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Population Health in the Digital Era of Medicine
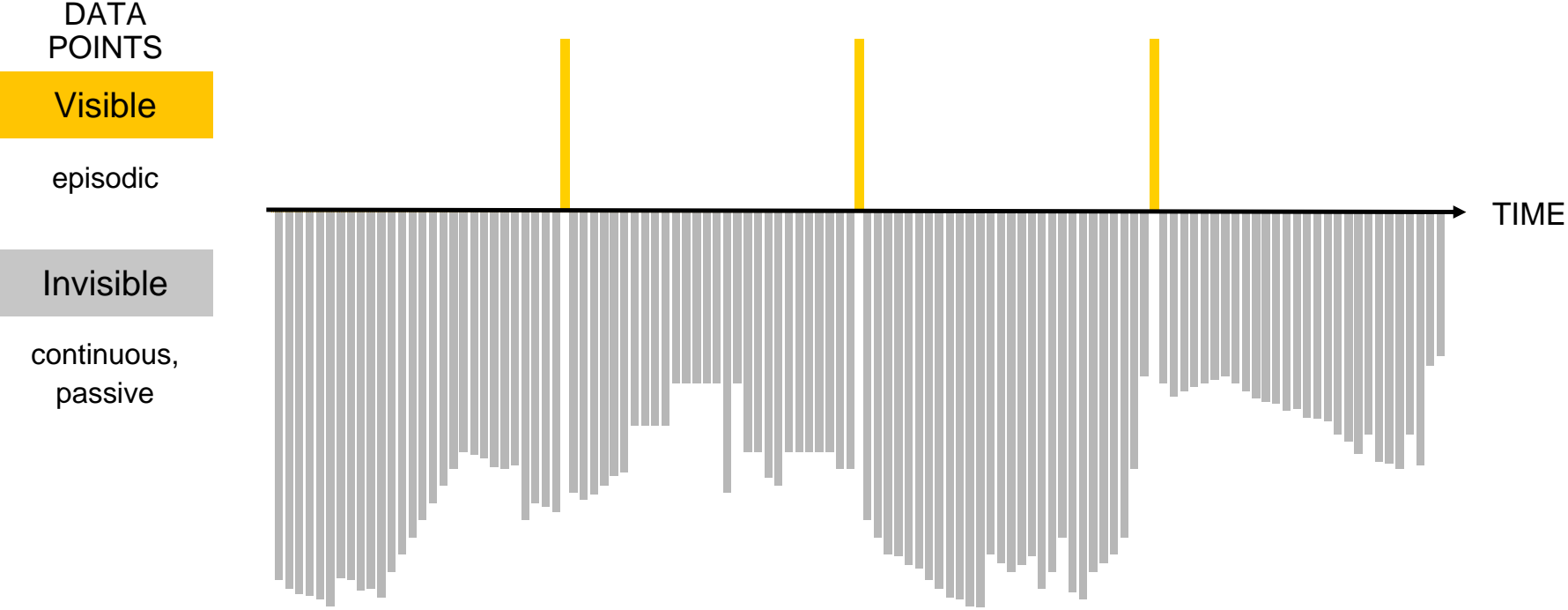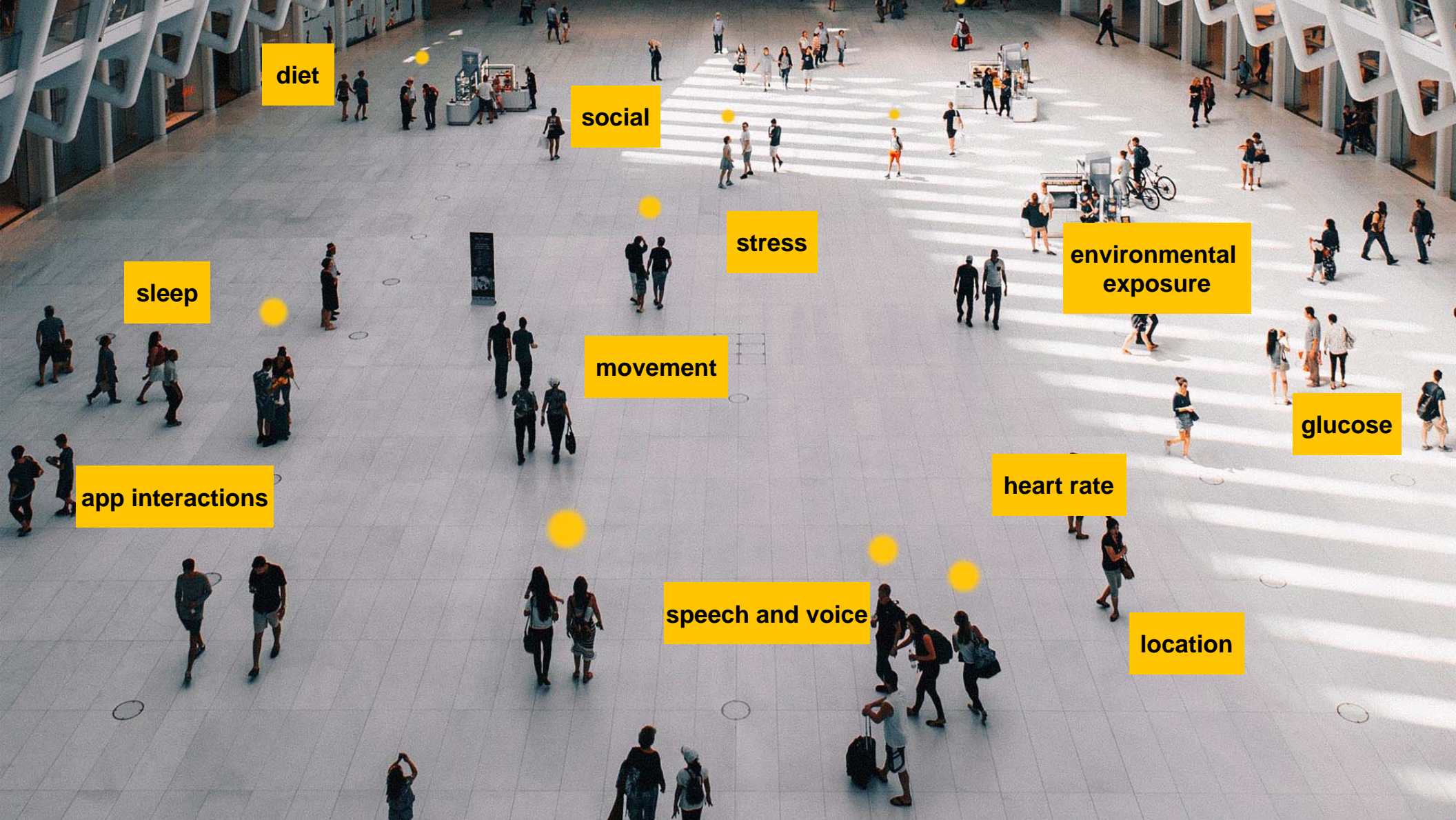
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Patients and their outcomes have historically been characterized using limited, visible-to-the-system data sets.

DATA POINTS

Visible

episodic

Invisible

continuous, passive

TIME

diet

social

stress

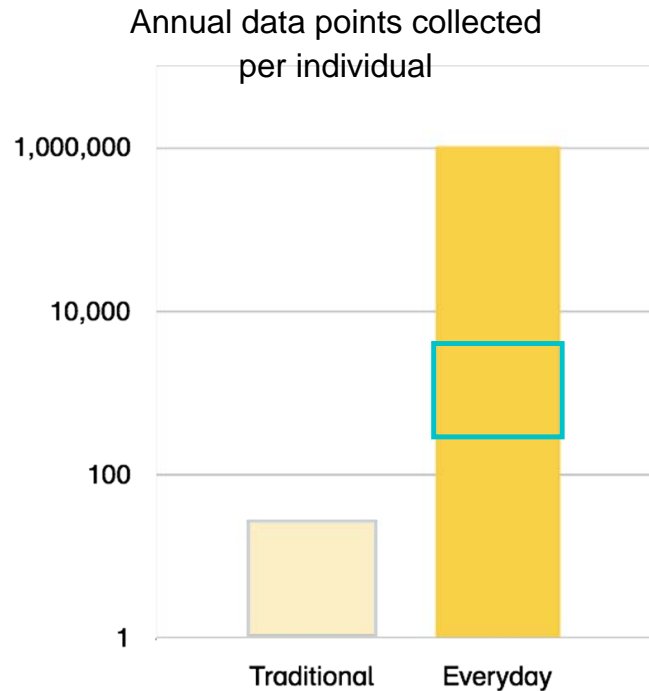sleep

environmental exposure

movement

glucose

app interactions

heart rate

speech and voice

location

The scale and utility of this everyday behavior data is one the most explosive forces in this era of medicine.

Annual data points collected per individual

SOURCE: KPCB (TRADITIONAL); EVIDATION (EVERYDAY)

COMES WITH NEW CHALLENGES

Complex: Very high volume, multi-source data that is difficult to de-noise

Mutable: Behavior is constantly changing, requiring a constant connection to the individual

BUT PROVIDES AN UNPRECEDENTED VIEW OF THE PATIENT

Accessible: Every individual generates and controls the data

Predictive power: Will hold high value for early diagnosis, intervention timing, and outcomes measurement

Everyday behavior data is processed into markers that characterize patients, identify relevant events, and drive improved outcomes.

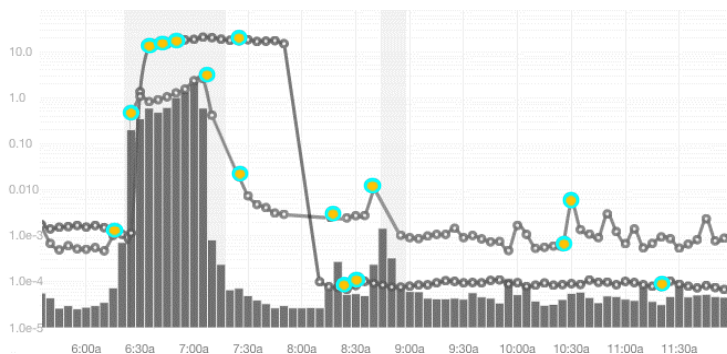| Behavioral data |
|---|
| Datapoints produced as a result of human actions, e.g., steps walked, sleep duration, app interactions, diet, etc. |

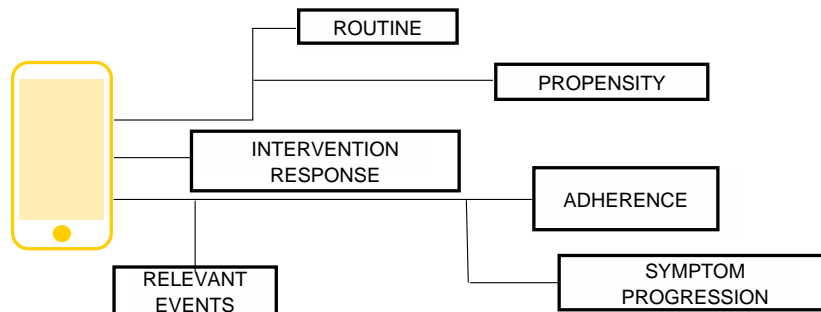| Behavioral markers |
|---|
| Markers derived from behavioral data reflect routines, propensities, symptomatology, intervention response, etc. |

FIGURE 1: BEHAVIORAL DATA

FIGURE 2: BEHAVIORAL MARKERS

Harnessing this new data source allows us to ask and answer different questions about human health.

Can everyday behaviors be used to predict adherence?

DIGITAL BIOMARKER DEVELOPMENT
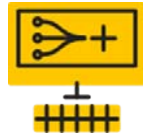
Is a patient's daily movement pattern a better measure of surgical recovery?

NOVEL ENDPOINT APPLICATION

How can we efficiently measure impact of digital therapeutics outside clinic walls?

VIRTUAL OUTCOMES STUDIES

Ochsner · evidation

Ochsner Health System patients join millions tracking health-related behaviors on Evidation platform

- Patients from large regional U.S. center are joining platform to enable linked behavior + medical data and virtual recruiting for outcomes studies
- Platform supports Ochsner-Evidation collaboration on patient-consented analysis projects to better understand what behaviors are driving specific outcomes
- **Evidation and Ochsner launched this collaboration in fall 2017 and are actively growing connected population across therapeutic areas**

Exacerbation warning signs, including tracking adherence, and sleep and activity levels, start days before the event.
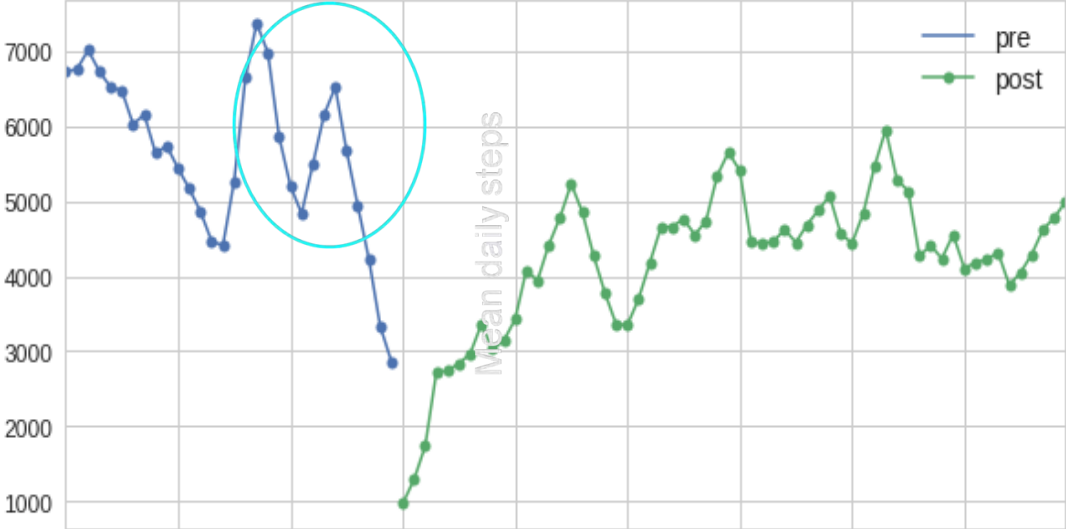
- **Steps:** Declines halve the day before hospitalization, with the decline beginning 3 days before hospitalization.

- **Sleep**: There is evidence that patients begin to go to sleep earlier, moving their average bedtime from 11pm to 9pm, beginning 4 days before hospitalization.
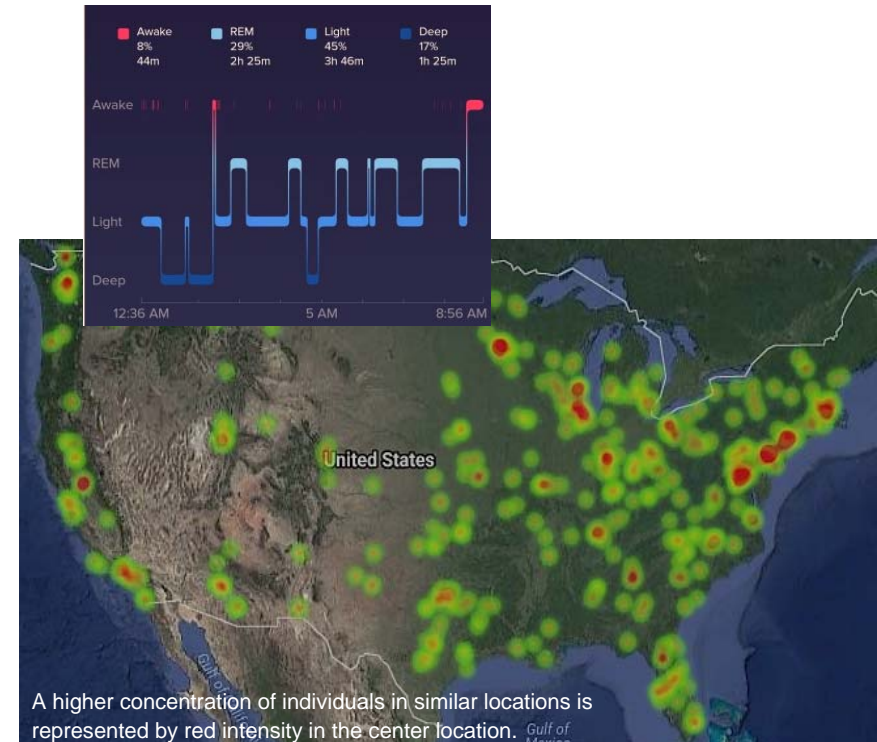
CASE STUDY

Activity Trackers Show That Inconsistent Sleep Patterns are Associated with Severe Forms of Anxiety
Kumar et al, SMDM 2017

- n>1100 with linked behavior and health data, enrolled in 6 wks
- Study assessed the relationship between daily behavior (e.g., sleep) and resource utilization in patients reporting severe anxiety
- Results show certain behaviors (e.g., inconsistent sleep patterns) link to severe forms of anxiety (PHQ-9, GAD-7 scales) and healthcare utilization
- **Results show the promise of this approach to identify high-risk periods and high-risk patients when symptoms are behavioral in nature**

A higher concentration of individuals in similar locations is represented by red intensity in the center location.

Kumar et al, Activity Trackers Show That Inconsistent Sleep Patterns are Associated with Severe Forms of Anxiety and Depression. Society for Medical Decision Making Conf, 2017.``
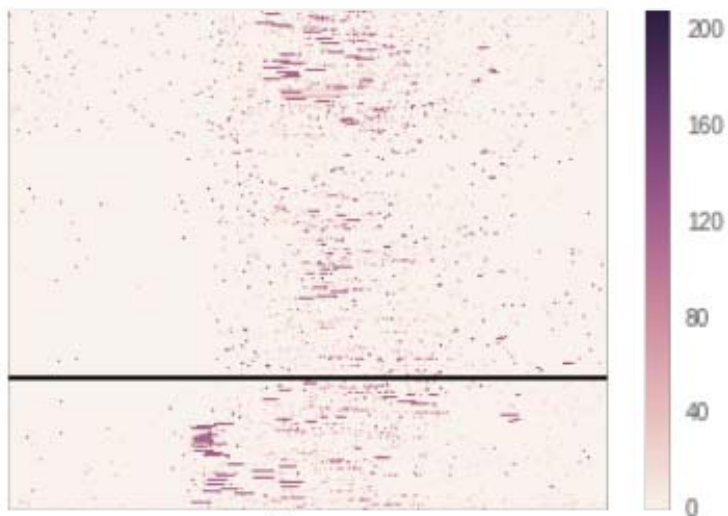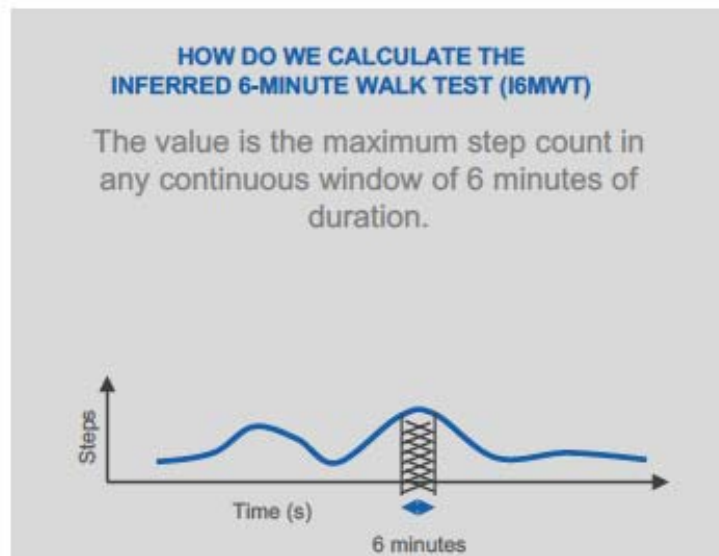
Replacing in clinic walk test

KEY BUSINESS QUESTIONS   1

Can novel data be used to replace tech driven mobility tests, enabling accurate remote monitoring and measuring?

Heatmap of Fitbit minute-level steps over a year from a patient before and after a mobility-impairing event (black line)

HOW DO WE CALCULATE THE INFERRED 6-MINUTE WALK TEST (I6MWT)

The value is the maximum step count in any continuous window of 6 minutes of duration.

Grant objective:
Determine signs of early cognitive decline through the use of digital biomarkers, using voice data
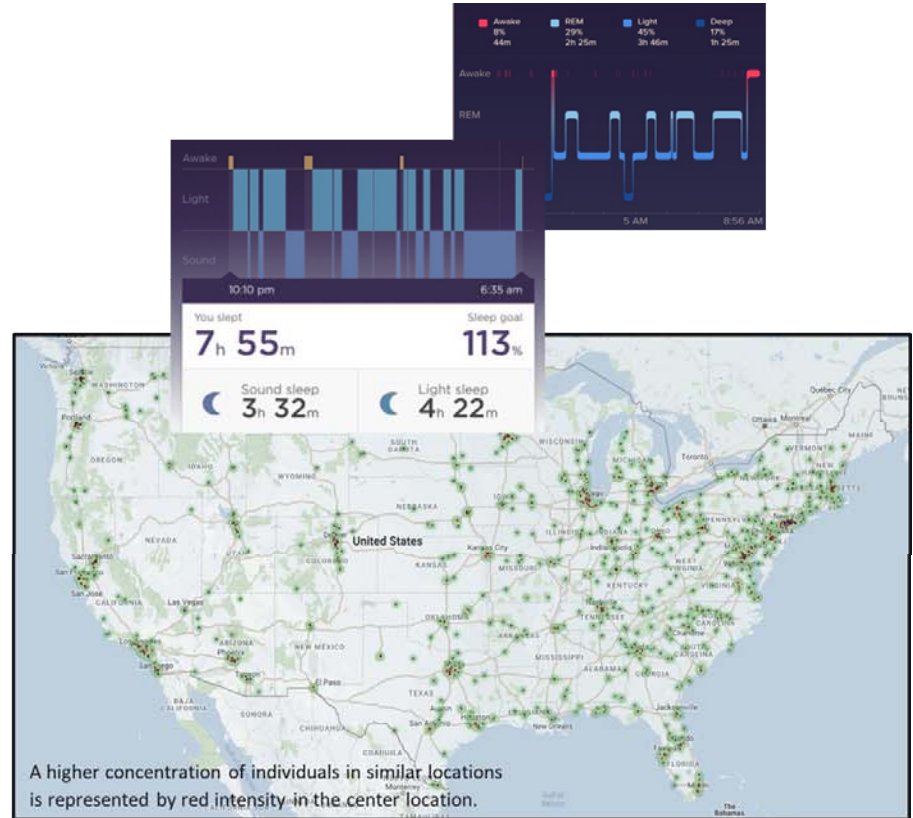
- Framingham cohort n~4000, and n~300 with complete audio + cognitive data from clinical visits performed over years
- Qualitative audio features (e.g., tone) on patient speech are computed leveraging Watson Speech-to-Text API, open source libraries, and advanced signal processing
- Quantitative audio features on patient responses are derived using output of Watson transcription and by applying NLP to resulting output text of patient responses
- **Work is currently ongoing**

American Sleep Apnea Association

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ASAA-Evidation partnering on the Sleep Health Web Study to accelerate and enhance sleep outcomes research

- Initial enrollment n>1000 in 2 days with linked behavior and health data, in a cross-platform (iOS, android and web) PRO and behavior registry
- Invited members of Evidation's connected population to participate across the U.S.
- Participants contribute self-reported outcomes and wearable device data to the research over time
- **Evidation and the ASAA are following the enrolled population for a year, with analysis underway for digital biomarker development**

A higher concentration of individuals in similar locations is represented by red intensity in the center location.

Our research finds that user interaction with wearable devices is highly persistent across time despite variability In usage patterns

Fitbit Cohort: 2016-01-04

Fitbit Cohort: 2017 -01
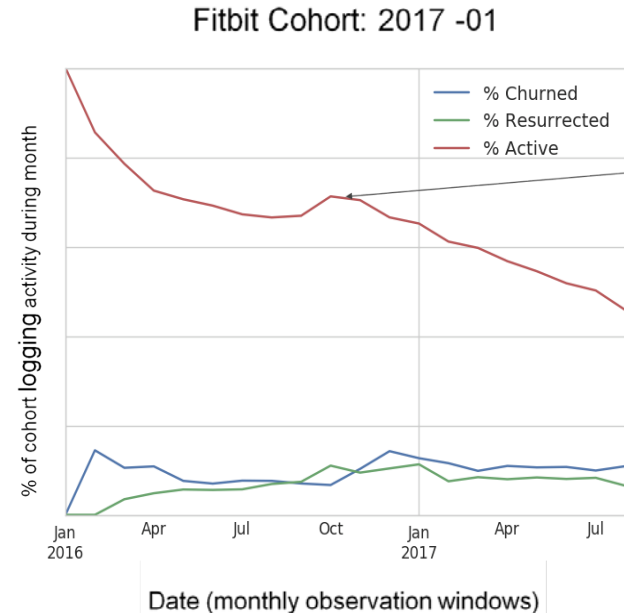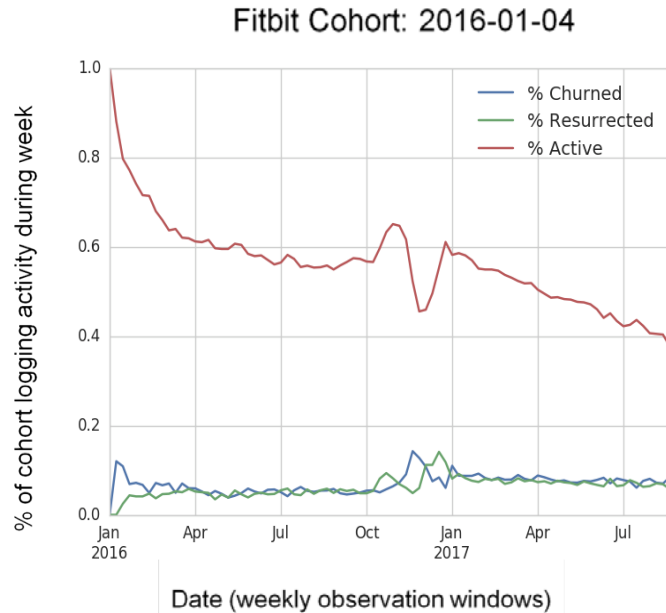
In the one month window a year after entering the cohort, ~70% of users logged at least one activity

Methodology: In order to measure user interaction with devices over time, we define cohorts of users whose first activity is observed over a fixed week or month. We then observe whether users have logged activity during subsequent weeks or months. This allows us to observe the percent of a cohort still active over time, as well as the percent of users churning or returning to the device after periods of inactivity.

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