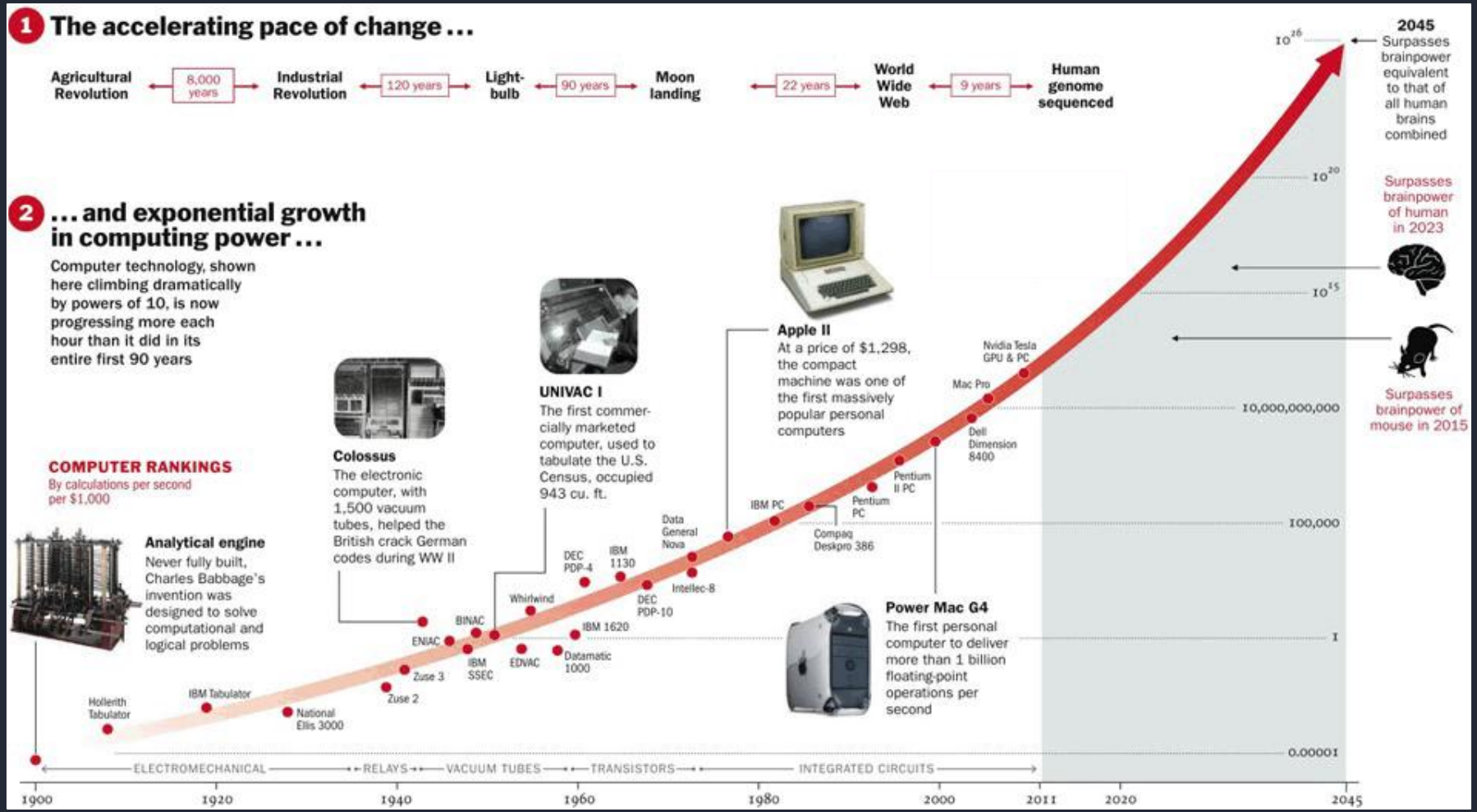
Digital Medicine

The Promise and Peril of a Connected Future

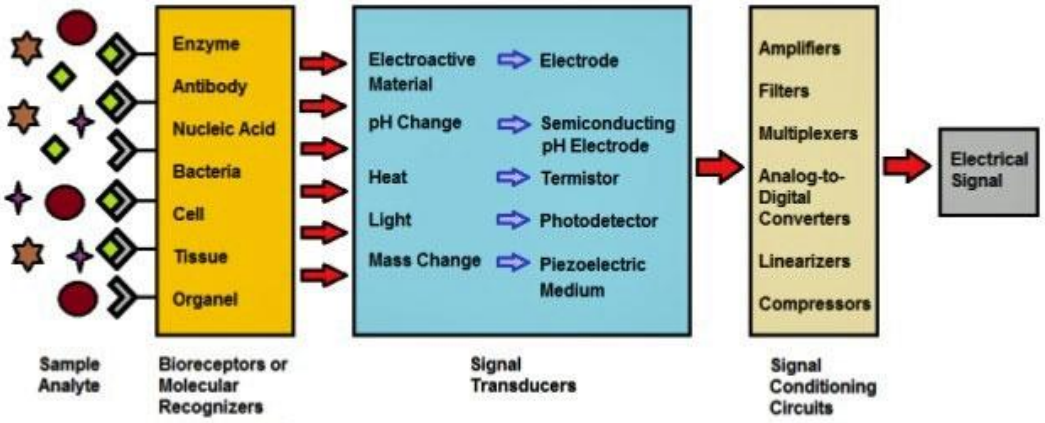
Factor 1: Accelerating Computing Power

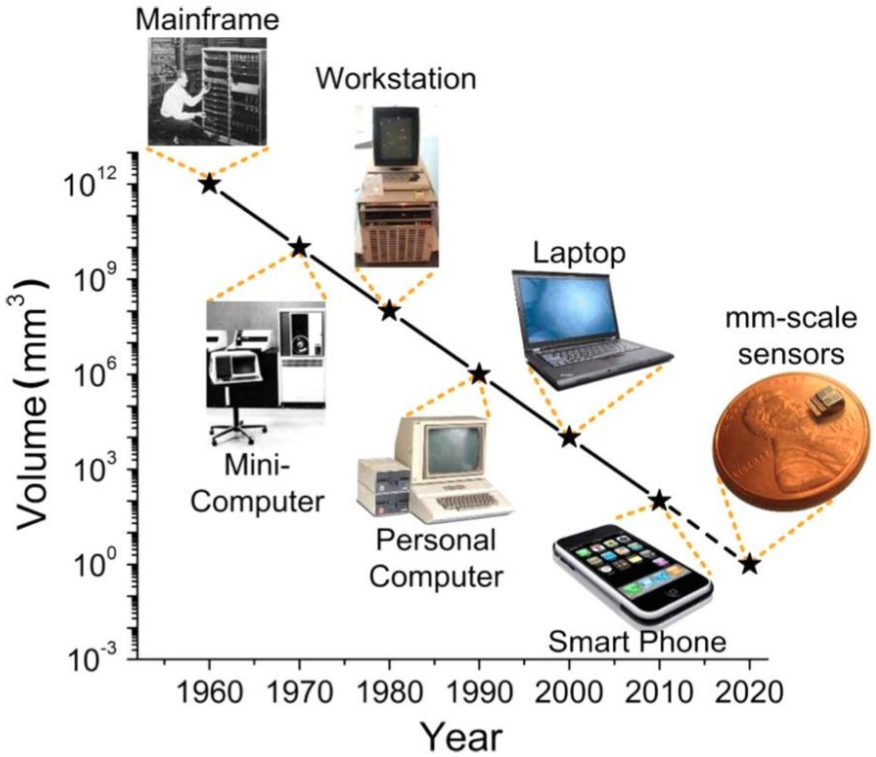


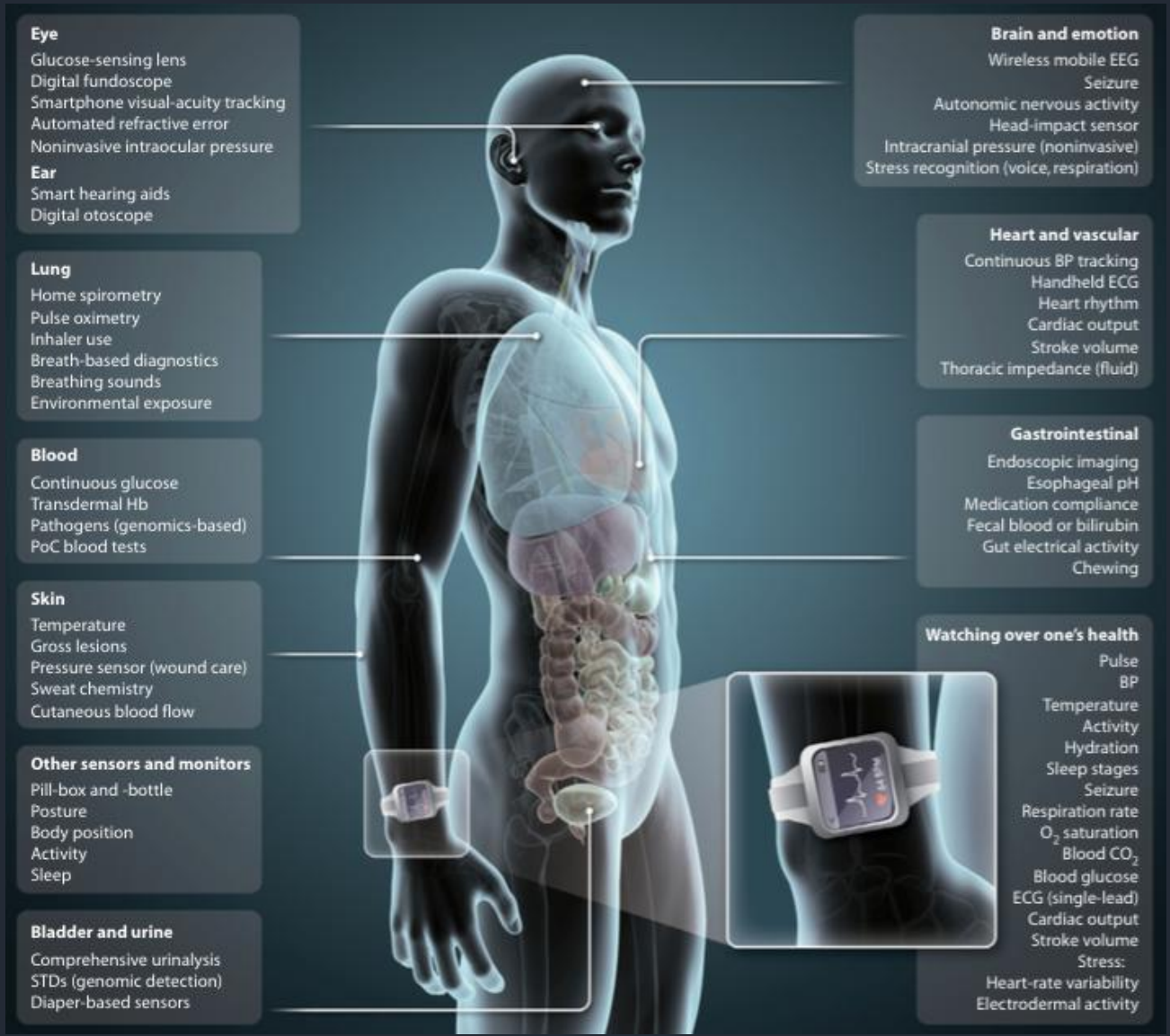
Factor 2: The Rise Of Biosensors

Parts of biosensor

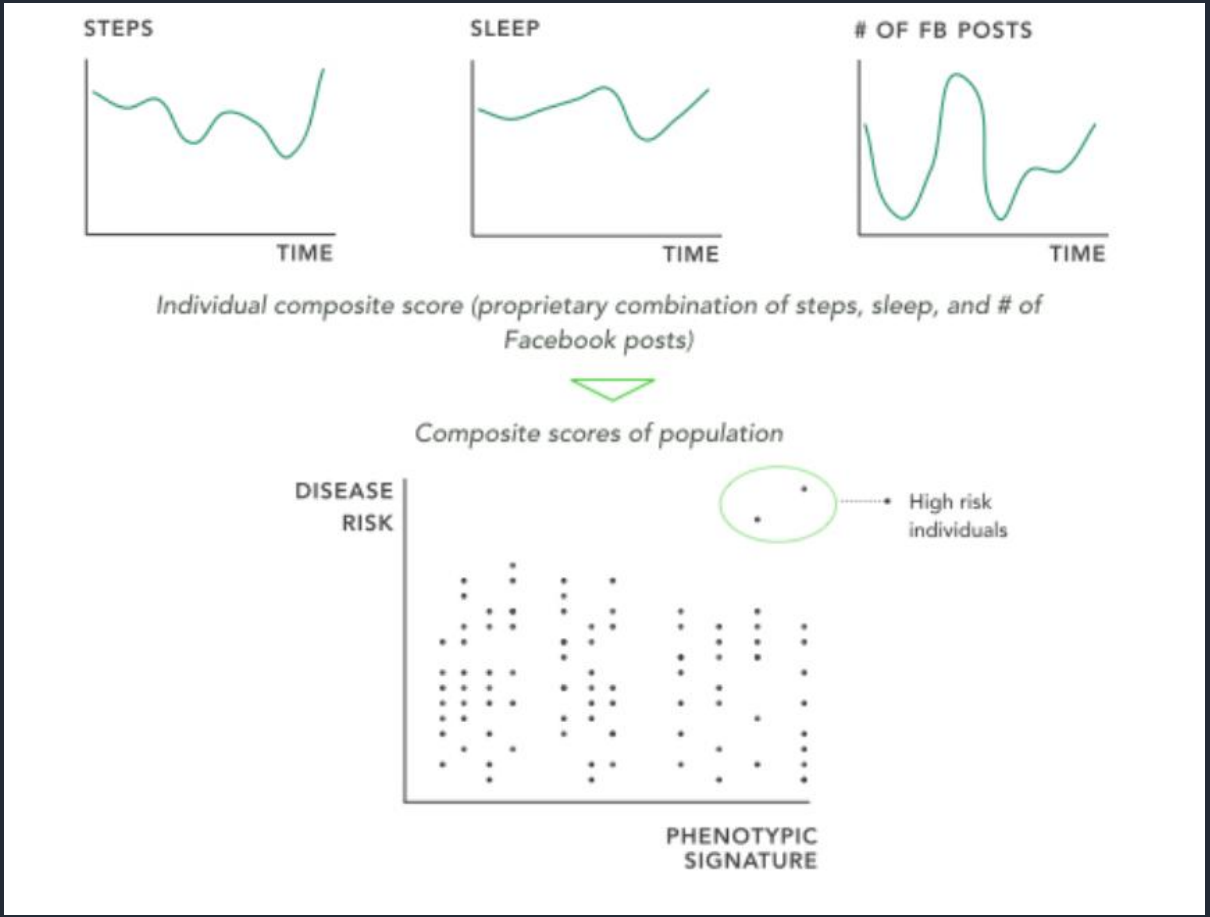
- Bioreceptors
- Transducer
- Signal processor



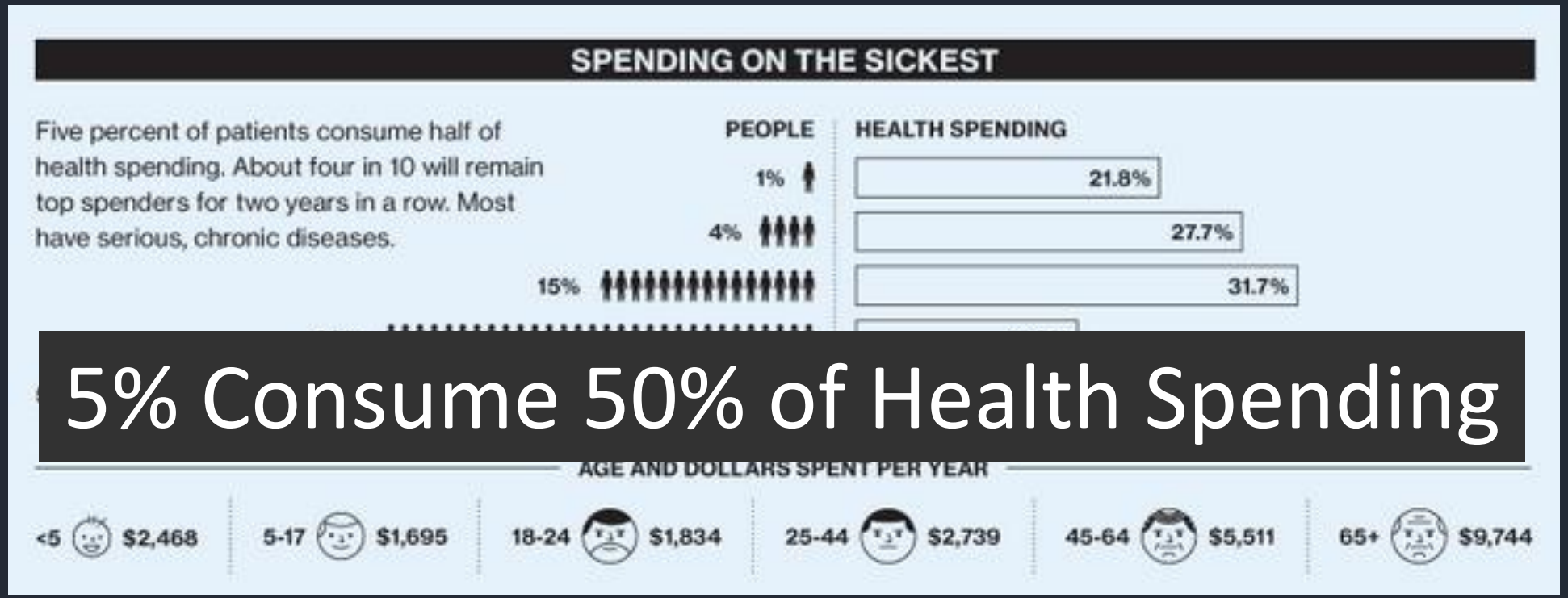



Eye
Glucose-sensing lens
Digital fundoscope
Smartphone visual-acuity tracking
Automated refractive error
Noninvasive intraocular pressure
Ear
Smart hearing aids
Digital otoscope
Lung
Home spirometry
Pulse oximetry
Inhaler use
Breath-based diagnostics
Breathing sounds
Environmental exposure
Blood
Continuous glucose
Transdermal Hb
Pathogens (genomics-based)
PoC blood tests
Skin
Temperature
Gross lesions
Pressure sensor (wound care)
Sweat chemistry
Cutaneous blood flow
Other sensors and monitors
Pill-box and -bottle
Posture
Body position
Activity
Sleep
Bladder and urine
Comprehensive urinalysis
STDs (genomic detection)
Diaper-based sensors
Brain and emotion
Wireless mobile EEG
Seizure
Autonomic nervous activity
Head-impact sensor
Intracranial pressure (noninvasive)
Stress recognition (voice, respiration)
Heart and vascular
Continuous BP tracking
Handheld ECG
Heart rhythm
Cardiac output
Stroke volume
Thoracic impedance (fluid)
Gastrointestinal
Endoscopic imaging
Esophageal pH
Medication compliance
Fecal blood or bilirubin
Gut electrical activity
Chewing
Watching over one's health
Pulse
BP
Temperature
Activity
Hydration
Sleep stages
Seizure
Respiration rate
O_2 saturation
Blood CO_2
Blood glucose
ECG (single-lead)
Cardiac output
Stroke volume
Stress:
Heart-rate variability
Electrodermal activity

Factor 3: A Data Explosion

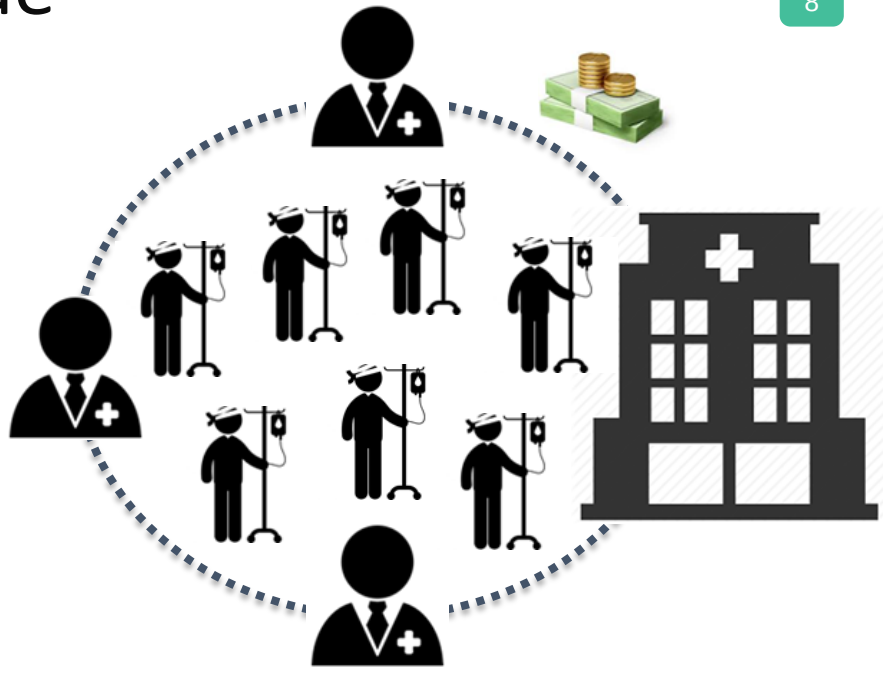


Factor 4: An Inefficient Healthcare system



A Cure for Health Care Costs, Business Report
MIT Technology Review

A Shift From Volume To Value



Fee for Service	**Payment**	Bundled, shared savings, capitated
Patient	**Focus**	Population
Treat	**Incentive**	Prevent


THURSDAY
10,821
Today
Now
36.6°C
36.9°C
55.6
63

Four Factors

Driving the Rise of the Digital Health

- **Accelerating Computing Power**
- **The Rise Of Biosensors**
- **A Data Explosion**
- **An Inefficient Healthcare System**


X-RAY
IN USE
CHECK - IN KIOSK
Do you have chest pain?
Yes
No
CHAPCHAP
CHECK - IN
SOAP
WATER
SOAP
WATER


ANDERSON.


FUEL
354 Cal
147
10:26
GOAL

Can activity trackers help you lose weight?

The IDEA Randomized Clinical Trial

- RCT to study whether activity tracker + standard weight loss intervention would lead to greater weight loss
- Study population – 15-35 yo, BMI between 25-40
- 6 month run in period of low calorie diet, prescribed physical activity goals, counseling.
- At 6 months, patients randomized to either self monitoring with an activity tracker (FIT core upper arm sensor) + website or website alone.

Can activity trackers help you lose weight?

The IDEA Randomized Clinical Trial

	6 months	12 months	18 months	24 months	P value		
Weight loss in kilograms (% change)					Group	Time	Group x Time
Standard Intervention	-8.6 (-9.4)	-8.3 (-8.9)	-7.3 (-7.9)	-5.9 (-6.4)	.07	<.01	.003
Fitness Tracker Intervention	-8.0 (-8.4)	-6.7 (-7.0)	-5.4 (-5.6)	-3.5 (-3.6)	.01	<.01	<.01

There were no differences between groups in

- Physical Activity
- Percent sedentary time
- Dietary intake
- Cardiopulmonary fitness

Does Ranolazine Improve Step Count in Patients with Microvascular Coronary Disease?

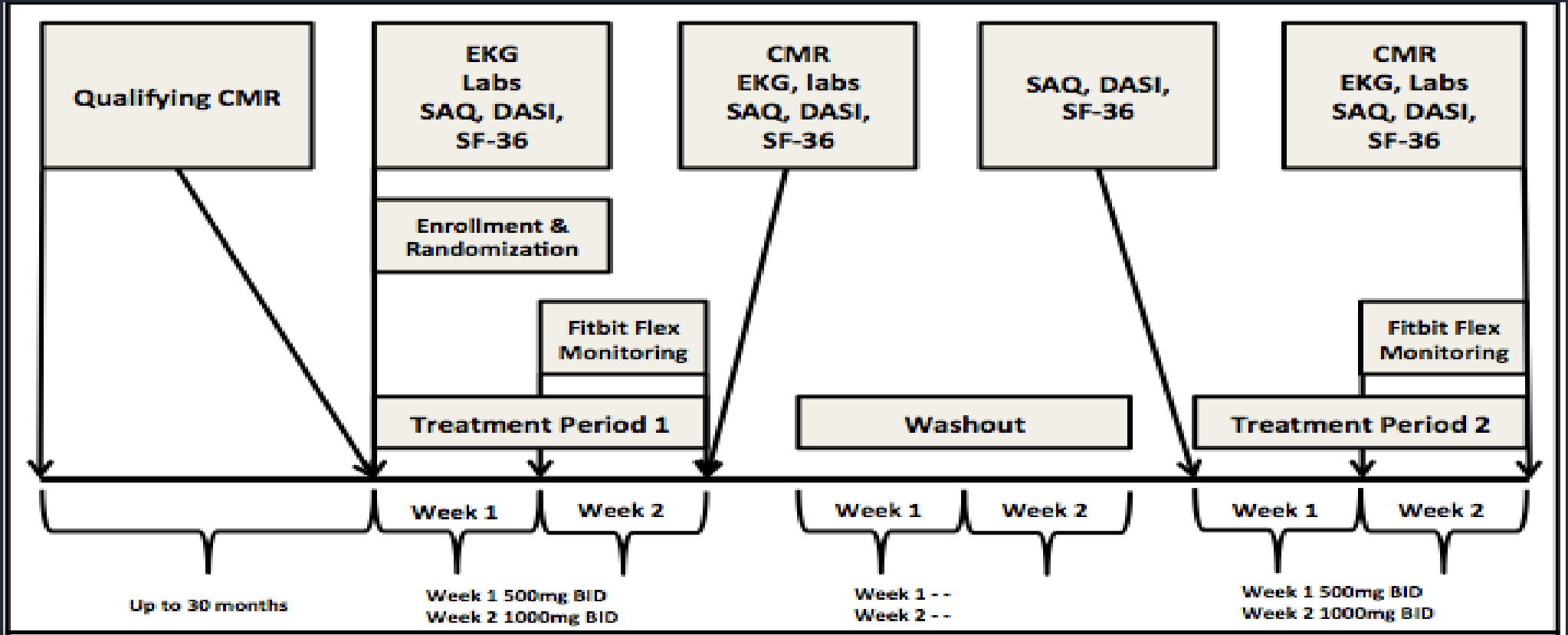
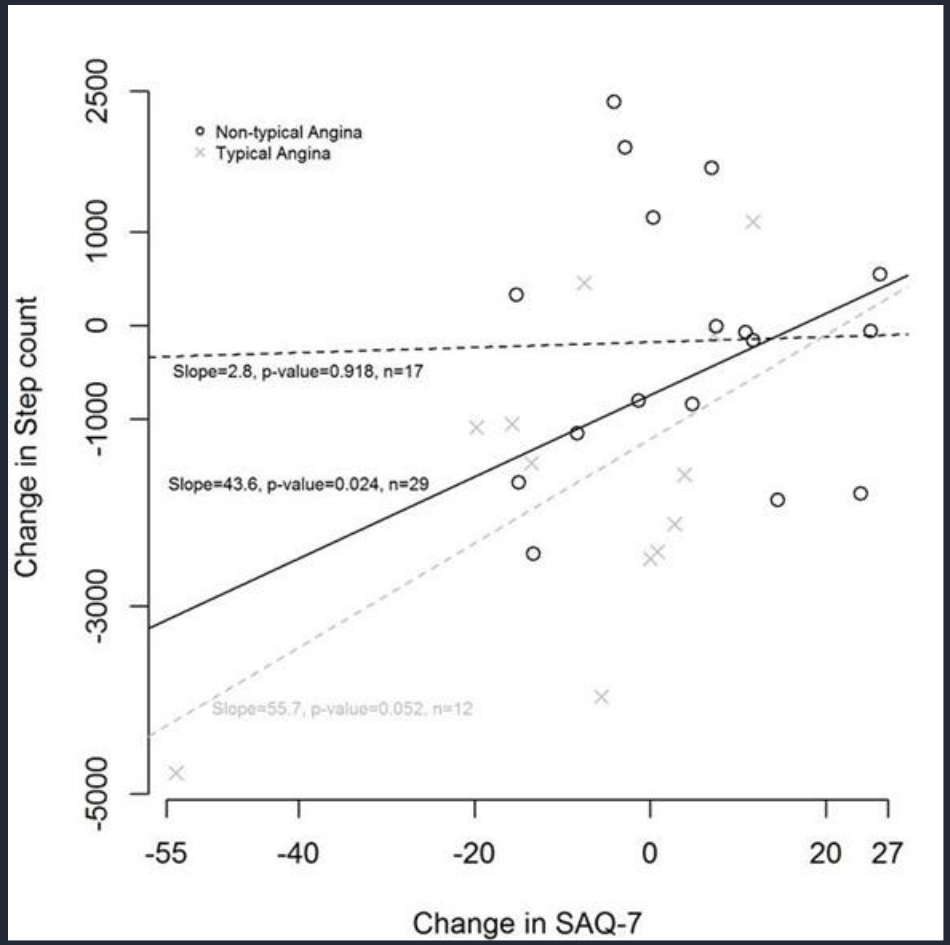


Figure 1. Study Design Flow Diagram
Treatment periods 1 and 2: randomized to sequence of ranolazine first followed by crossover to placebo or vice versa. CMR = cardiac magnetic resonance; SAQ = Seattle Angina Questionnaire; DASI = Duke Activity Status Index; SF-36 = Short-Form 36.

Does Ranolazine Improve Step Count in Patients with Microvascular Coronary Disease?



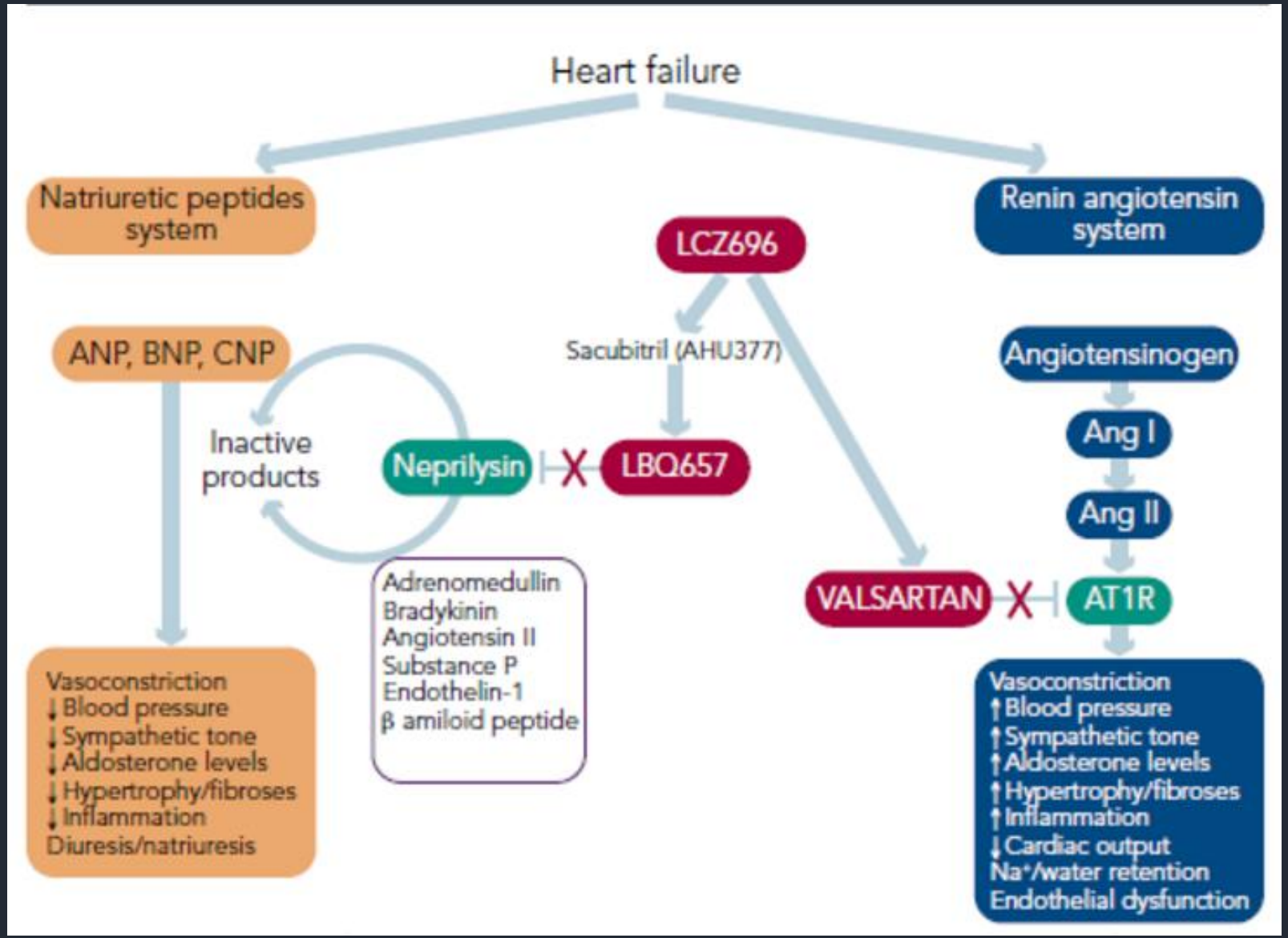
Increased step count correlates increased SAQ7 (decreased angina) independent of treatment

Ranolazine did not increase step count in this patient population

Less angina = more activity

First study to demonstrate a relationship between angina and step count using a wearable monitor

Birkeland K, Khandwalla R, et al. Circ Outcomes 2017


Heart failure
Natriuretic peptides system
Renin angiotensin system
LCZ696
ANP, BNP, CNP
Sacubitril (AHU377)
Angiotensinogen
Inactive products
Neprilysin
LBQ657
Ang I
Ang II
Adrenomedullin
Bradykinin
Angiotensin II
Substance P
Endothelin-1
β amiloid peptide
VALSARTAN
AT1R
Vasoconstriction
↓Blood pressure
↓Sympathetic tone
↓Aldosterone levels
↓Hypertrophy/fibroses
↓Inflammation
Diuresis/natriuresis
Vasoconstriction
↑Blood pressure
↑Sympathetic tone
↑Aldosterone levels
↑Hypertrophy/fibroses
↑Inflammation
↓Cardiac output
Na+/water retention
Endothelial dysfunction

Purpose: The purpose of this study is to investigate the effects of initiation of sacubitril/valsartan vs enalapril treatment on objective measures of physical activity and sleep as health-related quality of life functions in subjects with heart failure.

Primary objective: To evaluate the effect of initiation of sacubitril/valsartan treatment versus enalapril on *physical activity* during the waking hours as an objective measure of physical function and an effector of a subject's health-related quality of life.

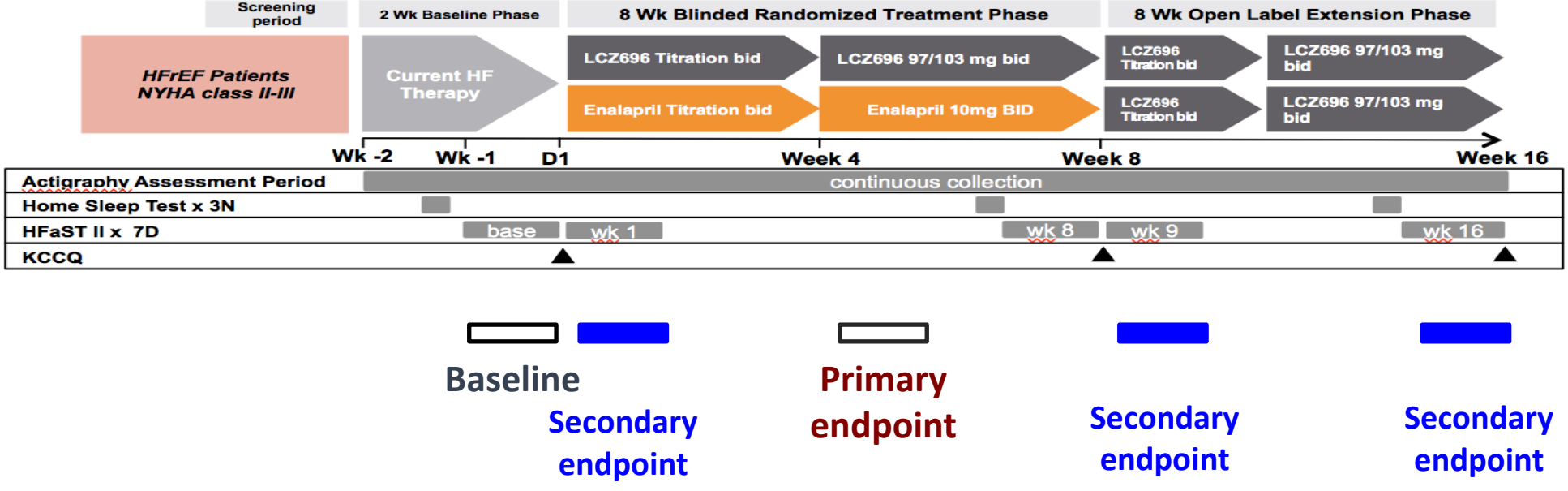
Methodology

- Multicenter, randomized, double blind, double dummy, parallel group, active control
- 18 week study, 11 patient visits, 3 tele-visits
- Estimated sample size – 136 patients, 23 centers

AWAKE-HF

meAsures of WAKing activity and sleep, as hEalth-related quality of life functions in subjects with Heart Failure and reduced ejection fraction

A multicenter, randomized, double-blind, double dummy, parallel group, active-controlled 8-week study with open label extension



Wearable Sensors

Philips Actiwatch Spectrum

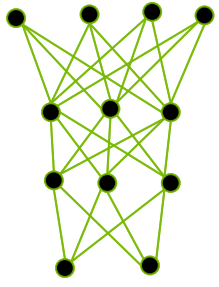
- Sleep/wake history
- Physical activity
- Light sensor
- Off-wrist detection

NovaSom Accusom III

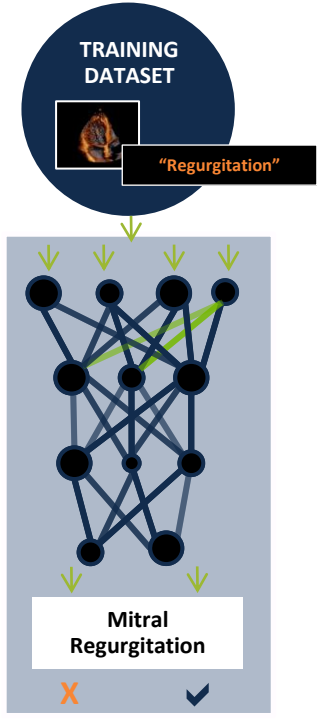
- Arterial oxygen saturation
- Pulse rate
- Respiratory effort
- Airflow wave form corrected for ambient room noise
- Data will be transmitted via cellular network on the morning following a self-administered home sleep test.

What is Deep learning?

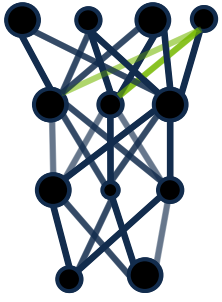
Modeled on the Human Brain and Nervous System

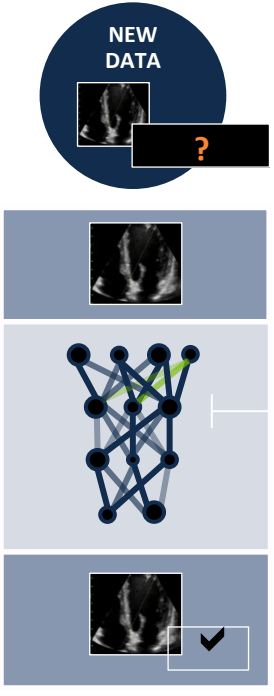


Learning a new capability from existing data



Trained Model
New Capability





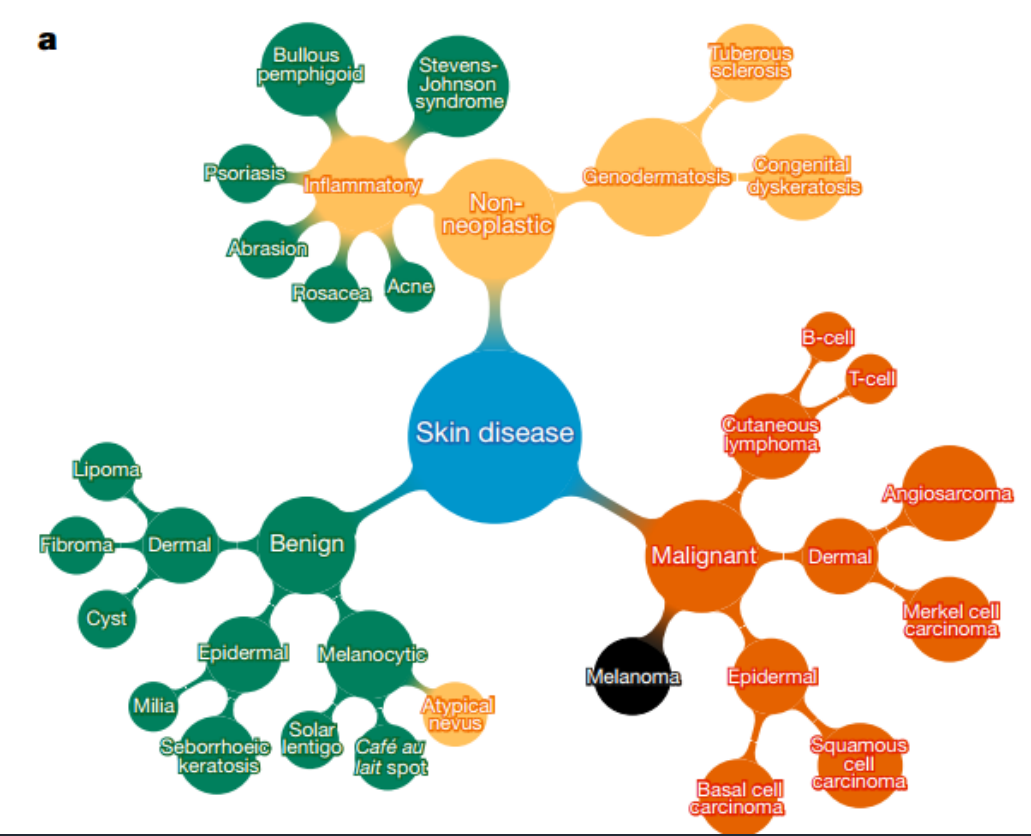
Trained Model
Optimized for Performance

Human versus machine – diagnosing melanoma

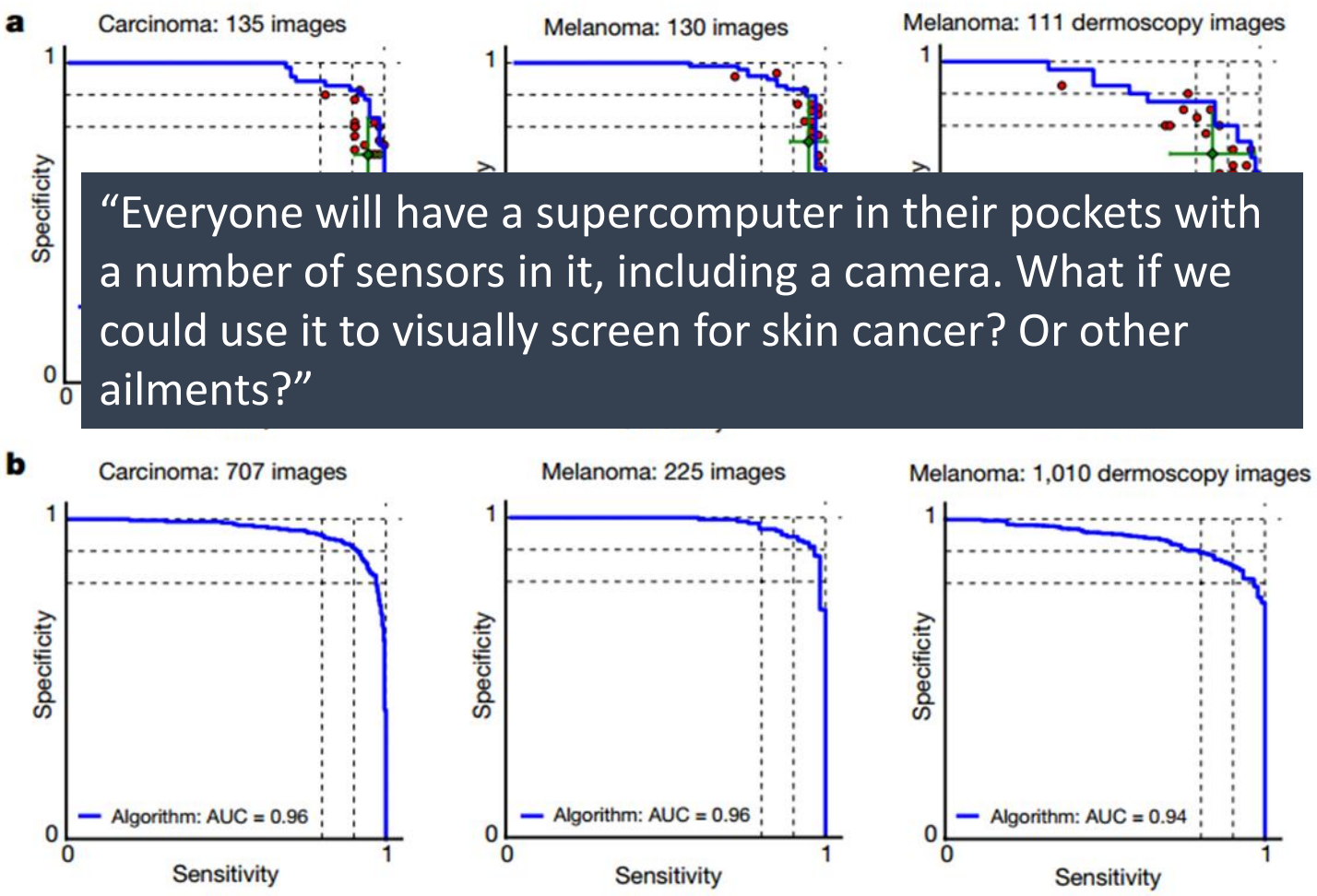
Dermatologist-level classification of skin cancer with deep neural networks 2 FEBRUARY 2017 NATURE

To test whether automated classification of skin lesions using a neural network could outperform dermatologists in identifying skin lesions.

The neural network used 127,463 training images and 1,942 biopsy proven clinical images of 2,032 different disease to test its performance against 21-board certified dermatologists.



Human versus machine – diagnosing melanoma



"Everyone will have a supercomputer in their pockets with a number of sensors in it, including a camera. What if we could use it to visually screen for skin cancer? Or other ailments?"

ACC.18

67th Annual Scientific Session & Expo

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ACC.18

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FUTURE HUB

THE FUTURE OF HEALTH TECHNOLOGY AND INNOVATION

LOEWS SANTA MONICA

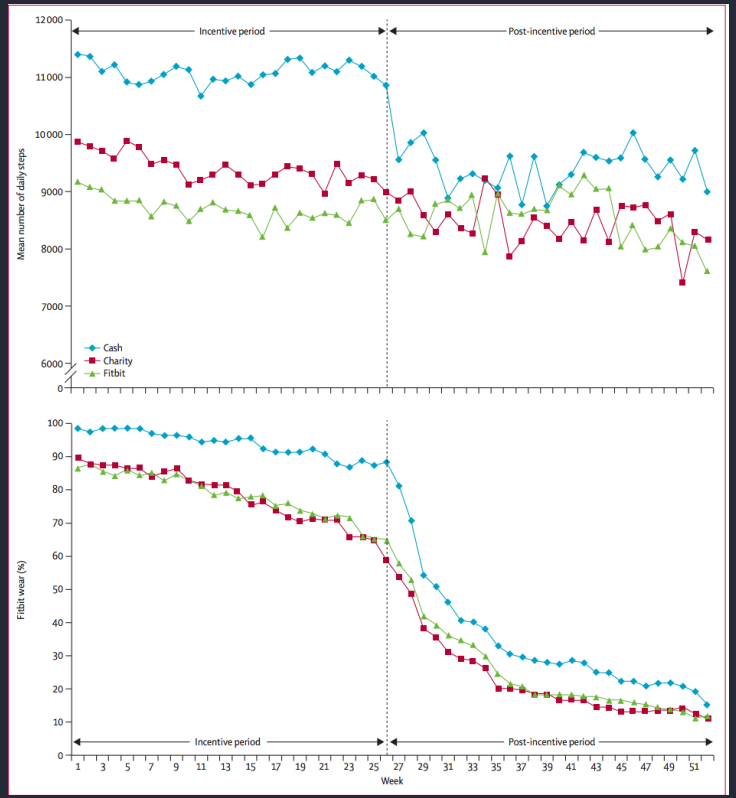
JUNE 9TH, 2018

raj.khandwalla@cshs.org

Can activity trackers + monetary reward help you lose weight?

The TRIPPA Randomized Clinical Trial

- 800 patients, 4-arm, 6 month RCT + 6 month post intervention follow up
  - Control,
  - Fitbit Zip,
  - Fitbit + charitable incentive,
  - Fitbit + cash
- S$15 for 50-70k/wk & S$30 >70k/wk
- Primary Outcome – bout of mod-vigorous physical activity/wk (MPVA)
- No difference between Fitbit and control (+16 MVPA 95% CI -2 – 35, p=0.09)
- Cash and Charity Groups increased activity (p=0.002)
- No improvements in weight, systolic blood pressure, or peak VO2
- Mean earnings in cash group was S$620

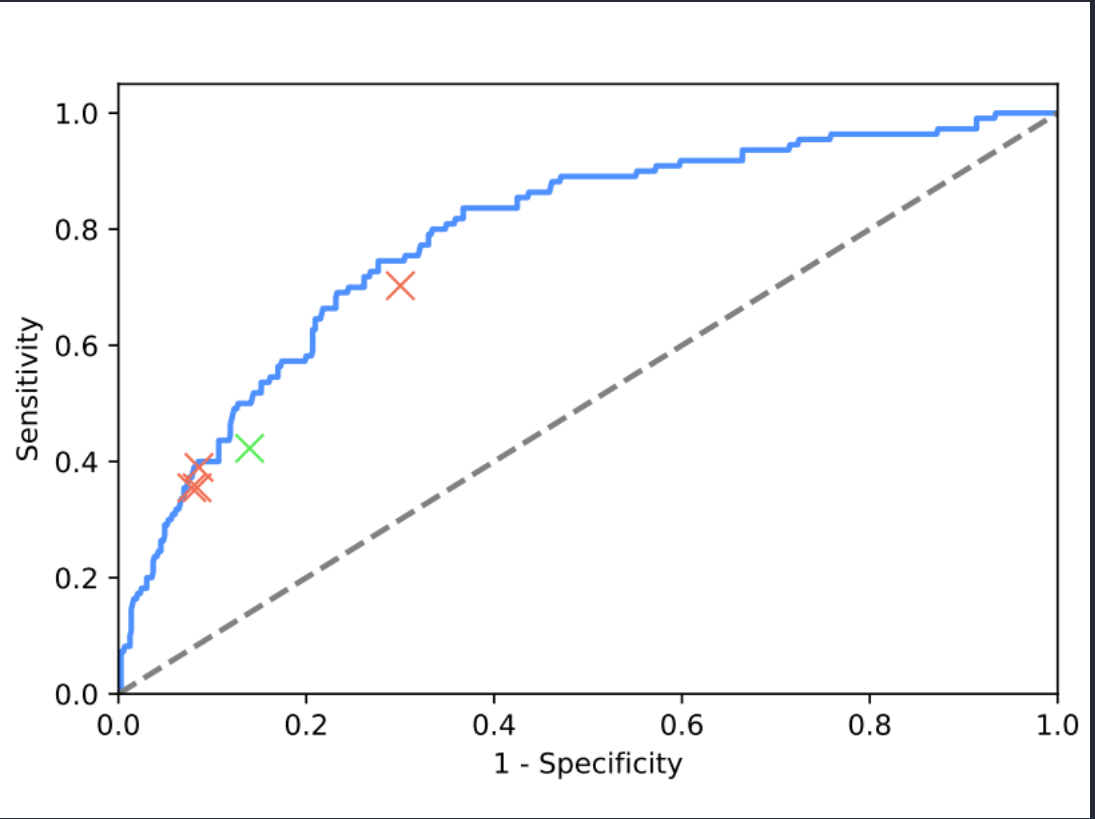



Back
5:24
66
BPM
Normal

Human versus machine – diagnosing pneumonia

CheXNet: Radiologist-Level Pneumonia Detection on Chest X-Rays with Deep Learning

- Developed an algorithm that could detect pneumonia on Chest Xrays
- 121 layer convoluted neural network
- Trained the neural network on a database of 100,000 Chest Xrays of 14 diseases
- Compared the algorithm to 4 practicing radiologists

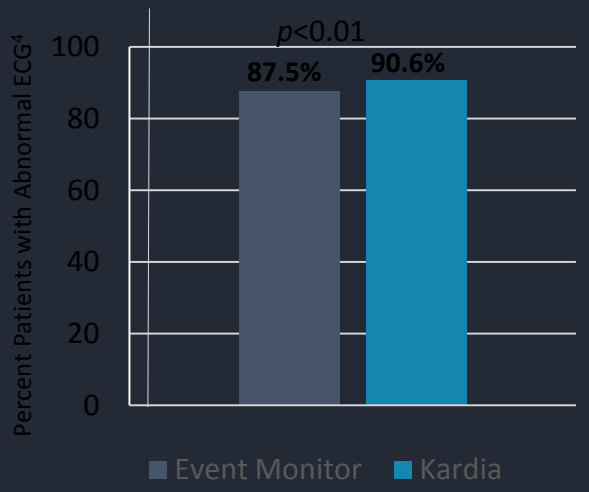


Rajpurkar, Pranav et al., arXiv, pre-publication Nov 14 2017

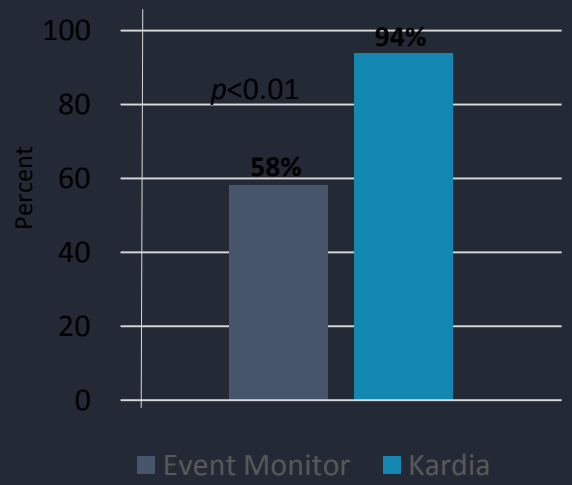
Arrhythmia Diagnosis

Kardia is accurate, user-friendly, and less expensive

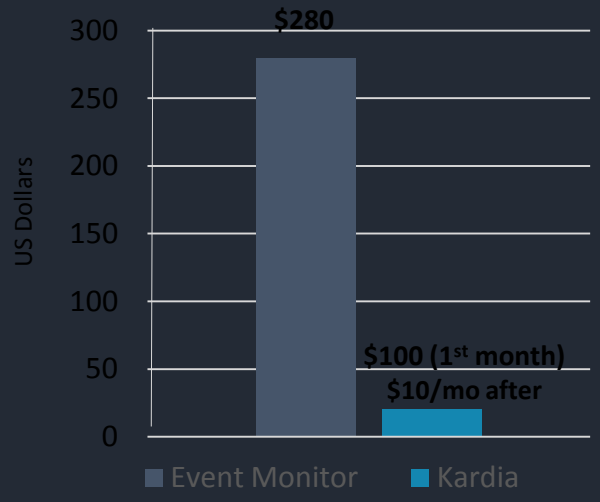
Diagnostic Yield[1,3]



Patient Compliance[1]



Cost of Service[2]



Patients find Kardia significantly more accessible and reported that they would use Kardia at work or social situations more than a traditional event monitor (81% vs. 33%; $p < 0.01$).[1]

1. Deepika Narasimha et al. "A smart phone-based ECG recorder is non-inferior to an ambulatory event monitor for diagnosis of palpitations". University of Buffalo. Presented at HRS, May 2016.
2. Holter monitoring costs based on San Francisco, Global CPTs for Hook-up, Technical, Professional; cms.gov/app/physician-fee-schedule
3. Non-inferior
4. Includes AFib, PAC, PVC arryhthmias

ACC Technology Committee

California Chapter

2017/2018 Strategic Objectives

- Connect companies that are performing digital medicine clinical trials with academic medical centers and private practices that can recruit and execute these trials.
- Create workshops for physicians who are interested in developing their own digital medicine companies or partnering with already established companies.
- Educate practitioners on how to implement digital medicine tools in their practices
- Develop a legislative strategy to enable reimbursement for new technology tools in the cardiology space