Los Angeles PRISMS Center
An mHealth Platform for Predicting Risk of Pediatric Asthma Exacerbation Using Personal Sensor Monitoring Systems
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Outline

• Asthma
• Design of the platform
• Deployment of the platform
  • Preliminary pilot data
“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.”

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

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

Los Angeles PRISMS Center
PI Alex Bui (UCLA)

Project 3, Real-Time Air Pollution and Asthma Study
PIs Habre and Gilliland
The Los Angeles PRISMS Center

- 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

- Self-reported symptoms, behaviors
- Child and/or caregiver
- Wireless sensor discovery and configuration
- Automatic, secure data upload to the cloud
- Sensor data collection
- Real-time environmental data
- Automated, scheduled data collection
- Integrated, synchronized data views
- Electronic health record
- Healthcare provider feedback
- Tailored predictive models
- Targeted material
- Real-time analysis
- Risk assessment and warnings
- About your asthma...

SENORS
**Breathe Kit**

**AirBeam (PM2.5)**

**AndroidWear Smartwatch + App**

**Android Smartphone + Apps (Sensors and EMA)**

**Inhaler**  
**Spirometer**

Ecological Momentary Assessment (EMA) Surveys + mobile dashboards

**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\textsubscript{2}, etc.)

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

U01 Sensors (2019)
- Black/brown carbon MA200 (Columbia)
- Particle sensor (UW)
- Ozone and VOCs sensor (ASU)

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
Breathe Kit Deployment in Asthma Study

1. Pilot study
   - Today’s talk
   - n=20, 1-week monitoring, baseline Breathe Kit sensors

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

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\textsubscript{1} and PEFR) *2x/day* (morning and evening)

Symptoms, context, physical activity, 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\textsubscript{2.5} peaks from primary combustion sources, high physical activity, etc..)
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.

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

Were you near any of the following just before the phone alert appeared?
Between-person

Within-person (over time, eg. days)

Within-day (within-person)
Preliminary Data Explorations (n=9)
### GPS Data

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<th>subject_id</th>
<th>Pct_Home Mean</th>
<th>Pct_Second Place Mean</th>
<th>Pct_Indoors Mean</th>
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</table>
AirBeam, Personal PM$_{2.5}$

*NOT calibrated yet
Diurnal Variability in Lung Function
Controller and Rescue Medication Use

Propeller sensors
**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)

| 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)

| Effect          | Est  | Std Err | Pr > |t| |
|-----------------|------|---------|------|---|
| Intercept       | 296.67 | 21.5493 | <.0001 | |
| PM              | -0.9281 | 0.4526 | 0.0570 | |

- **FEV\(_1\)** (PM, afternoon)

| Effect          | Est  | Std Err | Pr > |t| |
|-----------------|------|---------|------|---|
| Intercept       | -2.2467 | 1.7899 | 0.2777 | |
| lag_PM          | 0.1750 | 0.1485 | 0.2659 | |

- **Cough Score**

| 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 | |
Innovation for Pediatric Asthma Research

- Very promising early exploratory 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
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  • 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