Digital Medicine

The Promise and Peril of a Connected Future
Factor 1: Accelerating Computing Power

1. The accelerating pace of change ...
   - Agricultural Revolution 8,000 years
   - Industrial Revolution 120 years
   - Light-bulb 90 years
   - Moon landing 22 years
   - World Wide Web 9 years
   - Human genome sequenced

2. ...and exponential growth in computing power ...
   - Computer technology, shown here climbing dramatically by powers of 10, is now progressing more each hour than it did in its entire first 90 years

- UNIVAC 1: The first commercially marketed computer, used to tabulate the U.S. Census, occupied 943 cu. ft.
- Colossus: The electronic computer, with 1,500 vacuum tubes, helped the British crack German codes during WW II
- Apple II: At a price of $1,298, the compact machine was one of the first massively popular personal computers

- Power Mac G4: The first personal computer to deliver more than 1 billion floating-point operations per second

COMPUTER RANKINGS
- By calculations per second per $1,090
- Analytical engine: Never fully built, Charles Babbage’s invention was designed to solve computational and logical problems
- ENIAC: The first fully electronic computer
- IBM SSIC: IBM 1620
- Mainframe: IBM 402, DEC PDP-8
- Personal computers: Apple II, IBM PC, Pentium PC

2045: Surpasses brainpower of human in 2023
Surpasses brainpower of one mouse in 2015

Superslead times to achieve:
- 1996: Human genome sequenced
- 2045: Surpasses brainpower of human in 2023

Surpass brainpower of one mouse in 2015
Factor 2: The Rise Of Biosensors

Parts of biosensor

- Bioreceptors
- Transducer
- Signal processor
Factor 3: A Data Explosion

Individual composite score (proprietary combination of steps, sleep, and # of Facebook posts)

Composite scores of population

High risk individuals
Factor 4: An Inefficient Healthcare system

A Cure for Health Care Costs, Business Report
MIT Technology Review
A Shift From Volume To Value

<table>
<thead>
<tr>
<th>Fee for Service</th>
<th>Payment</th>
<th>Bundled, shared savings, capitated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td>Focus</td>
<td>Population</td>
</tr>
<tr>
<td>Treat</td>
<td>Incentive</td>
<td>Prevent</td>
</tr>
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</table>
Four Factors Driving the Rise of the Digital Health

• Accelerating Computing Power
• The Rise Of Biosensors
• A Data Explosion
• An Inefficient Healthcare System
Do you have chest pain?
- Yes
- No
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

<table>
<thead>
<tr>
<th></th>
<th>6 months</th>
<th>12 months</th>
<th>18 months</th>
<th>24 months</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight loss in kilograms (% change)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Intervention</td>
<td>-8.6 (-9.4)</td>
<td>-8.3 (-8.9)</td>
<td>-7.3 (-7.9)</td>
<td>-5.9 (-6.4)</td>
<td>.07</td>
</tr>
<tr>
<td>Fitness Tracker Intervention</td>
<td>-8.0 (-8.4)</td>
<td>-6.7 (-7.0)</td>
<td>-5.4 (-5.6)</td>
<td>-3.5 (-3.6)</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

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?
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

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

meAasures 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

INFERENCE Applying this capability to new data

Mitral Regurgitation

NEW DATA

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.
“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?”
THE FUTURE OF CARDIOVASCULAR HEALTH CARE STARTS NOW. The Future Hub will inform, educate and inspire ACC.18 attendees with the latest innovations in Digital Health, Medical Devices, and Ed Tech (Educational Technology).

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

- Developed an algorithm that could detect pneumonia on Chest X-rays
- 121 layer convoluted neural network
- Trained the neural network on a database of 100,000 Chest X-rays 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

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%; $p < 0.01$).\textsuperscript{1}

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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 arrhythmias
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.