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Wearable Sensors (& other tech) in Aging Research: From Diagnosis to Intervention

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Outline and Disclosures

I. Frailty in practice
II. Accelerometry and frailty
III. Experience taking tech from idea to efficacy

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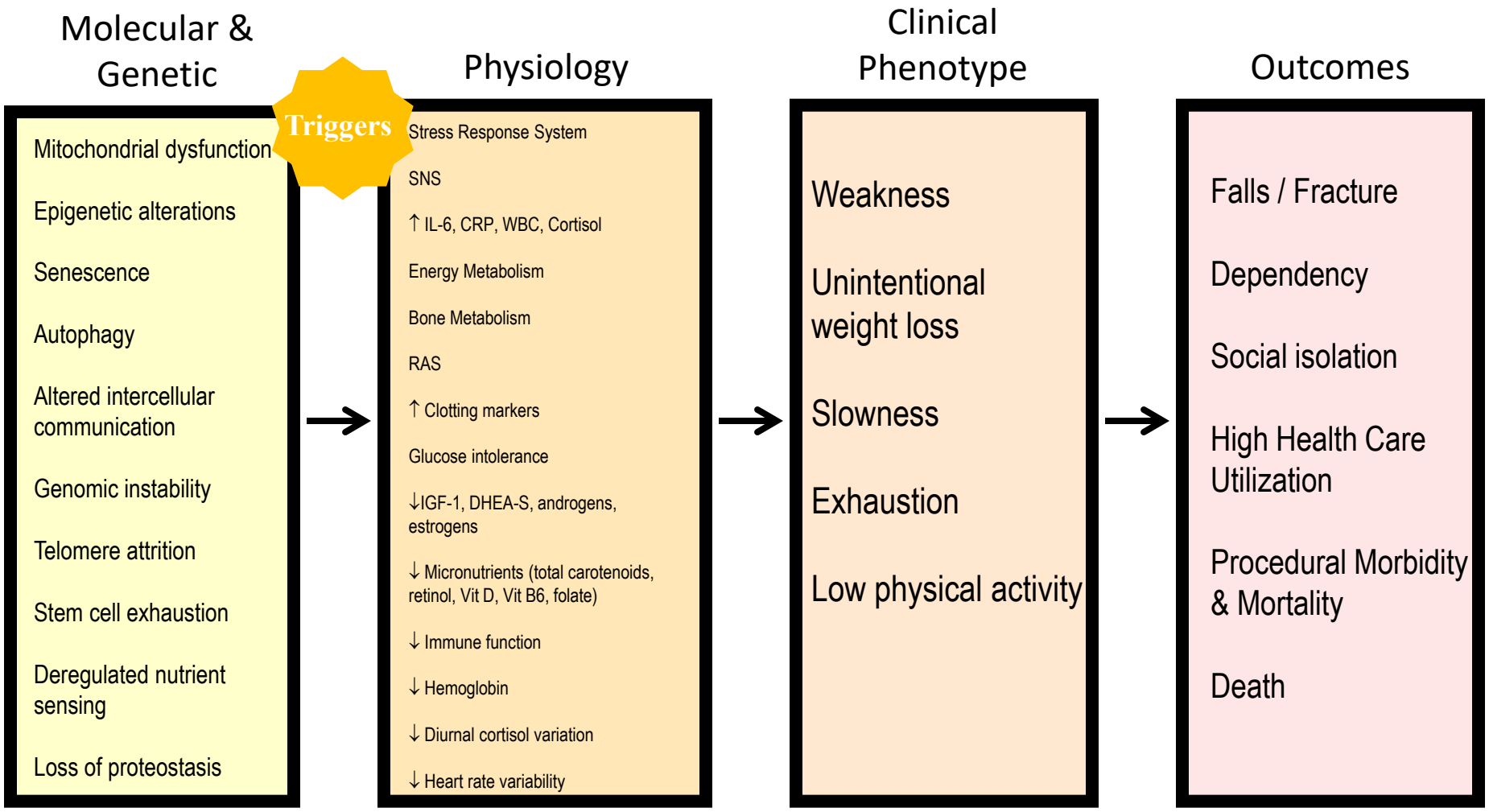
The University of Chicago and NORC hold Intellectual Property Rights to EngAGE, a technology program which will be discussed today. To date, EngAGE has not been licensed.

How did I begin as a geriatrician and end up in tech research?

Physical frailty reflects impaired physiology



Walston 2017, figure adapted with permission

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Frailty measurement included in guidelines and best practices

Early guidance

Age-Friendly Health Systems: A Guide to Using the 4Ms in the Care of Older Adults
– Mobility assessment at all encounters and visits

Frailty Screening Expert Recommendations
– ≥ 70 years
– ≥ 5% weight loss in prior year

Symptom / Event Triggers
– During a fall evaluation
– Prior to elective procedures
– At the time of diabetes treatment decision making
– At the time of cancer treatment decision making
– At the time of valvular disease treatment decision making

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The Successful Aging & Frailty Evaluation (SAFE)™ Clinic

Est 2011

Geriatricians, Geriatrics APP, Social Workers, Physical Therapist

Frailty implementation into practice continues to face challenges.

1) 15-20 minute in-person measurement required.

2) Insufficient long-term programming to manage frailty

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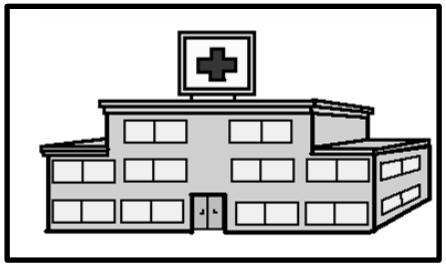
Reimagining Older Adult Care

Patients must come to us.



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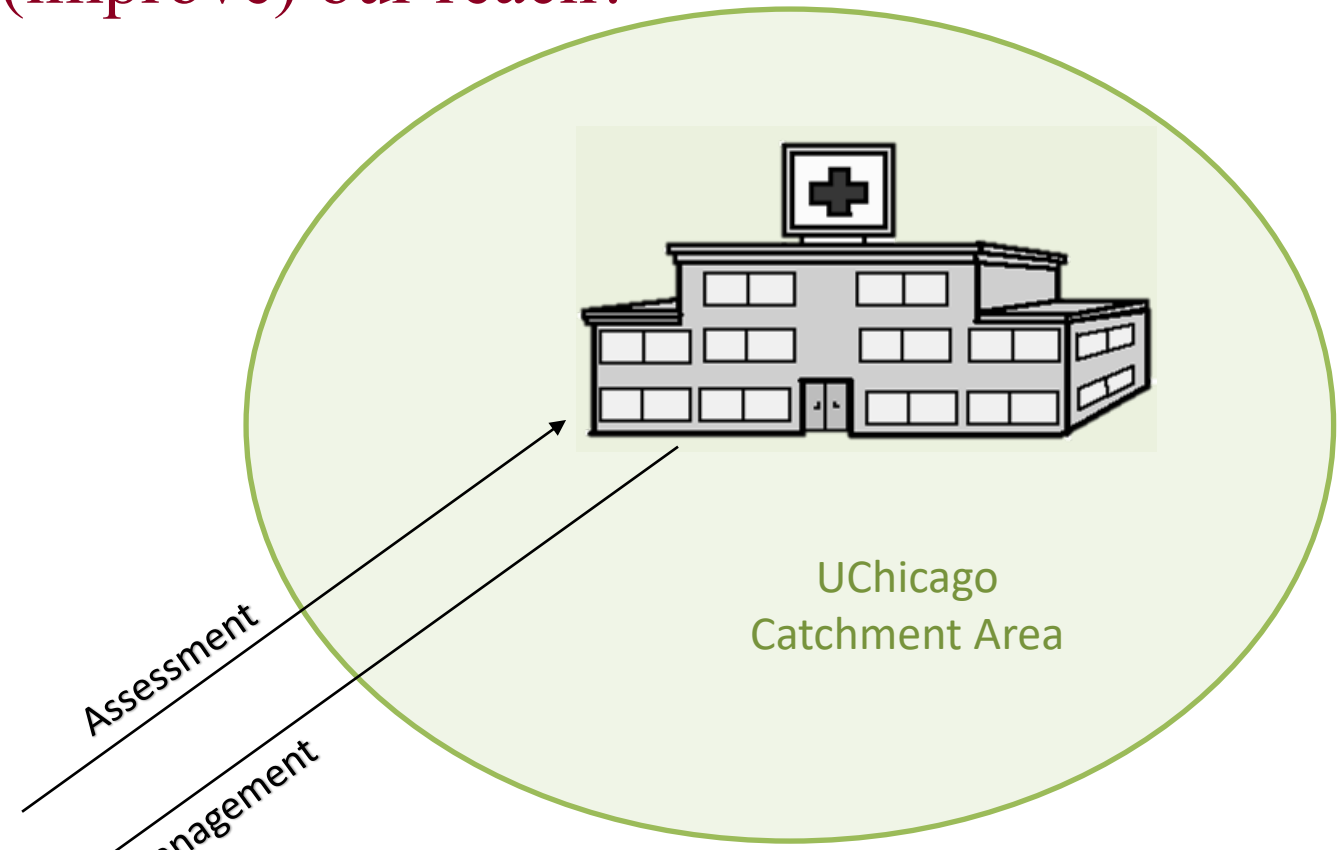
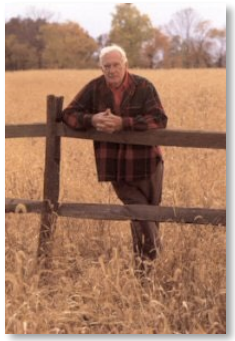
Ornstein, K. A., et al, *JAMA Intern Med,* 2015

Can we expand (improve) our reach?





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NORC at the UNIVERSITY of CHICAGO

Accelerometry in Frailty Assessment

Accelerometers

- Wearable, non-invasive devices (hip, wrist, ankle, thigh, chest…)
- Collect continuous acceleration data (passive, 3-7+ days, real life)
- Frailty → activity, gait speed, strength
- Acceleromtry → seemed like a good surrogate candidate

Hip

Wrist

Thigh

Chest

Older adult research studies with accelerometry:

- National Health and Nutrition Examination Survey (NHANES)
- United Kingdom Biobank
- Baltimore Longitudinal Study on Aging (BLSA)
- Study To Understand Vitamin D in Falls Reduction in You
- National Social Life, Health and Aging Project (NSHAP)
- Peripheral Artery Disease Study of Latinos
- Atherosclerosis Risk in Communities study
- National Health and Aging Trends Study (NHATS)
- Lifestyle Interventions and Independence for Elders (LIFE)

Moderate and Vigorous Activity Participation Among U.S. Older Adults is low.

Mean minutes per day above 2020 & 5999 hip accelerometry count cut points				
	Males		Females	
Age	**Moderate**	**Vigorous**	**Moderate**	**Vigorous**
60-69	16.3 min	0.4 min	12.3 min	0.1 min
70+	8.6 min	0.1 min	5.4 min	0.0 min

Will accelerometry patterns really be able to differentiate aging outcomes?

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Activity level is associated with many aspects of older adult health.

Accelerometry + Covariates = Health Outcome

- **3-Meter Timed Gait**
- **Chair Stands**
- **Self-Rated Physical Health**
- **Self-Rated Mental Health**
- **Diastolic Blood Pressure**
- **Hgb A1c**
- **C-Reactive Protein**
- **Heart Problems**
- **Diabetes**
- **Any ADL Difficulty**
- **Any IADL Difficulty**
- **Social Network Size**
- **Social Network % Friends**
- **Visiting Neighbors**
- **Attending group Meetings**
- **Cognition**

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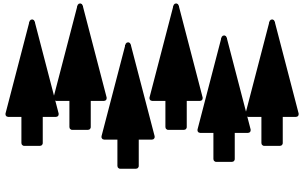
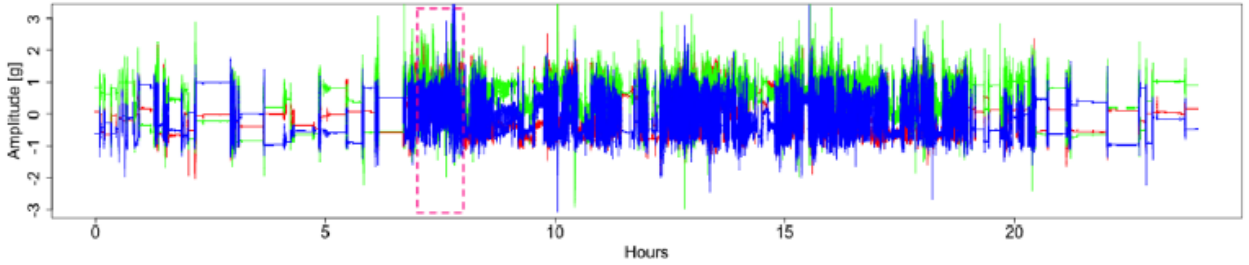
Accelerometry provides high resolution logs of mobility.

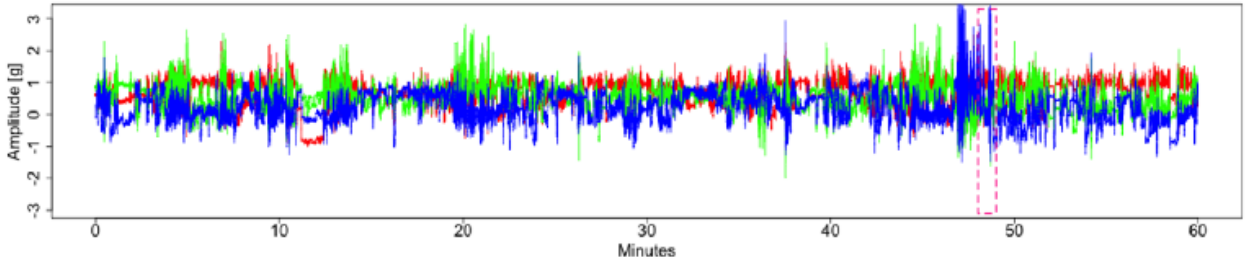


Forest View

24 hours of data

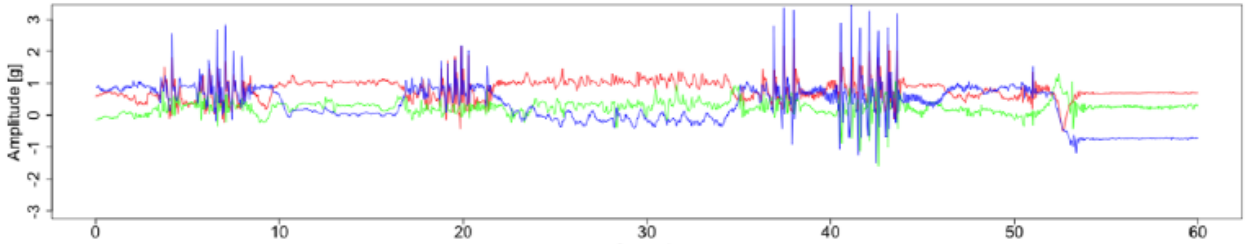


1 hour of data



Tree View

1-mintue of data



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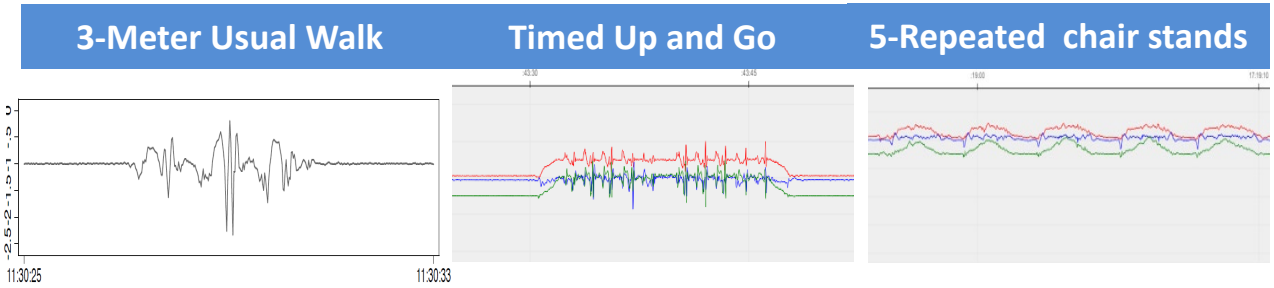
Branch View

A few seconds



Accelerometry measures are associated with & predict frailty & function

Sedentary Behavior

Activity Fragmentation

Mod-Vig Activity

Activity Timing

Frailty & Physical Function

Stride Amplitude

Activity Variance

Activity Bouts

Cadence

Stride Periodicity

Total Activity

Performance tests

Stride-to-Stride Variabilty

Circadian patterns

Average Activity

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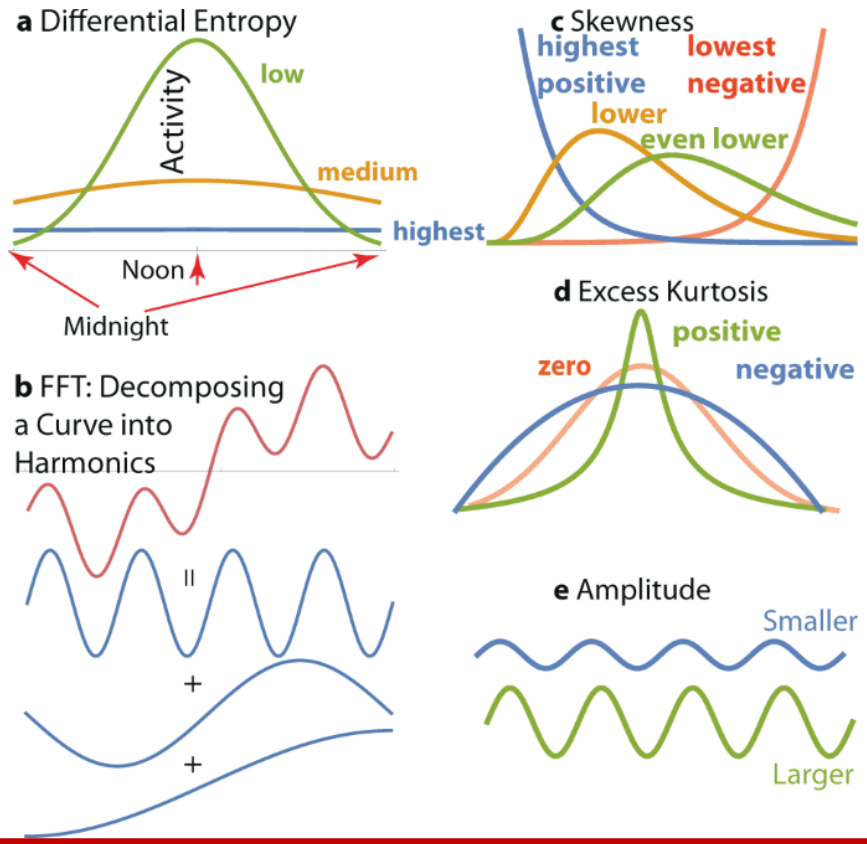
It's complex.

The accelerometry measures may provide unique information

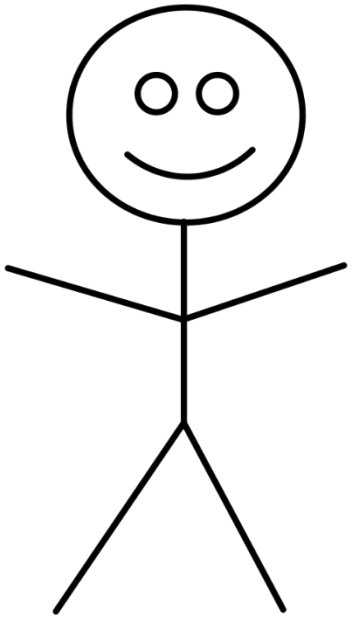
>100 Circadian & Activity Accelerometry Metrics



Accelerometry pair correlation range: = -0.01 to 0.91

Image from: Shi C, Babiker N, Urbanek JK, Grossman RL, Huisingh-Scheetz M, Rzhetsky A (co-senior authors)). Free-living wrist and hip accelerometry forecast cognitive decline among older adults without dementia over 1- or 5-years in two distinct observational cohorts. *Npj Aging* 2022;**8**:7.

Remote, non-invasive measures of physiology & function are now broad!

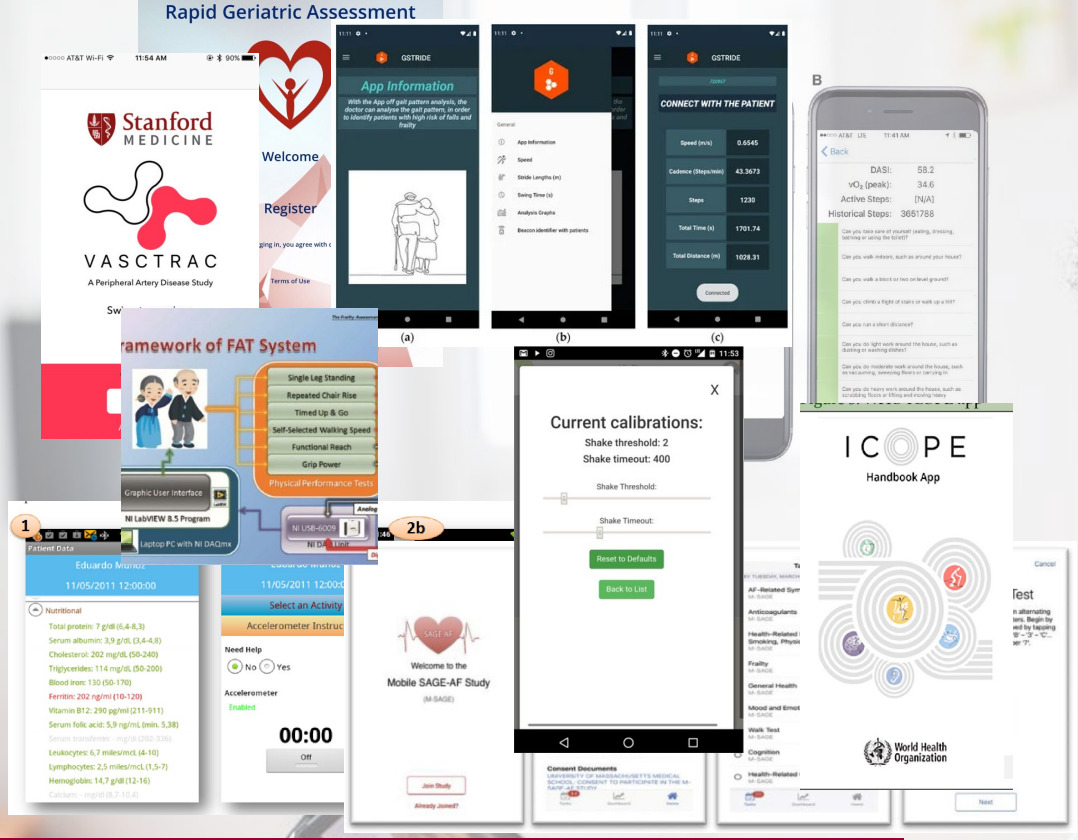


Geographic location
Sound exposure
Cognition
Light exposure
Sensory function
Environment temperature
Medication, microwave, fridge use
Living patterns
Self-administered capillary blood draws
WiFi connectivity and use
Continuous glucose
Trachea vibrations
Oxygen saturation
Activity
Skin temperature
Sleep
EKG
Heart rate & variability
Circadian rhythm
Microbiome
Arm and leg swing
Symptoms & questionnaires
Gait speed
Functional reach
Body composition
Balance
Insole pressure
Falls
Reaction time
Physical function performance
Sit-to-stand
Urine
Arm flexion

Can we create a remote frailty surrogate measure?

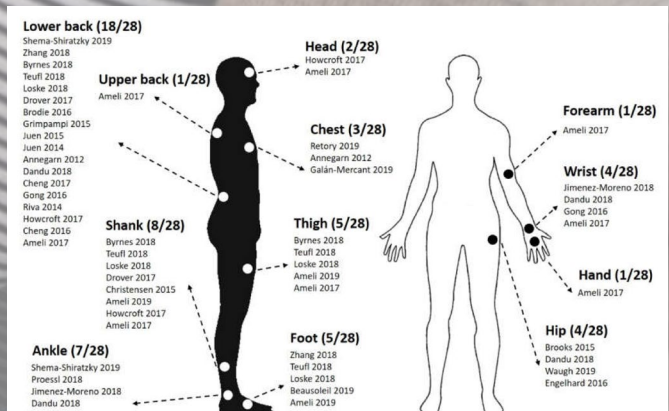
Apps

Modes of Frailty Assessment



Remote tools & home sensors

Wearable sensors



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Future Directions

Assessment

Management

- Develop comprehensive scores
- Quantifying “value add” to clinical care
- Establish thresholds for monitoring
- Test feasibility in routine care
- Establish cost-effectiveness
- EMR integration

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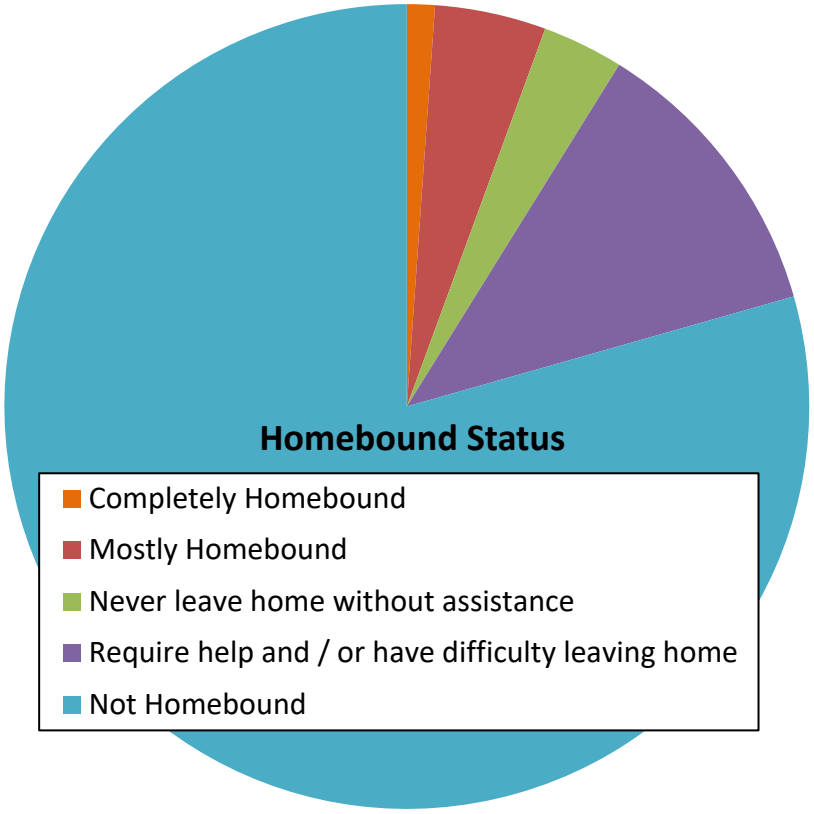
Experience taking tech from idea to efficacy

We have very little programming to help frail older adults stay active.

- **Disrupted cardiovascular, metabolic, or musculoskeletal physiology**.[1, 2]
- **1/5 community-dwelling adults are 'homebound**.[3,4]
  - Non-White race
  - Multimorbid
  - Lower income
- **Reliance on informal caregivers**.[3-6]
  - No formal training
  - Target = dyad
- **No Medicare-covered long-term exercise programming the home**. [7-9]
  - Trials: in-person classes, coaching
- **Social engagement ≈ physical engagement**.[10]
  - Relationships motivate & maintain habits[11]
- **Local patients**:
  - ~70% minority, 20% impoverished, ↑frailty & multimorbidity



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Engage

Empowering and connecting for a happier, healthier you

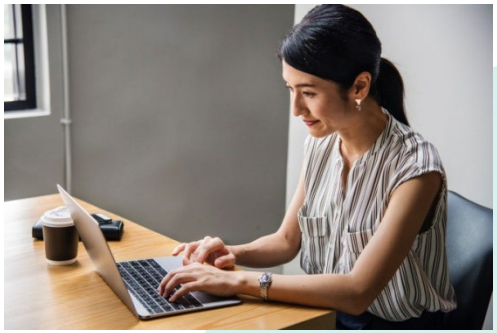

Photo b

Website

Voice Activated Device

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orbita

Older adult user

- Custom Alexa skill
- NIA Go4Life Program Exercises
- Audio & visual instructions
- Pictures
- Music
- Reads encouraging family messages
- Auto adjusts intensity

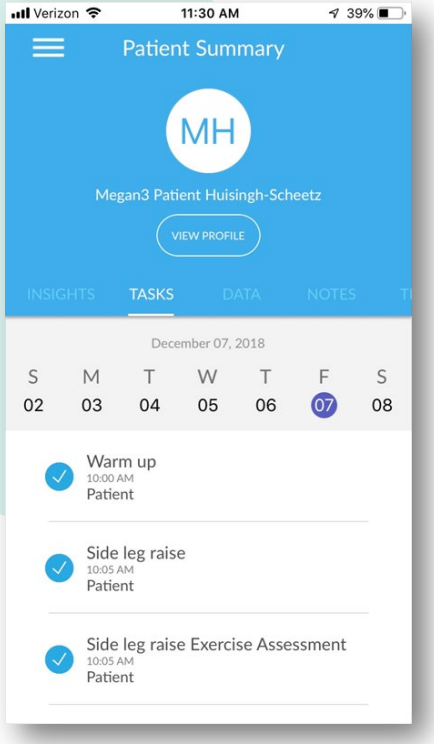
Overhead Arm Raise

Back Leg Raise

Chair Stand

Care partner user

- Daily exercise tracking
- Notices of (in)activity
- Send and receive messages
- Data from website are stored on HIPPA-approved server.



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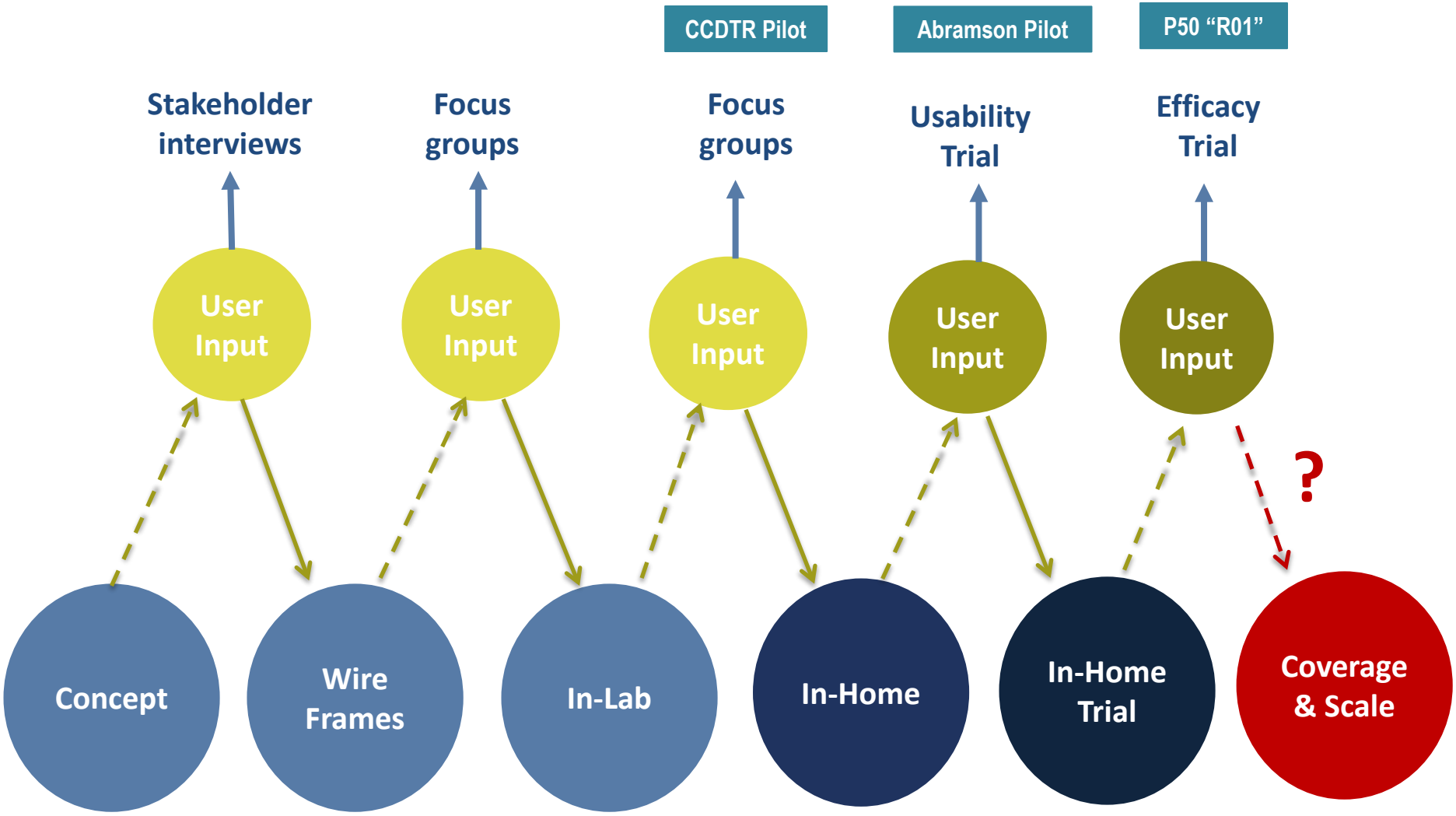
Tech from idea to efficacy: 6 years on a slide



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Target group

N=124 Community-Dwelling, African-American, multimorbid, frail, homebound older adult + care partner dyads

Inclusion

Prescreen over phone:

- ≥ 65 years;
- African American;
- 2+ chronic conditions + homebound:
- Can read newspaper w/ glasses; Can hear spoken voice from 2-ft;
- Has a trusted and valued individual in their life 18+
- WiFi was NOT required. Hotspots provided.

Screen at baseline assessment:

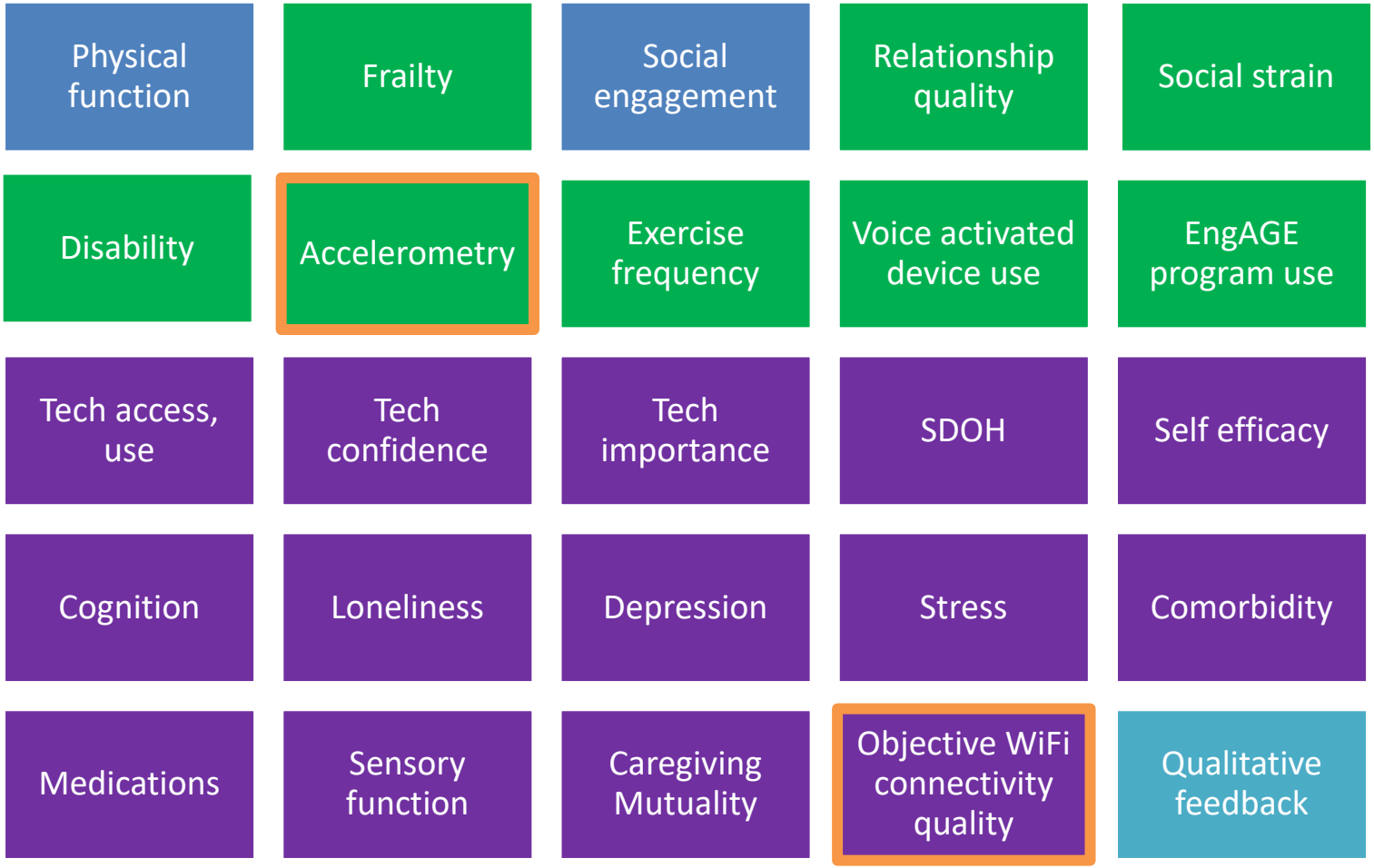
- SPPB score of ≤8 but >3 / 12

Exclusion.

Prescreen over phone:

- Moderate to advanced cognitive impairment
- Inability to stand unassisted
- Inability to understand English
- Life expectancy <12 months or enrolled in Hospice
- A medical condition unsupervised activity potentially unsafe

Variable domains



Questions for discussion

- *What will the future geriatric assessment look like?*
- *How can we be engaged in the design and planning now?*
- *How can we advocate for older adults to be engaged in design now?*
- *How do we ensure health tech does not worsen health disparities?*
- *How to we ensure we have clinical evidence for the tech?*

Thank you!

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