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Wearable Device Data: Signal or Noise?

Session 197, February 14, 2019

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Conflict of Interest

Karl A. Poterack, MD, FAMIA

Has no real or apparent conflicts of interest to report.

https://www.consumerreports.org/cro/fitness-trackers/buying-guide/index.htm

Agenda

- Objectives
- Background and Present state
  - Devices/Data
  - Accuracy
  - “Quantified Self”
- Challenges and Barriers
  - Technical
  - Legal/Regulatory
  - Structural
- Solutions
- “Chicken and egg” problem
- Summary and Future

https://www.mensjournal.com/gear/best-fitness-trackers-every-athlete-and-athletic-endeavor/

Learning Objectives

- **After participating in this activity, the learner will be able to:**
- Identify the types of physiologic data that can be captured, now and in the near future, by wearable physiologic monitoring devices
- Recognize the considerations in obtaining, curating, storing and retrieving data from wearable physiologic monitoring devices
- Explain the considerations involved in ensuring data provenance and providing artifact detection when acquiring and managing data from wearable physiologic monitoring devices
- Analyze the changes that will be required in both clinician outlook and health care delivery in order to make use of the data from wearable devices to improve outcomes at both individual and population levels

Background and Present State

- >400 different devices from >100 brands.
- >100 million sold worldwide/yr., inc. >18%/year.
- >50% Americans use
- Fitbit, Xiaomi, Apple, Garmin, Samsung
- **Vendors are collecting the data**
  - >75 trillion steps, >3 billion nights sleep by Fitbit *alone*
- **Very little wearable device data utilized clinically**
- Can this data improve outcomes????

Wearable devices

- Typically wrist watch/band
- Sensors
  - Pedometers, accelerometers, gyroscopes, magnetometers, barometers, altimeters, GPS, photoplethysmogaphers(HR)
- Data
  - Steps, energy, sleep, heart rate, blood pressure, oxygen saturation, glucose, weight, BMI

https://www.self.com/gallery/newest-fitness-monitors-slideshow

How is wearable data “different”

- Device not under health system’s control
- Not “medical grade” (technical, regulatory, etc)
- “Continuous” rather than intermittent
- Novel measurements (steps, etc)

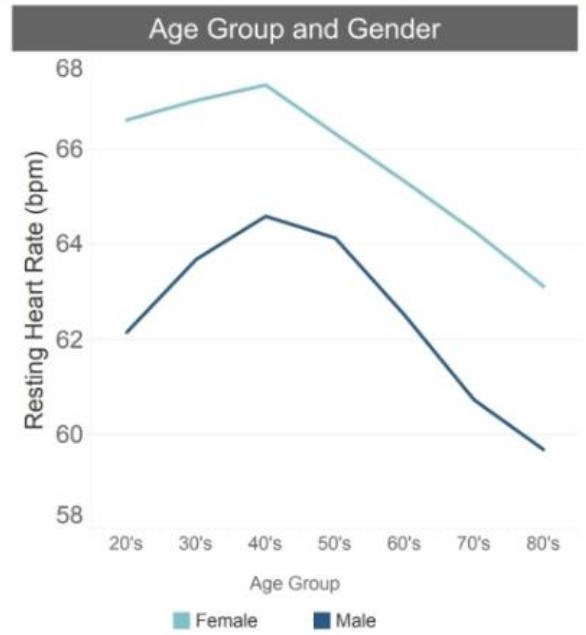
HR Accuracy

- “variable accuracy among wrist-worn HR monitors; none achieved the accuracy of a chest strap–based monitor…accuracy … was best at rest and diminished with exercise.”
  - Wang R, Blackburn G, Desai M, Phelan D, Gillinov L, Houghtaling P, Gillinov M. Accuracy of Wrist-Worn Heart Rate Monitors. JAMA Cardiol. 2017 Jan 1;2(1):104-106
- “There were very good correlations with the criterion during walking (L: r=0.97; R: r=0.97), but good (L: r=0.93; R: r=0.92) and poor/good (L: r=0.81; R: r=0.86) correlations during jogging and running.”
  - Khushhal A, Nichols S, Evans W, Gleadall-Siddall DO, Page R, O'Doherty AF, Carroll S, Ingle L, Abt G. Validity and Reliability of the Apple Watch for Measuring Heart Rate During Exercise. Sports Med Int Open. 2017 Oct 18;1(6):E206-E211.

Fitbit resting HR data

Fitbit's 100+ Billion Hours of Resting Heart Rate User Data Reveals Resting Heart Rate Decreases After Age 40

Fitbit analysis of millions of global users also shows U.S. and Singapore have highest resting heart rate



Resting heart rate data analysis by age and gender (Graphic: Business Wire)

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Sleep data

A sleeper issue

Bed time and wakeup times for Australian Jawbone users

City ▼	Average bed time	Average wake time
Adelaide	11:09 pm	7:04 am
Brisbane	10:43 pm	6:33 am
Canberra	11:01 pm	6:59 am
Fremantle	10:45 pm	6:37 am
Melbourne	11:14 pm	7:09 am
Newcastle	10:51 pm	6:45 am
Perth	10:53 pm	6:44 am
Sydney	11:07 pm	6:55 am
World average	11:35 pm	7:13 am

Fairfax Media graphic

Source: Jawbone,

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Step data

(Graphic: Business Wire)

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Quantified Self Movement

- “incorporate technology into data acquisition on aspects of a person's daily life” (Wikipedia)
- “life logging”
- Everything from detailed records of dietary intake to spreadsheets of multiple activity tracker variables
- Wired magazine article 2007
- quantifiedself.com
- qsinstitute.com

Health Care Paradigm vs. QS

- Evidence based vs. case report
- Population level vs. individual level
- Acknowledge the anecdote
- Precision medicine

What does this data mean?

- Accuracy
- Relevance
- **Your doctor doesn’t know what to do with your daily steps, or daily heart rate changes**

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Challenges and Barriers

- Technical
  - Devices not under the health care system's continuous control
  - Integration into an existing architecture
  - Developing scalable solutions to gathering, storing and curating vast amounts of data
  - Data provenance
  - Artifact rejection - what constitutes artifact?
  - Security (NIST)
- Legal /Regulatory/Privacy
  - HIPAA, etc
- Structural
  - Integrating this continuously obtained data into existing pathophysiologic models
  - Determining how this data may improve health/change outcomes

Not our device

- WHO IS WEARING THE DEVICE??
- Quality control
- Not “Medical grade”
  - standards
  - interfaces

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“Obtaining, curating, storing and retrieving data”

- Sheer volume
- Integration with EHR
- Interoperability between EHRs
- Where stored? Who responsible? Who “owns”?
- “Outside labs” analogy

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Data provenance

- Where does the data come from?
- How is the data obtained?
- Format? Sampling interval?
- Fitbit HR ≠ Apple HR

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Artifact rejection

- Arm movement example
- Vendor’s internal work
- Machine learning vs. human rejection

Data Validation

Crit Care Med. 2011 May ; 39(5): 1006–1014. doi:10.1097/CCM.0b013e31820eab8e.

Clinician blood pressure documentation of stable intensive care patients: an intelligent archiving agent has a higher association with future hypotension

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Results

- “During periods of hemodynamic stability in an ICU patient population, clinician documented BP values were inferior to an intelligent automated archiving method, as early indicators of hemodynamic instability.”
- **“Human oversight may not be necessary for creating a valid archive of vital signs data within an electronic medical record.”**

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SECURING TELEHEALTH REMOTE PATIENT MONITORING ECOSYSTEM

Cybersecurity for the Healthcare Sector

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NCCoE NATIONAL CYBERSECURITY CENTER OF EXCELLENCE

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Security

ars TECHNICA

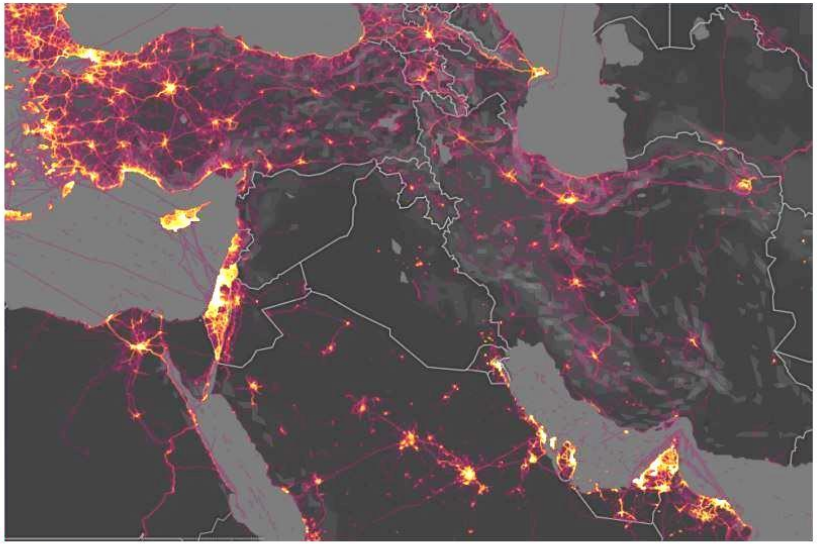
BIZ & IT TECH SCIENCE POLICY CARS GAMING & CULTURE STORE

INFORMATION LEAKAGE —

"Heatmap" for social athlete's app reveals secret bases, secret places

Data map inadvertently reveals movements of people in dangerous and sensitive places.

SEAN GALLAGHER - 1/28/2018, 8:35 PM



Enlarge / A heatmap of Strava "workout" data revealed sensitive locations around the world, including some mysterious places in Syria.

https://arstechnica.com/information-technology/2018/01/heatmap-for-social-athletes-app-reveals-secret-bases-secret-places/

HIPAA

Fitbit Extends Corporate Wellness Offering with HIPAA Compliant Capabilities

Fitbit's HIPAA compliance safeguards support new business and deeper integration opportunities with corporate customers

September 16, 2015 09:00 AM Eastern Daylight Time

SAN FRANCISCO--(BUSINESS WIRE)--Fitbit, Inc., the leader in the connected health and fitness market, today announced that it supports HIPAA compliance, enabling Fitbit Wellness to more effectively integrate with HIPAA-covered entities, including corporate wellness partners, health plans and self-insured employers. The U.S. Health Insurance Portability and Accountability Act (HIPAA) is the primary U.S. law governing the security and privacy of personal health information used by health insurance plans and other covered entities.

Overcoming Challenges

- Technical are “easier”
- Legal/Regulatory are “easier”
- Structural are “harder” (i.e. evidence, best practice, change management)

Structural challenges require paradigm shift

- Previous collection of physiologic data has been limited to patients' intermittent physical interactions with the healthcare system
- Our models of the implications and predictive value is predicated on this
- What do “we” (the health care system) do with wearable data and what does it mean? How can it be used to improve health?

Signal vs. Noise

- An accuracy and artifact question
  - Is the data “real” ?
- Also a usefulness question
  - Is the data meaningful?

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Review

Review

Using wearable technology to predict health outcomes: a literature review

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Literature review

- Objective: To review and analyze the literature to determine whether wearable technologies can predict health outcomes.
- Results: Eight unique studies were directly related to the research question, and all were of at least moderate quality…..studies developed models for readmission and …..mortality. In each of the eight studies, data obtained from wearable technology were predictive of or significantly associated with the tracked outcome.

Literature review results

- 168 studies
- 8 studies (mortality and readmission)
- 17, 285 patients
  - 16760 in 2 of the studies
- 4 studies used steps to predict mortality
- 5 studies used steps to predict readmissions
- 1 study of 25 patients
  - 89 features of Fitbit data
  - Predicted readmission with 88.3% accuracy

“Chicken and Egg" or “Bootstrapping” problem:

- The utility of wearable physiologic monitor data in improving outcomes can't really be determined until large amounts of data are collected and use cases are thereby identified
- BUT large amounts of data can't be collected until the infrastructure is put into place to do so
- AND FURTHER the resources to put that infrastructure in place may not be allocated until use cases are known ...

A solution ?

- Vendors have the device data…..
- Health Care Systems have the patient outcome data
- Partnerships between device vendors and Health Systems to link device data with clinical outcomes
- Could identify potential use cases for utilizing this data to improve clinical outcomes.

Summary and Future

- Tremendous volume of potentially useful physiologic data
- The signal to noise ratio is unclear
  - what data is accurate and what is artifact
  - what are the clinical outcome implications of such data.
- Existing infrastructures do not facilitate the easy integration of patients' wearable device data into the medical record.
- Technical challenges can be overcome; they require scalable solutions.
- The systemic and attitudinal barriers to utilizing this data need to be addressed as well.
- The "chicken and egg" or "bootstrapping" problem described above will need to be solved, perhaps by opportunities to link vendor data with outcomes contained in health system EHRs.

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Questions

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- Please complete online session evaluation!

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