# The Emerging Role of Mobile Phones Healthcare

**Shwetak N. Patel**

WRF Endowed Professor

Allen School of Computer Science & Engineering

Electrical & Computer Engineering

Ubicomp lab

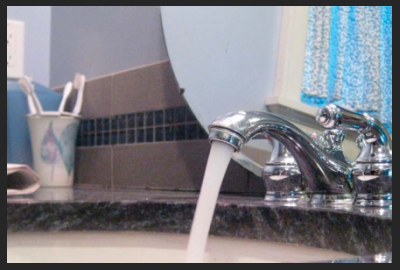
**University of Washington**

Director of Health Technologies

**Google**

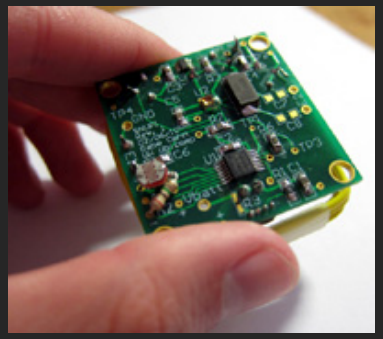
# Quick Research Overview

Energy monitoring

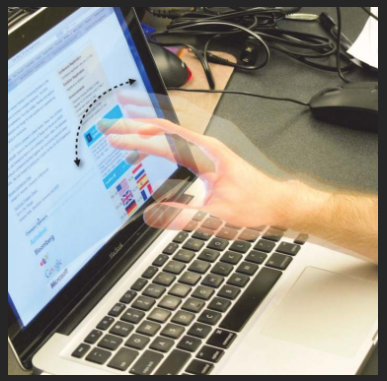


Health

Low-power wireless sensing



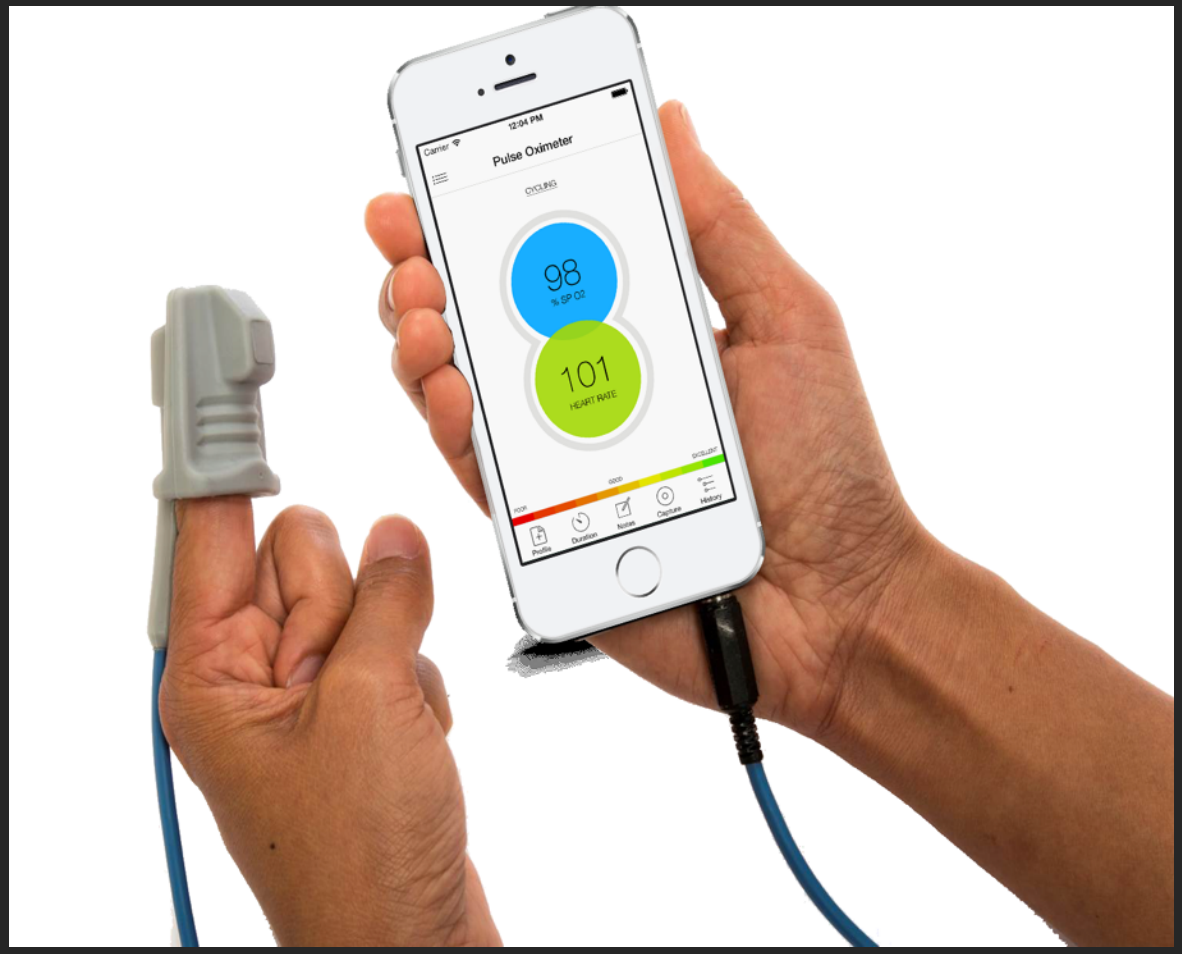
New interaction techniques



# Personal Health Monitoring

# Point of Care Diagnostics

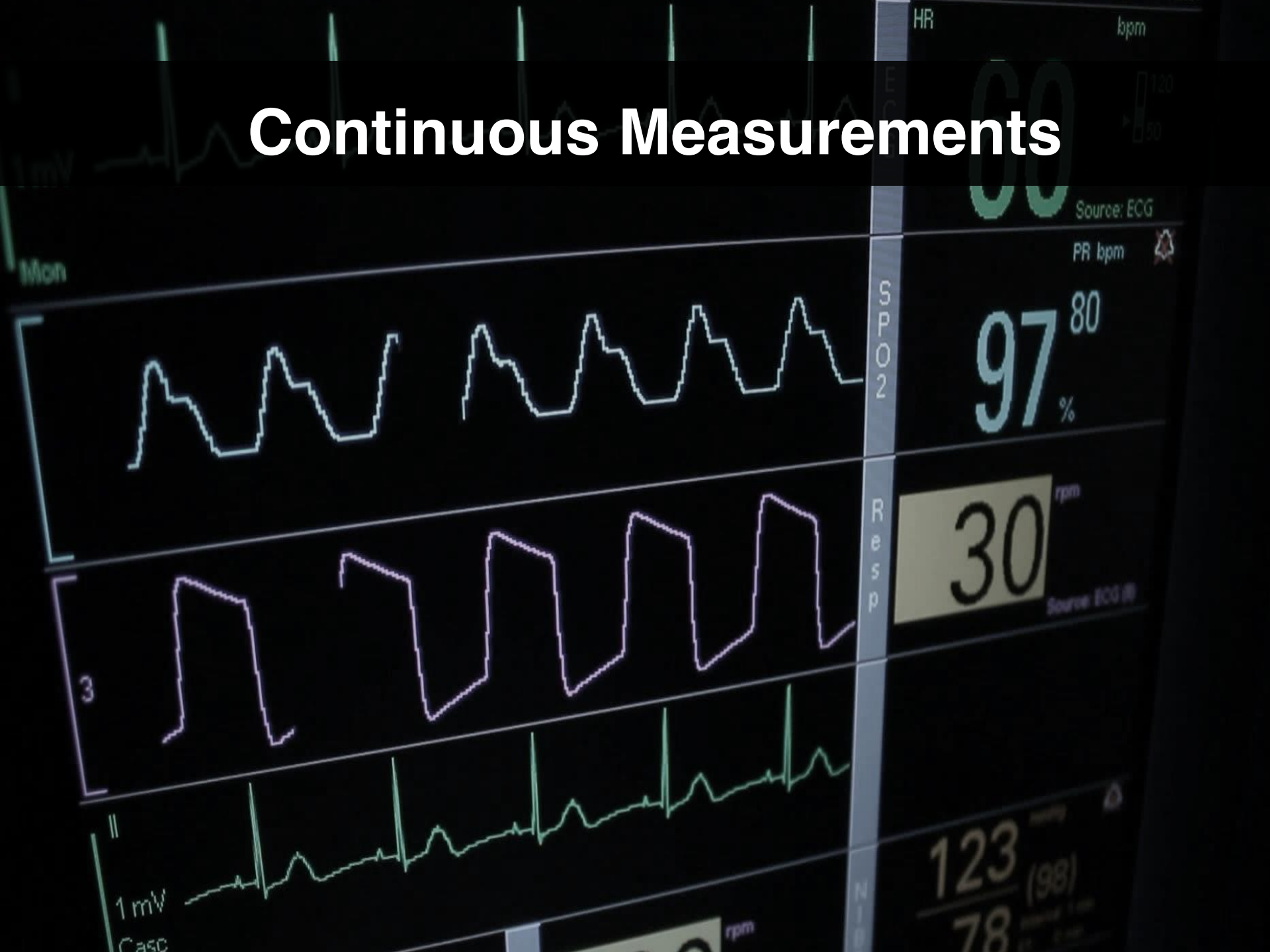
# Another Paradigm Shift in Health Care



# Opportunities with Mobile Health

- New screening tools
- Population health
- New discoveries in diagnostics
- Improvement in treatment

- Possibly leapfrog traditional approaches through global health applications




# Continuous Measurements

PROGRESS
412 REMAINING OF 1200
592
Net
-220
Burned
812
Consumed
FOOD DIARY
TRANING SCHEDULE
MICRONUTRIENTS CHART
42%
31%
27%
Proteins: 53.97
Carbs: 32.18
Fats: 95.34

# The Modern Smartphone

*Headphone jack*

*Wireless Antenna/Signal*
*GSM/LTE/WIFI/BT*

*Speakers*

*Camera/Flash*

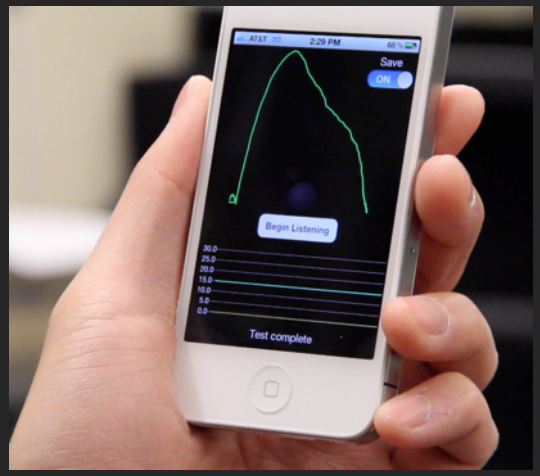
*Capacitive touch*

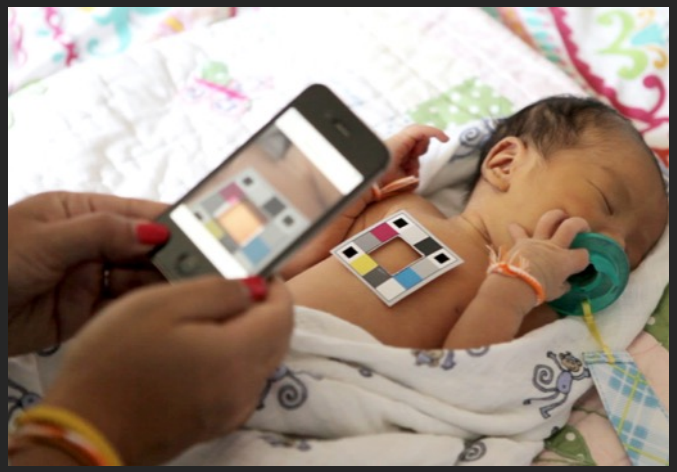
*Accelerometer/Gyro*

*Microphone*

# Mobile Health Sensing

- Using existing sensors on mobile phones for health sensing



# Using Mobile Phones for Diagnostics

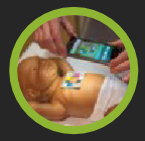
## Pulmonary

Spirometry

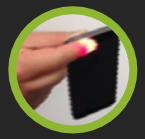
Cough analysis

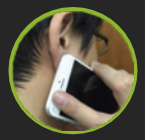
## Blood screening

Hemoglobin

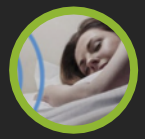

Bilirubin

## Cardiovascular


$SP0_2$


Blood pressure

## Disease Specific


Sleep

Osteoperosis

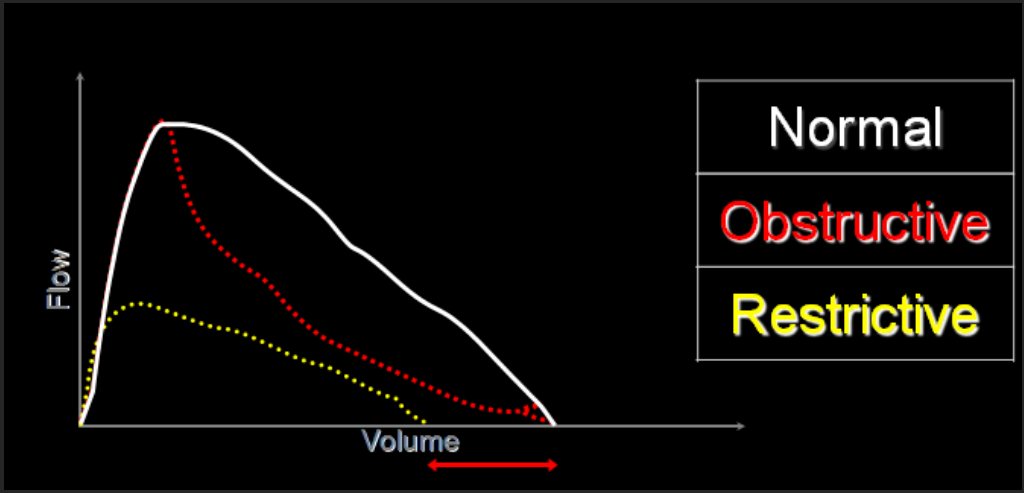
# Measuring Lung Function

- Spirometry
  - Mainstay of monitoring respiratory conditions (Asthma, COPD, CF)

*Clinical Spirometers*

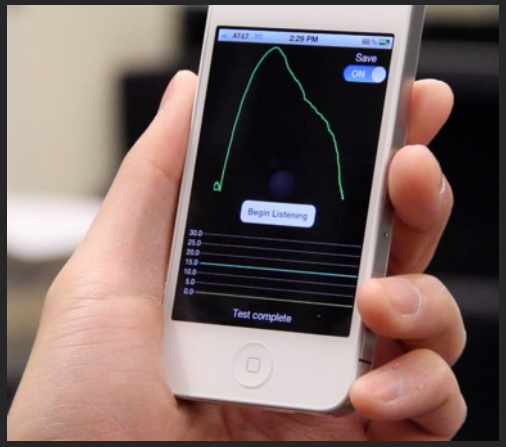
*Home Spirometer*

# Measuring Lung Function

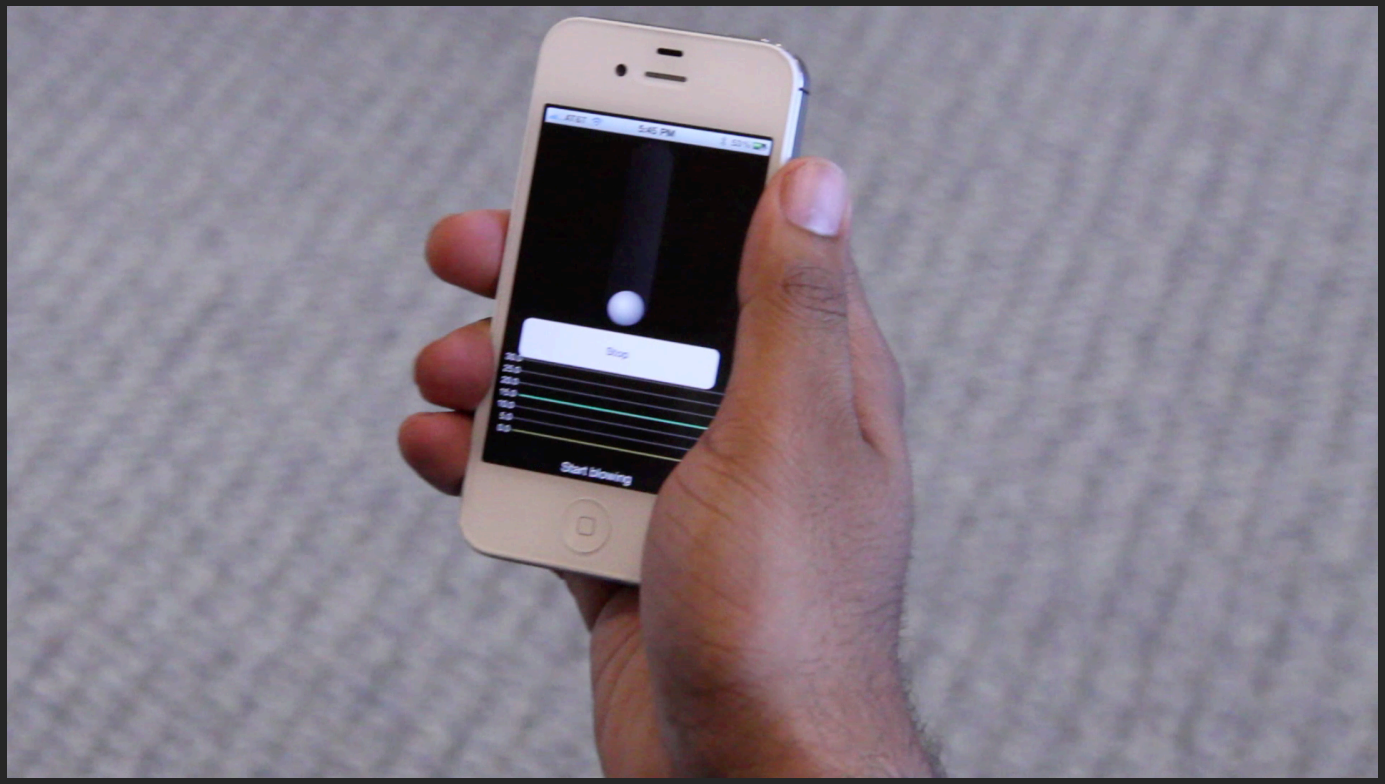


# SpiroSmart: Mobile Phone Spirometer

- No additional hardware needed
  - All done with software

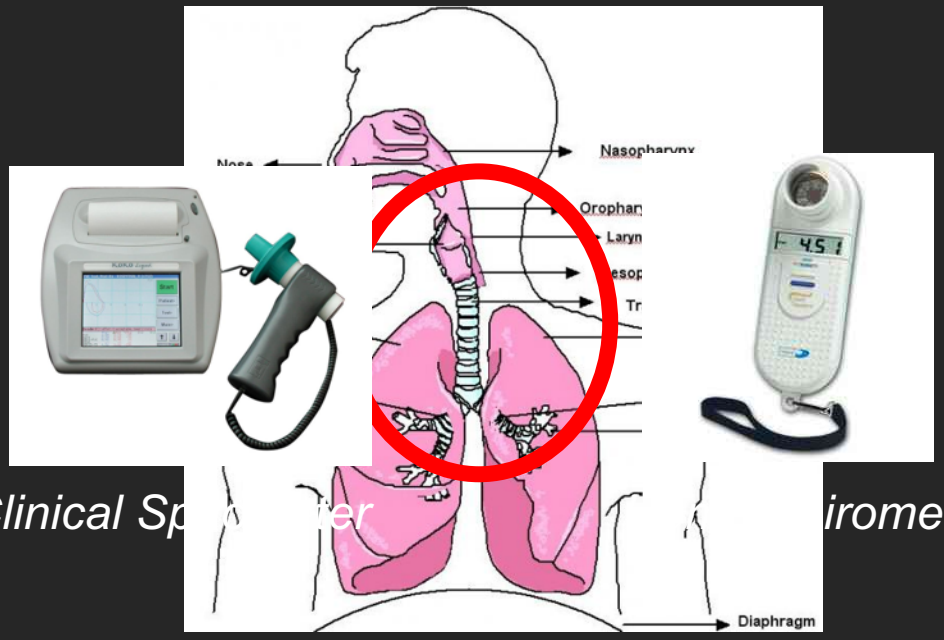


# SpiroSmart: Mobile Phone Spirometer



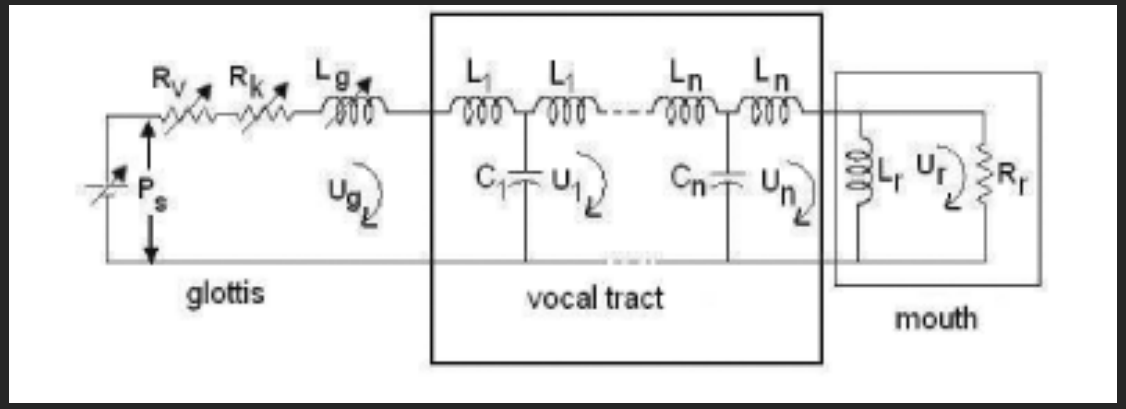
# How it Works

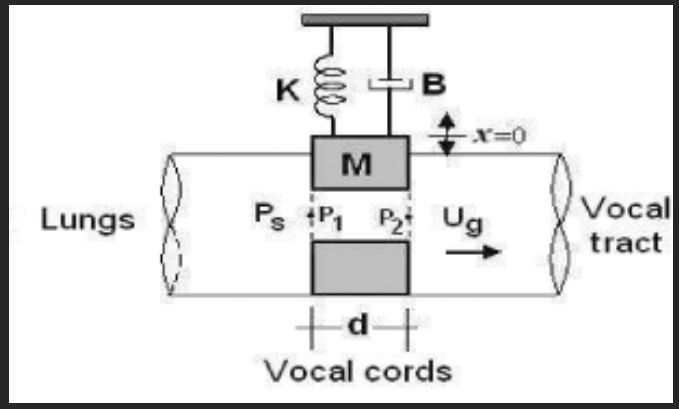
- Traditional spirometers use a flow sensor (e.g., turbine) – we only have the microphone
- Vocal tract resonances to infer flow
  - The “noise” in speech recognition




*Clinical Sp[illegible]er* *[illegible]irometer*

# Vocal tract model

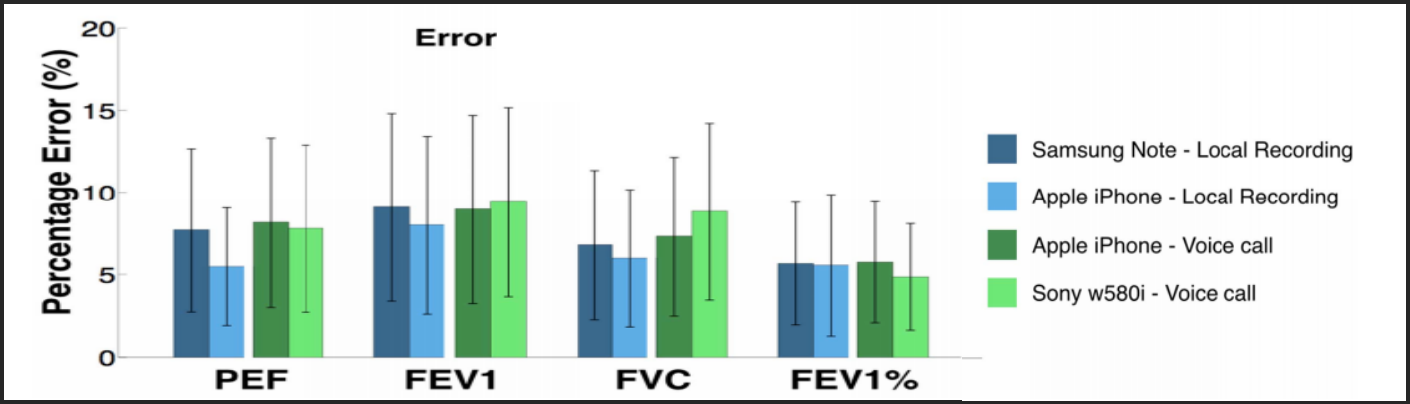


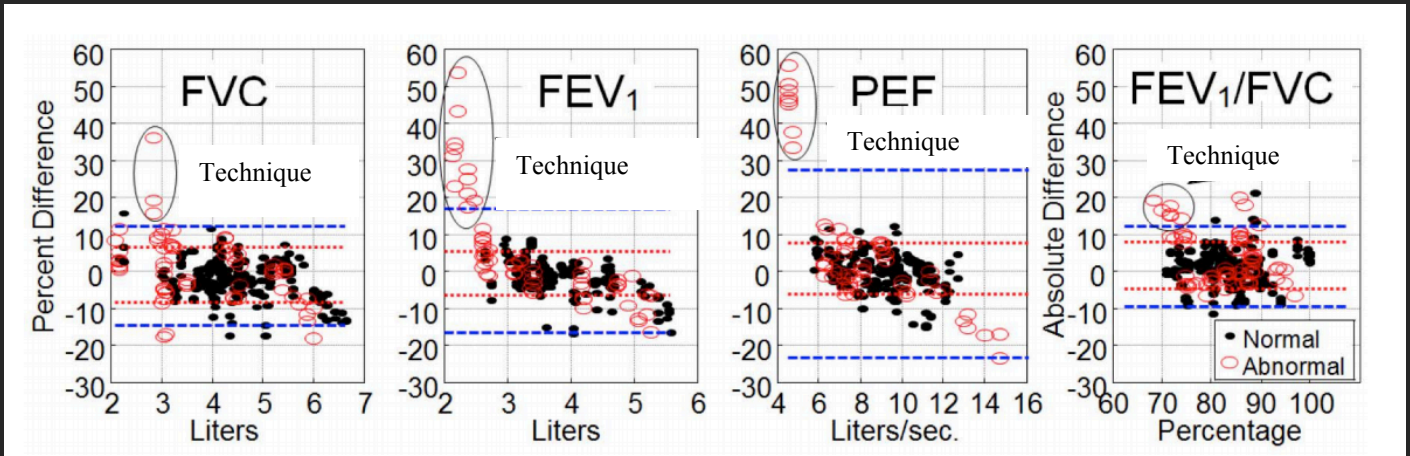



# SpiroCall

NOKIA
+12064148216
Your SpiroCall
results:
FEV1: 4.41 L
FVC: 5.35 L
FEV1%: 82%
PEF: 11.42 L/s
Options
Back

# SpiroSmart and SpiroCall Clinical Trials



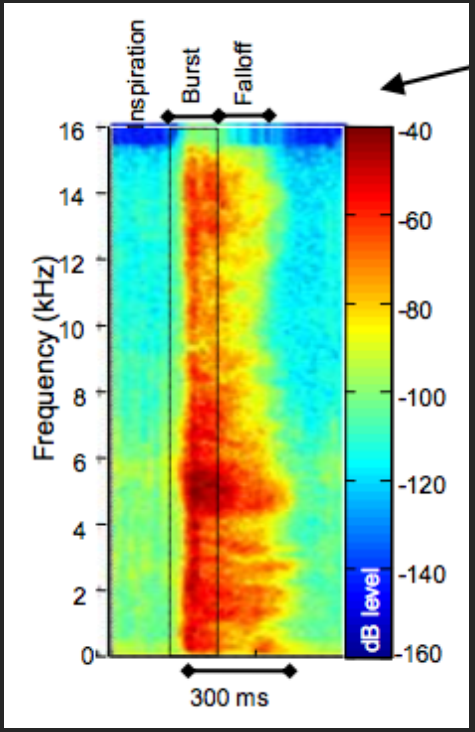



# Detecting and Studying Cough

- Cough is a common symptom, but not quantifiable
- Might be useful for studying the spread of disease
- Cough may tell us a lot about a disease
- Human ears miss subtle characteristics

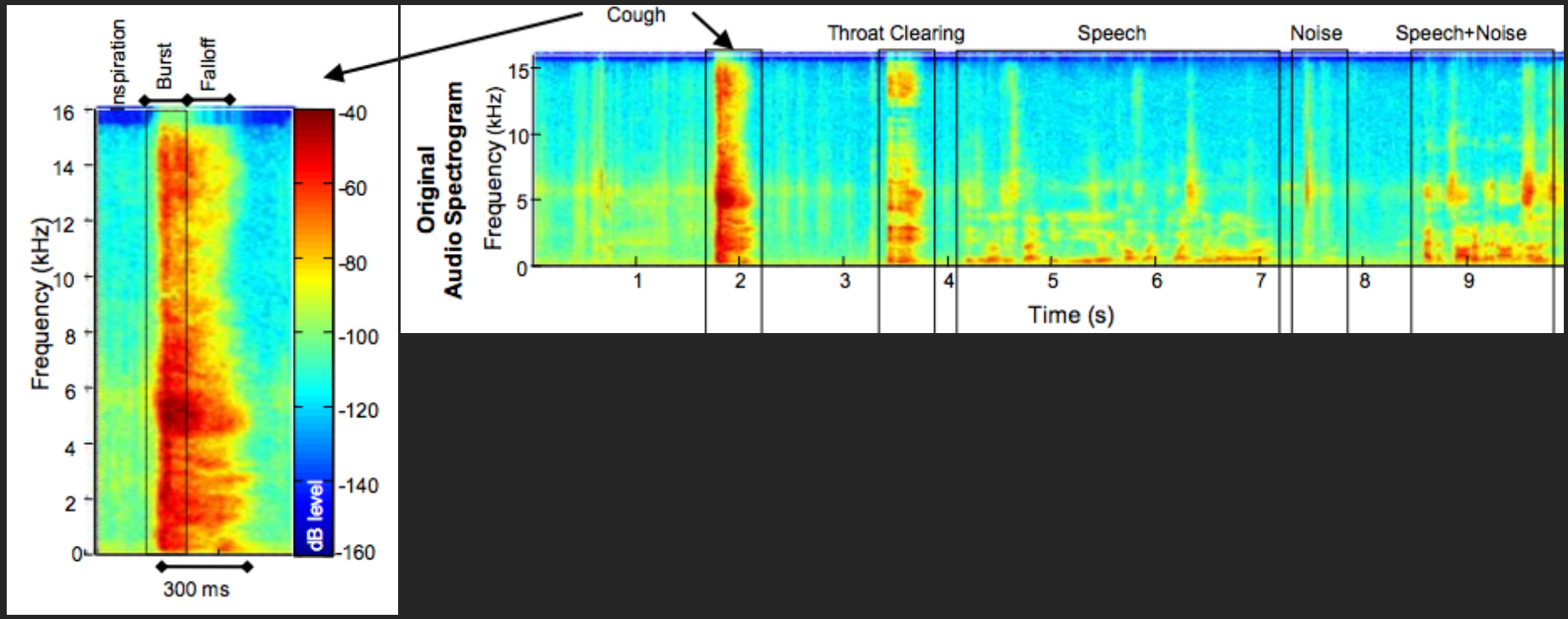
# Sound Analysis from Microphones

- Frequency based analysis with associated glottis model



# Sound Analysis from Microphones

- Frequency based analysis with associated glottis model

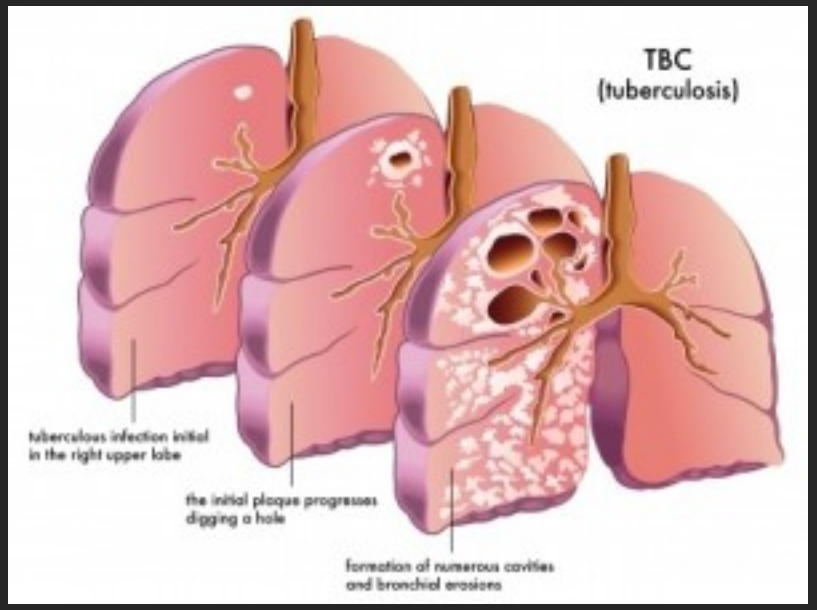


# Studying Tuberculosis

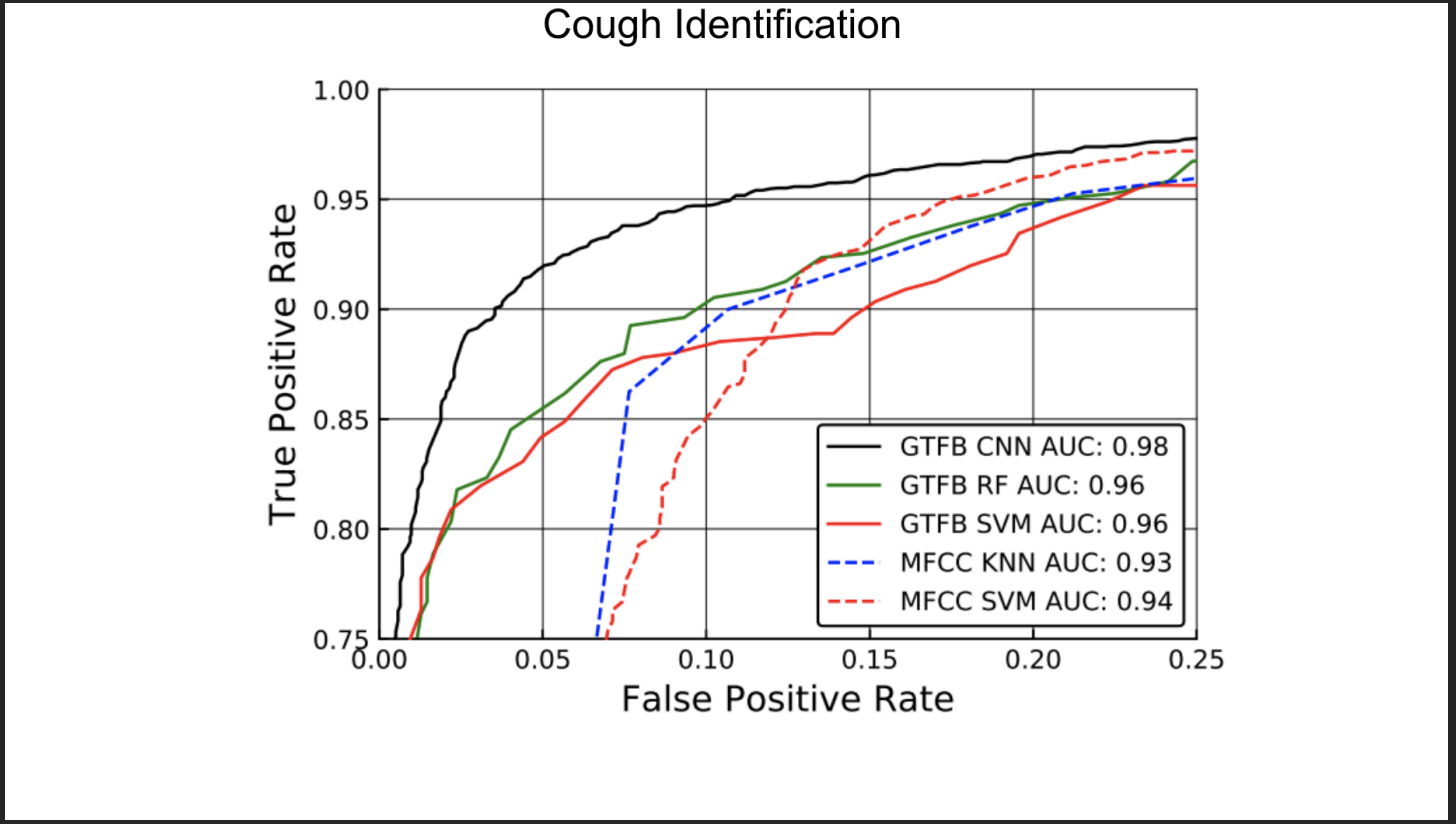
- Highly infectious lung disease
- The spread of TB spreads is still being studied
- Coughing is a major symptom

BILL & MELINDA GATES foundation

# TB Study in South Africa



# Cough Identification



# BiliCam

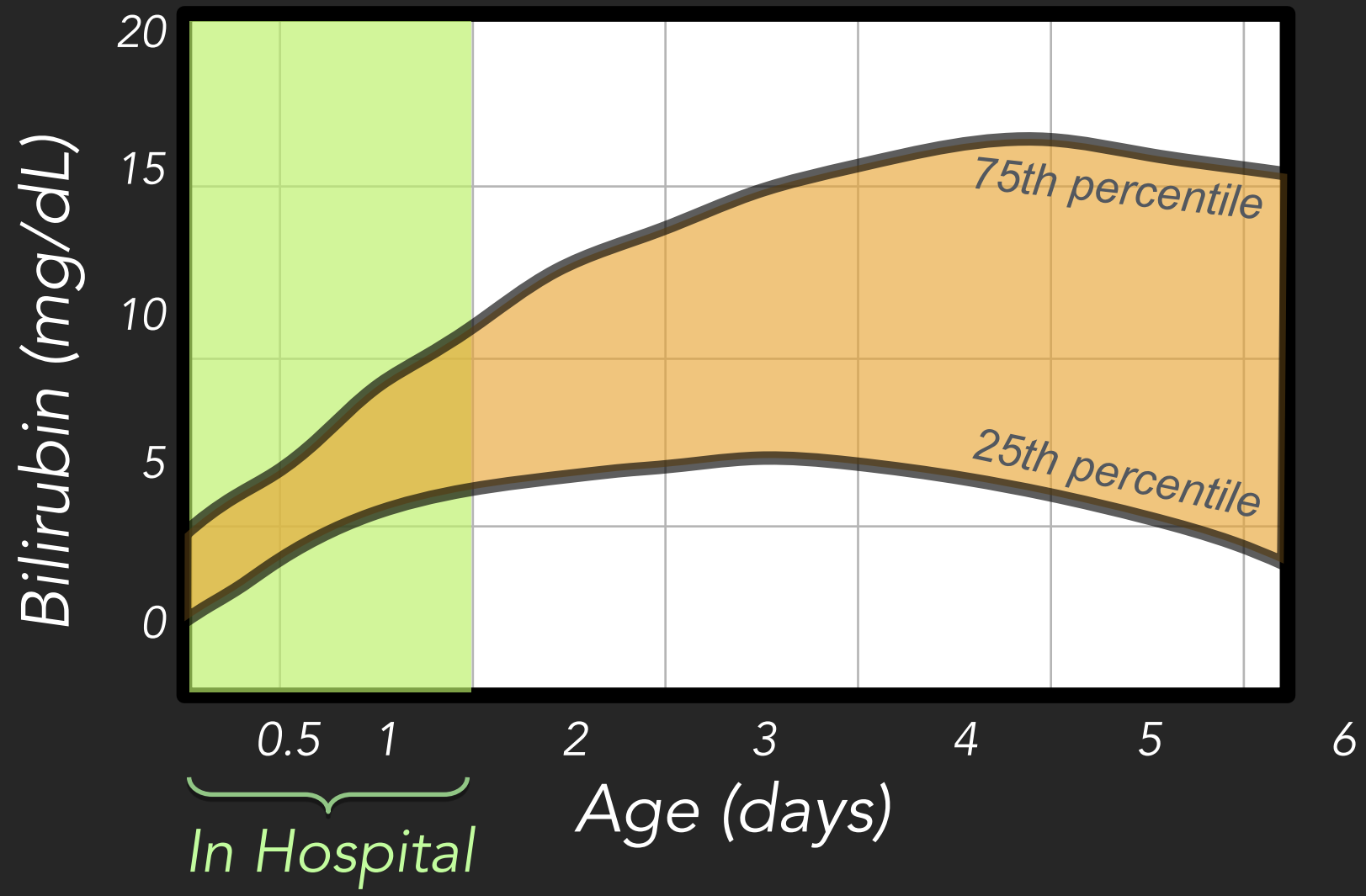
- Using mobile phones to monitor newborn jaundice

# Current Technology

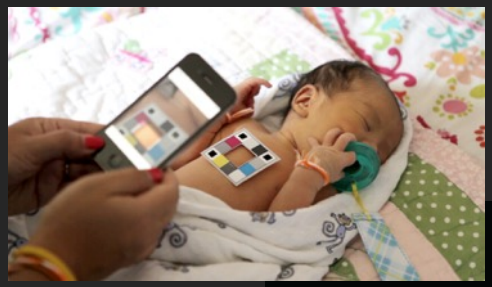
- Total serum bilirubin (TSB)

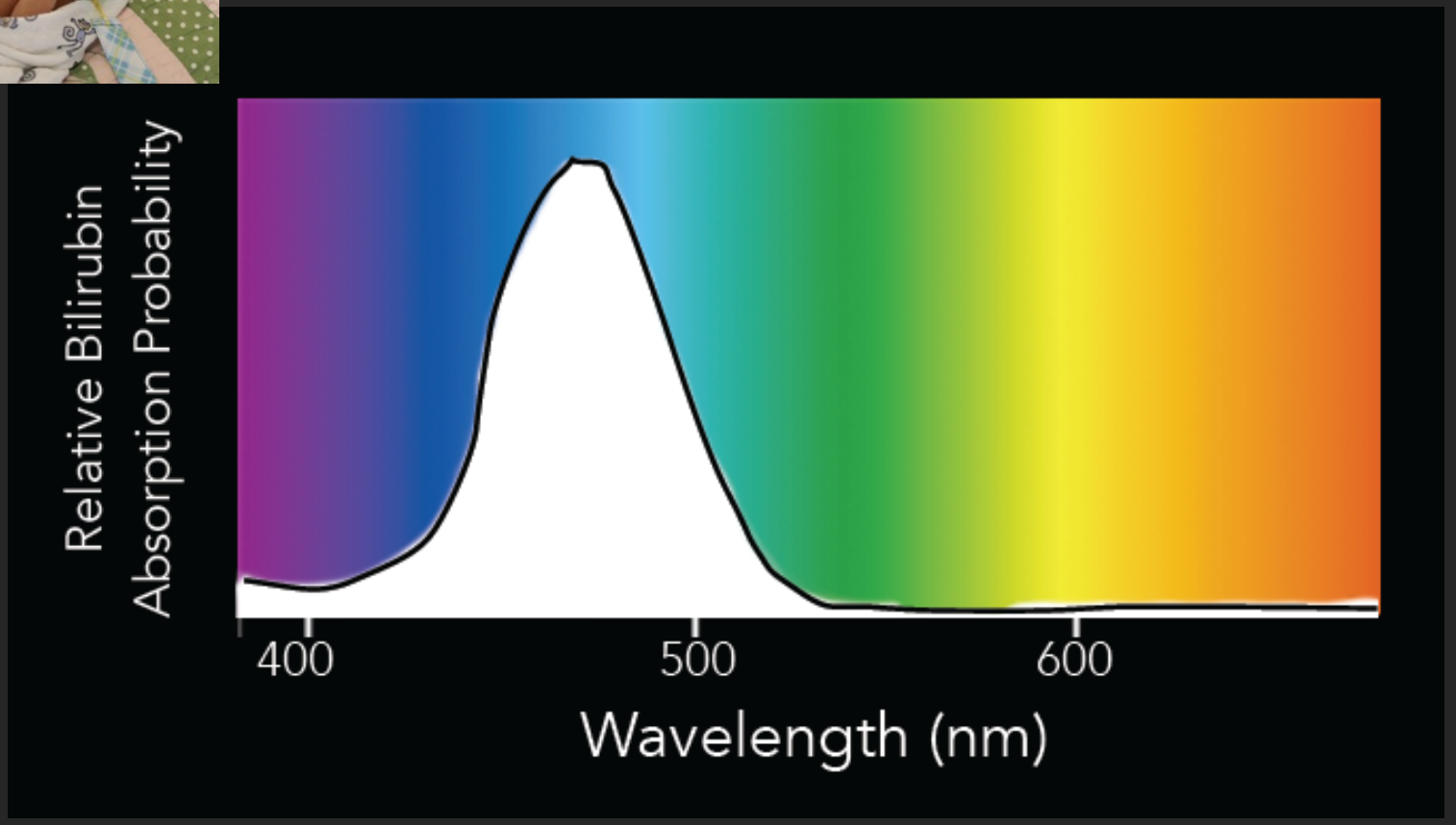
- Transcutaneous Bilirubinometer

# Bilirubin Levels

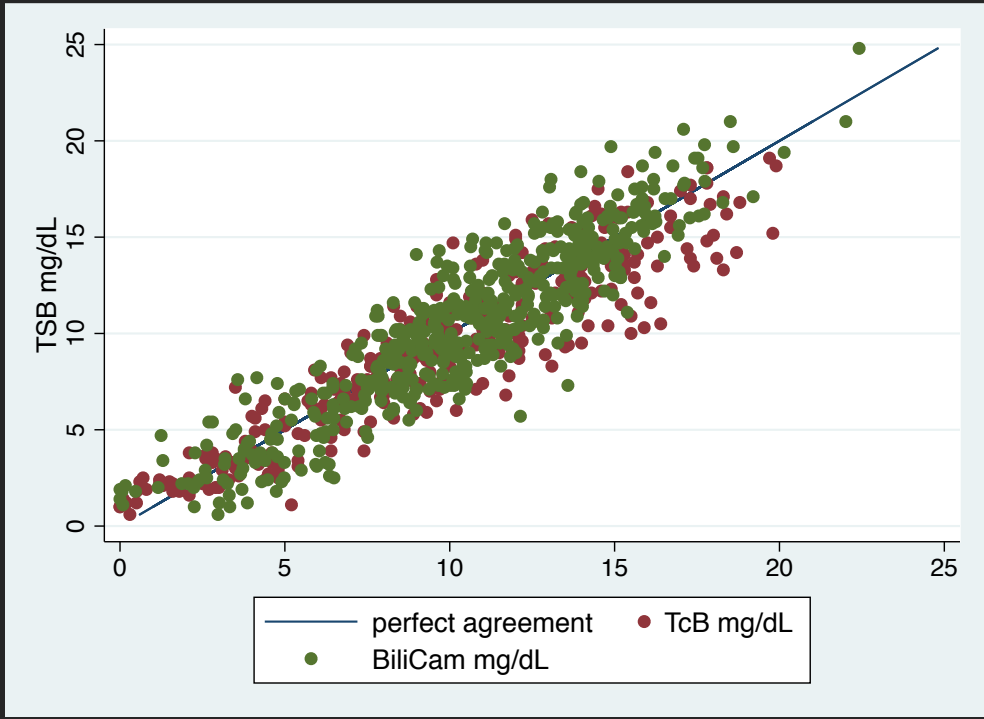


# Absorption Properties of Bilirubin





# Trial of 530 Newborns

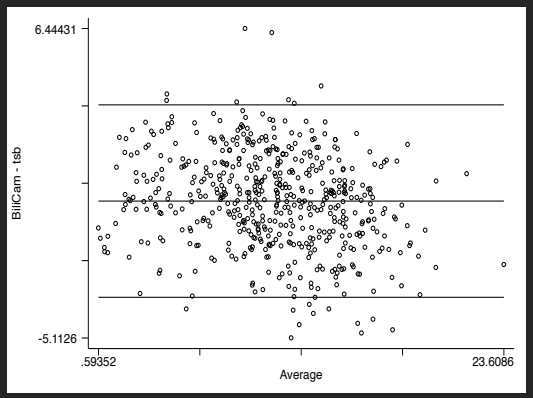



***BiliCam***

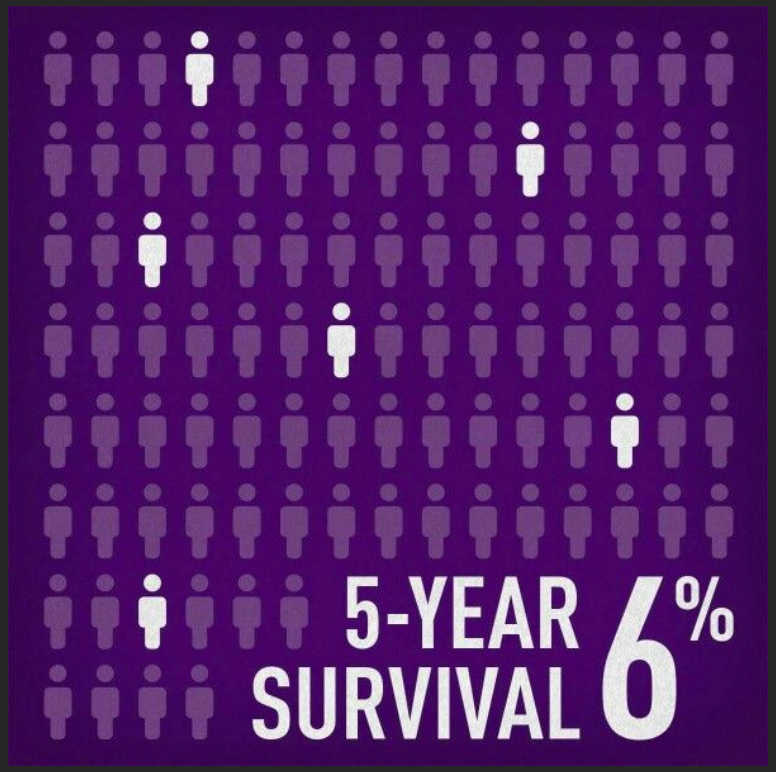
***0.91 correlation***

***TcB***

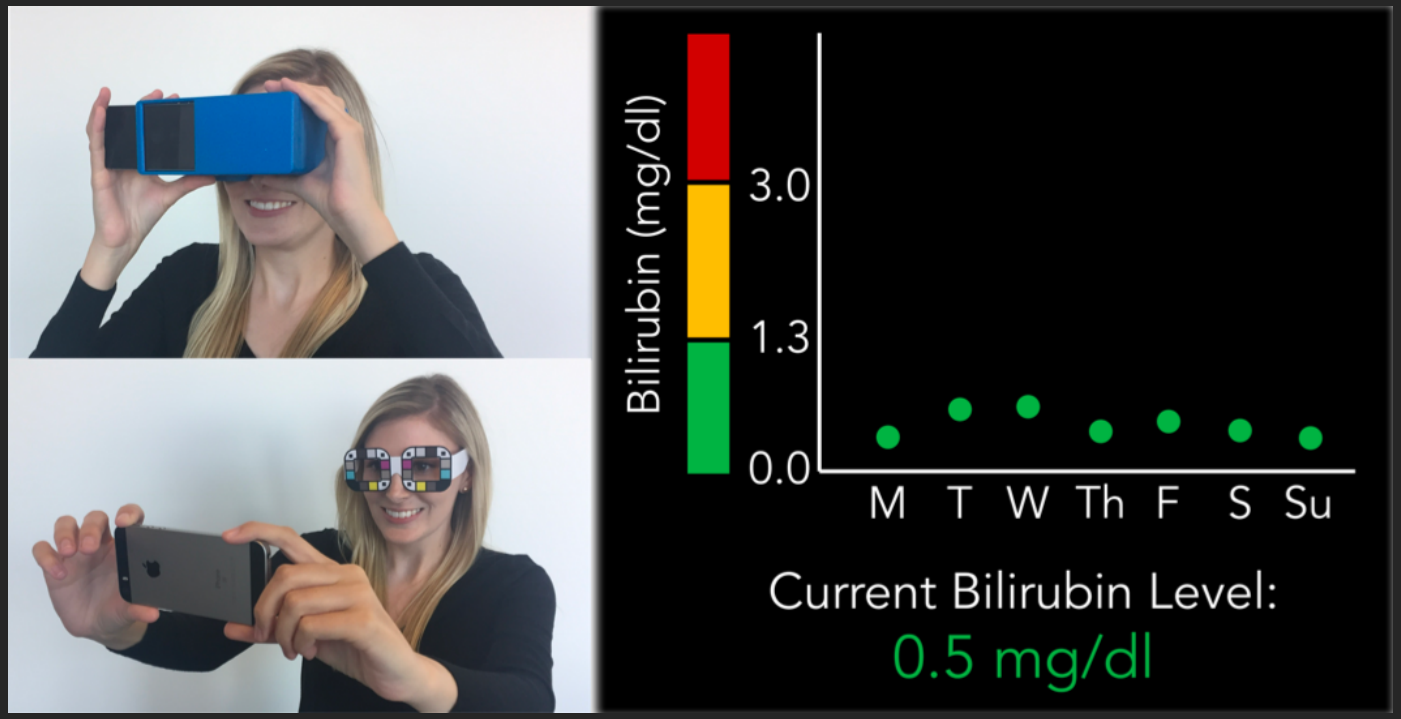
***0.92 correlation***

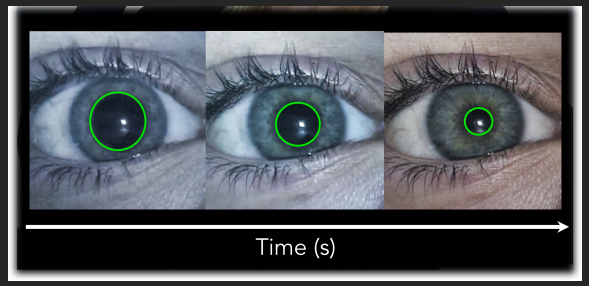


# Bilirubin in Adults: Pancreatic Cancer

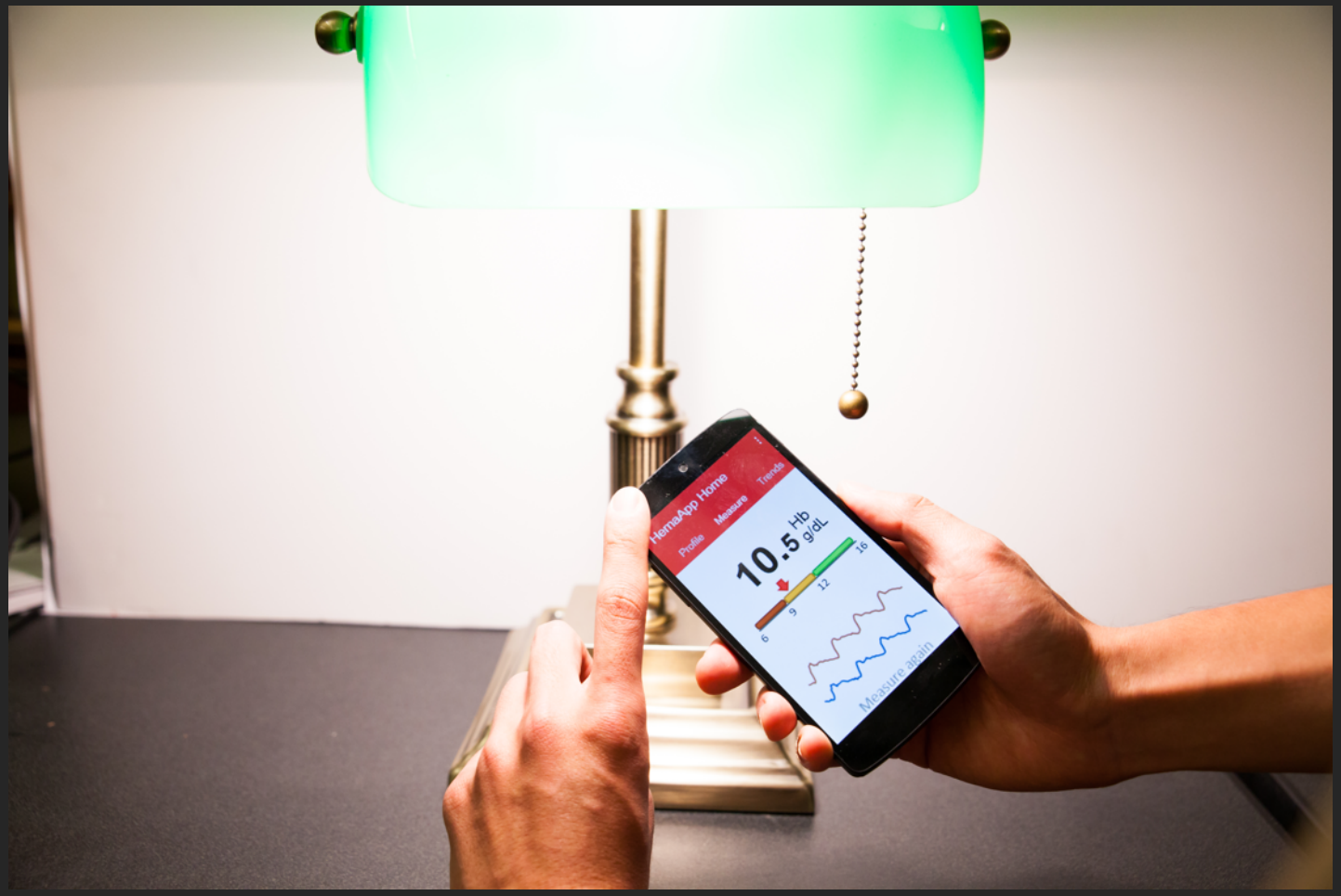


# Observable Jaundice in the Sclera

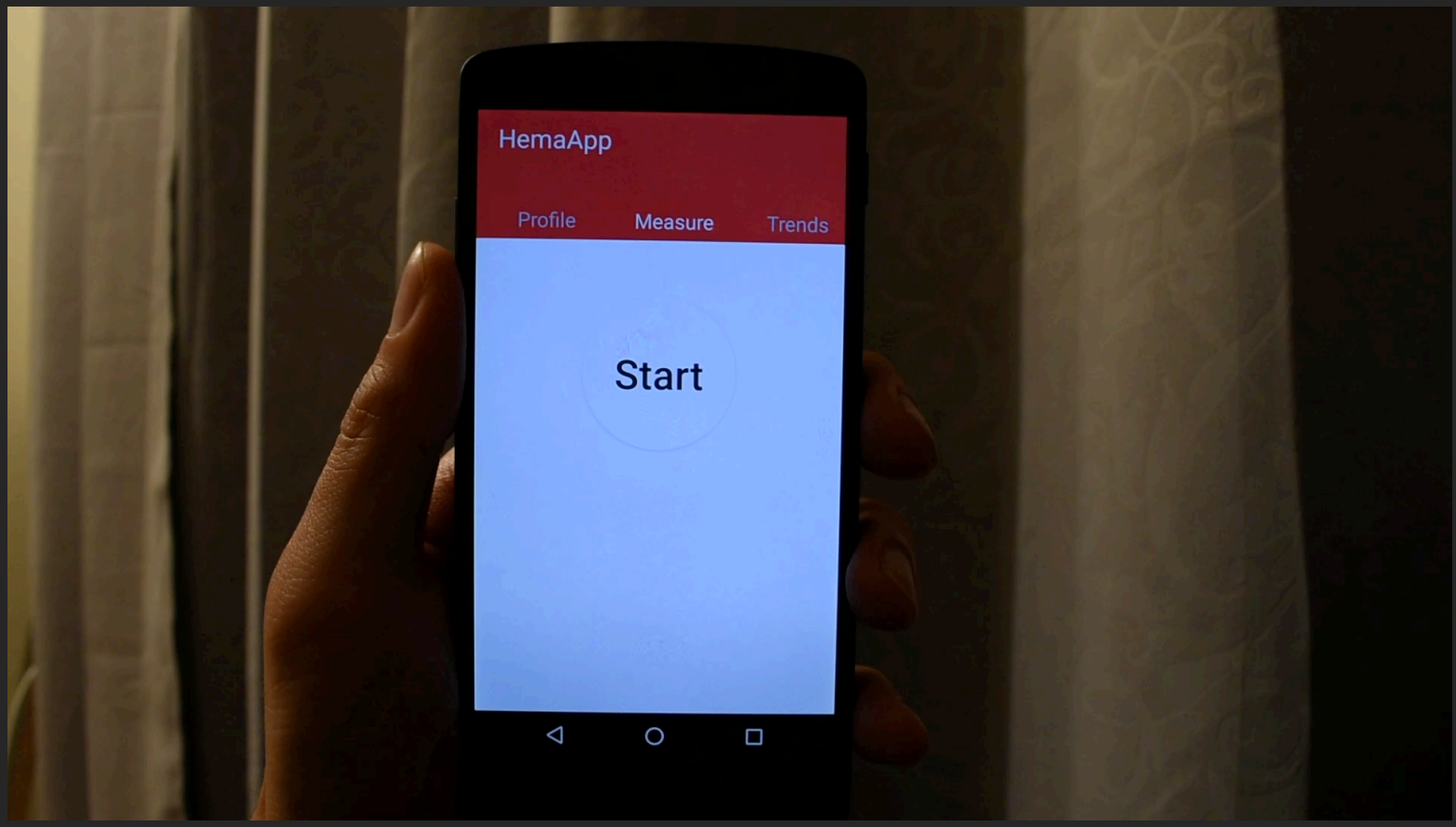


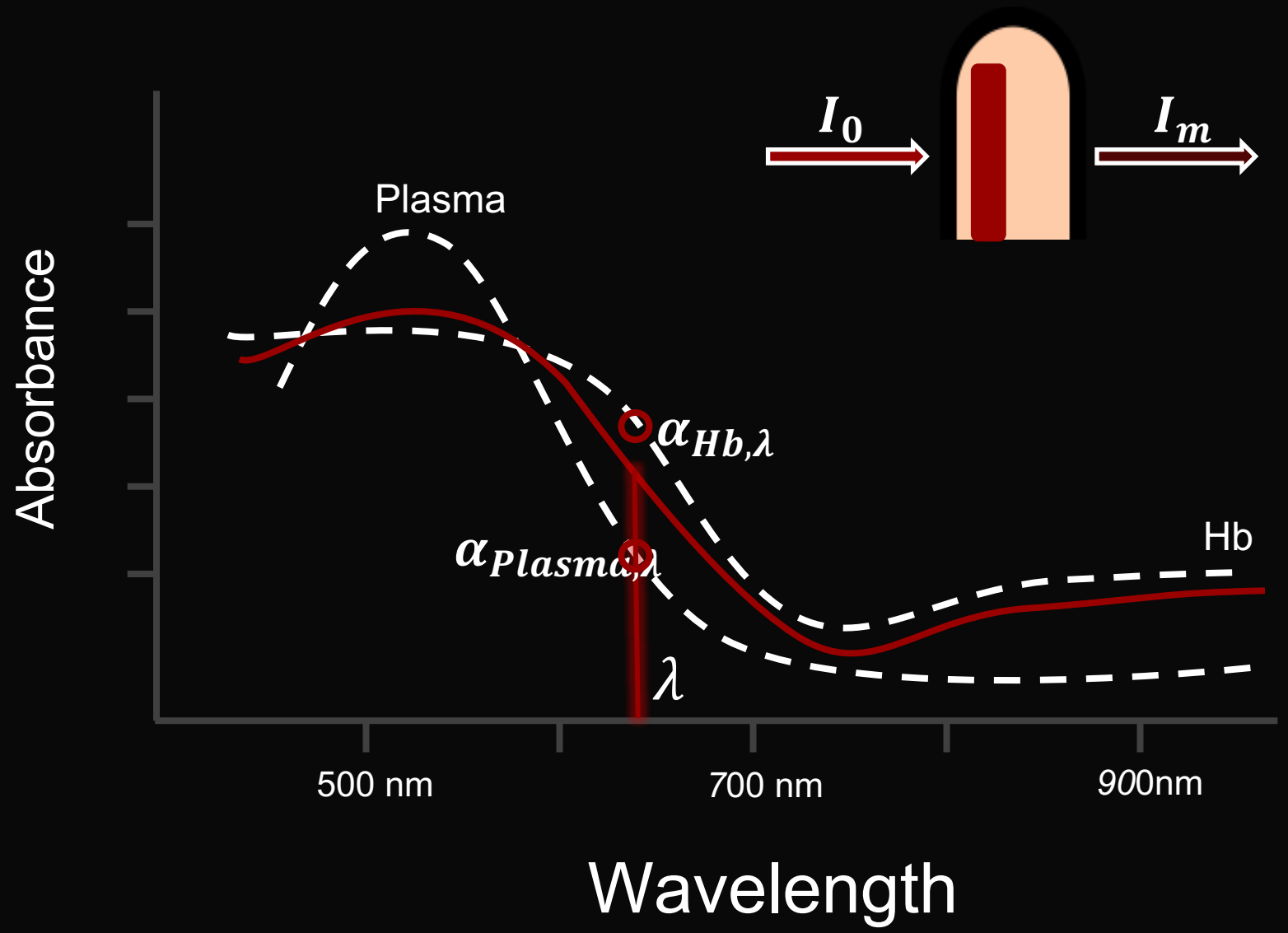
# Mobile Phone Hemoglobin



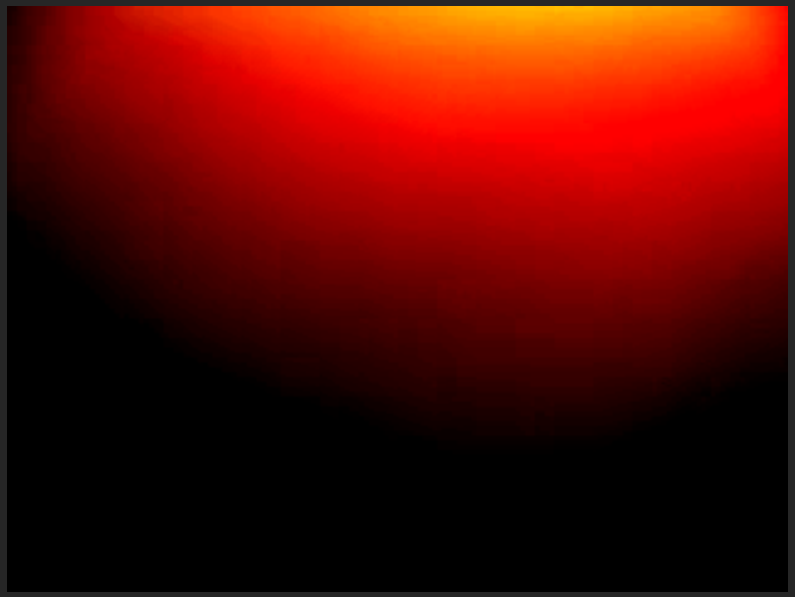
# Mobile Phone Hemoglobin



# Hemachrome Analysis



# Isolate Blood Absorption



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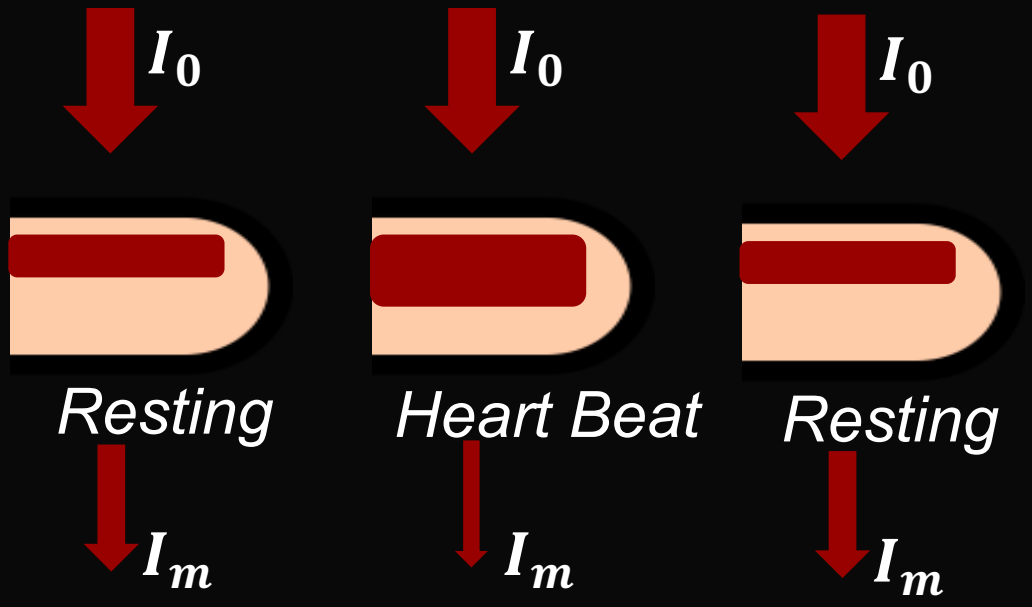
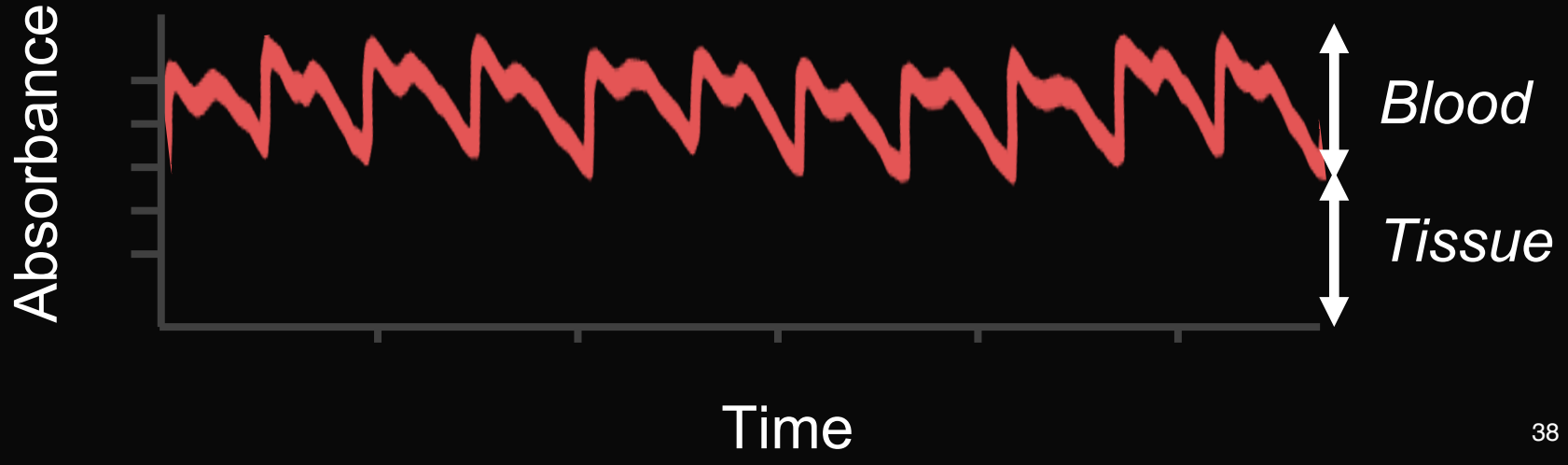
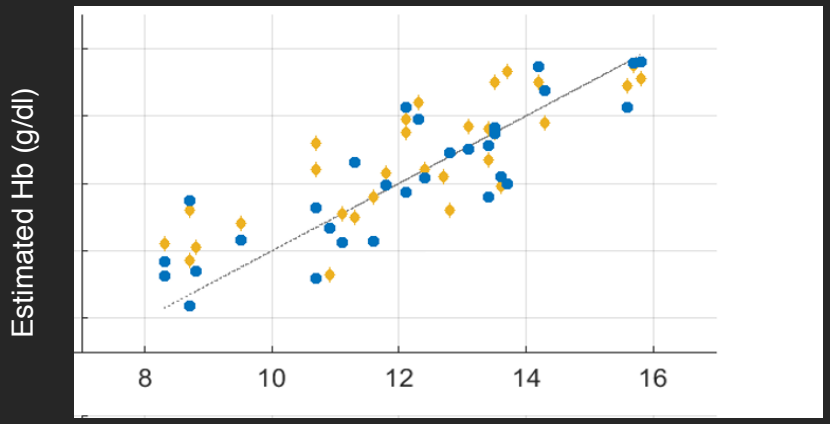
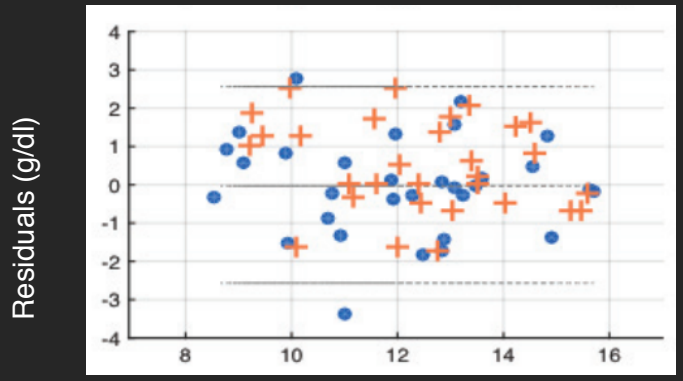


# Evaluation



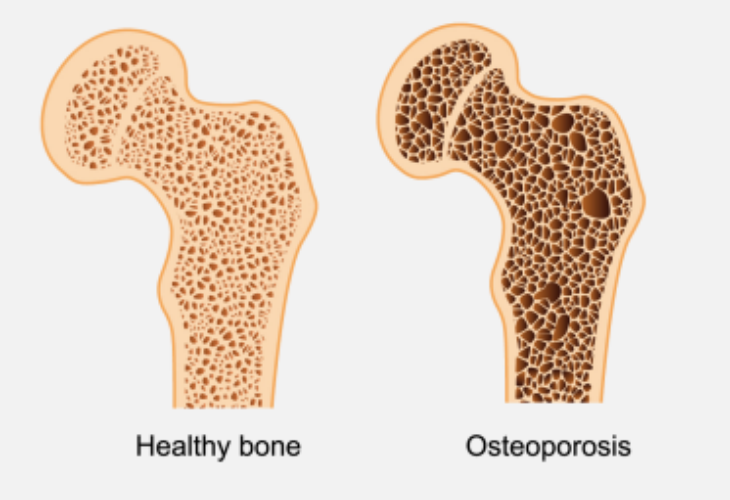

- ***HbApp***
  ***0.81 correlation***
- ***Pronto***
  ***0.82 correlation***

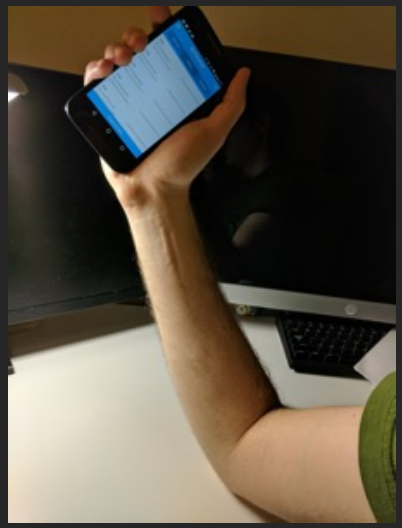


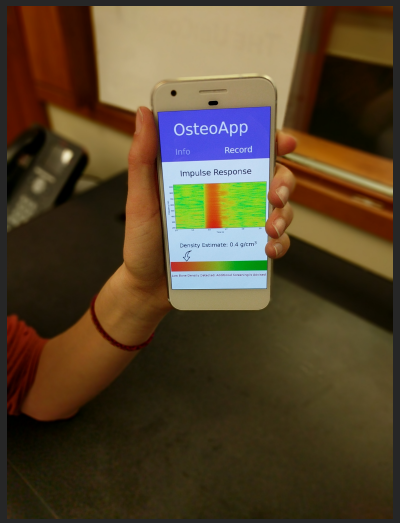
# Peru Deployment

# OsteoApp

- Inferring bone density with resonance tracking for osteoporosis

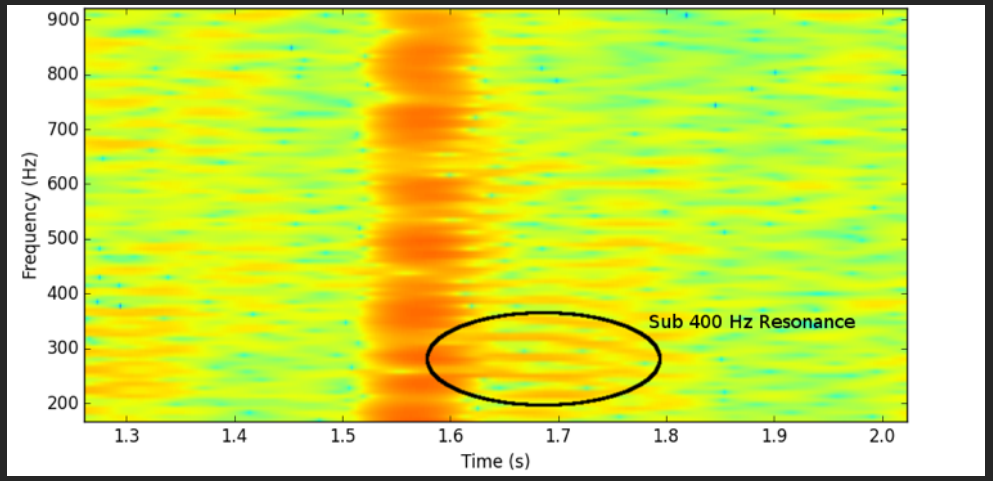


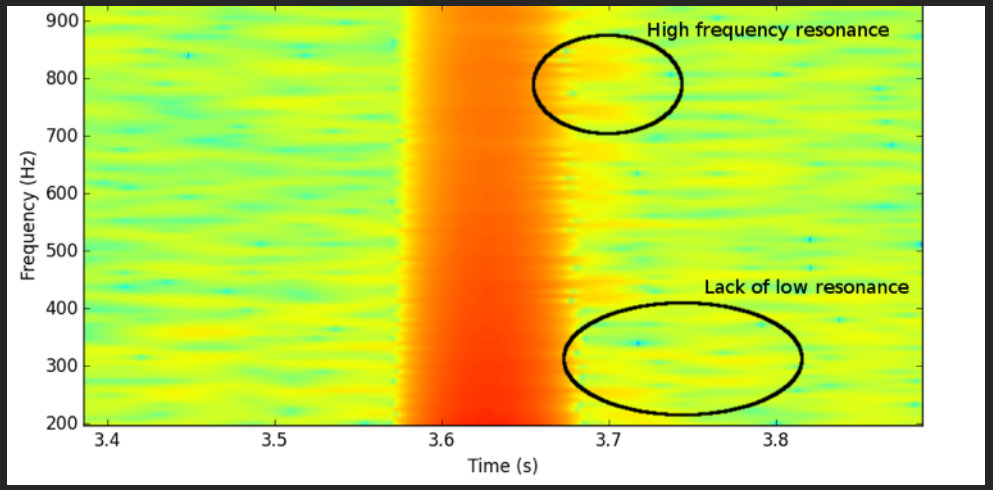


# OsteoApp

Healthy bone


900
800
700
600
500
400
300
200
Frequency (Hz)
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
Time (s)
Sub 400 Hz Resonance

Osteoporosis


900
800
700
600
500
400
300
200
Frequency (Hz)
3.4
3.5
3.6
3.7
3.8
Time (s)
High frequency resonance
Lack of low resonance

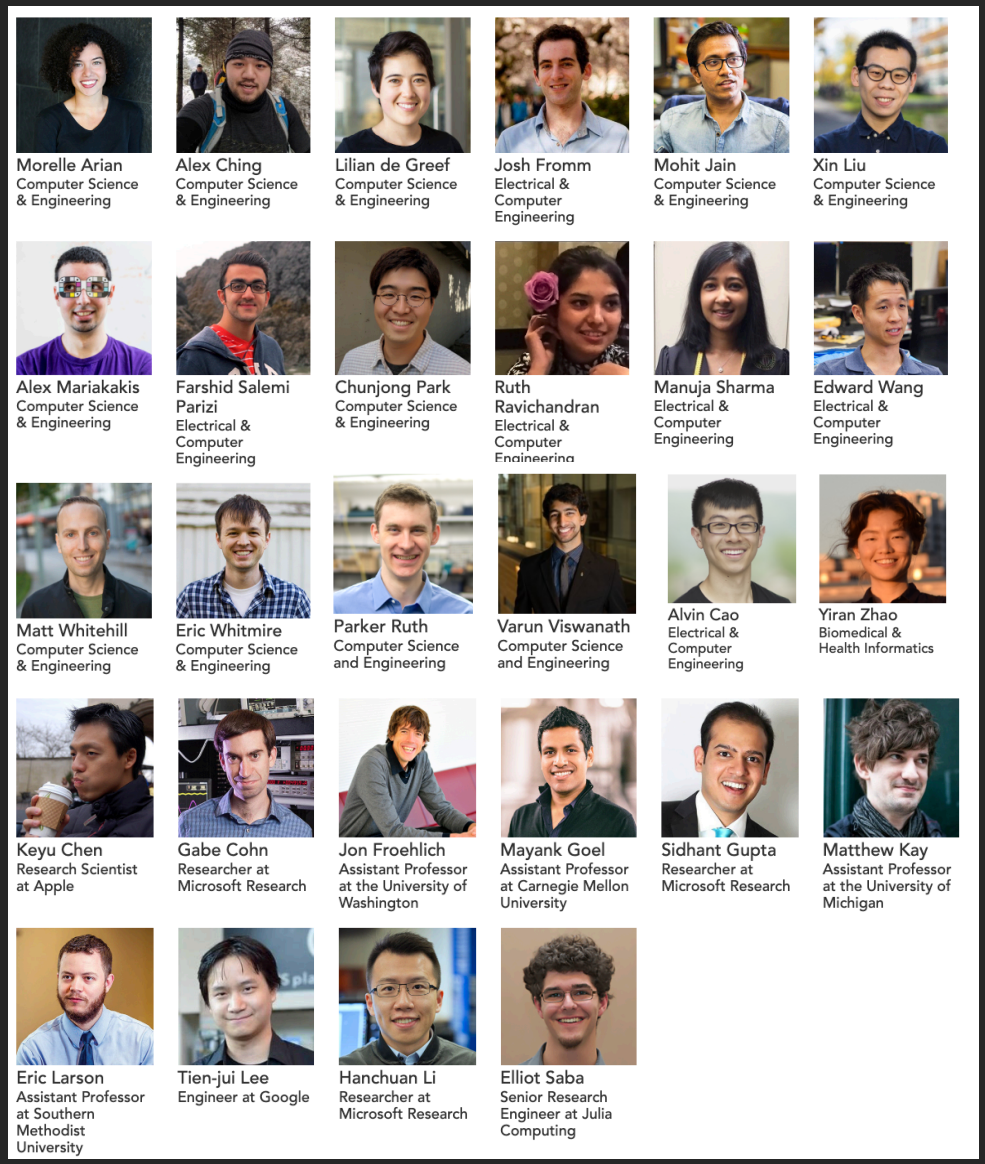
# Considerations in Mobile Health

- Regulatory
- Safety and trust
- Patient - provider interaction
- Inform new advances in medical devices

- Still need to take into accounts other factors such as social determinants

# Advice to the Young Researchers

# Thanks!


Morelle Arian
Computer Science & Engineering
Alex Ching
Computer Science & Engineering
Lilian de Greef
Computer Science & Engineering
Josh Fromm
Electrical & Computer Engineering
Mohit Jain
Computer Science & Engineering
Xin Liu
Computer Science & Engineering
Alex Mariakakis
Computer Science & Engineering
Farshid Salemi Parizi
Electrical & Computer Engineering
Chunjong Park
Computer Science & Engineering
Ruth Ravichandran
Electrical & Computer Engineering
Manuja Sharma
Electrical & Computer Engineering
Edward Wang
Electrical & Computer Engineering
Matt Whitehill
Computer Science & Engineering
Eric Whitmire
Computer Science & Engineering
Parker Ruth
Computer Science and Engineering
Varun Viswanath
Computer Science and Engineering
Alvin Cao
Electrical & Computer Engineering
Yiran Zhao
Biomedical & Health Informatics
Keyu Chen
Research Scientist at Apple
Gabe Cohn
Researcher at Microsoft Research
Jon Froehlich
Assistant Professor at the University of Washington
Mayank Goel
Assistant Professor at Carnegie Mellon University
Sidhant Gupta
Researcher at Microsoft Research
Matthew Kay
Assistant Professor at the University of Michigan
Eric Larson
Assistant Professor at Southern Methodist University
Tien-jui Lee
Engineer at Google
Hanchuan Li
Researcher at Microsoft Research
Elliot Saba
Senior Research Engineer at Julia Computing

# Questions?

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