# **Research on Tap:**
# High Tech and High Touch: Digital Innovations from BU's Mobile and Electronic Health-ARC

March 20, 2019

# Mobile and Electronic Health-ARC at Boston University


# Belinda Borrelli, PhD

ME-ARC Principal Investigator & Director
Professor, Dept. of Health Policy & Health Services Research, GSDM
Director, Center for Behavioral Science Research

ARC Co-Directors:
Lisa Quintiliani, PhD, Assistant Professor, Boston University School of Medicine;
&
Tibor Palfai, PhD Professor and Director of Clinical Training, Boston University Department of Psychological and Brain Sciences



Funded by:

- BU Evans Center for Interdisciplinary Biomedical Research
- BU Interdisciplinary Biomedical Research Office (IBRO)




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# Mobile and Electronic Health

## Mobile Health

- Text messaging
  - 99% of US
- Apps
  - 77% of US
- Wearable devices
  - 170 million in US
- Social media
  - 202 million in US
- Chat bots
- Non-graphical interfaces

Adjunct to health care delivery "provider extenders"

## eHealth

- Internet
- Virtual reality
- Robotics

Integrate into health care delivery

No or little difference in prevalence by income, race/ethnicity, or education

# Mission of Mobile and Electronic Health-ARC (ME-ARC)

- To conduct state of the art research and training in mobile and electronic health to improve health across the lifespan with an emphasis on underserved and vulnerable populations.
- To foster transdisciplinary collaboration among researchers across BU who strive to improve health outcomes through digital research and scholarship
- Develop a scientific vision and strategy for digital health at BU

# Transdisciplinary Approach

- Medical informatics
- Behavioral and clinical sciences
- Biomedical engineering
- Computer science
- Implementation science
- Global health
- Health literacy/disparities

- Enhance integration
- Foster innovation
- Build on multidisciplinary strengths
- Poised to answer major funding calls for grants

## Director & PI: Belinda Borrelli
## Co-Directors: Lisa Quintiliani & Tibor Palfai

Crosscutting Cores/Steering committee Resources for mHealth and eHealth Projects

- Center for Implementation and Improvement Sciences (Walkey)
- Behavioral Science Intervention Research (Borrelli, Quintiliani, Palfai)
- Medical Informatics (Mishuris, Paschalidis, Adams, Shanahan)
- Mobile app development (Lapets)
- Community-based Participatory Research and Health Disparities (Borrelli, Quintiliani)
- Health Literacy (Paasche-Orlow)
- Engineering (Klapperich, Paschalidis)
- Global Health (Don Thea)

Project 1

Using Mobile Technology to Address Barriers to Quitting Cigarettes among Hospitalized Smokers with Opioid Use Disorders
PI: Hasmeena Kathuria

Project 2

Addressing hazardous Drinking and Chronic Pain with Web-based Intervention and Coaching in Primary Care
PI: Tibor Palfai

Project 3

Using Facebook to Deliver a Smoking Cessation Intervention to Disabled Adults

PI: Belinda Borrelli, PhD

Co-Is: Romano Endrighi, Lisa Quintiliani

External Advisory Board

- David Felson
- Sandro Galea
- Azer Bestavros

Member Affiliates

Those who are not directly involved in the projects but benefit by, and contribute to, the ARC

Resources for Members, Affiliates and BU Community

- Symposia/lectures
- Grant reviews
- Consultation
- mHealth registry
- Networking

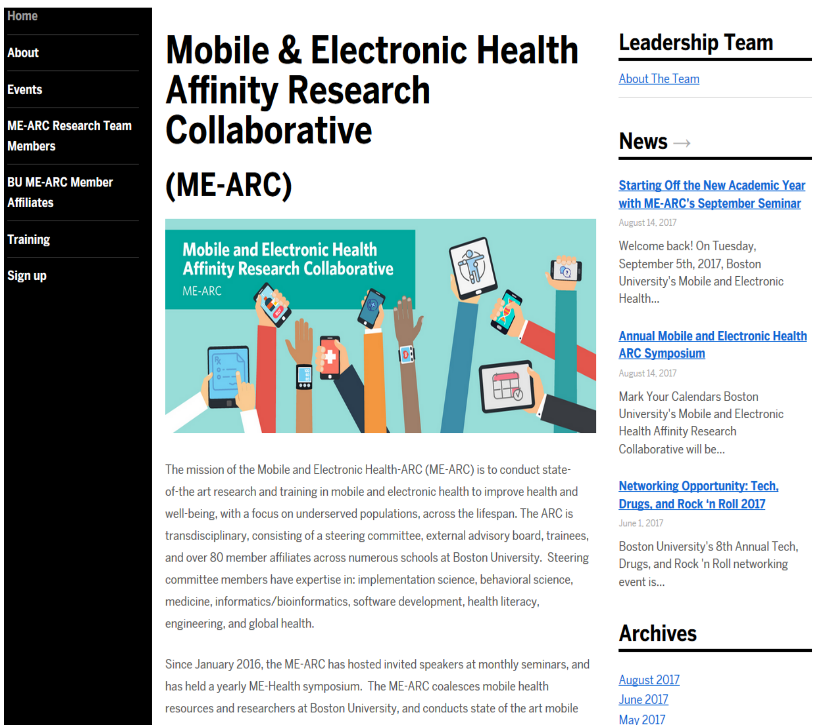
Post-docs /K Mentees

Romano Endrighi, PhD
Jacqueline You
Alaa Qari, DMD
Deepak Kumar, PhD
Brenda Heaton, PhD

# ME-ARC Activities

- Annual mobile and electronic health symposium
  - Over 85 people from industry & academia
- Collate BU's existing strengths in digital health
  - Online assessment of current capacities at BU
- Monthly seminars
- Provide training for post-docs / junior faculty
- Accomplishments:
  - Pilot projects = 5
  - Publications = 24
  - Grants (submitted or funded) = 17
  - 153 BU members

http://sites.bu.edu/me-arc/



# ME-ARC Pilot Grants

Collaborations across schools and the two campuses
Basic, clinical & public health scientists + clinicians

Integrating smoking cessation into dental visits using mobile health

**PI: Belinda Borrelli**

Development of an mHealth system for lifestyle changes among breast cancer survivors from underserved populations

**PI: Lisa Quintiliani**

Using mobile technology to address barriers to quitting cigarettes among hospitalized smokers with opioid use disorders

**PI: Hasmeena Kathuria**

Addressing hazardous drinking and chronic pain with web-based intervention and coaching in primary care

**PI: Tibor Palfai**

Using Facebook to deliver a smoking cessation intervention to disabled adults

**PI: Belinda Borrelli**

# ME-ARC Affiliated Grants

Interactive parent-targeted text messaging in pediatric clinics to reduce ECC
**Lead Co-PI: Belinda Borrelli**
**Co-PI: Michelle Henshaw**
(funded)

Secondary prevention of atrial fibrillation randomized pilot study
**PI: Robert Helm**
(funded)

Mobile app to enhance well-being and encourage cessation
**PI: Belinda Borrelli**
(funded)

NeXT-Framingham novel exam using technology
**PI: Joanne Murabito**
(funded)

Mobile app to increase physical activity in people with knee osteoarthritis and comorbidities
**PI: Deepak Kumar**
(funded)

Delivery of a smoking cessation induction intervention via virtual reality headset during a dental cleaning
**PI: Belinda Borrelli**
(submitted)

Digital weight management among public housing residents
**PI: Lisa Quintiliani**
(submitted)

Pilot test of an mHealth intervention for healthy eating and physical activity among veterans
**PI: Lisa Quintiliani**
(funded)

Identifying and correcting misinformation and misuse of antibiotics and AMR through social media interventions
**PIs: Walker/Groshek/Borrelli**
(funded)

Photo-enhanced messages to reduce dietary sugars for oral health
**PI: Brenda Heaton & Lisa Quintiliani**
(funded)

Internet-based videoconferencing to address alcohol use and pain among heavy drinkers in HIV-care
**PI: Tibor Palfai**
(funded)

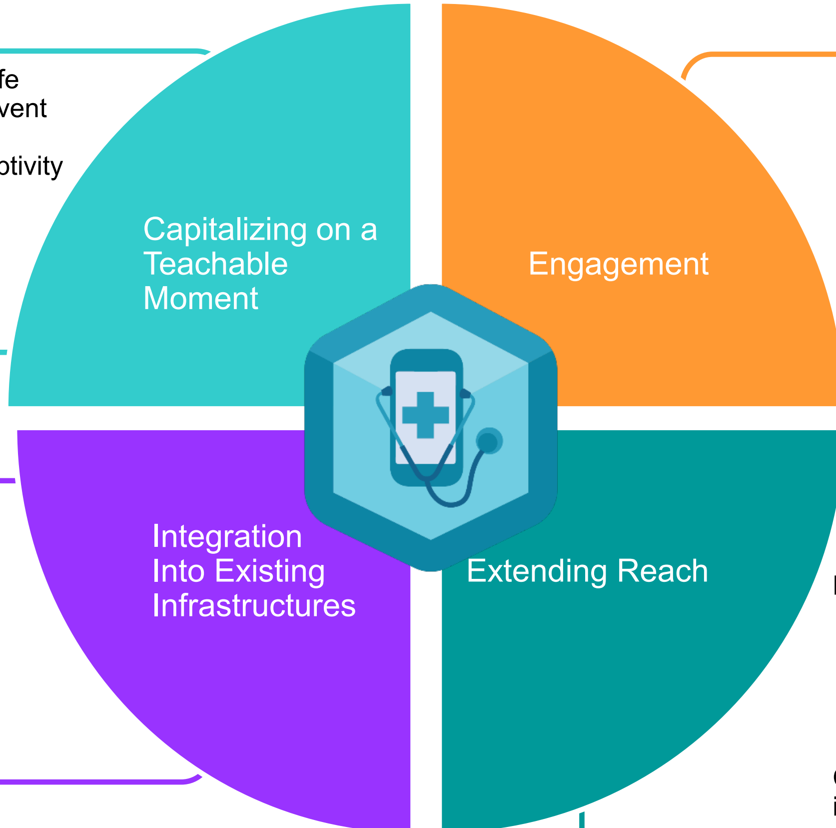
# Motivating Health Behavior Change Using Mobile & Electronic Health


## Belinda Borrelli, PhD

*Professor, Health Policy & Health Services Research &*
*Director, Center for Behavioral Science Research, GSDM*
*Director, Mobile & Electronic Health-ARC*

# Four Pillars of Optimization of Mobile & Electronic Health Solutions

- Naturally occurring life transition or health event that increases health awareness and receptivity to health messages.




- Customization
- Tailoring
- Co-design
- Gamification
- Credibility
- Usability
- Animation/photos
- Explain why's and how's

- Medical care
- Dental Care
- Public Housing
- Churches
- Beauty Salons

Populations who are not interested in:

- Changing risky behaviors (substance abuse; gambling)
- Adapting healthy behaviors (exercise; taking medication)

Connect mobile health solution to what's important to them:

- What do they most value; connect content to things they care about
- Find 'the hook'

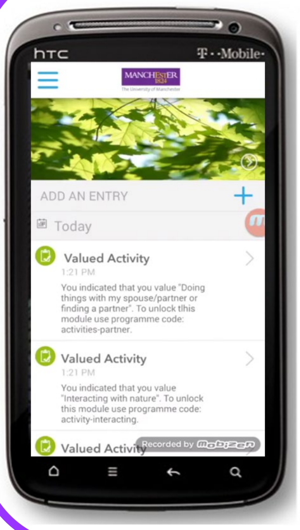
iSMILE
INTERACTIVE SHORT MESSAGES INITIATE LASTING EDUCATION

## Text Messages to Improve Child Wellness and Oral Health in Vulnerable Populations

- Randomized controlled trial n=850
- Target pediatric community clinics
- Automated, yet interactive
- Customized
- Gamified
- Co-designed with clinicians & target population

## Delivery of a Smoking Cessation Intervention Via Virtual Reality Headset During Dental Cleaning

- Mixed methods: Feasibility/Usability
- Reduces provider burden; 14/23 pts set quit date; 5 quit
- All smokers receive evidenced-based treatment, regardless of motivation to quit
- Capitalization on down-time
- Helps with dental anxiety/pain




## Mobile App for Smokers Unmotivated to Quit

- Phenotyped unmotivated smokers through qualitative and quantitative
- Engages unmotivated smokers through focusing on mood and stress management
- Intermittent motivational messages for smoking cessation and resources for quitting: 'foot in the door'
- Randomized controlled trial completed

ABLE

## Using Facebook to Motivate Cessation among Smokers with Mobility Impairments

- 35% smoke
- High levels of depression
- Low social support
- Barriers to treatment
- Integrate evidenced based treatment for depression and smoking into Facebook platform

# Weight Management for Breast Cancer Survivors using mHealth


Lisa Quintiliani, PhD

*Assistant Professor*
*Boston University School of Medicine*

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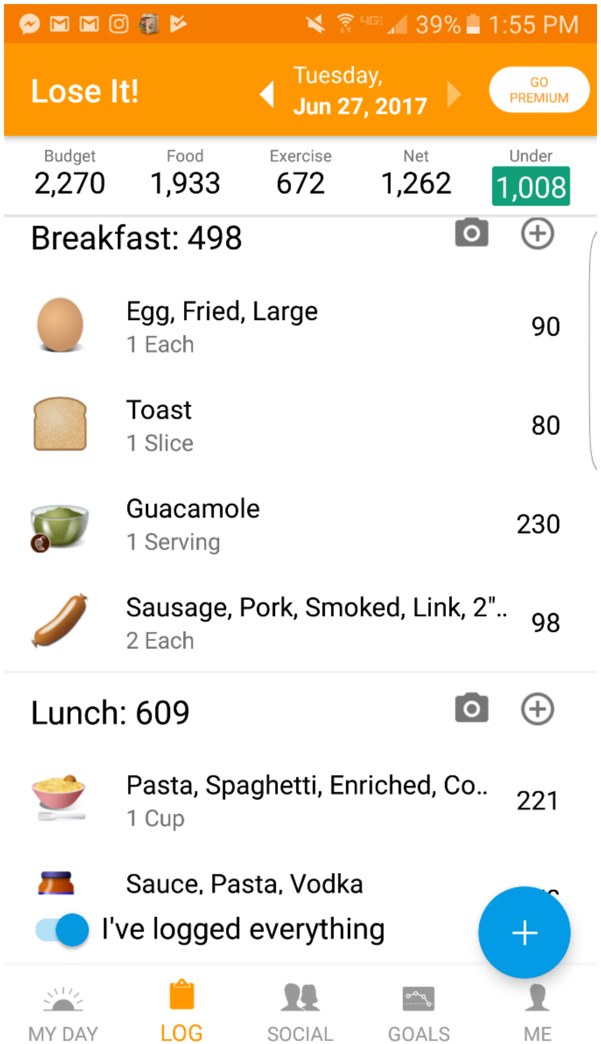
# Why mHealth targeted for breast cancer survivors?

- Obesity post-diagnosis increases chances of recurrence & other chronic diseases
- Most weight management apps do not follow evidenced-based guidelines
- High need for mHealth solutions in breast cancer survivors
  - Review of 101 apps (25% about behavior & 17% about survivorship)
  - Better use of plain language principles needed
- What evidenced-based features should be included?
  - Study: Take features from non-mHealth studies & ask women to rate importance of each one for use in an app

## Self-Monitoring of Behavior




Highly valued features:
Receiving feedback & self-monitoring of weight

Highly variable:
Social support

Want apps that are:
9 Simple/low burden
9 Had new/engaging information
9 Targeted to breast cancer survivors

Next Steps:
Conduct field test of app for engagement, usability, and preliminary efficacy

# Mobile Health Approaches to Address Hazardous Alcohol Use: Multi-media Messaging Adjuncts to Brief Interventions


Tibor Palfai, PhD

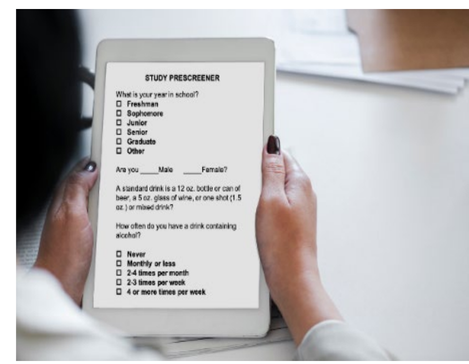
*Professor*
*Department of Psychological and Brain Sciences, CAS*

# Hazardous alcohol use: esp. risks of heavy episodic drinking

Young Adults


## Challenges

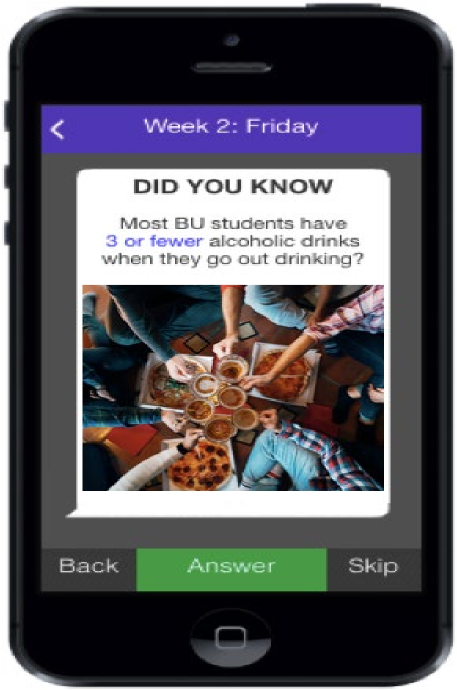
- Most do not view drinking as problematic or seek interventions
- Limited resources to address at the individual level

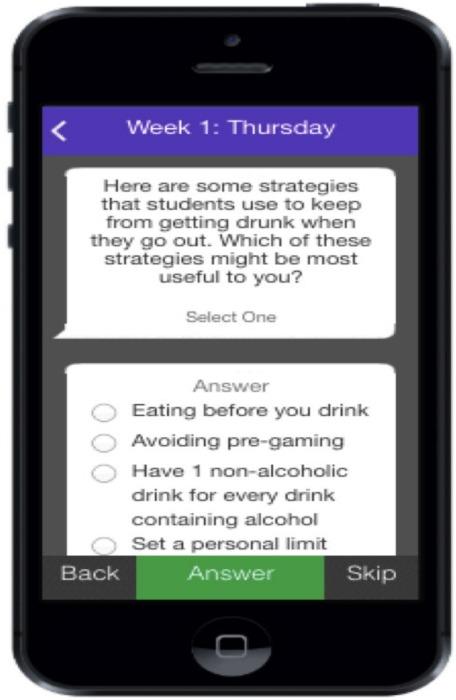


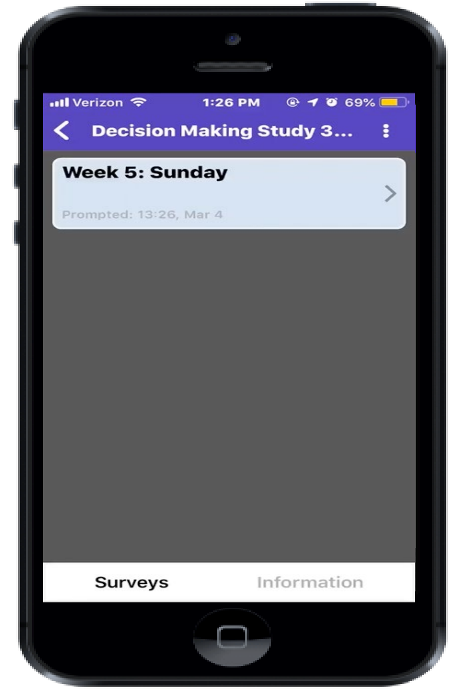

## e-Screening and Brief Intervention

- Utility across opportunistic contexts (e.g. health care)
- Effects have been modest ..diminish after 6 weeks
- Effectiveness trials:  smaller effects, fewer benefits for specific populations

## Q:  How to create a low cost approach to enhance & extend the impact of brief interventions with minimal participant effort?




## Q: What messaging approach is most useful (engagement, behavior change)?
## Q: How do they work?

Tahaney & Palfai (2018). Text messaging as an adjunct to a web-based intervention for college student alcohol use: a preliminary study. *Addictive Behaviors*, 73, 63-66.
Chavez & Palfai (under review). The use of a combined web-based intervention and interactive text messaging adjunct for heavy drinking college students.

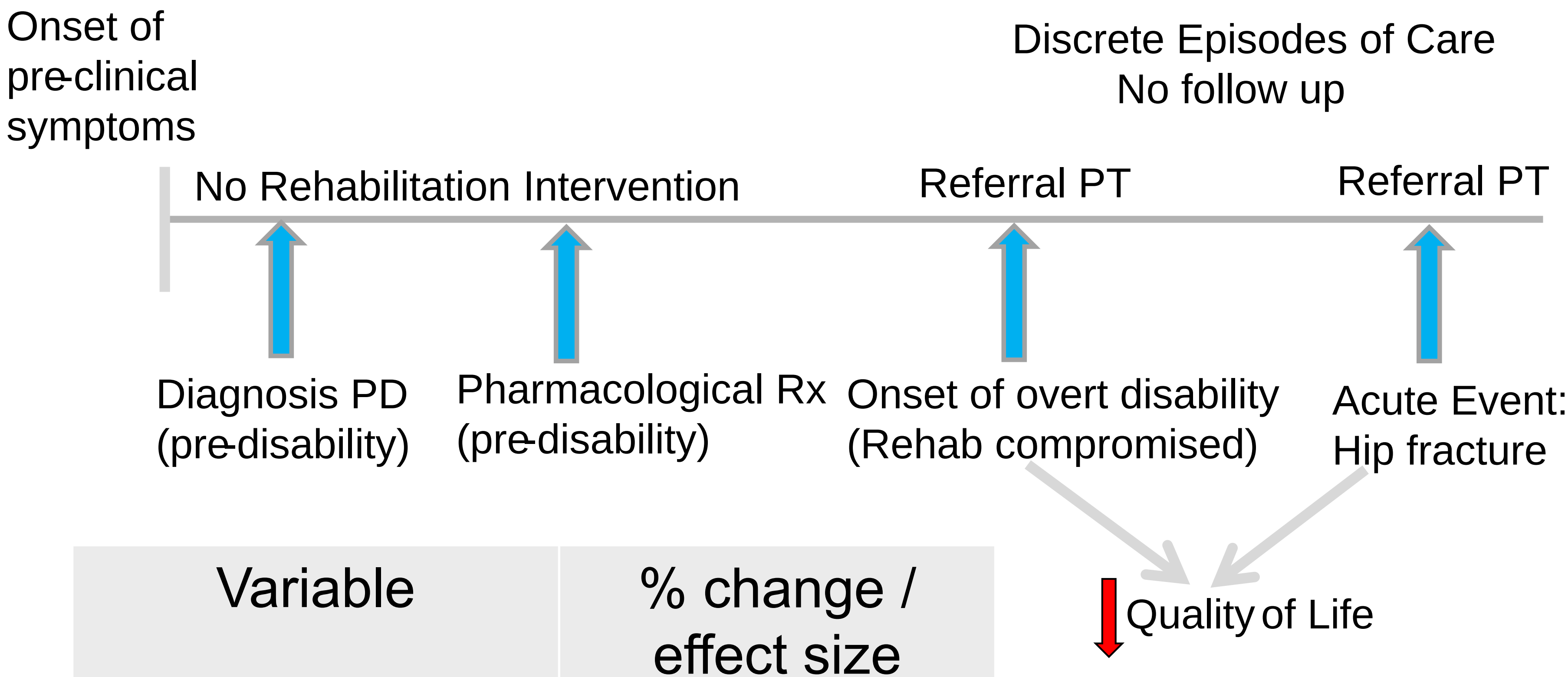
**Other Applications:** Use of text messaging as an adjunct to a brief intervention for reducing hazardous drinking and sexual risk among MSM [NIAAA R01 AA022301–S1]

# Connected Health Improves Rehab Outcomes in Patients with Parkinson Disease


Terry Ellis, PhD, PT

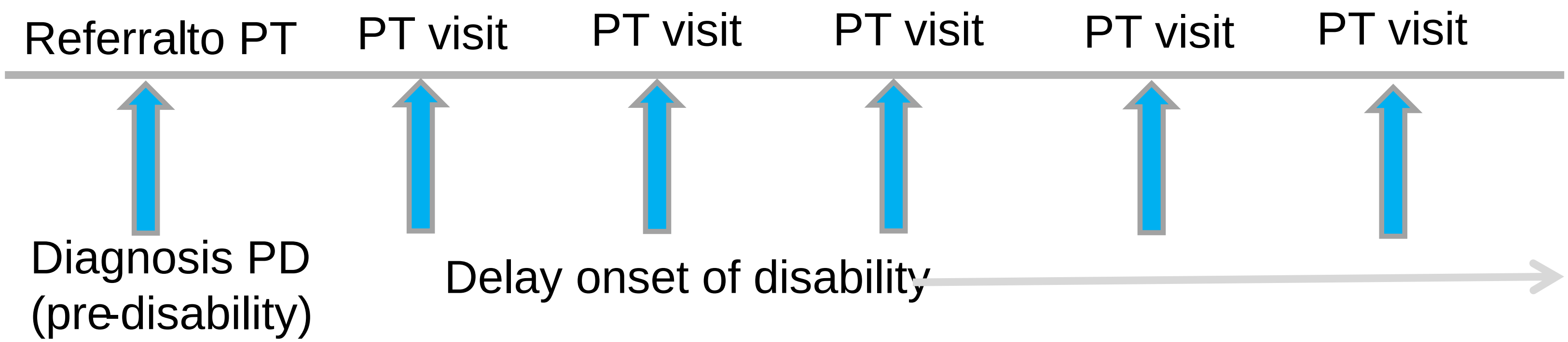
*Assistant Professor*
*Physical Therapy & Athletic Training*
*College of Health & Rehabilitation Sciences: Sargent*

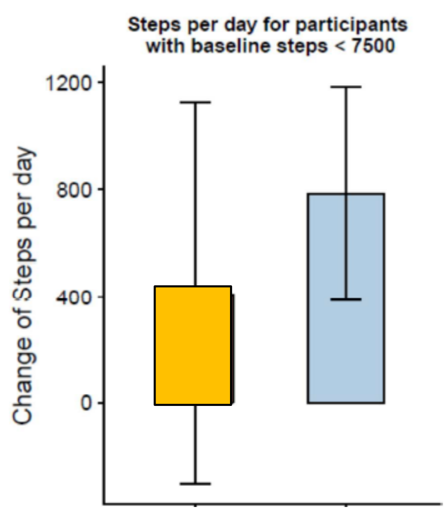
# Traditional Model of Rehabilitation in Parkinson Disease



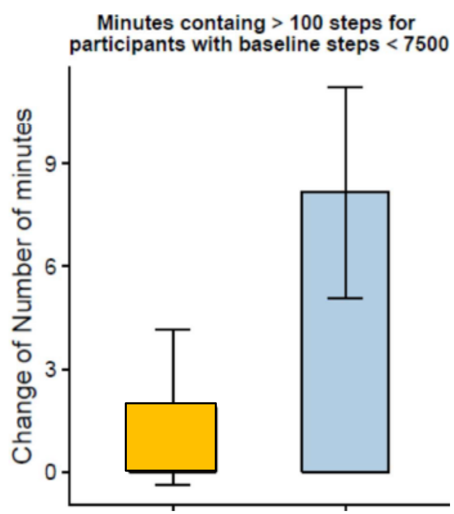

| Variable | % change / effect size |
|---|---|
| Steps | -12 / 0.28 |
| Moderate intensity minutes | -40 / 0.30 |

# Secondary Prevention Model of Rehab (Dental Model) in Parkinson Disease

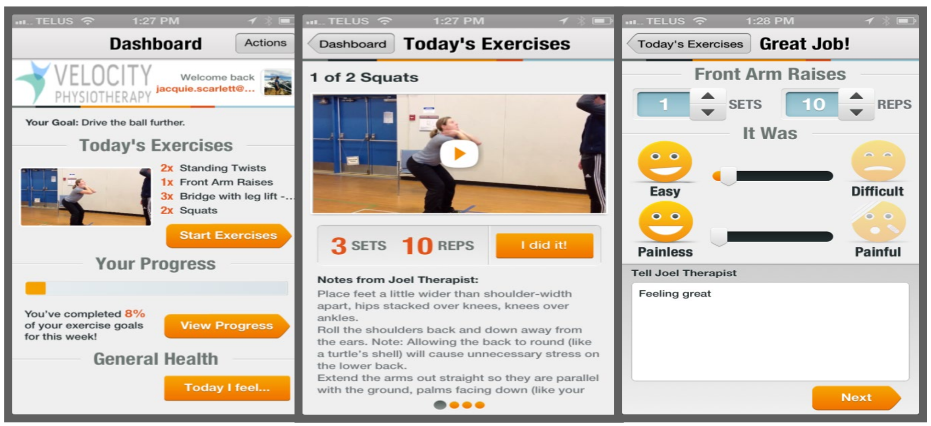



MCID > 800 steps per day




Control = ↑15 mins/wk  mHealth = ↑56 mins/wk
Moderate Intensity Minutes



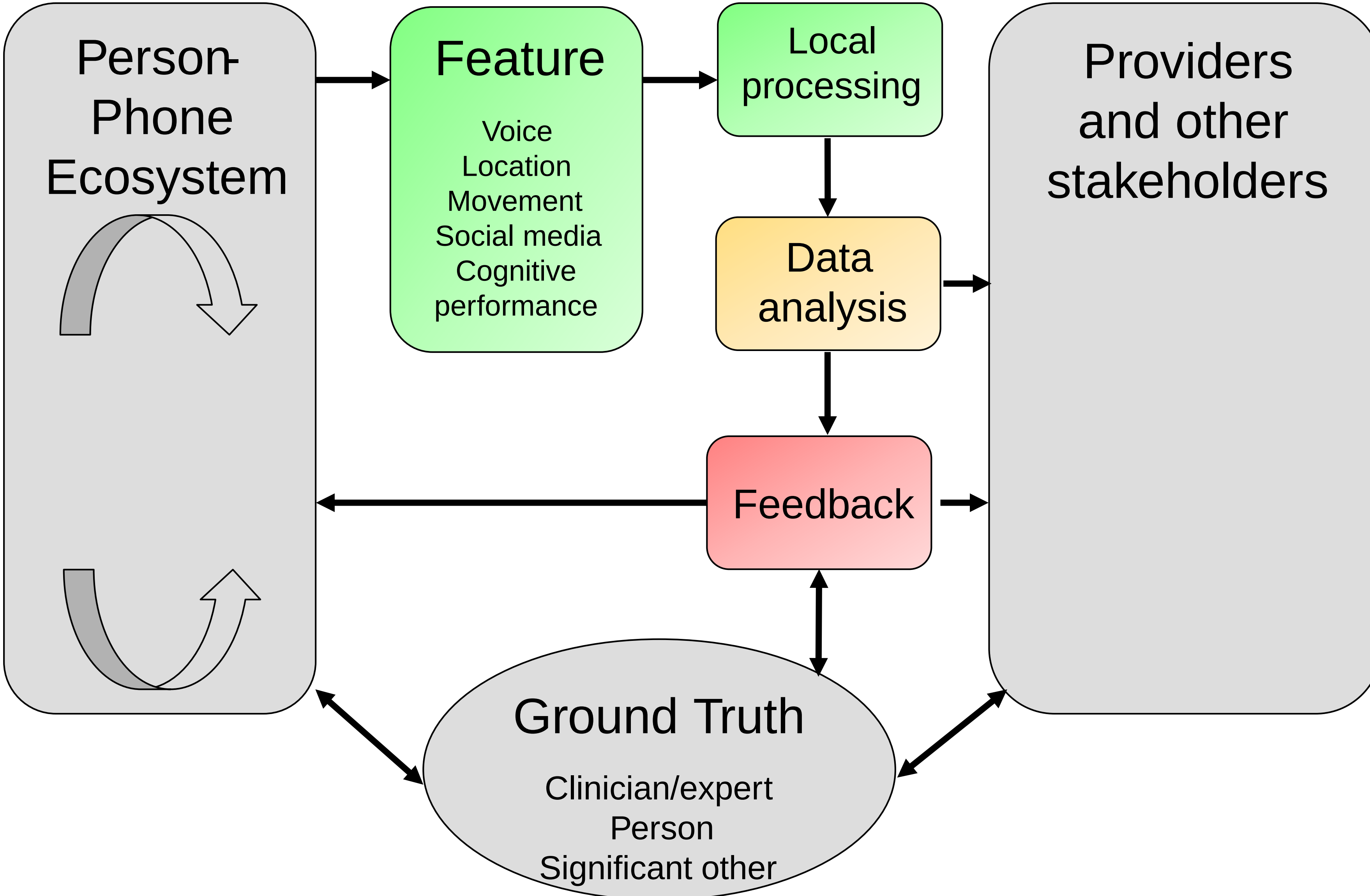

mHealth Application

# The Promise of Digital Phenotyping for Mobile Health


Daniel Fulford, PhD

*Assistant Professor*
*Occupational Therapy, Rehabilitation Sciences, and Psychological & Brain Sciences*

# Digital Phenotyping for mHealth



# Leveraging Social Network Analysis to Identify Hubs of Health (Mis-)Information

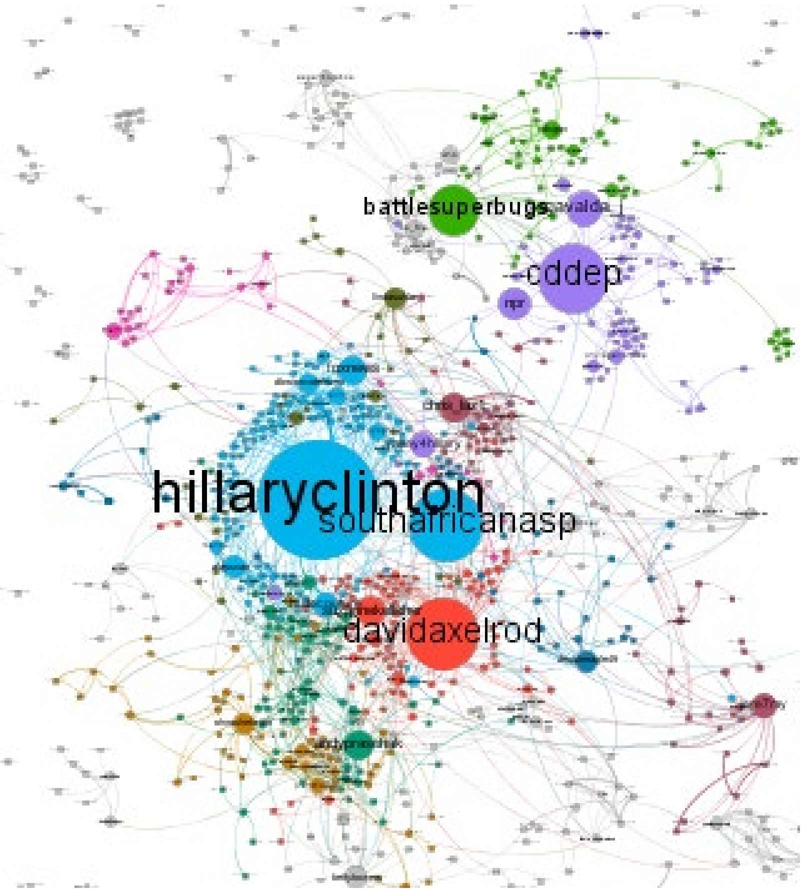

Jacob Groshek, PhD

*Associate Professor*
*Division of Emerging Media Studies, College of Communication*

# Who uses social media for health & how?

- Previous studies suggest that users active discussing health on social media are less knowledgeable, which can lead to the rapid spread of misinformation.
- After collecting (public) social media data at scale, network analysis can sort and algorithmically filter data to better understand user behavior.
- Three key elements as guideposts in these analyses:
  - Size nodes to identify users of prominence w/ betweenness centrality
  - Color nodes to identify communities w/ modularity
  - Spatialize graphs to identify network structure w/ openord
- Importantly, these are *starting points* that can be used to categorize users and content that are influential hubs of (mis-)information for additional engagement.

# Examples – Understanding and Diagnosing Antibiotics and Antimicrobial Resistance on Social Media




| Original Tweet | # RTs / user |
|---|---|
| Antibiotics DOCTOR: why did you take your antibiotic Medicine at 6 am , when I told you 9 am? PATIENT : I wanted to surprise the Bacteria | 7,096 @akashahghazi |
| It's World Antibiotic Awareness Week! #AntibioticResistance is one of the biggest threats to global health https://goo.gl/Lutlmz | 3,456 @WHO |
| Sleep as a target of antibiotic use in chronic fatigue syndrome? - http:// allscienceglobe.com/sleep | 2,851 @MoreScience News |

# Solving the World's Antibiotic Resistance Problem – What if……………………?

## Pneumonia – Four Fast Facts

- Most common diagnosis in the world
- Most episodes caused by viruses – no antibiotics needed
- Difficult to know if pneumonia is viral or bacterial
- Most people get antibiotics anyway – risk of AMR bugs


Patricia L Hibberd, MD, PhD

*Chair, Professor of Global Health. Medicine, Pediatrics*
*Department of Global Health, BUSPH*
*Department of Medicine and Pediatrics, BUSM*

# What if

**… we could determine who has bacterial pneumonia and needs antibiotics and who has viral infection and does not need antibiotics?**

**… we could diagnose bacterial pneumonia where most people in the world are diagnosed with pneumonia – Primary Health Centers**

**… we could make the diagnosis even in places with no**

- **Thermometers**
- **Stethoscopes**
- **Labs**
- **X-rays**
- **Electricity**

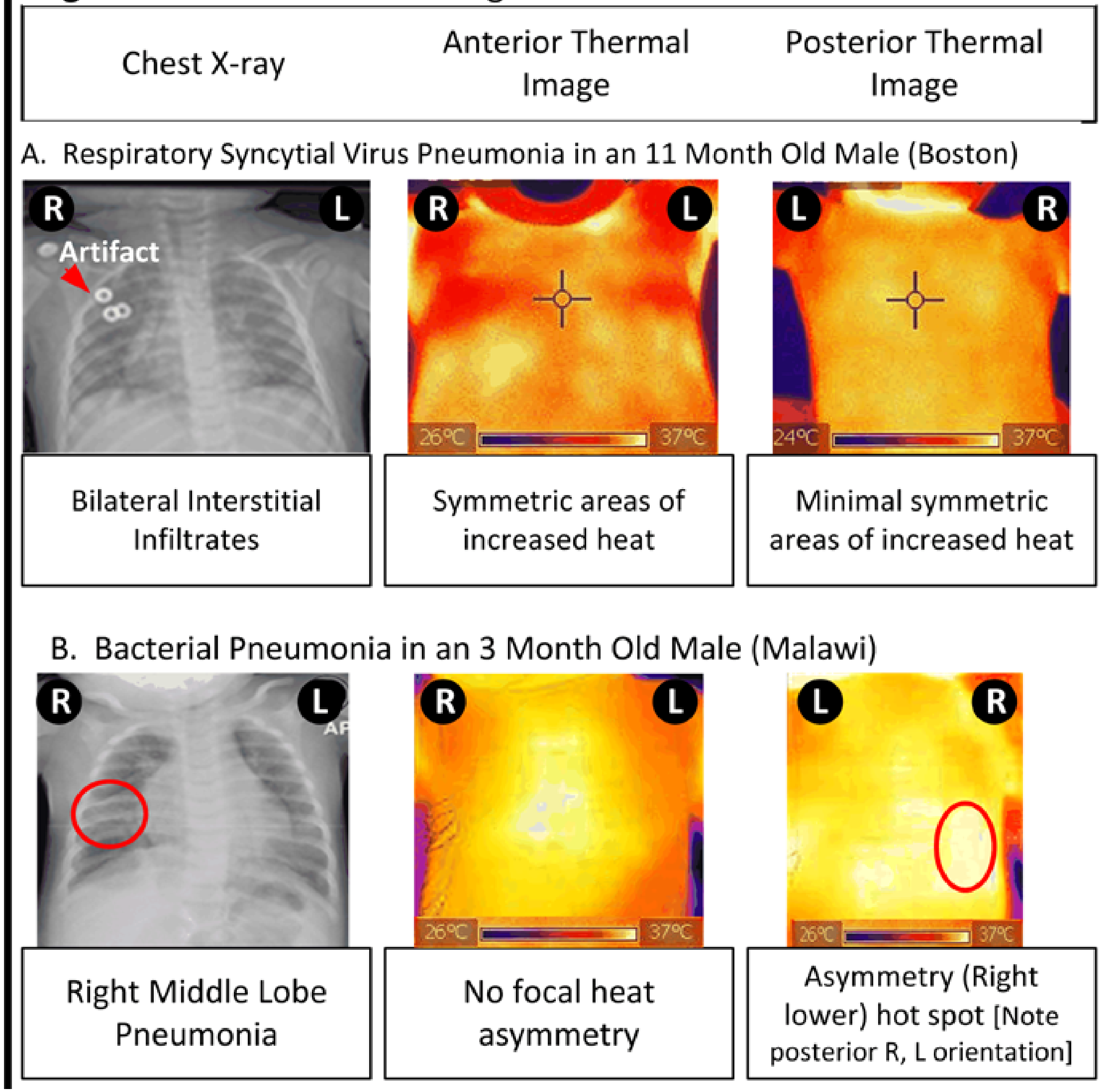



**Figure 1:** Chest Thermal Images in Children with Pneumonia

**Clinical readings** of thermal images

Sensitivity – 80%
Specificity – 58%

**Machine Learning** of thermal images

Sensitivity – 83%
Specificity – 72%

- Global Impact
- US Impact
- Reduce X-rays for kids?

**R U Interested?**

# mHealth Physical Activity Intervention for People with Knee Osteoarthritis and Comorbidities

Deepak Kumar

*Assistant Professor*
*Physical Therapy & Athletic Training, Sargent College*



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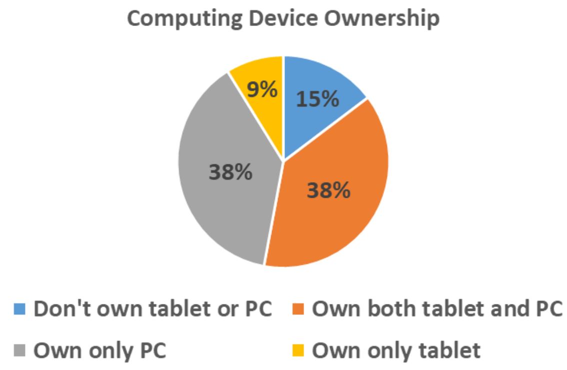
# Knee Osteoarthritis, Comorbidities, and Physical Activity

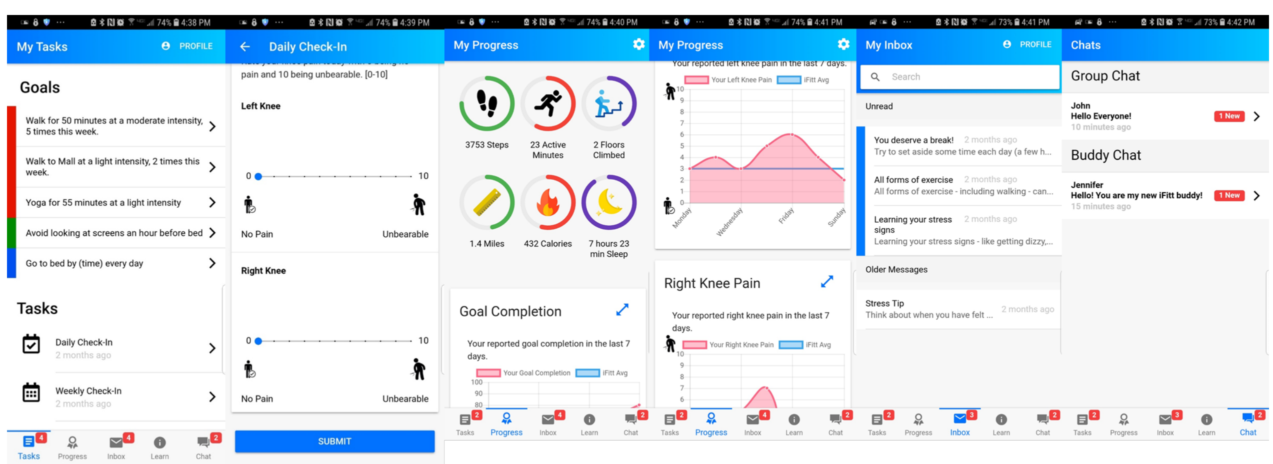
- Knee osteoarthritis (OA) impacts 1/10 adults in America over the age of 55.
- Dose-response relationship between reduced walking activity and risk of early mortality in knee OA.
- Up to 40% of people with knee OA reported depressive V\PSWRPV LQ SUHVHQFH RI FKURQLF SD reduced activity.
- Need for scalable intervention that addresses pain, mood, and physical activity
- **Development of Social Cognitive Theory (SCT) based mHealth intervention**

| | |
|---|---|
| **n** | **34** |
| **Age (years)** | 63.8 (7.7) |
| **BMI (kg/m²)** | 28.8 (4.6) |
| **Female (%)** | 67.6 |
| **Black (%)** | 29 |
| **Pain Score (%)** | 56.1 (16.8) |
| **CES-D** | 13.3 (12.2) |
| **CES-D •** | 29 |




Ratingof mobile health application features using modified Delphi technique

| SCT Construct | **Mobile app feature** | Participant Rating | |
|---|---|---|---|
| | | **Mode** | Range |
| Motivation | Motivational Messaging | 9 | 1-9 |
| SelfEfficacy | Goal Setting | 9 | 5-9 |
| BehavioralCapability | Instructional Videos | 9 | 1-9 |
| ObservationalLearning | Social Interaction | 9 | 1-9 |
| Reinforcement | Reminders | 9 | 4-9 |
| | Badges | 1 | 1-9 |
| | Competition | 1 | 1-9 |
| Outcome Expectation | Tracking Mood, Pain, Activity | 9 | 1-9 |
| | Selective Feedback | 9 | 1-9 |

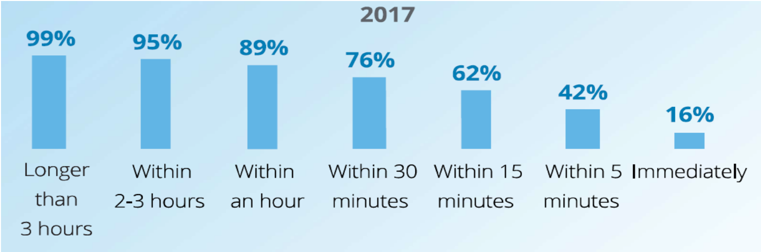



# Electronic Framingham Heart Study (eFHS): mHealth technologies to help people improve their health


Joanne M. Murabito

*Professor of Medicine*
*Medicine, Boston University School of Medicine*

## Time between waking & looking at phone




"Most of us can't imaging life without a smartphone since mobile makes the mundane exciting"

Deloitte 2017 Global Mobile Consumer Survey

&XVWRP PRELOH DSS DW FXUUHQW )&0 H[DP


**2.Test strategies to improve long-term use of devices**

(RCT NCT03516019)

- **Personalized vs standardized messages**
- **Day of week**
- **Time of day**

McManus DD, et al JMIR 2019

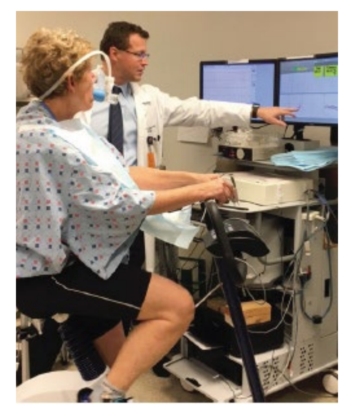
## 3. Allow participants to access device data in a meaningful way


## 4.Understand factors associated with use

| Inhibitors | Adherence Domains | Facilitators |
|---|---|---|
| •Older age •Female sex •Non-white Race | *Social and Demographic Factors* | •Education •Family in FHS •Not working |
| •Smoking •Alcohol use •Poor diet | *Health Behavior Factors* | •Physically active |
| •CVD •Depression •Anxiety | *Condition-Related Factors* | •Certain conditions (i.e., hypertension) may motivate to monitor |
| •Low system usability (i.e., low SUS) •High participant burden (i.e., high relative subjective count) | *System Factors* | •Dashboard to engage •Messaging for adherence •Technical support •In-person training |

## 5. Compare digital data to data collected in the FHS Research Center to understand the value of this novel data collection

- **Cardiopulmonary fitness evaluation**



The Team

Emelia Benjamin David McManus
Ludovic Trinquart Belinda Borrelli
Chunyu Liu Honghuang Lin
Nicole Spartano Emily Manders
Kelsey Fusco

**CareEvolution**

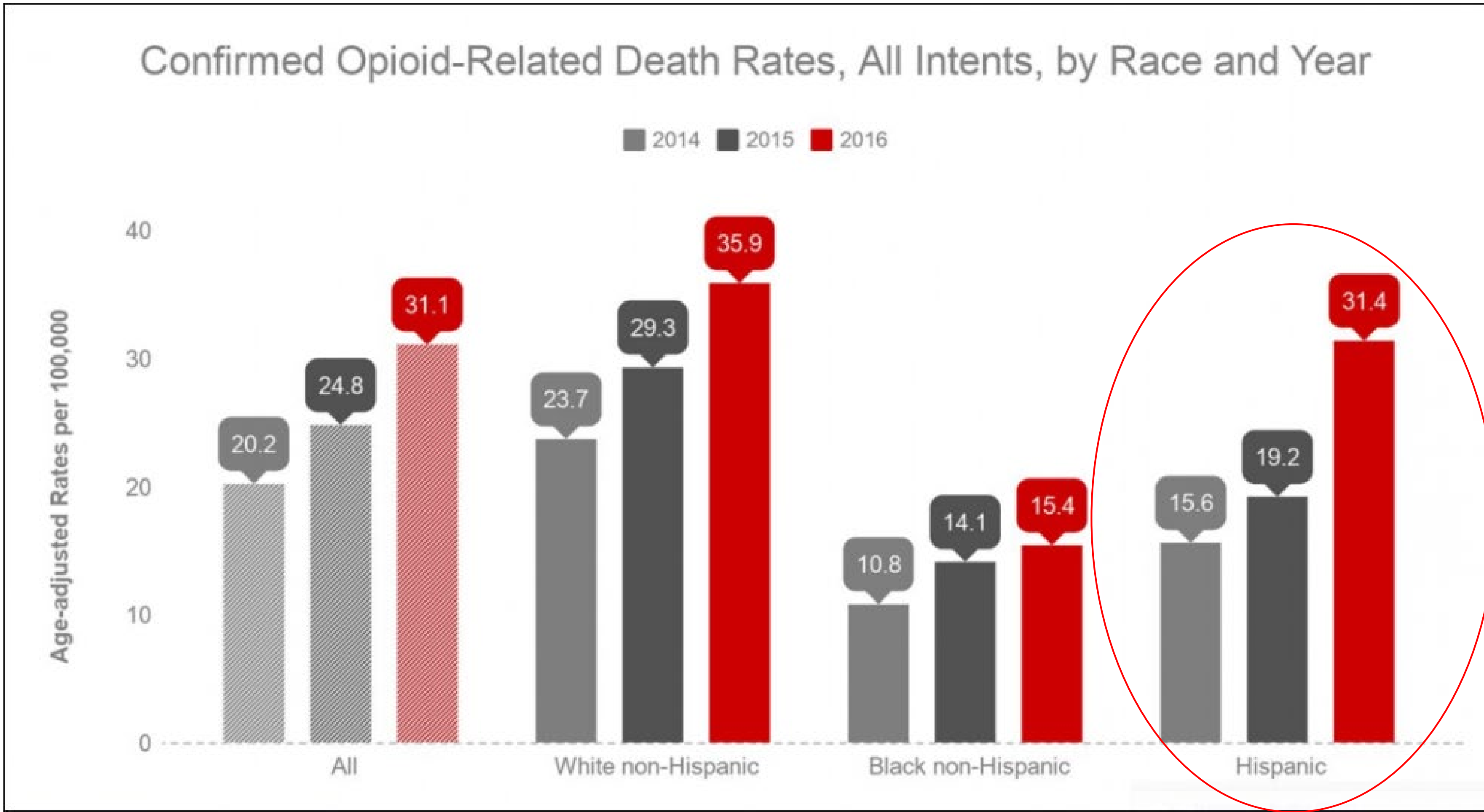
RWJ Award #74624; R01HL141434

# Smartphone Relapse Prevention Tool for /DWLQ[ Spanish Speakers

Jordana Muroff, PhD, MSW

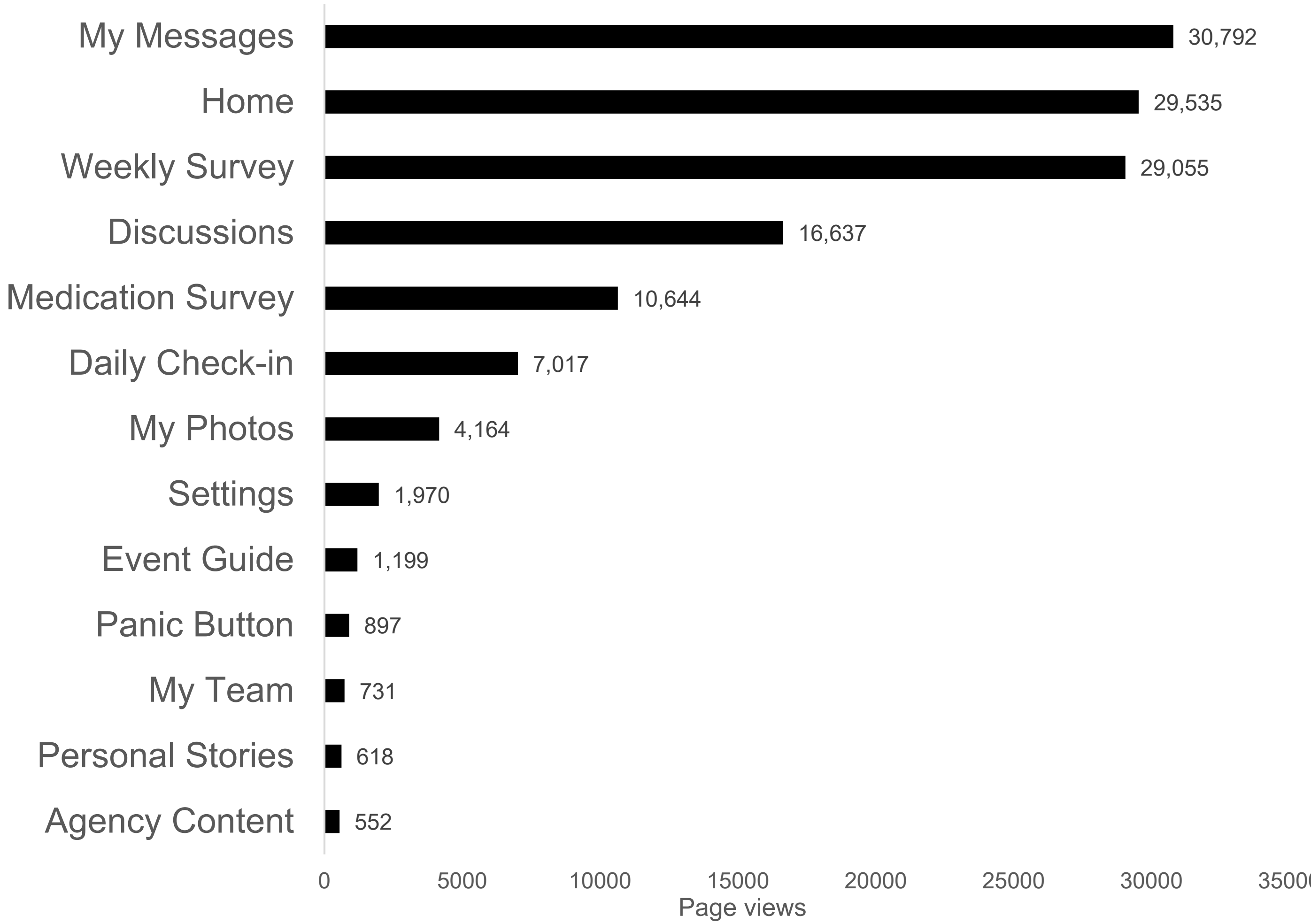
*Associate Professor*
*School of Social Work*

- Latinx communities lack access to culturally and linguistically competent services (SAMHSA, 2012).
- Latinx population is a rapidly growing segment of the population that bears a disproportionate disease burden, mental illness, poverty, incarceration
- The rate of substance dependence or abuse among Latinx people, higher than members of other racial/ ethnic groups (≥12 years old) (SAMHSA, 2014).



# CASA-CHESS Features


CASA CHESS HOME SCREEN




WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

CASA ESPERANZA

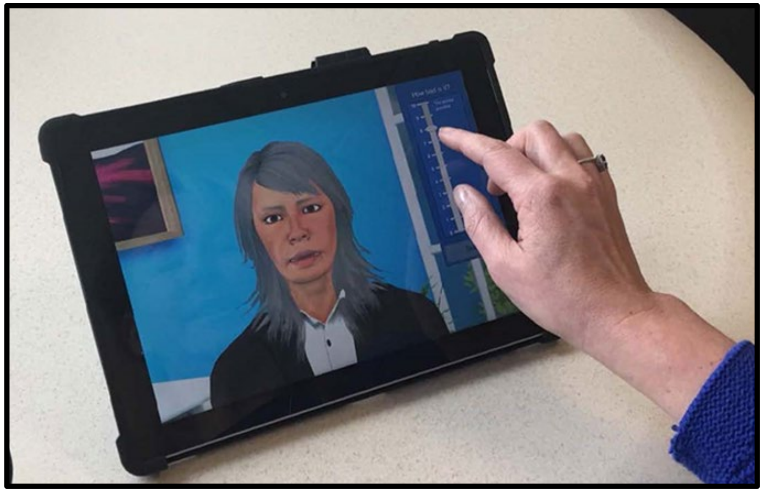
# Research in Health Literacy

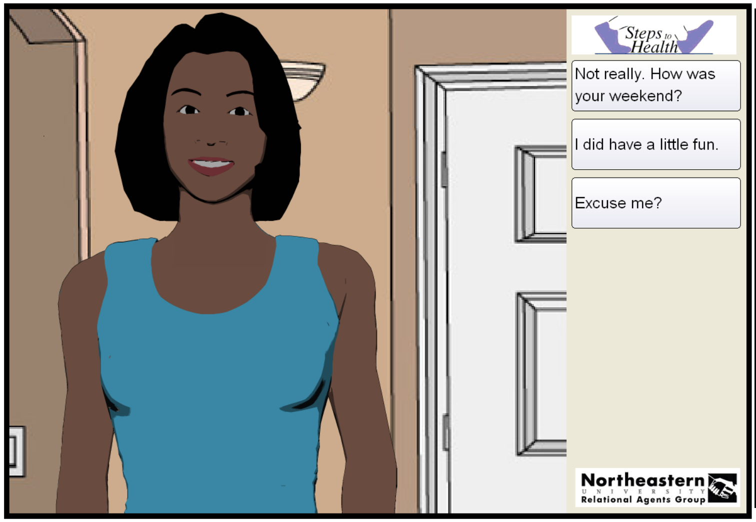

Michael Paasche-Orlow MD, MA, MPH

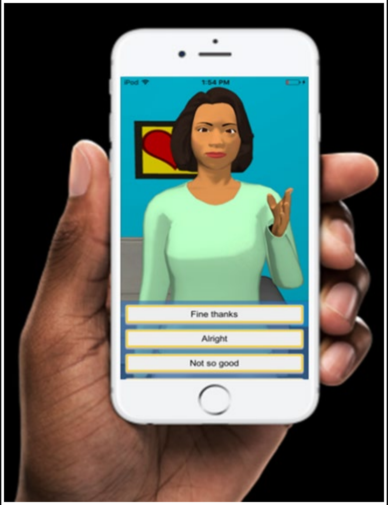
*Professor of Medicine*
*Section of General Internal Medicine*
*Boston University School of Medicine*

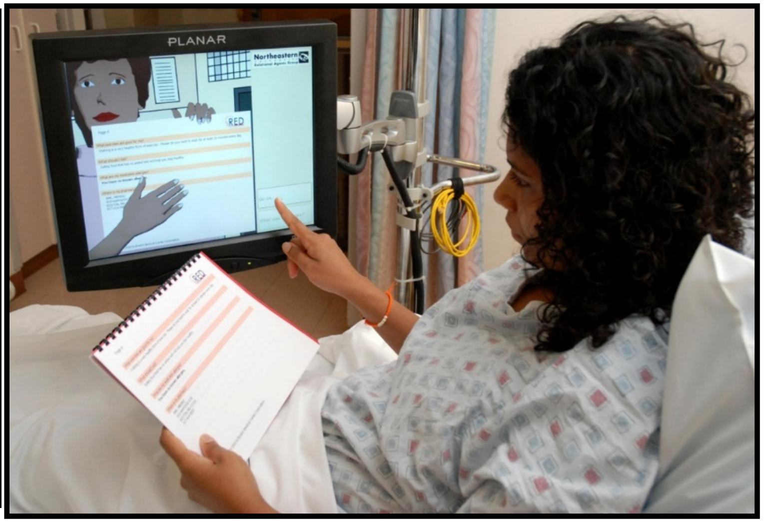
# Embodied Conversational Agents

- Emulate face-to-face comm w/ touch screens
- Develop therapeutic alliance using
  Empathy, Gaze, Posture, Gesture
- Tailored longitudinal conversations





# Marie: Tablet-based ECA for patients w/ advanced illnesses

(1) Symptom monitoring and med counseling
(2) Physical activity promotion
(3) Stress reduction
(4) Spiritual needs assessment and support
(5) Advanced care planning
(6) Story telling

- "I felt like something happened in my life in 6 months that I had something to look forward to. Started with the tablet and the phone calls and I still like that."
- "She was very good - the way she talked to me. Her attitude. She had a very good attitude. She explained different things to me. She can understand what I am saying, because of what I am going through."
- "Meditation made me relax. When I was feeling down I would do it and it would make me relax and take me away and I was in another place. I liked the peaceful place and the wise one meditation. Really enjoyed it."
- "…it was really satisfying because two days after -- he called me, and I was very very happy because I felt that I have some importance to him. So that make me very happy. He called me at 3:15 so from that time until I slept I was very happy."

# Learning from Medical Data to Predict and Intervene

Yannis Paschalidis, PhD

*Electrical & Computer, Systems, and Biomedical Engineering*
*Center for Information and Systems Engineering*
*Boston University*

http://sites.bu.edu/paschalidis/
yannisp@bu.edu

# Research Themes

- **PREDICT &**
- **PREVENT Hospitalizations**

- **CONTROL**
- **REGULATE**
- **PRESCRIBE**
- **OPTIMIZE Treatment**

- **DETECT ANOMALIES**