Los Angeles PRISMS Center

An mHealth Platform for Predicting Risk of Pediatric Asthma Exacerbation Using Personal Sensor Monitoring Systems

Sep 2018 | ASIC Meeting

Rima Habre, ScD
habre@usc.edu
Assistant Professor
Division of Environmental Health
USC Keck School of Medicine

UCLA

USC

Outline

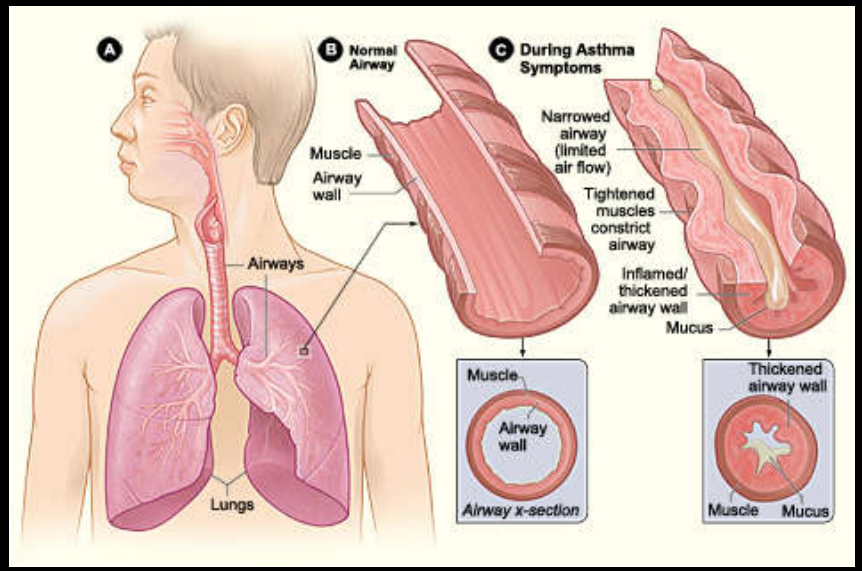
- Asthma
- Design of the platform
- Deployment of the platform
  - Preliminary pilot data

Air Pollution as an Underappreciated Cause of Asthma Symptoms

George D. Thurston, ScD
David V. Bates, MD

JAMA The Journal of the American Medical Association

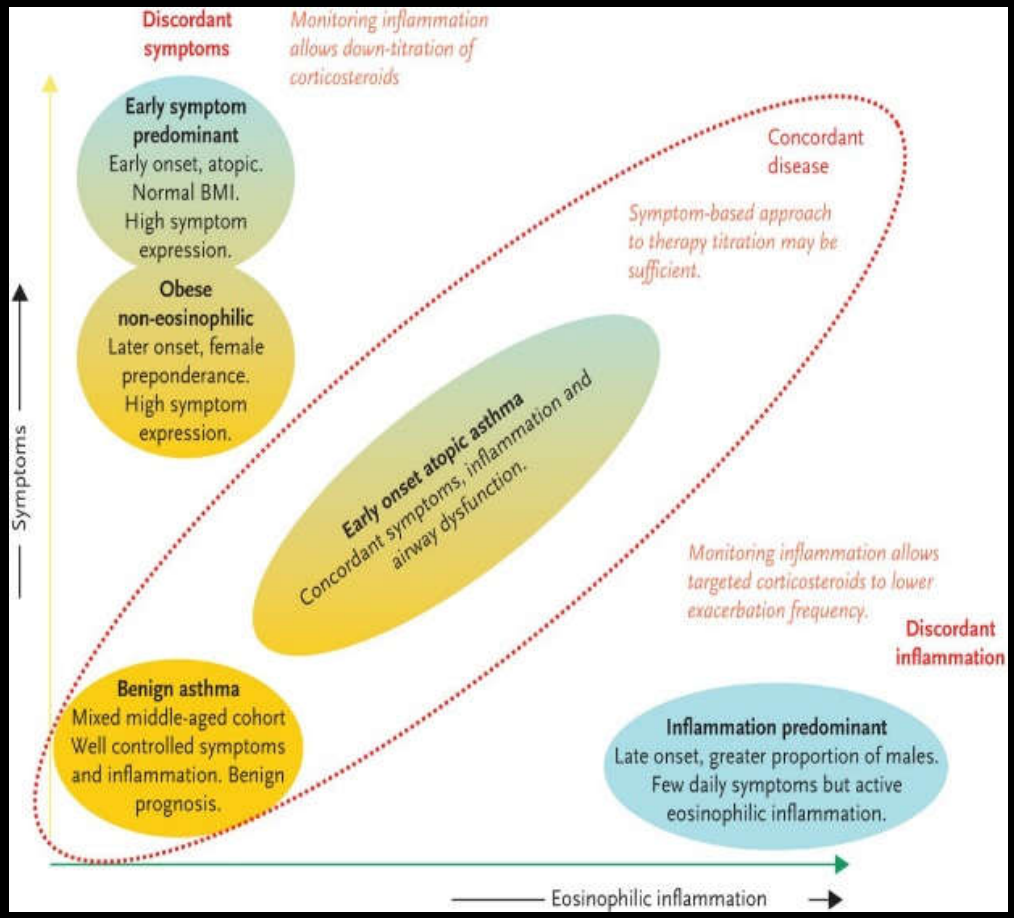
EDITORIALS



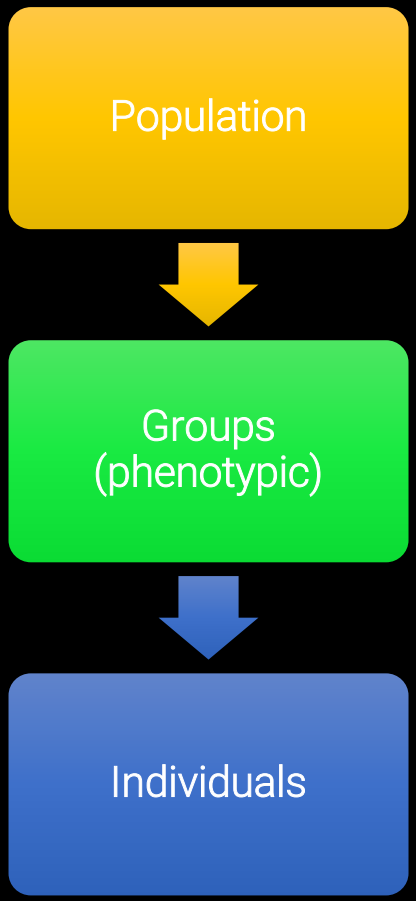
"While physicians no doubt recognize that they cannot do much about modern urban air pollution on an individual level, they can make recommendations to patients with asthma to help them avoid the potentially adverse effects of air pollution."

Thurston, G.D. and Bates, D.V., 2003. *JAMA*, *290*(14), pp.1915-1917.

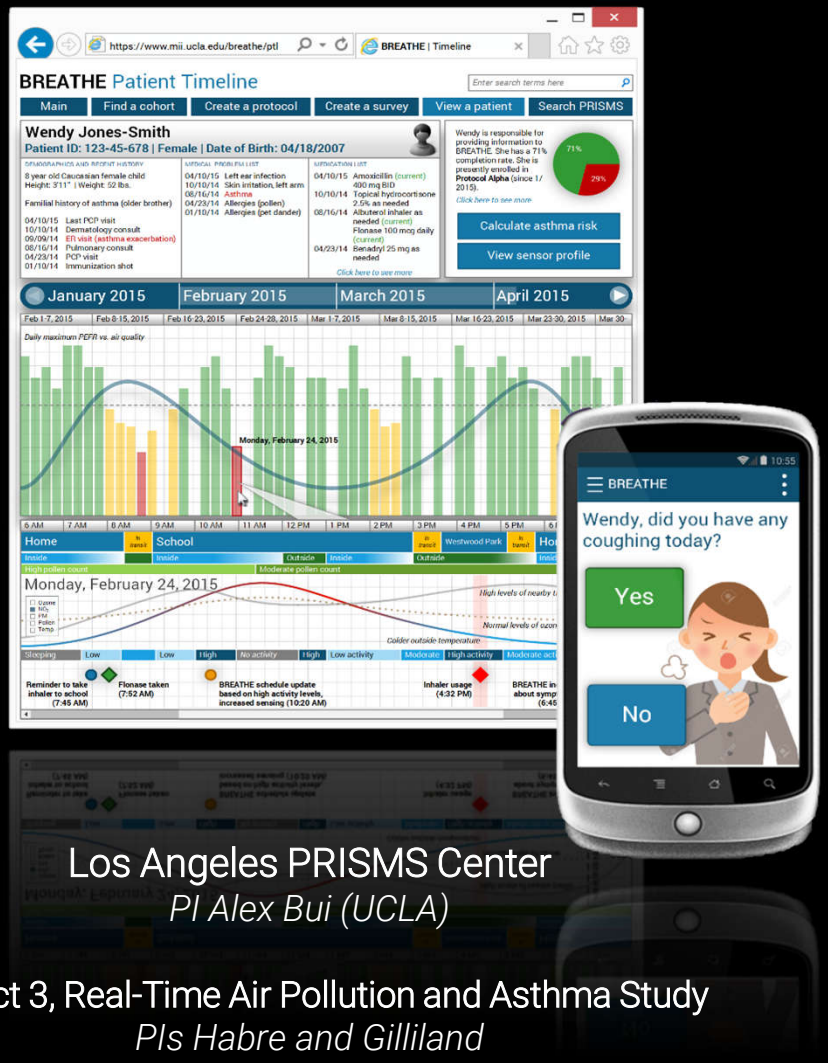
Pediatric Asthma



Clementine Bostantzoglou et al., Clinical asthma phenotypes in the real world: opportunities and challenges. *Breathe* 2015;11:186-193



The Los Angeles PRISMS Center



Los Angeles PRISMS Center

PI Alex Bui (UCLA)

Project 3, Real-Time Air Pollution and Asthma Study

PIs Habre and Gilliland

What if you could predict ahead of time, for a given individual, an asthma attack, and mitigate if not prevent it?

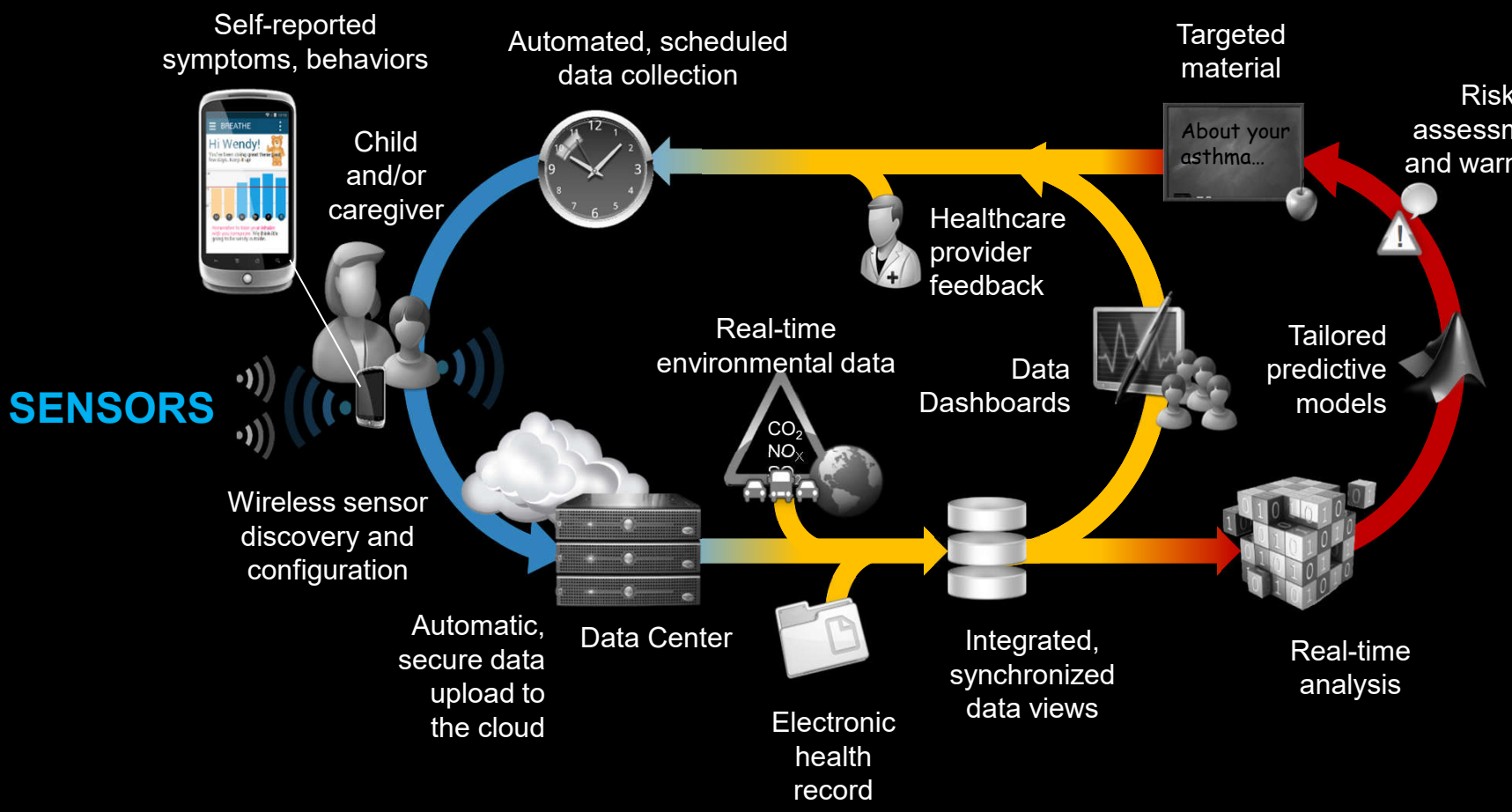
The Los Angeles PRISMS Center

Los Angeles PRISMS Center
PI Alex Bui (UCLA)

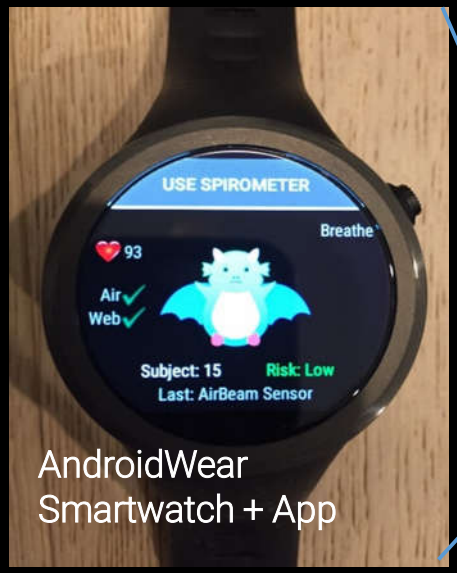
Project 3, Real-Time Air Pollution and Asthma Study
PIs Habre and Gilliland

- Build a secure, non-invasive, sensor-based informatics platform for pediatric asthma environmental health studies
- Enable individualized 'trigger discovery'
- Advance our scientific understanding of
  - Time lag between exposure and response
  - Relevant dose metrics for asthma (peak exposures vs average?)
  - Role of multiple exposures and behaviors in context
  - Variation in personal exposures and risk at short temporal and fine spatial scales

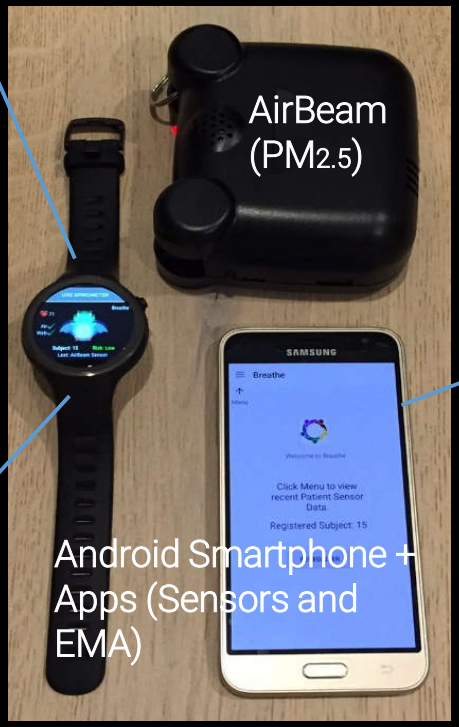
The Los Angeles PRISMS Center BREATHE Informatics Platform for Epidemiological Studies of Pediatric Asthma



Breathe Kit

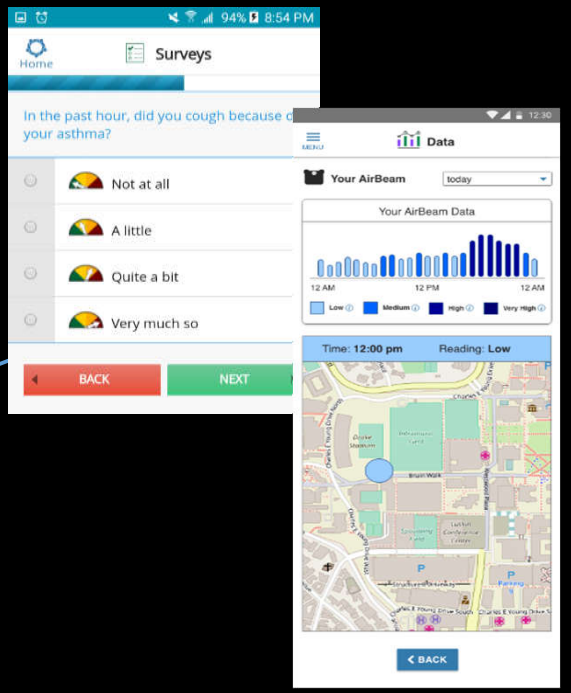


AndroidWear
Smartwatch + App



AirBeam
(PM2.5)

Android Smartphone +
Apps (Sensors and
EMA)



Ecological Momentary
Assessment (EMA) Surveys
+ mobile dashboards

Inhaler

Spirometer

BREATHE Kit: Biomedical REAl-Time Health Evaluation

Data Integration

Sensors

- GPS
- Spirometry
- Inhaler usage
- Activity monitoring (accelerometry to classify lying, sitting, standing, walking, running, etc.).
- Environmental measures (PM, NO_2, etc.)

Self-reported measures

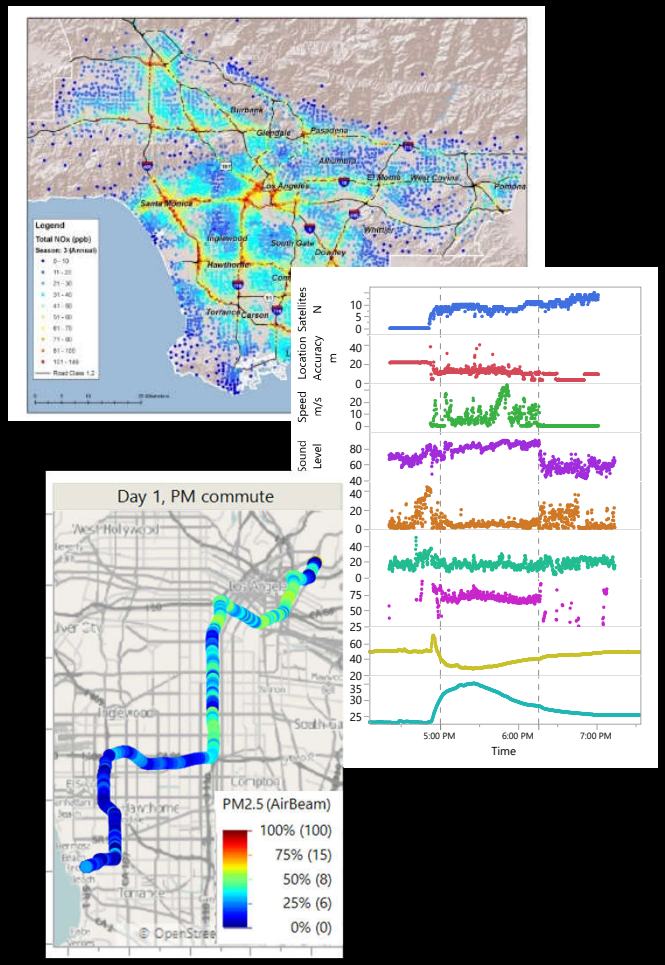
- Ecological momentary assessment (EMA) for asthma symptoms, stress
- Questionnaires (health status, physical activity, etc.)

Geospatial data

- Weather
- Pollen
- Air quality indices
- Nearby traffic volumes
- Indoor/outdoor metrics

Electronic health record

- Demographics, vitals
- Medications
- Allergies and documented triggers
- Health status and comorbidities
- Pulmonary function tests, other labs
- Past exacerbations (e.g., ER visits)



High spatial and temporal resolution

U01 Sensors (2019)

- Black/brown carbon MA200 (Columbia)
- Particle sensor (UW)
- Ozone and VOCs sensor (ASU)

Breathe Kit Deployment in Asthma Study

Today's talk
n=20, 1-week monitoring,
baseline Breathe Kit sensors

Starting 2019
n=40, 2-week monitoring,
integrating U01 sensors

Clinic-Based Recruitment

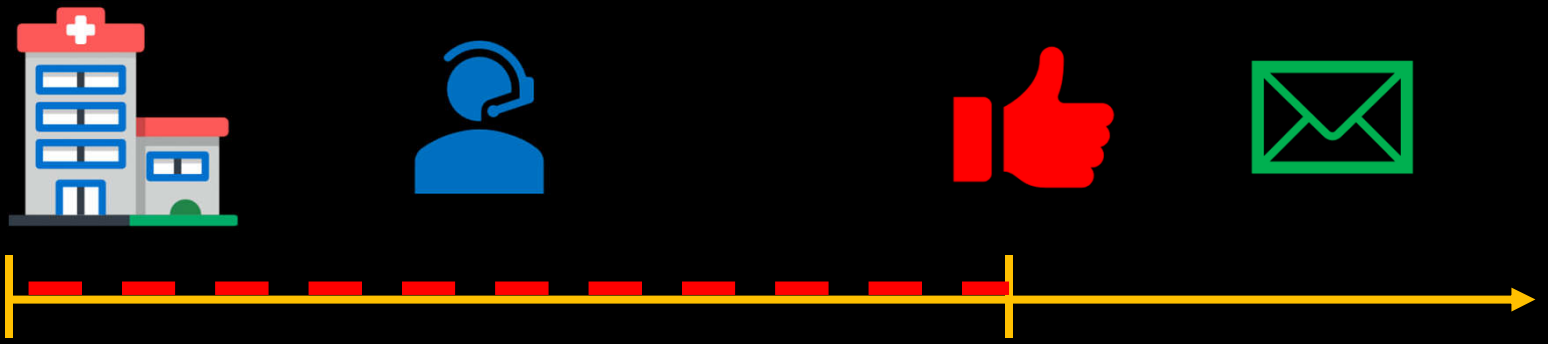
Study coordinator reviews medical records ahead of time to determine eligibility and medications. On day of appointment, recruitment, informed consent, in-clinic questionnaire and explanation of the study and the kit take place in the clinic during the doctor's visit.

UCLA MATTEL Childrens Hospital
Pediatric Pulmonology & Sleep Medicine

Dr. Sande Okelo

Two Pediatric Pulmonology clinic sites led by Dr. Sande Okelo
Westwood and Santa Monica

Participant Timeline

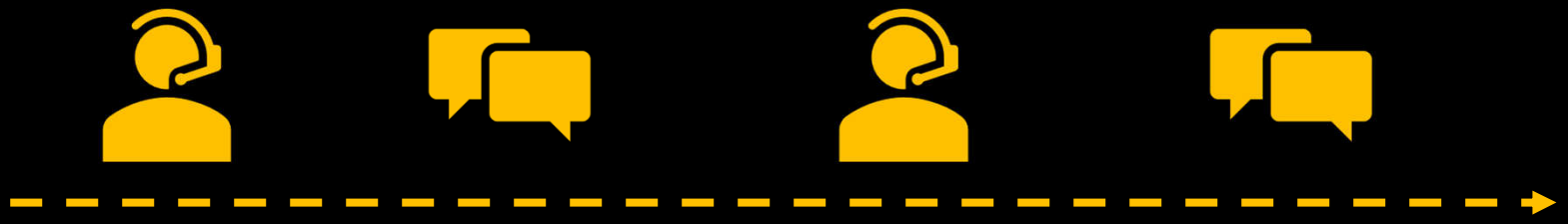


Day 1
Consented, **in-clinic questionnaire**, monitoring started

Day 2
Baseline questionnaire conducted over the phone

Day 14
Monitoring ended

Day 15
Breathe Kit and devices mailed back, **exit survey** conducted over the phone, gift card sent over email



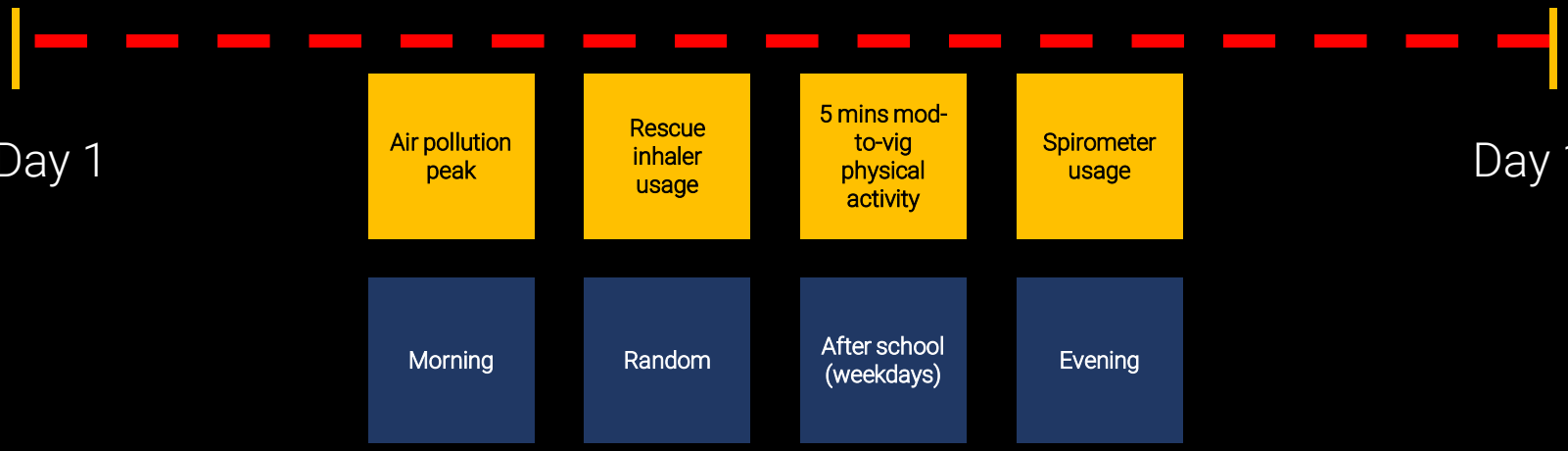
Throughout the monitoring period
Regular contact and verification of data flows through BREATHE researcher dashboards and 24/7 support on standby

Data Collection

Air pollution exposures, heart rate, respiration rate, physical activity, GPS, etc… streaming *continuously, in real time*

Controller and rescue medication captured *every use*

Spirometry measurements (FEV_1 and PEFR) *2x/day* (morning and evening)

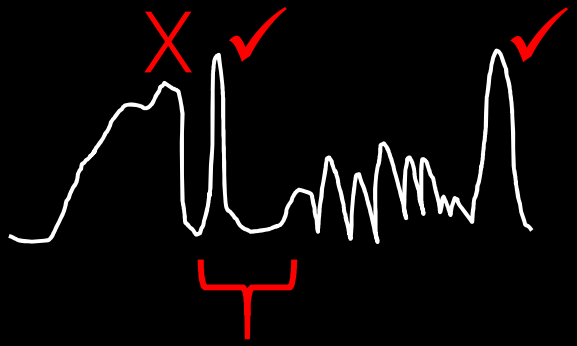


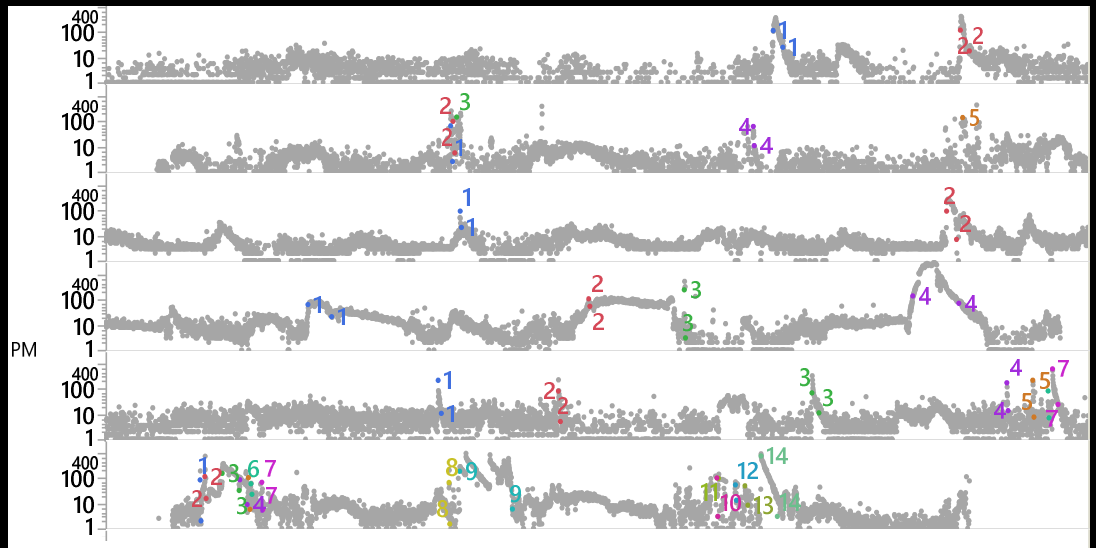
Symptoms, context, physical acitivity, etc.. with random and context-sensitive EMA surveys *5-8x/day* with tailored suppression logic and prioritization scheme to manage participant burden and select for suspected triggers ($PM_{2.5}$ peaks from primary combustion sources, high physical activity, etc..)

Context-Sensitive Data Collection

Capture exposures and behaviors in real time (proximal to outcome) and in context to formally evaluate as potential asthma triggers

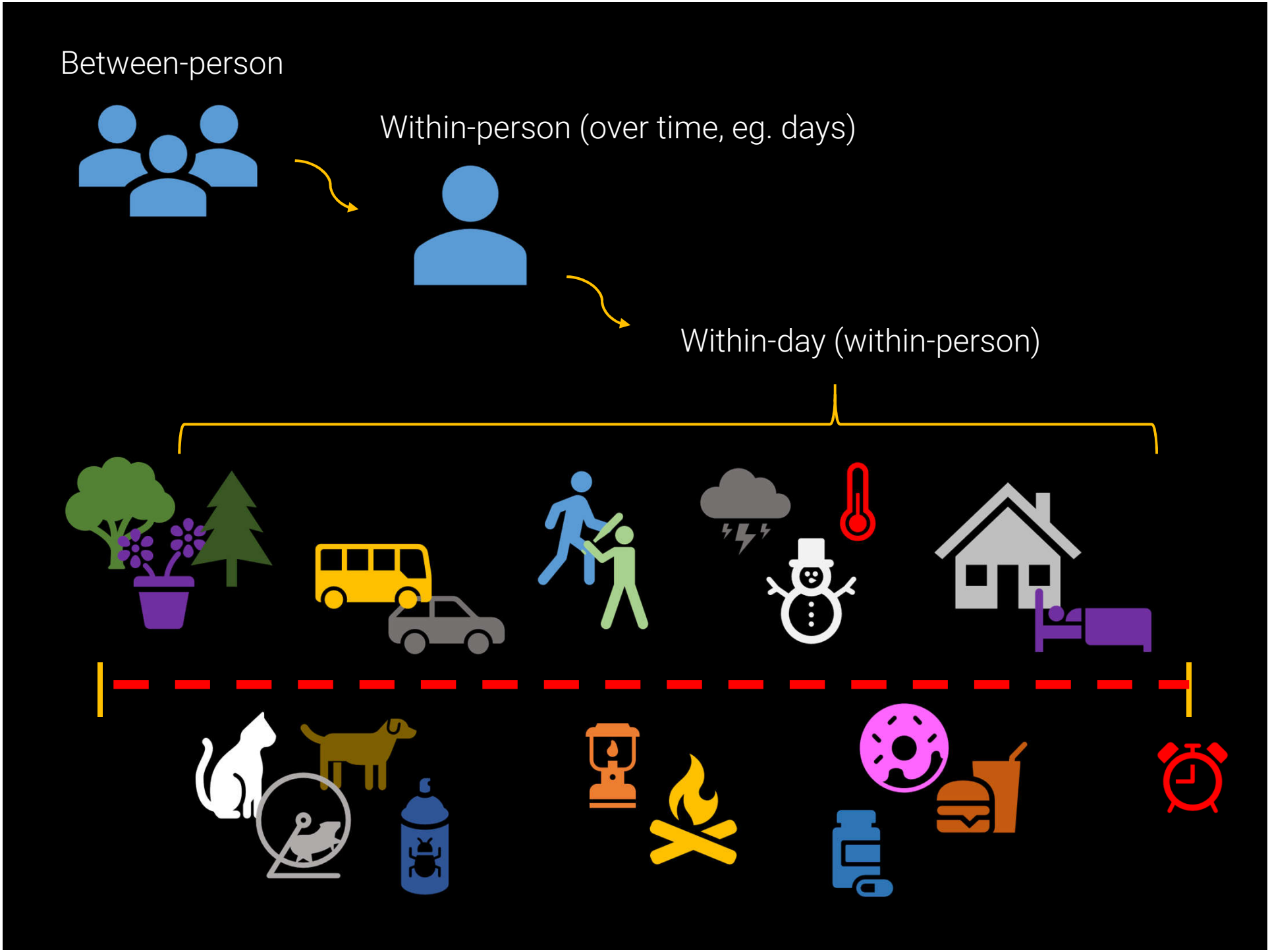
eg, $PM_{2.5}$ peaks from primary combustion sources



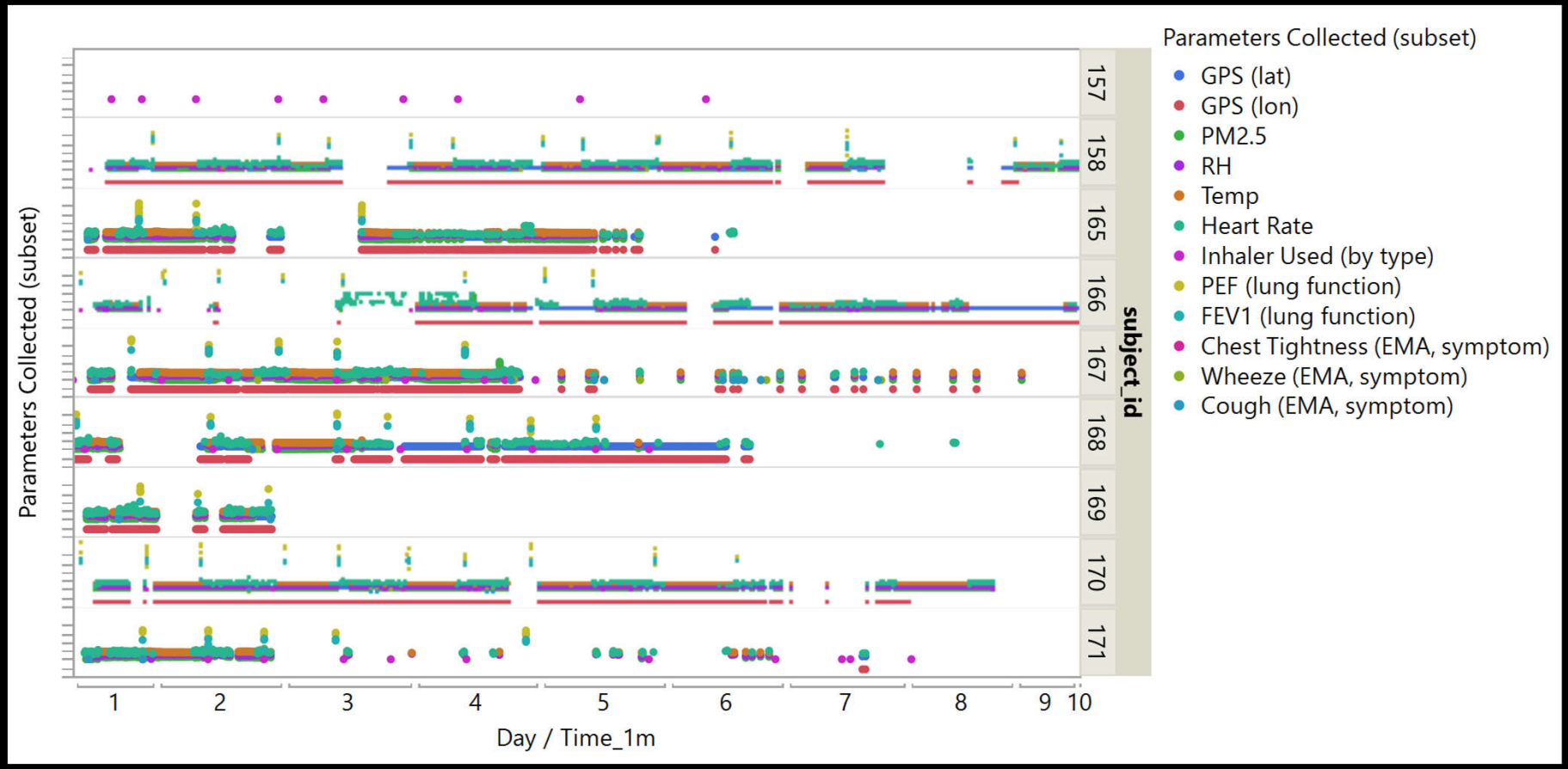


Item
Were you near any of the following just before the phone alert appeared?

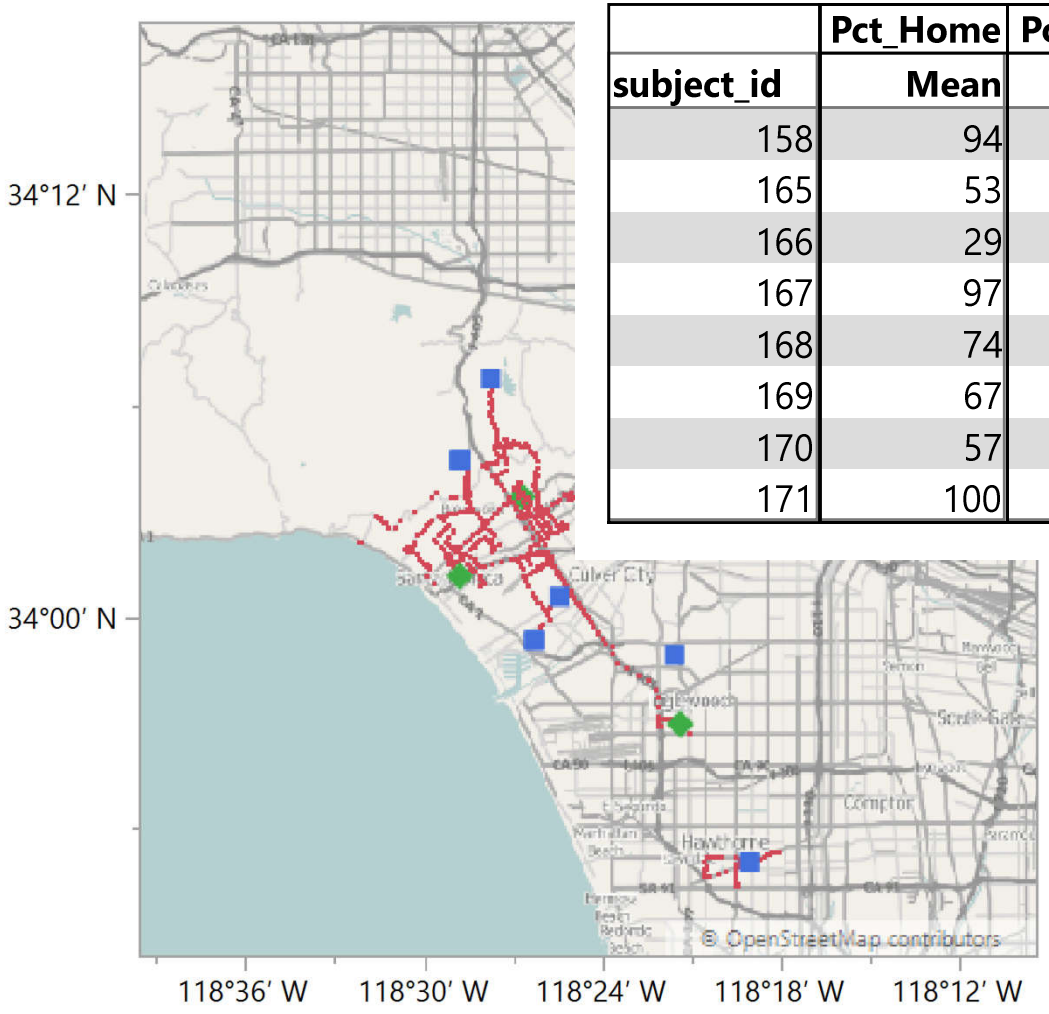
Response Choices
Traffic (cars, buses or trucks)
Cigarette smoke
Vaping/e-cigarette vapor
Cooking or barbequing (BBQ)
Lit fireplace (burning wood or gas)
Space heater (burning fuel)
Burning candles or incense
Other smoke


Between-person
Within-person (over time, eg. days)
Within-day (within-person)

Preliminary Data Explorations (n=9)

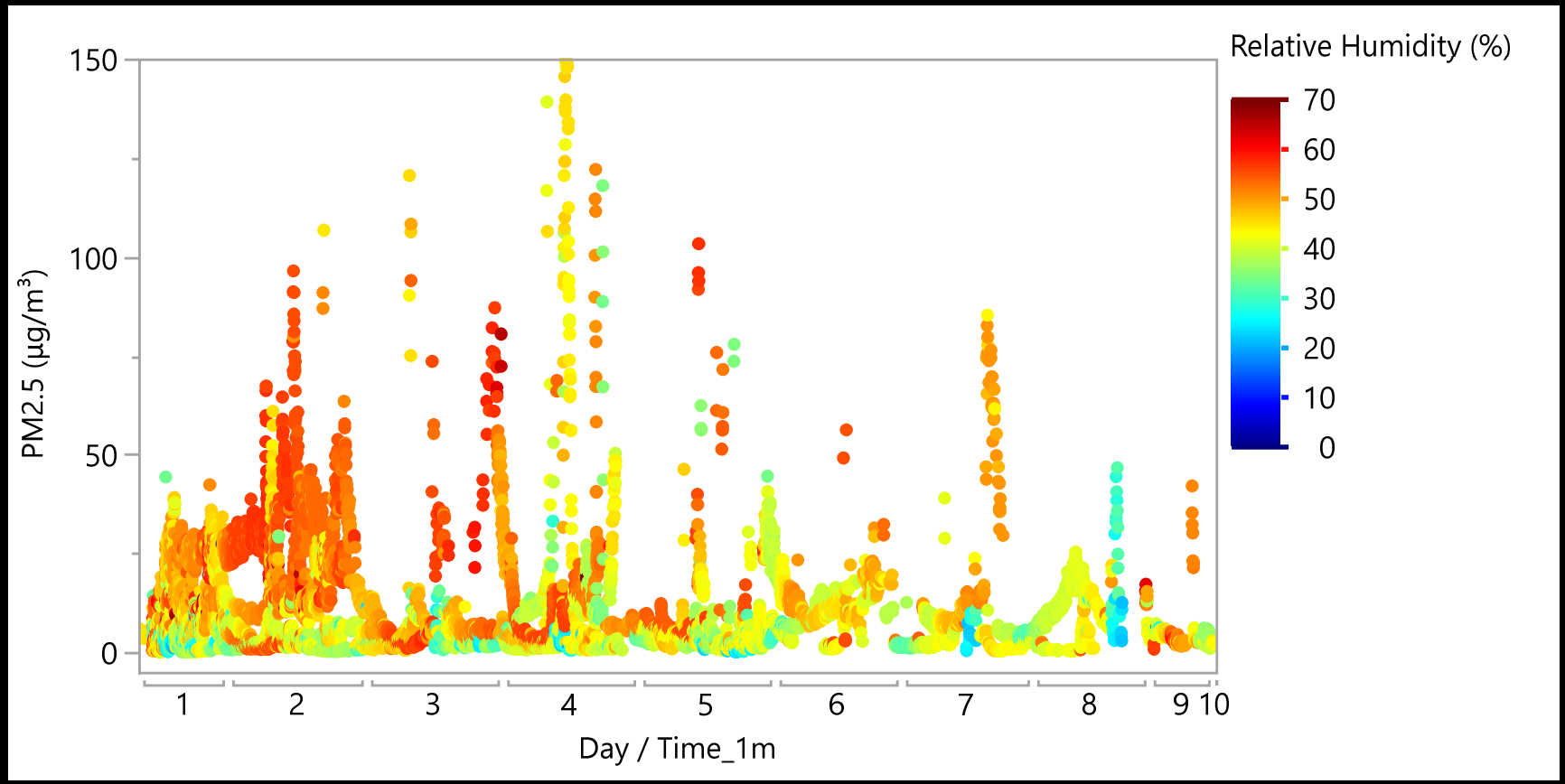


GPS



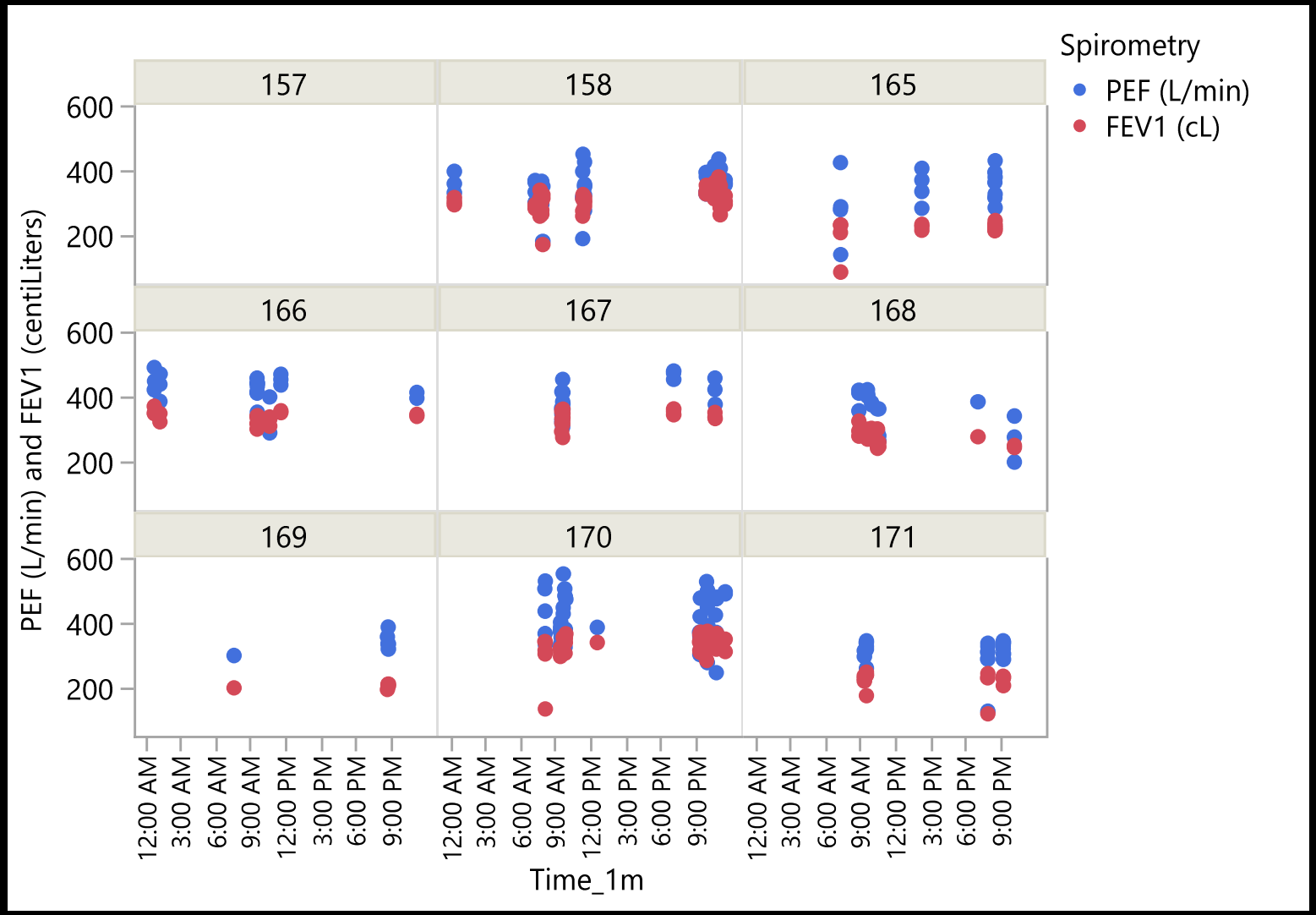
	Pct_Home	Pct_Second_Place	Pct_Indoors
subject_id	Mean	Mean	Mean
158	94	0	95
165	53	43	96
166	29	60	89
167	97	0	97
168	74	1	75
169	67	0	67
170	57	26	83
171	100	0	100

AirBeam, Personal $PM_{2.5}$

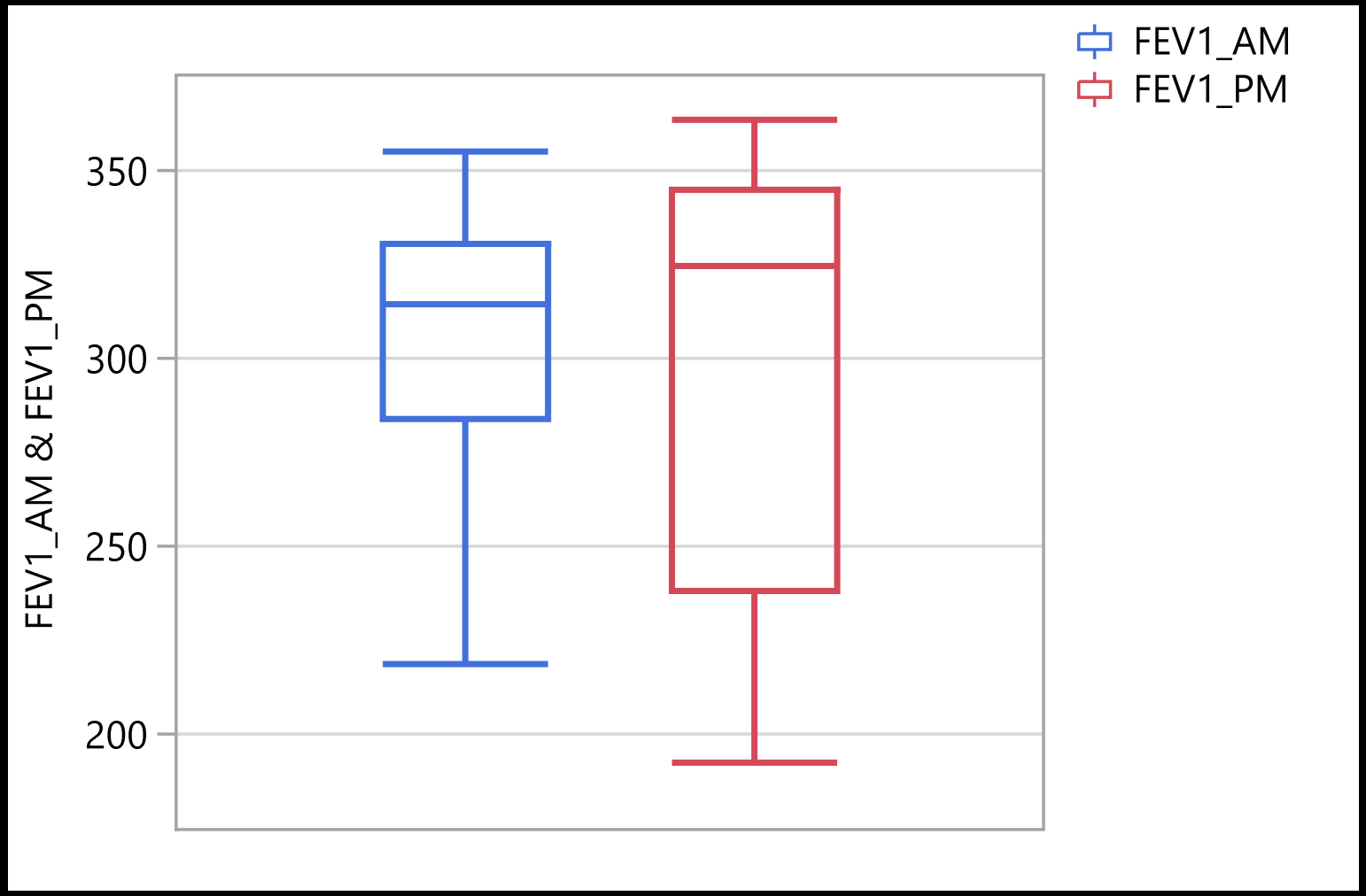


*NOT calibrated yet

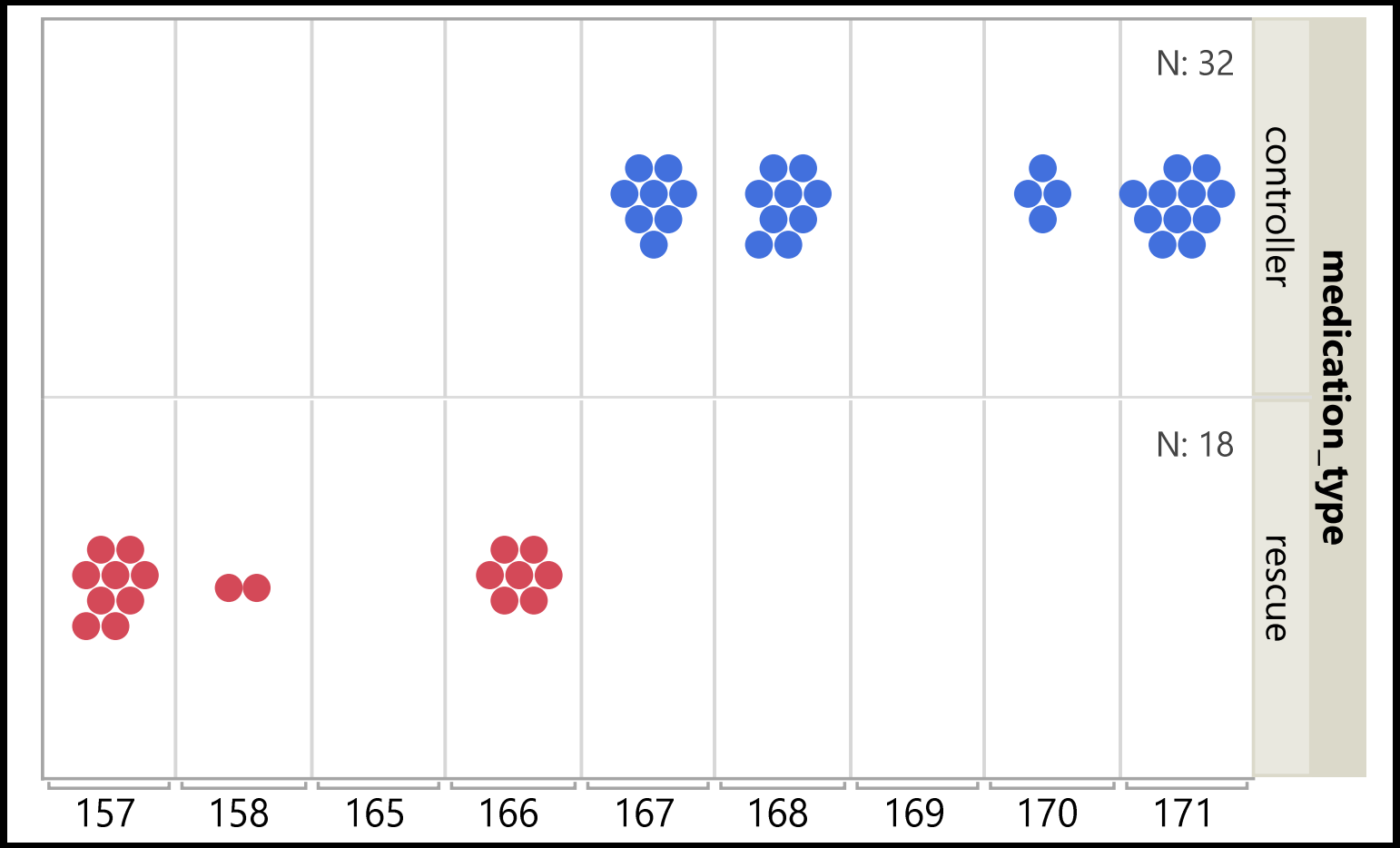
Lung Function



Diurnal Variability in Lung Function



Controller and Rescue Medication Use



Preliminary Health Models (n=9)

- Basic mixed effects model at day-level (j), random intercept for subject (i)

$$Y_{ij} = \beta_0 + \beta_i + X_{ij} + \varepsilon$$

- PEF lability or % diurnal variation as marker of airway responsiveness (Redell et al, BMJ. 1999; 319(7201): 45–47)

PEF Lability, n=13 person-days			
Effect	Est	Std Error	Pr > |t|
Intercept	-12.6052	5.3777	0.0661
lag_PM	**0.7834**	**0.4691**	**0.1459**

Please do not cite.

Preliminary Health Models (n=9)

- FEV_1 (PM, afternoon)

FEV1 (PM), n=25 person-days			
Effect	Est	Std Err	Pr > |t|
Intercept	296.67	21.5493	<.0001
PM	**-0.9281**	**0.4526**	**0.0570**

- Cough Score

Cough, n=16 person-days			
Effect	Est	Std Err	Pr > |t|
Intercept	-2.2467	1.7899	0.2777
lag_PM	**0.1750**	**0.1485**	**0.2659**

Cough, adjusted for % time spent indoors, n=16 person-days			
Effect	Est	Std Err	Pr > |t|
Intercept	10.9610	29.3630	0.7337
lag_PM	**0.7172**	**0.3631**	**0.0765**
Pct_Indoors	-0.2214	0.3601	0.5524

Please do not cite.

Innovation for Pediatric Asthma Research

BREATHE: Biomedical REAl-Time Health Evaluation

- Very promising <u>early exploratory</u> findings with very limited, small sample size pilot data
- Individualized 'trigger discovery' at high time and space resolutions, looking at *multiple* environmental *exposures*, *behaviors* and *psychological* factors *in context*
- Need sensor-based health studies to answer research questions – minutes to hour scales
  - Need health outcomes assessment at matching time resolution!
  - Repeated measures designs are very powerful

Thank You

- Questions? habre@usc.edu
- Acknowledgements
  - The Los Angeles PRISMS Center team, led by Dr. Alex Bui (UCLA), NIH U54 EB022002
    - Majid Sarrafzadeh and Anahita Hosseini (P1)
    - Rose Rochio and the OIT Mobilize Team
    - Frank Gilliland, Sandrah Eckel, Genevieve Dunton and the USC team
    - Sande Okelo and the UCLA Pediatric Pulmonology team
    - http://www.mii.ucla.edu/research/projects/prisms/
  - The NIH/NIBIB PRISMS Program: Pediatric Research Using Integrated Sensor Monitoring Systems
    - https://www.nibib.nih.gov/research-funding/prisms