

Leveraging wireless inhaler sensors to estimate the impact of rising temperatures and pollutant levels on asthma symptoms

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The Problem

→ High unmet need despite good medicines

The burden of chronic respiratory disease remains high



US direct costs of asthma and COPD beyond \$100B annually in the US



\$14B spent on drugs in US

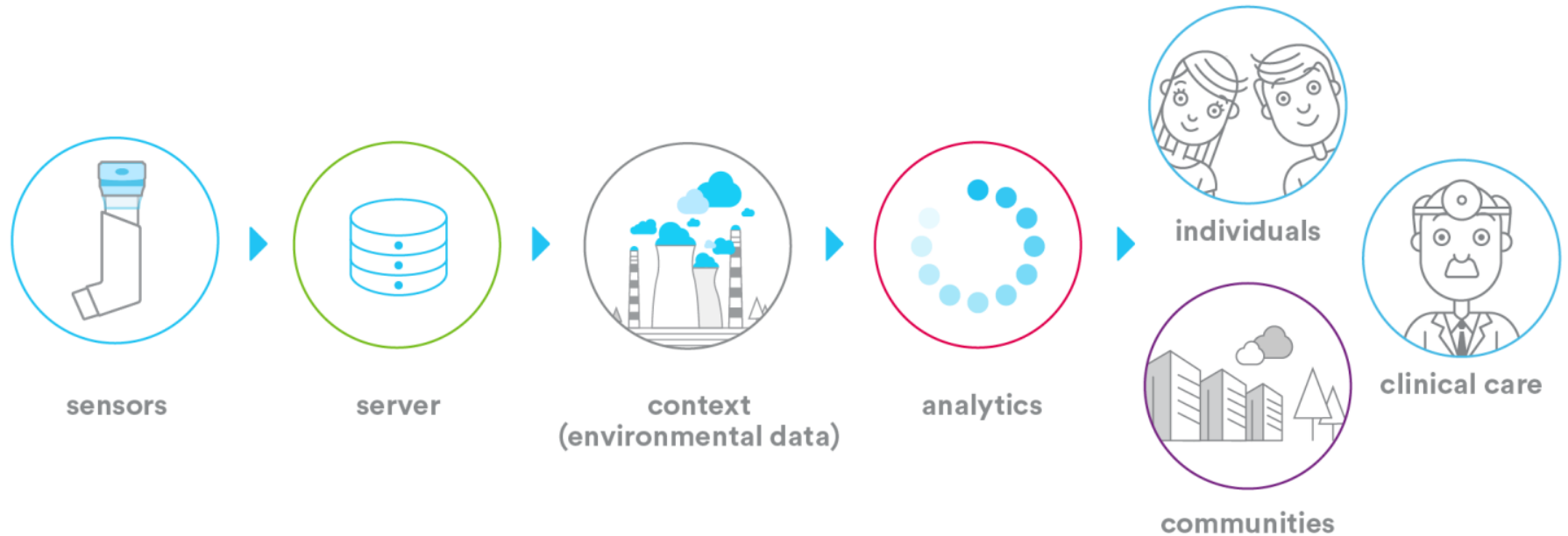


Existing drugs can be clinically effective



Limited innovation in the pipeline (and many big brands losing patent exclusivity)

→ Sensors + analytics to inform individuals, clinical care, communities and policy



Louisville, KY



→ AIR Louisville Goals

People

- Improve asthma and COPD outcomes among residents by providing actionable information to support self-management

Populations

- Identify hotspots of respiratory disease in the community, and better understand how environmental drivers are influencing these patterns.

Policy

- Create a direct loop from data collection to policy action.
- Increase public awareness of air quality and respiratory disease in Jefferson County.



→ Unique public-private partnership

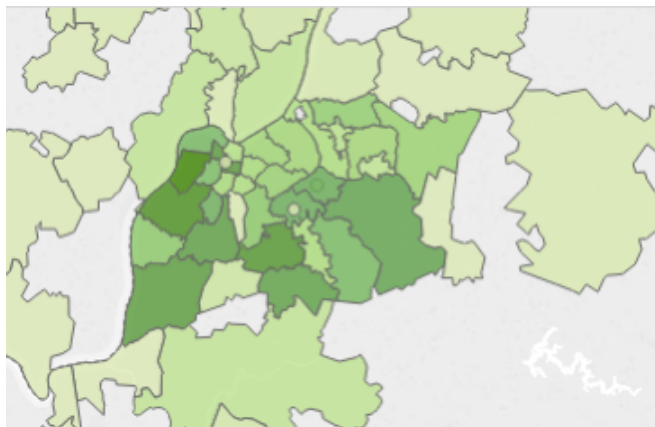




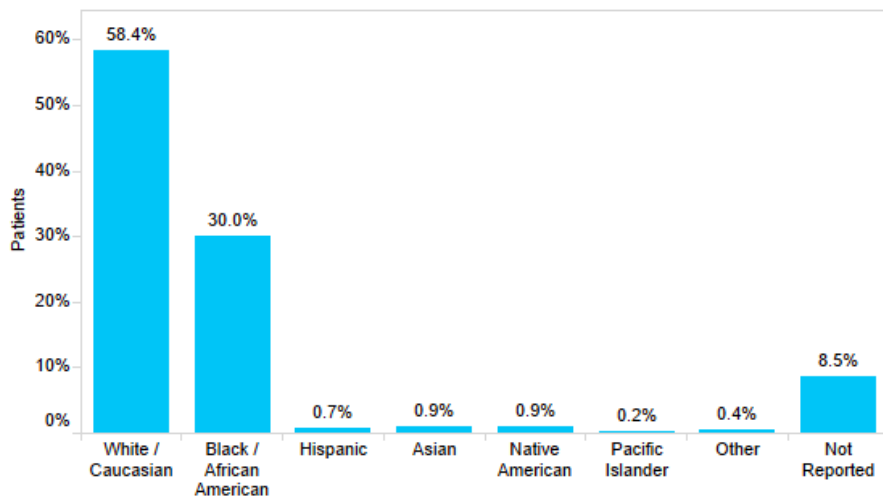
People

→ **1,147 participants - 115% of our goal**

We aimed to capture a signal that is representative of respiratory disease in Metro Louisville by neighborhood, race, SES, and disease severity.

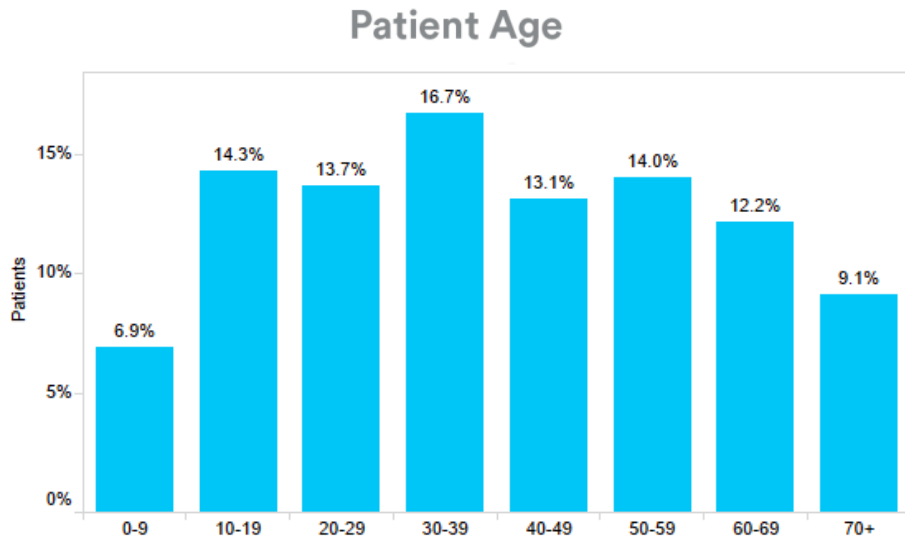


Patient Race

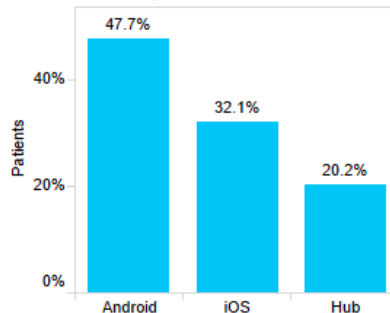


→ Age, gender and technology access

Enrollment across age groups



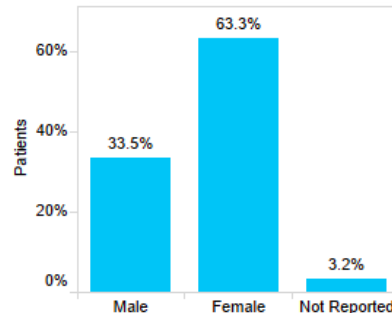
Sync Device



80%

of participants
use smartphones

Patient Gender

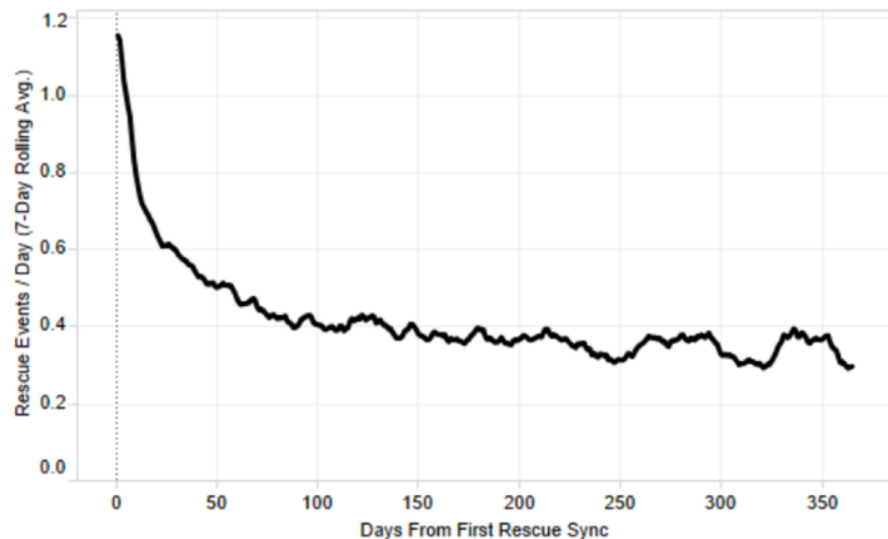


65%

of participants
are female

→ Reduction in rescue inhaler use

Rescue Curve

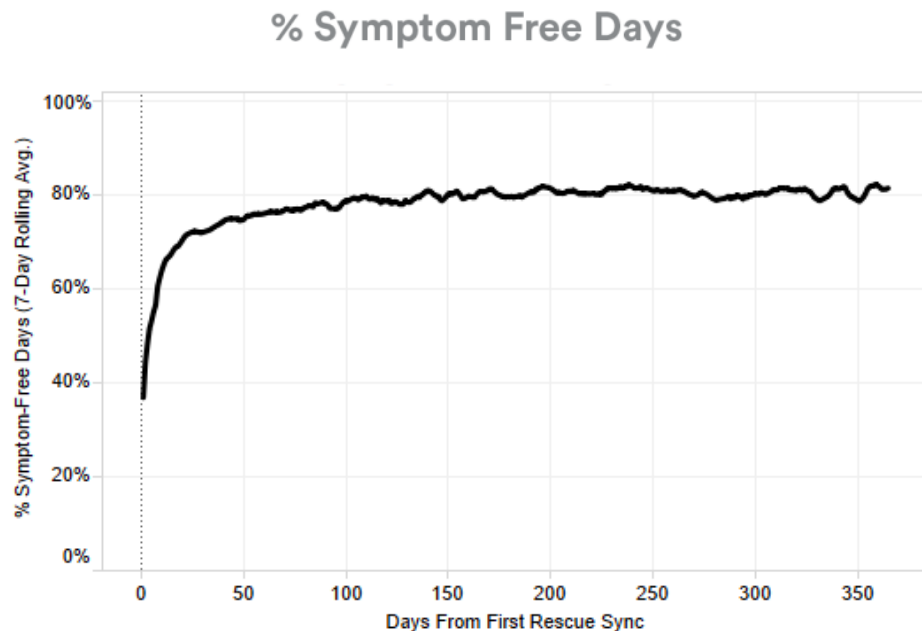


The frequency of rescue inhaler use represents one of the most valuable indicators of acute worsening.

Decrease in rescue use at 12 months:

- 82% decrease for asthma
- 62% decrease for COPD

→ > 2x increase in symptom-free days



Participants experienced more than 2x the number of healthier days - free from the burden of symptoms



Populations

→ AIR Louisville: Unprecedented Data Collection

Building the largest database of real-time respiratory disease symptom data ever collected.

>1.16m data points collected, including 251,379 medication use events (rescue and controller).

- Date and time
- Medication
- Number of doses
- Location

5.4m environmental data points including:

- Air pollutants: NO₂, PM_{2.5}, Ozone, SO₂
- Pollen Count
- Temperature, Humidity, Wind speed/direction
- Land use (zoning, tree cover, impervious surface)
- Major roadways and highways

1:38:08 PM PST

AQI 102

Pollen Count 5.2

N47°34.4452. W110°77.8257
Winds from SW, 13mph

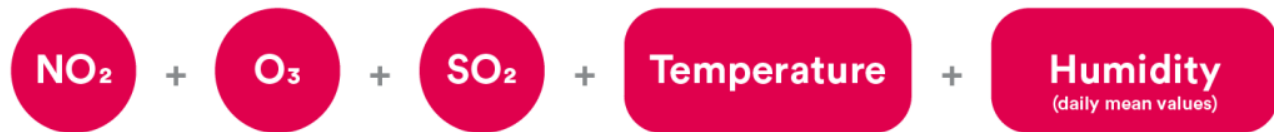
2 inhalations of ProAir (120mcg)
20 seconds apart



→ Spatiotemporal model

Model type: Generalized linear mixed model with quadratic terms and repeated measures

Rescue medication use count per person per day ~

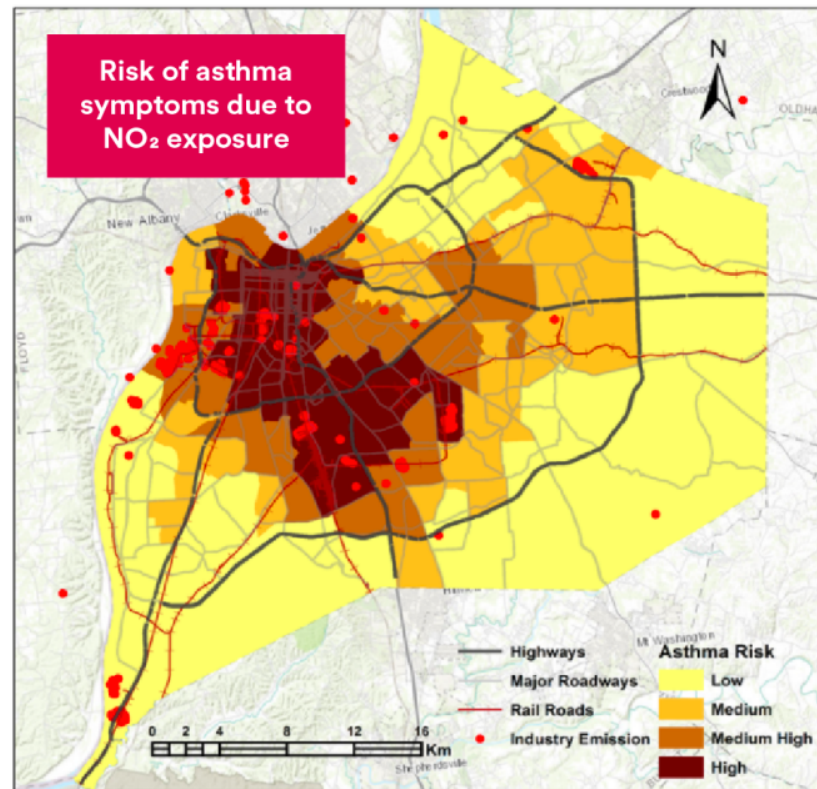
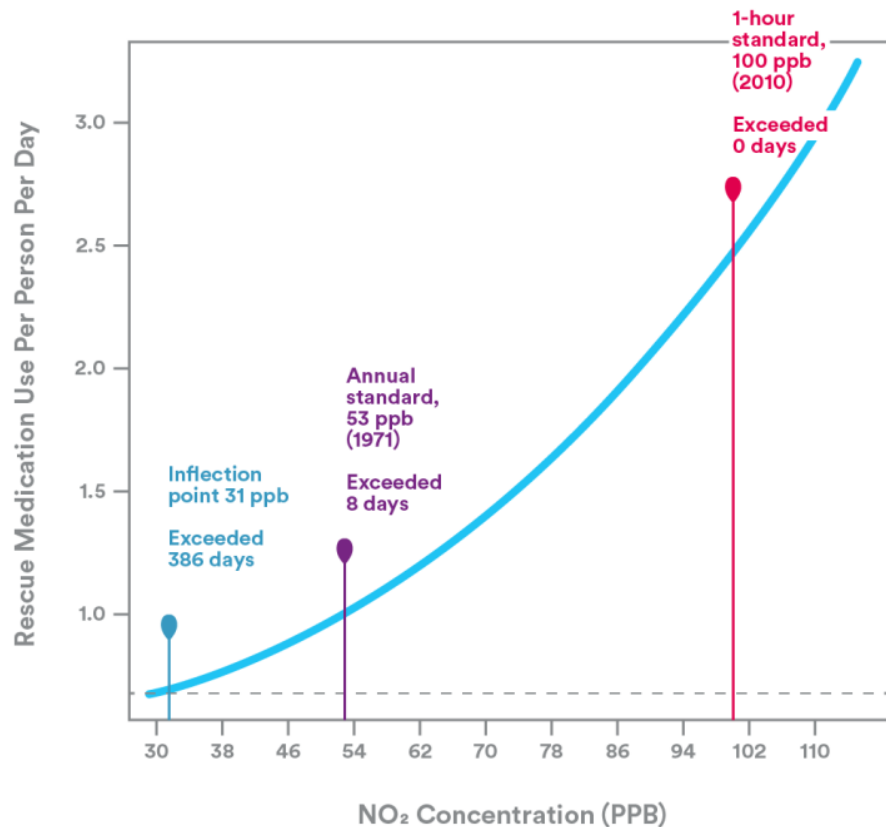


Data range: June 2012 - Nov 2016

Significant, nonlinear relationships:

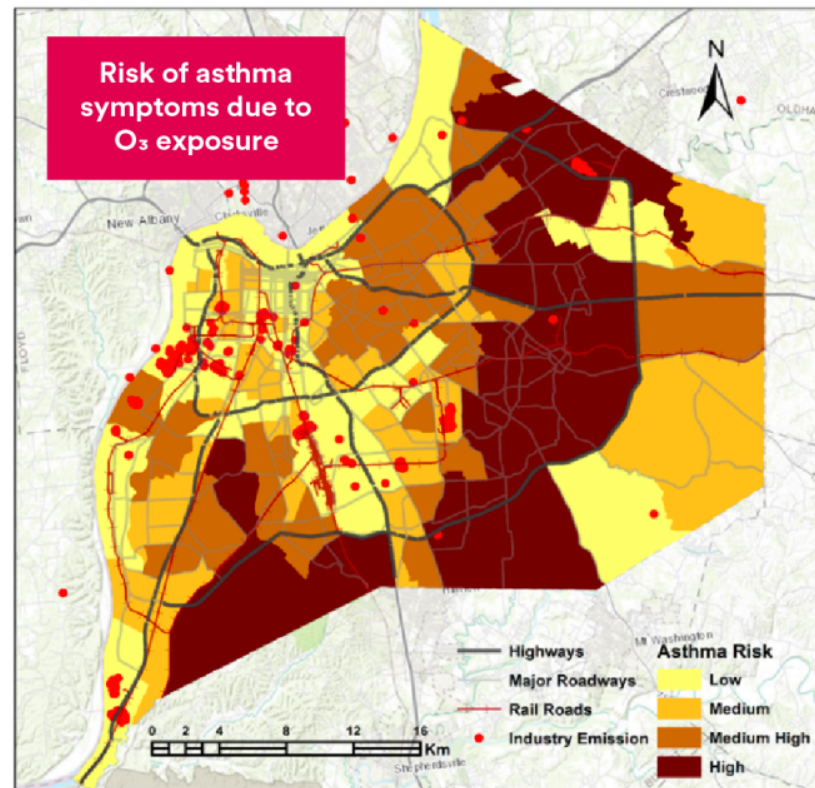
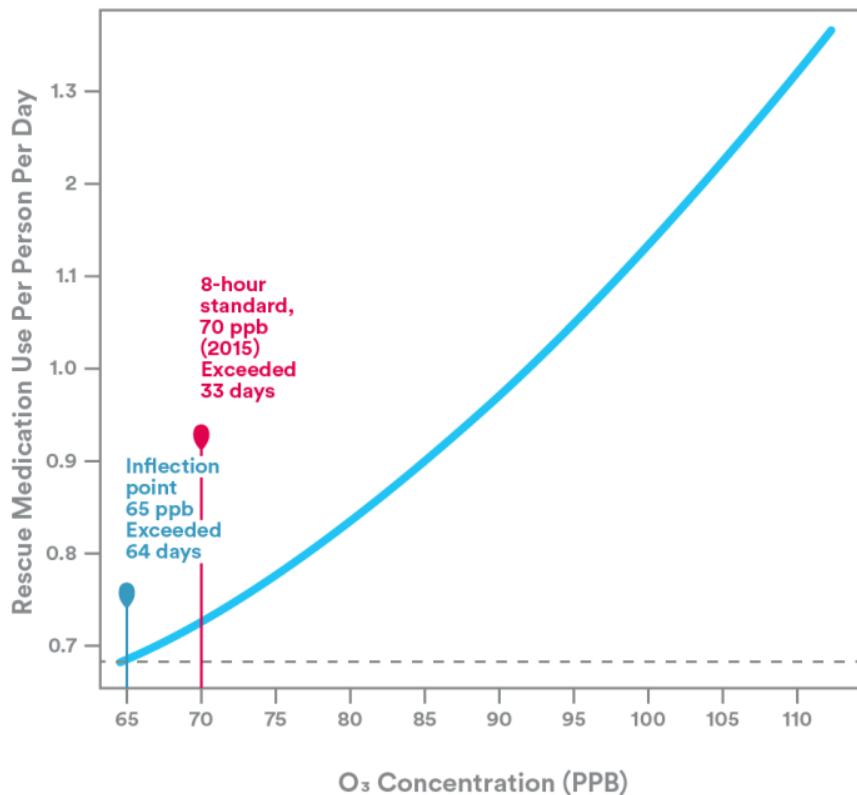
- NO_2
- SO_2 ,
- Ozone
- Temperature

→ Impact of NO₂ concentration on rescue medication use



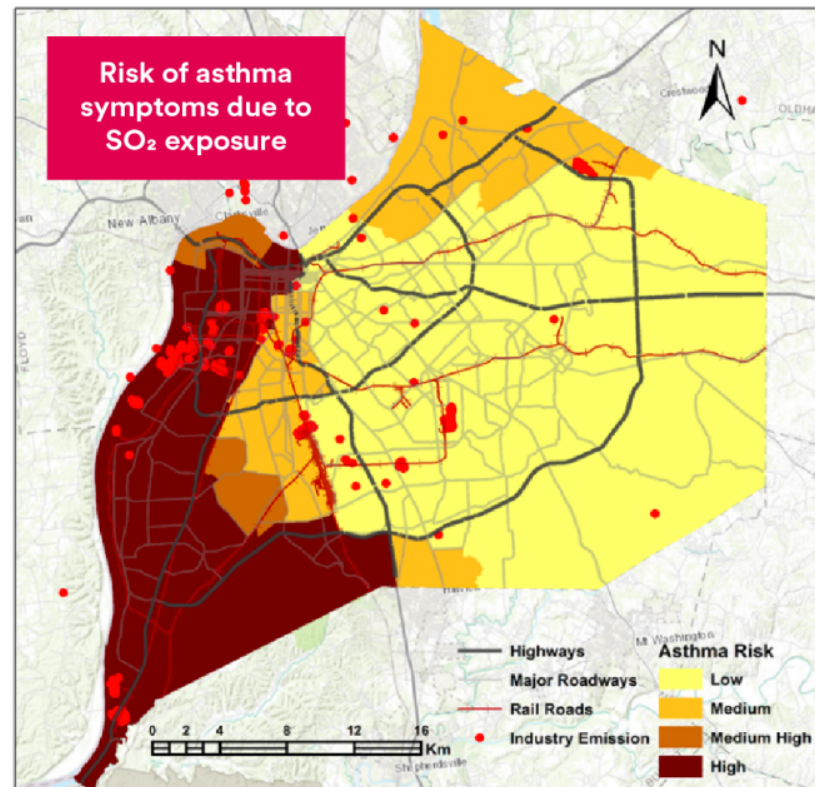
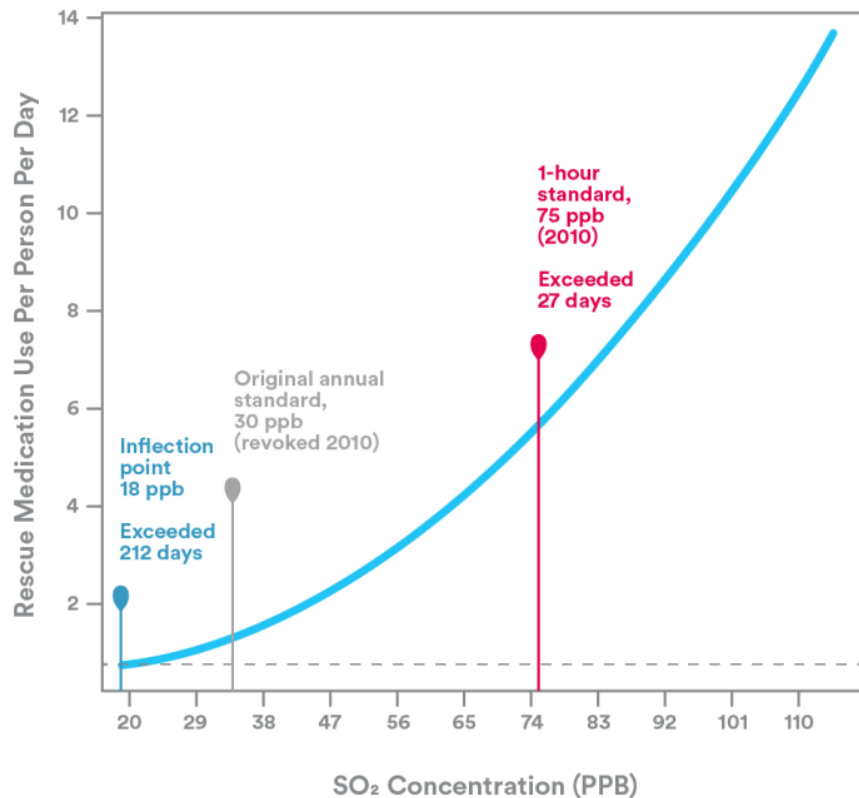
→ Impact of O₃ concentration on rescue medication use

Annual standard, 120 ppb (revoked 1997)

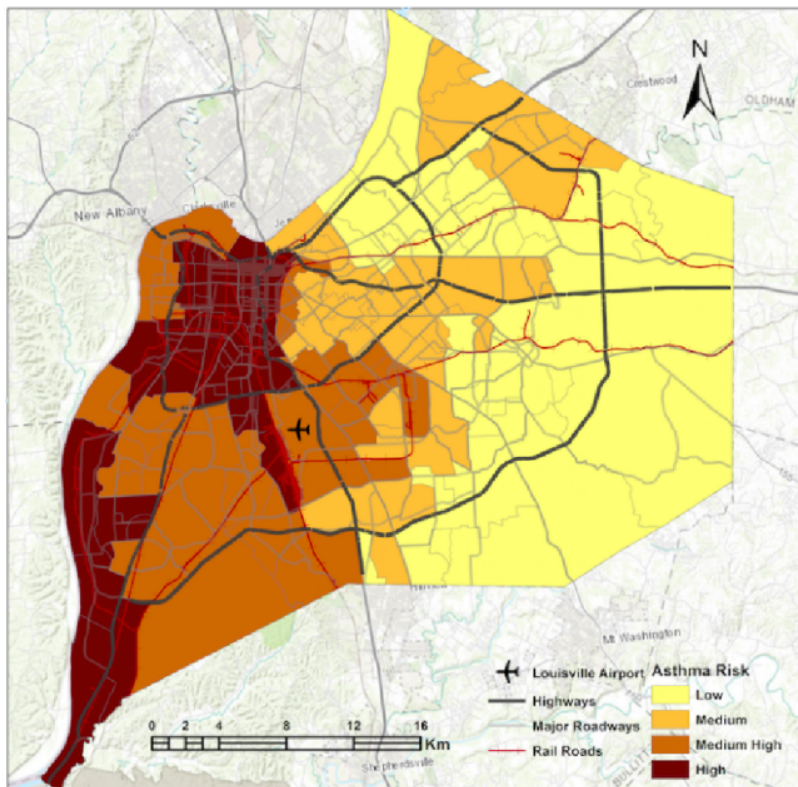


→ Impact of SO₂ concentration on rescue medication use

3-hour standard, 500 ppb, (1971) | Exceeded 0 days



→ Assessment of asthma symptom risk in Louisville neighborhoods



Represents risk of asthma symptoms per census tract as a function of:

- NO₂
- SO₂
- Ozone
- Temperature
- Humidity

(controls for neighborhood socioeconomic characteristics)

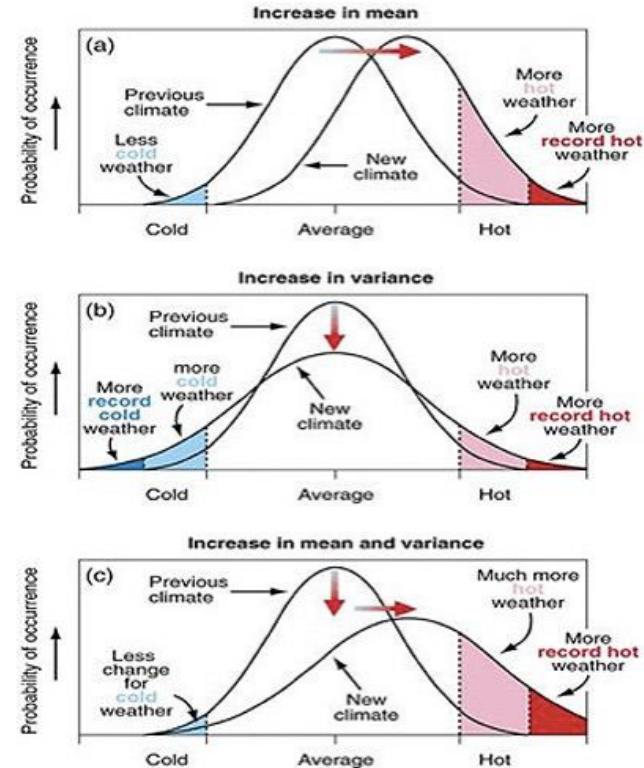
Impacts of climate change

Association of air pollution exceedances with extreme temperatures

Pollutant	Exceedances (2015-2016)	Associated with Extreme Temperatures (%) (<40 or > 80)
Nitrogen dioxide (NO ₂)	5	4 (80%)***
Ozone (O ₃)	27	27 (100%)***
Sulfur dioxide (SO ₂)	1	1 (100%)**

Anticipated 4x increase in extreme heat events

- Increasing mean and variance of temperature shifts (hotter, more extreme)
- Extreme hot temperatures slated to increase 4-fold by 2075
- Temperature inversions may trap pollutants
- Heat involved in ozone formation

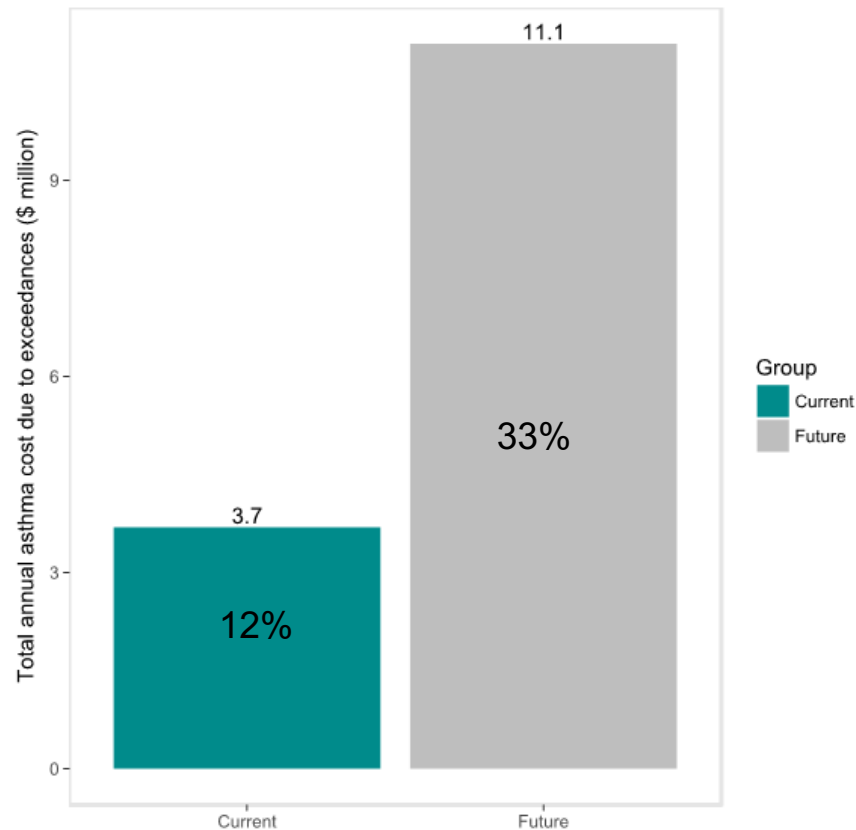


Cost of poor air and climate change

Current cost of exceedances & extreme temperatures:
\$3.7 (12% of annual spend in 2017 USD)

x3

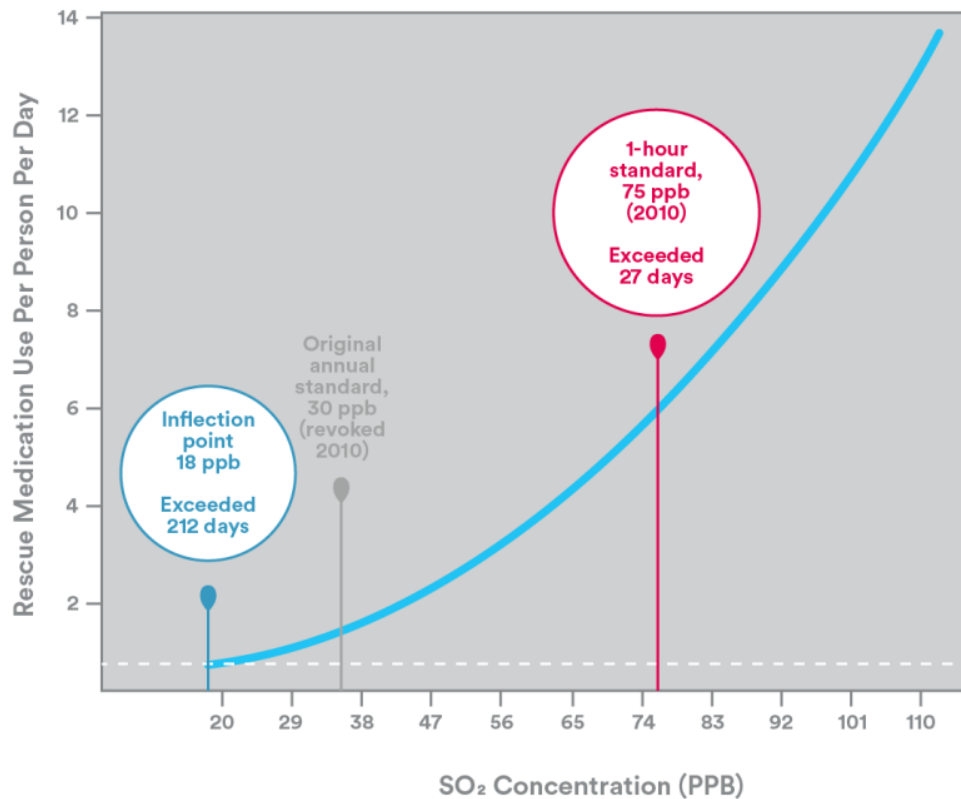
Future cost of exceedances & extreme temperatures:
\$11.1 (33% of annual spend in 2075 USD)



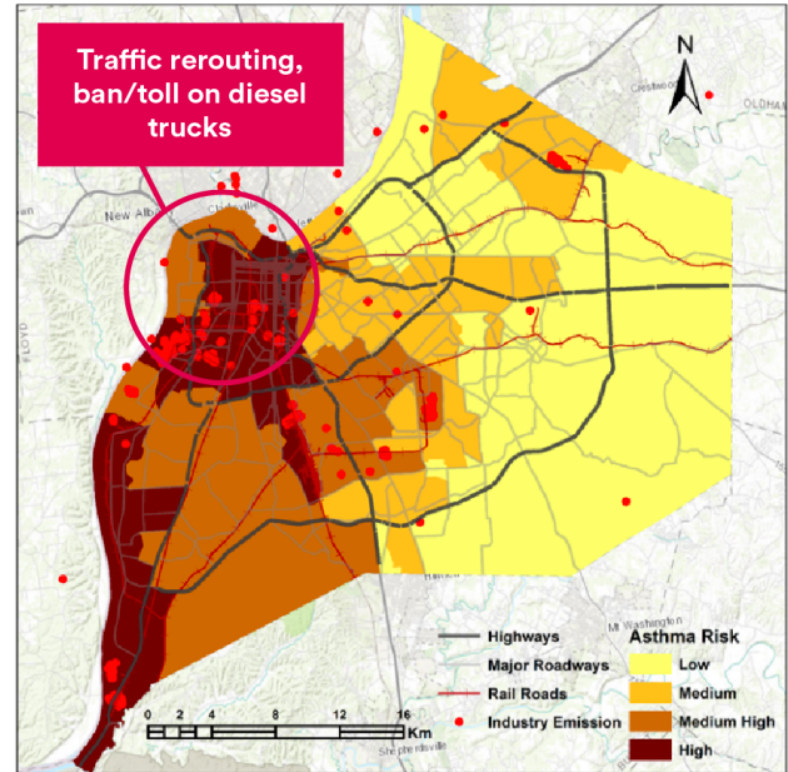
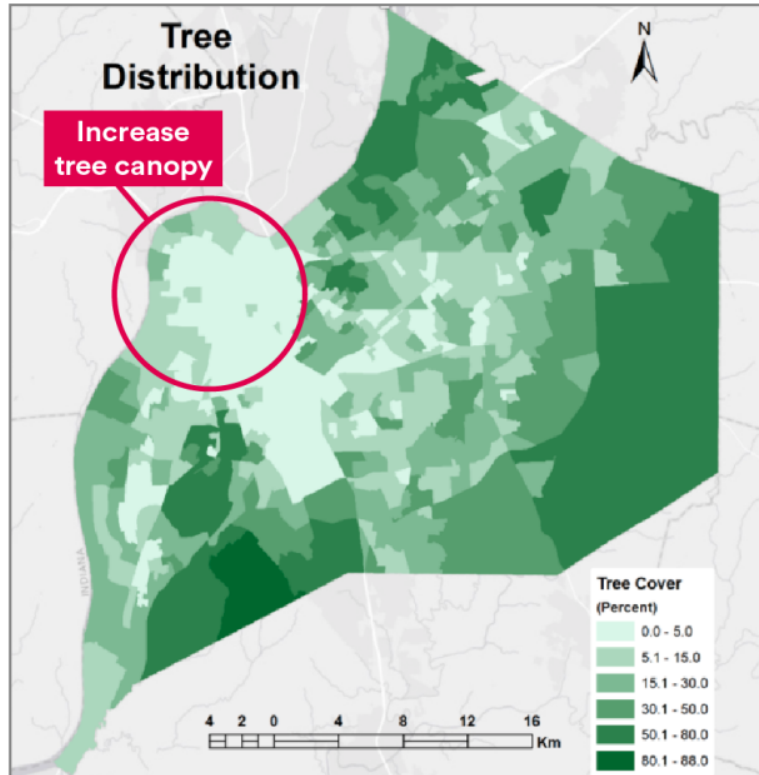


Policy

→ Evidence to support stricter national standards



→ Enhancing green infrastructure in high-risk neighborhoods



Revisions to Comprehensive Plan 2040

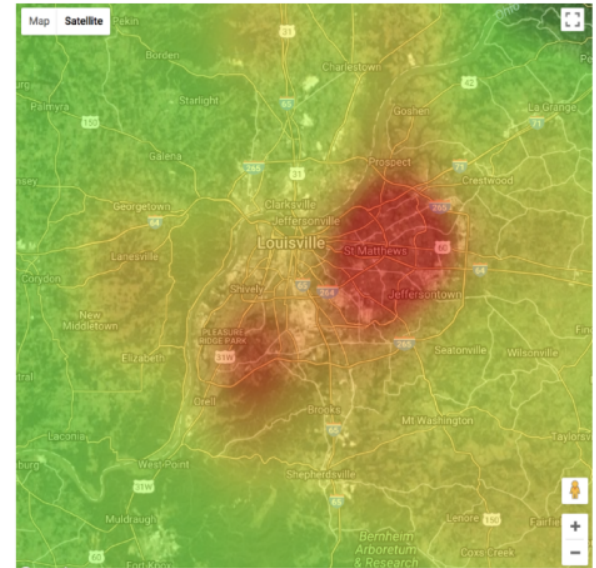
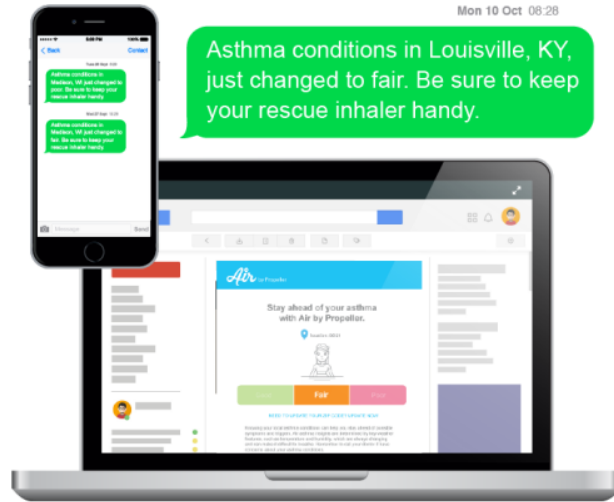
15% vs. 45%



500-ft buffer (APA)



→ Air Forecast: Alerts about local asthma risk due to environmental conditions



→ **Thank You**



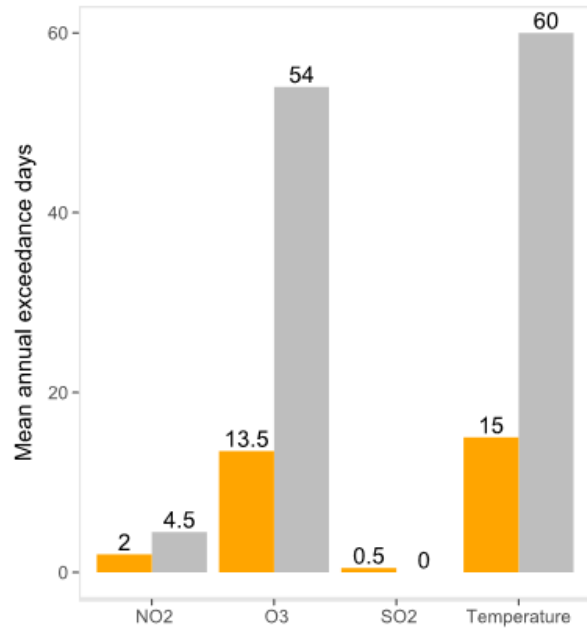
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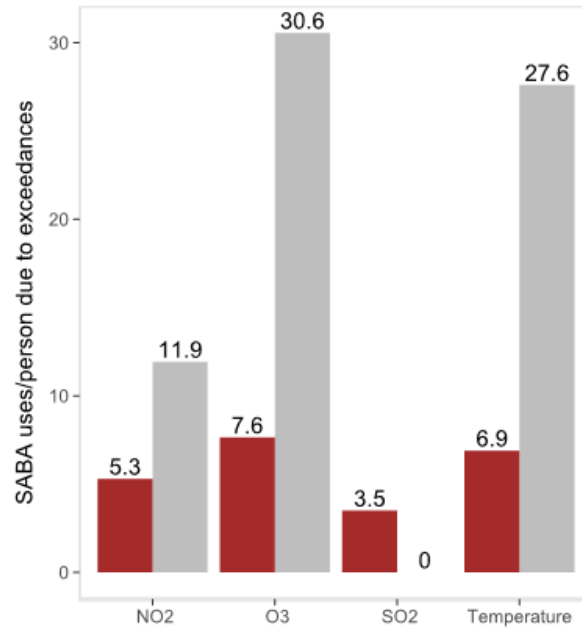


Appendix/Extra Slides

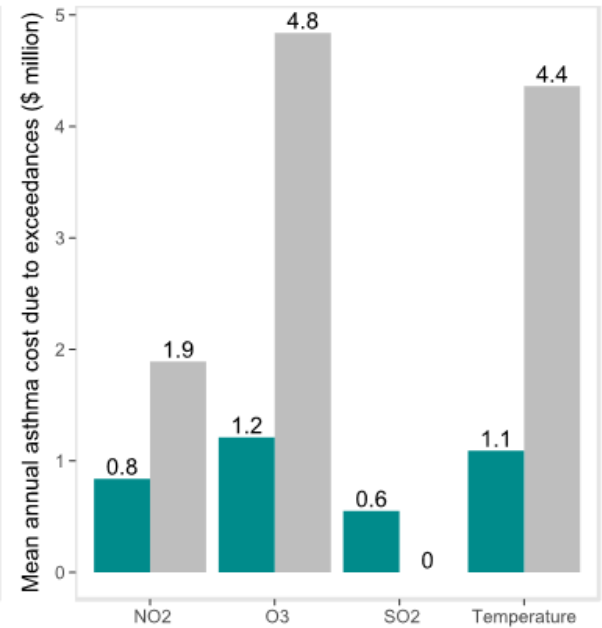
Future climate: 2-4x number of exceedance days, asthma symptoms and asthma-related cost



Days: ■ Current ■ Future

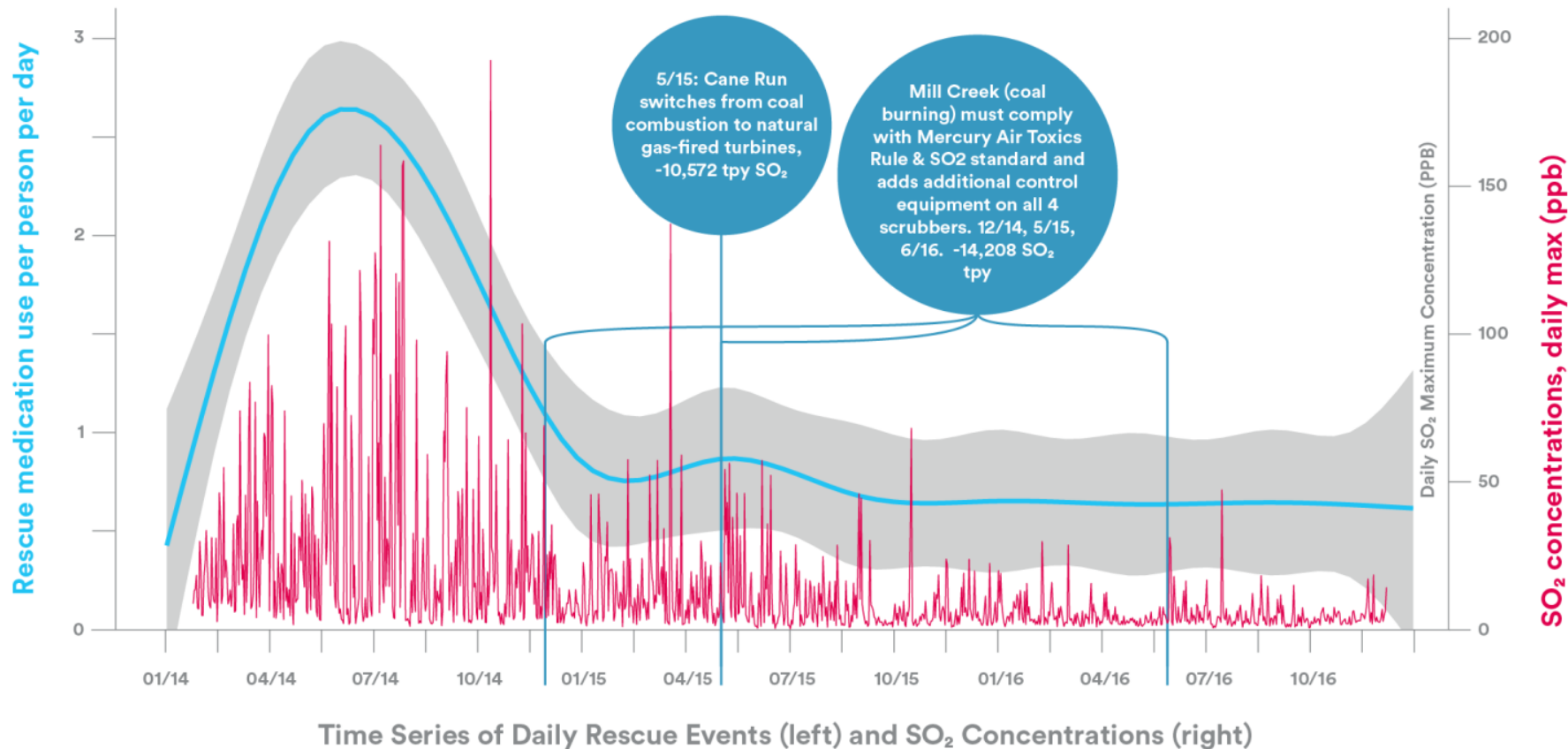


SABA Use: ■ Current ■ Future



Cost: ■ Current ■ Future

→ SO₂ reductions demonstrate health benefit of regulation



→ **How many people could be at risk?**

- 21% of the general population
- 23% of the asthma population
- 64 educational sites
- 49 parks

