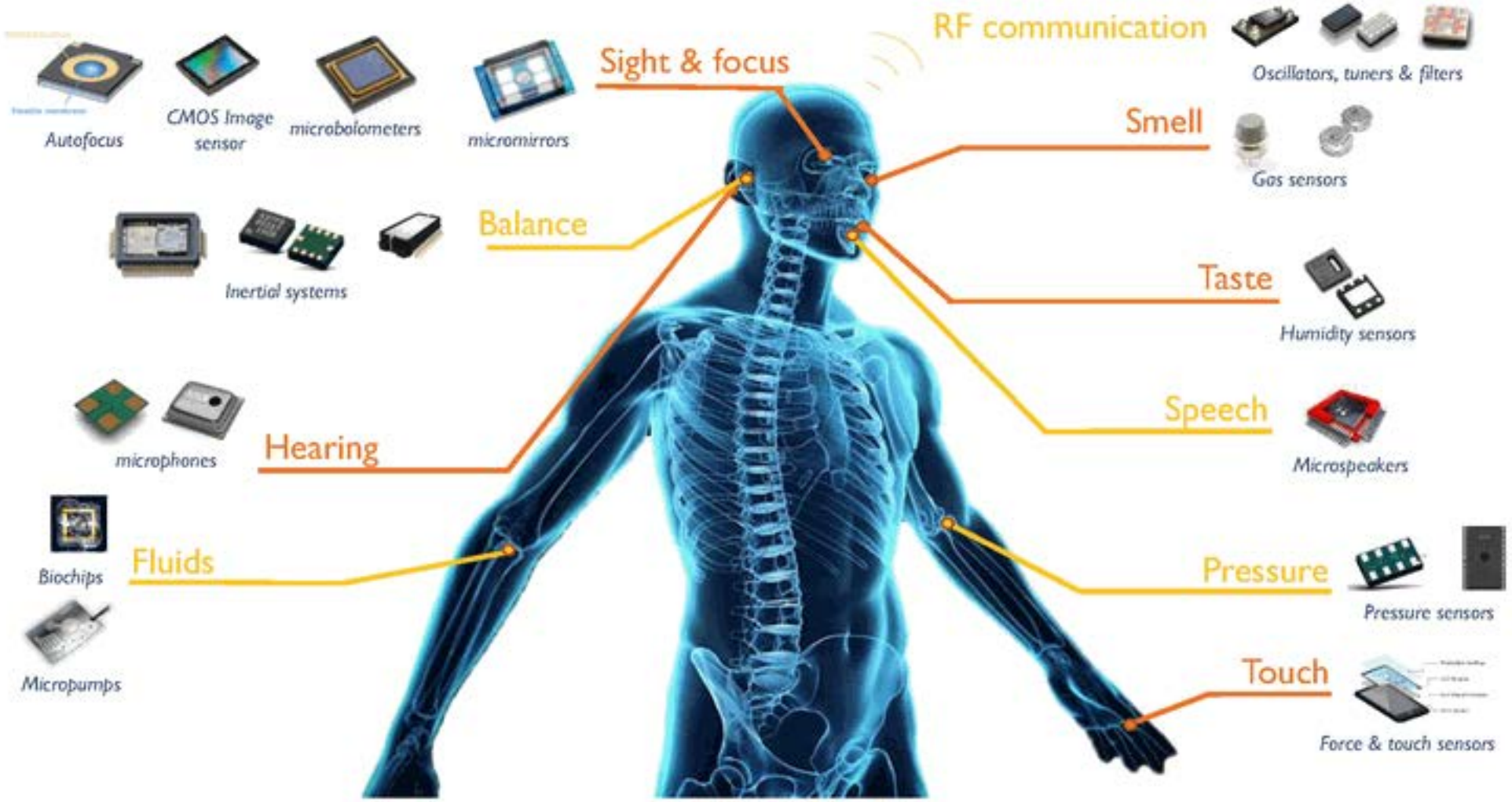
How do we traditionally achieve data?



©2019 MFMER | 3868227-12

The need to go beyond the office

©2019 MFMER | 3868227-13



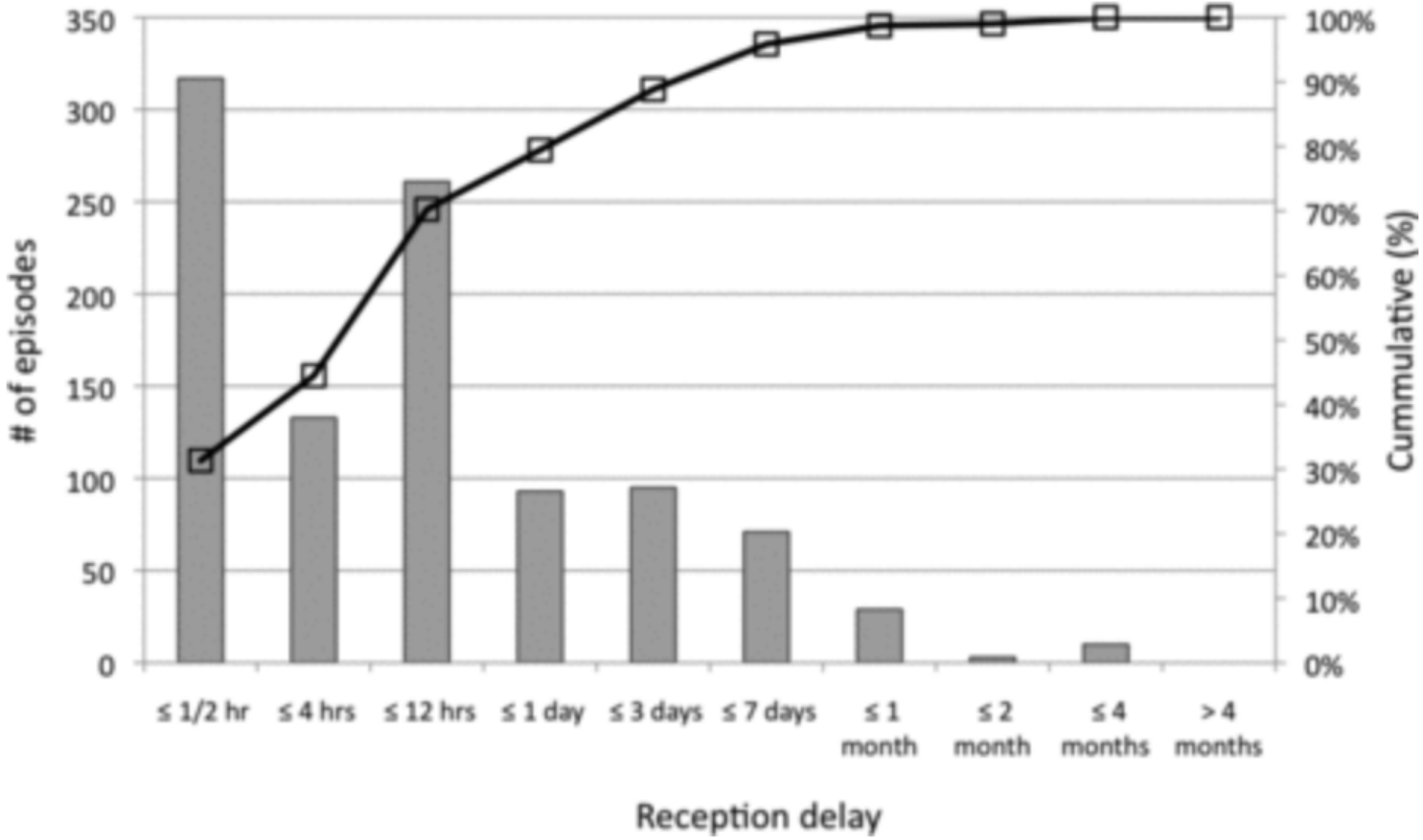
©2019 MFMER | 3868227-14

Are physician-prescribed ambulatory recordings enough?

- Require engagement into a physician's office
- Access issues to technology
- Appropriate data management and interpretation opportunities amongst treating practitioners

©2019 MFMER | 3868227-15

Delay in receipt of data



Arrocha, et al. PACE 2010

©2019 MFMER | 3868227-16

“The patient will see you now”

“There’s a growing expectation among patients and the general public for transparent and secure access to health data” – Khaldoun Tarakji

©2019 MFMER | 3868227-17

IOT Nation

©2019 MFMER | 3868227-18

Digital Health Summit HRS

“I call this the new symptom in cardiology – a high heart rate on a wearable device” – Nassir Marrouche, 2019

“It’s clearly the future – It’s obvious to us that this train has left the station and we can either try to catch up or we can lead.” – David Slotwiner, 2019

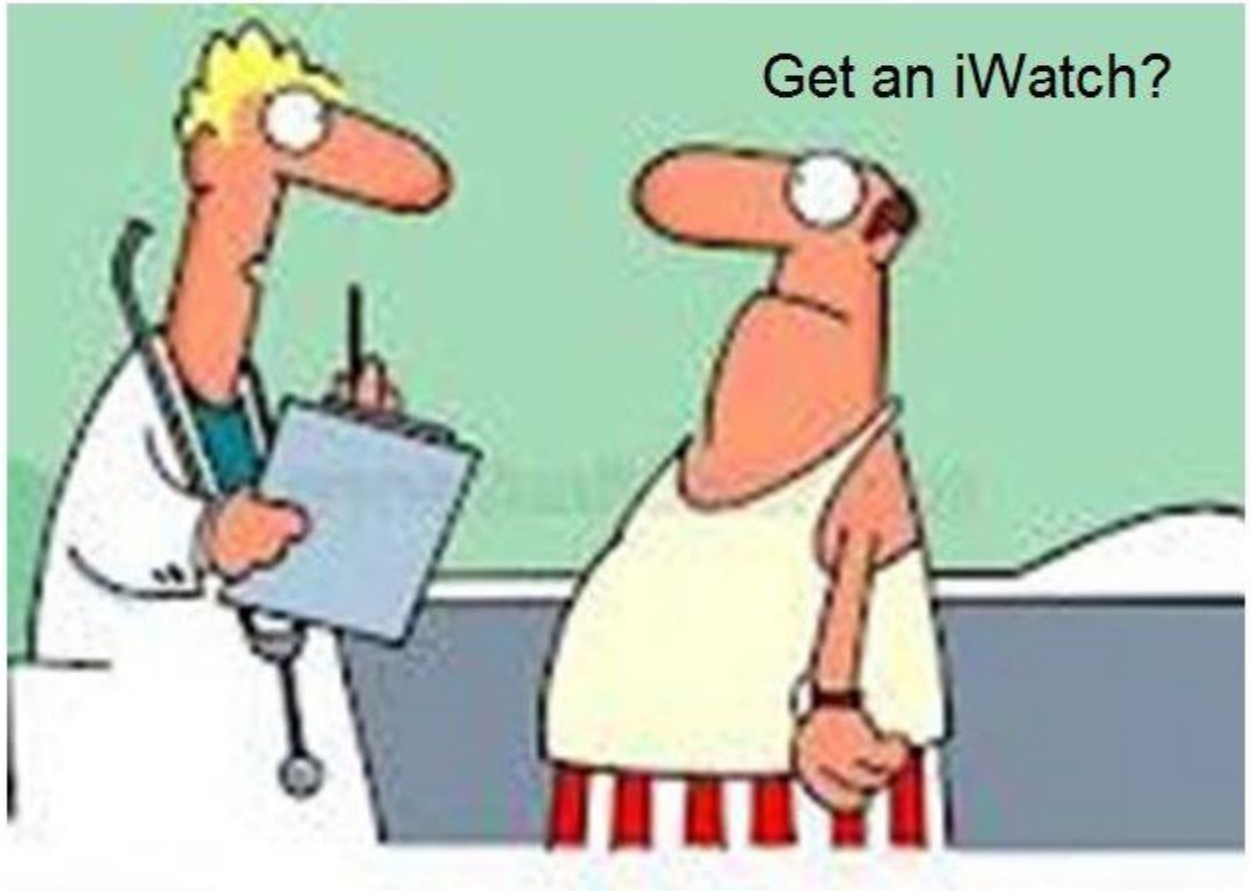
©2019 MFMER | 3868227-19

Apple Heart Study

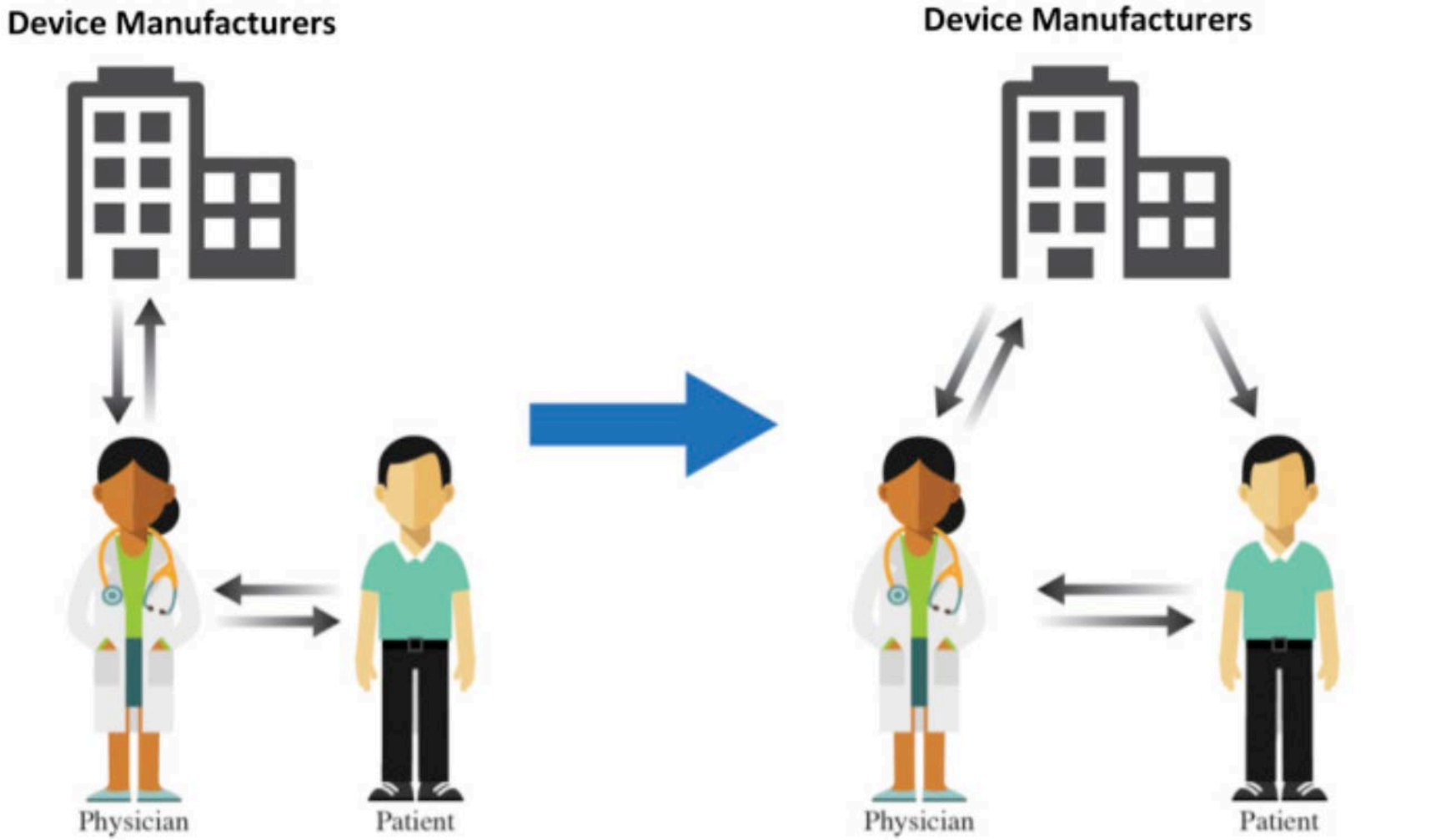
- 400,000 patients enrolled in 8 months
- Pulse notification in 2,161 patients (0.52%)
  - 84% consistent with afib
- Afib identified in 34% with follow up patch monitoring

©2019 MFMER | 3868227-20

What is the best management for atrial fibrillation?



©2019 MFMER | 3868227-21



Opportunities

1. Supportive and widely used technologies (smart devices)
2. Patient engagement
3. Education
4. Potential for better and more affordable care

Obstacles / Challenges

1. Adoption by patients and physicians
2. Physician burden
3. Multiple and disconnected portals
4. Medical vocabulary and terminology
5. Regulatory concerns

Slotwiner, et al. Heart Rhythm 2019

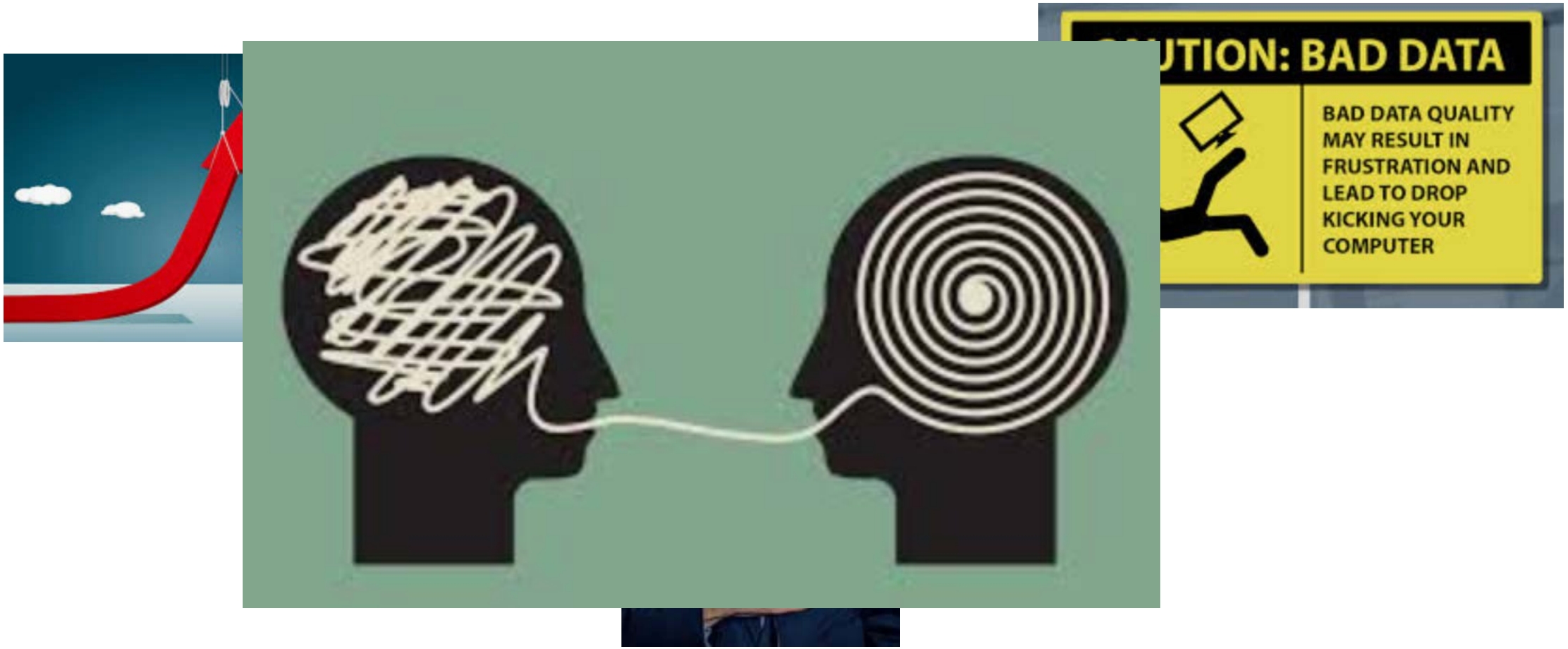
©2019 MFMER | 3868227-22

How can elements work together

- Low cost physiologic monitors may inform implantable devices
- Scalable population health becomes more feasible the more we help annotate ambulatory data and engage AI
- The health of all versus the benefit of some

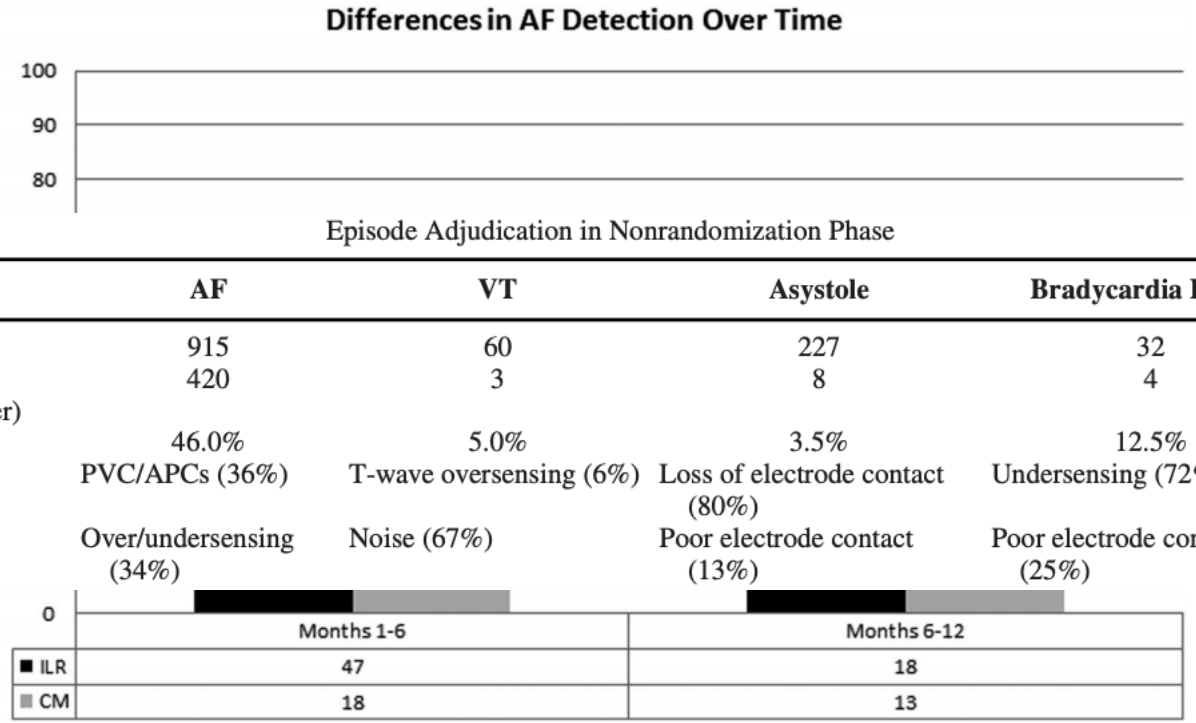
©2019 MFMER | 3868227-23

What are we truly scared of?



©2019 MFMER | 3868227-24

Is interpretation really that much better with current monitors?



Episode Adjudication in Nonrandomization Phase

	AF	VT	Asystole	Bradycardia Events	Total
ILR episodes (number)	915	60	227	32	1234
EP agreement with ILR interpretation (number)	420	3	8	4	435
ILR accuracy	46.0%	5.0%	3.5%	12.5%	35.2%
Causes of ILR misinterpretation	PVC/APCs (36%)	T-wave oversensing (6%)	Loss of electrode contact (80%)	Undersensing (72%)	
	Over/undersensing (34%)	Noise (67%)	Poor electrode contact (13%)	Poor electrode contact (25%)	

Kapa. JCE 2013

©2019 MFMER | 3868227-25

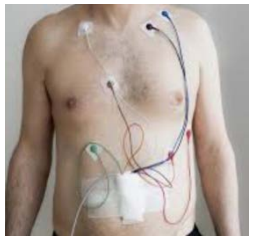
How do we properly deal with the data influx?

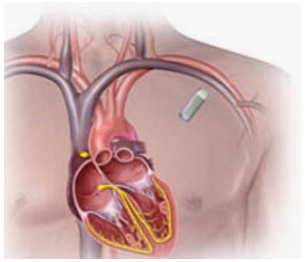
- Work with industry
- Build rapidly modifiable, teachable systems
- Integrate across healthcare systems

©2019 MFMER | 3868227-26

Does it really have to be that bad?

"I have random dizzy spells"





"I have random dizzy spells …
Here's my rhythm strip"

©2019 MFMER | 3868227-27

Conclusions

- AI is an evolving tool to gain rapid insights from traditional medical diagnostics
- AI can allow for data to be rapidly analyzed at large scales rapidly
- Wearable monitors will facilitate the distribution of AI algorithms and AI will facilitate clinician management of monitoring data

©2019 MFMER | 3868227-28

Questions & Discussion

©2019 MFMER | 3868227-29