



# Air Pollution Exposure in Urban Schools and the Influence on Childhood Asthma

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# ENVIRONMENTAL JUSTICE:

## *Adding the Freedom of Choice*

“

The color of your skin or the thickness of your wallet shouldn't determine your ability to breathe clean air.

”



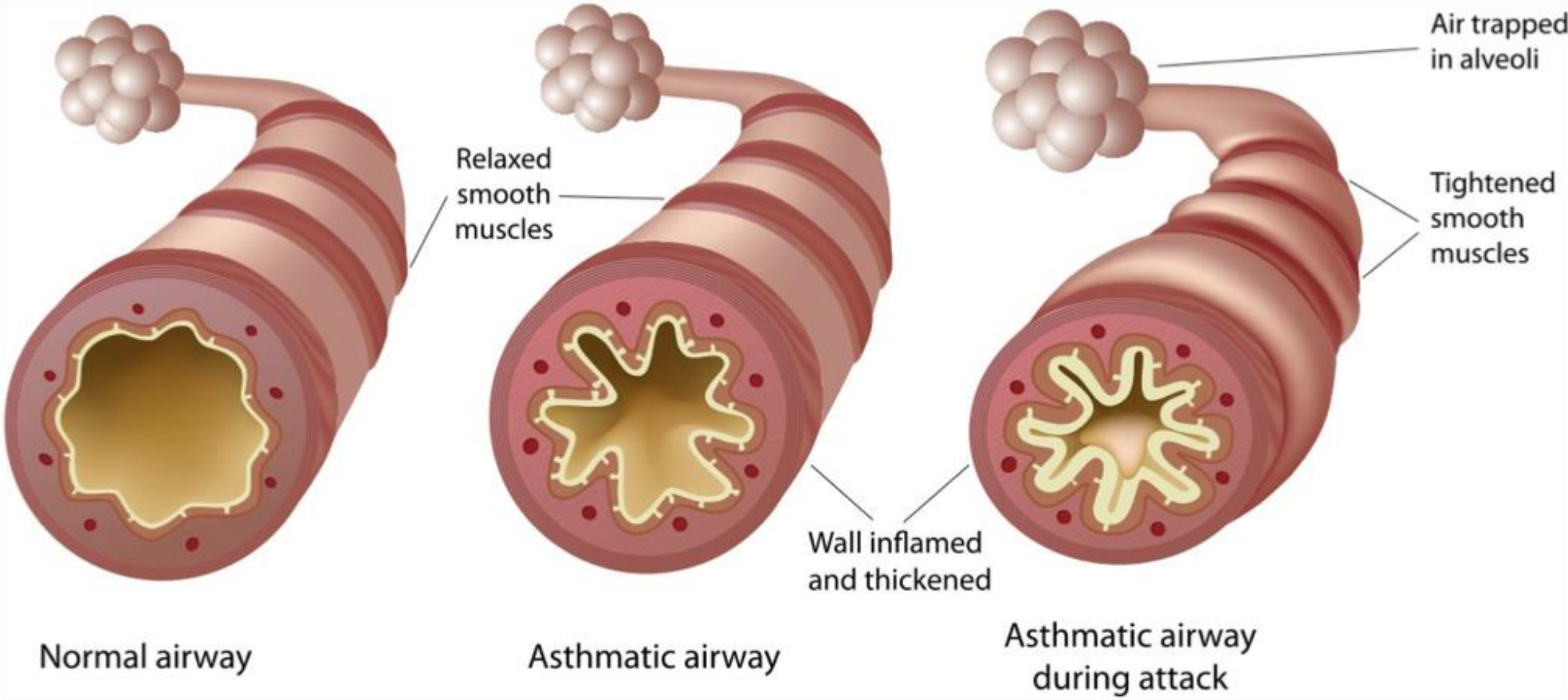
# Learning Objectives

1. What do we know about air pollution exposure and childhood asthma?
2. How are children exposed to air pollution in the school environment?
3. What measures can be taken to reduce air pollution in the school environment?





# Asthma is Both Chronic and Episodic

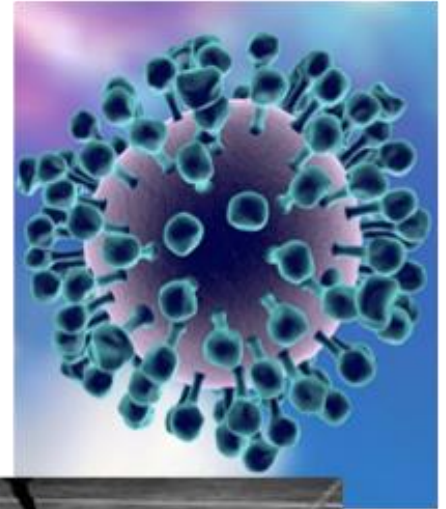


# Triggers of Asthma

Allergens (pollen, mold, animal dander, and dust mites)



Respiratory infections



Weather

Tobacco smoke



Exercise

**Air pollution**



# Environmental Protection Agency – Criteria Pollutants

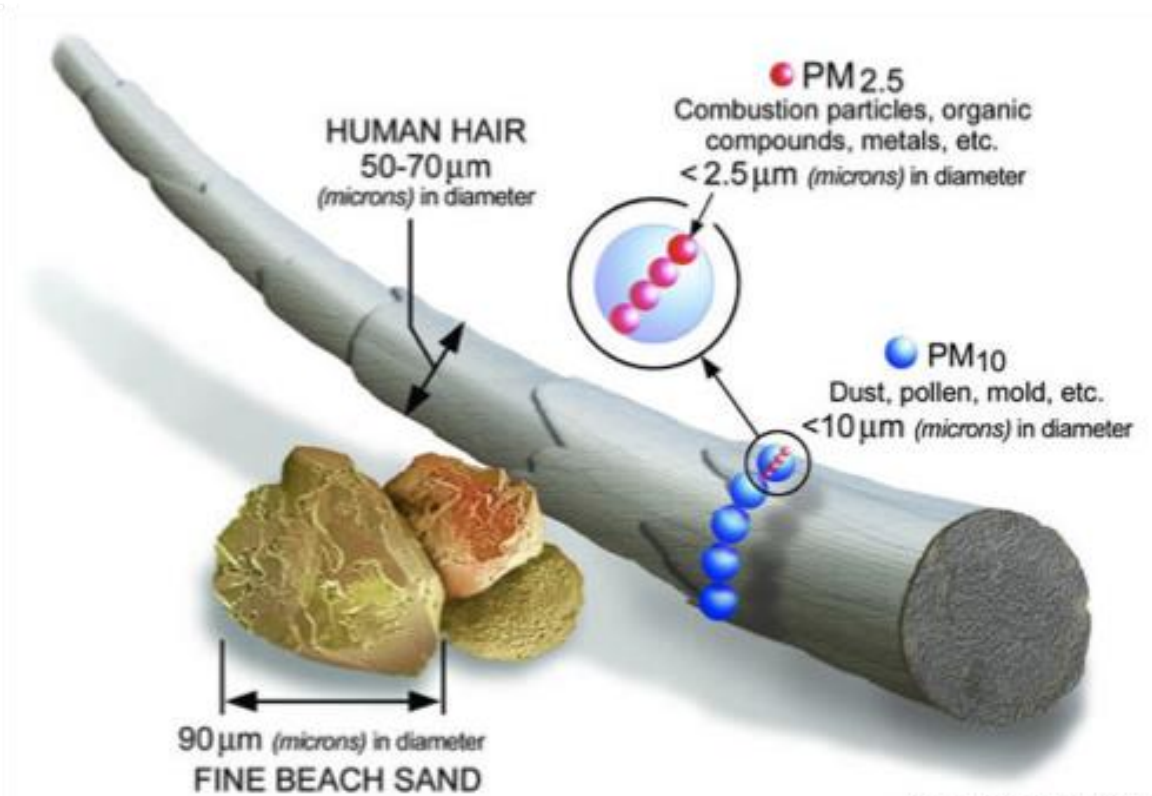
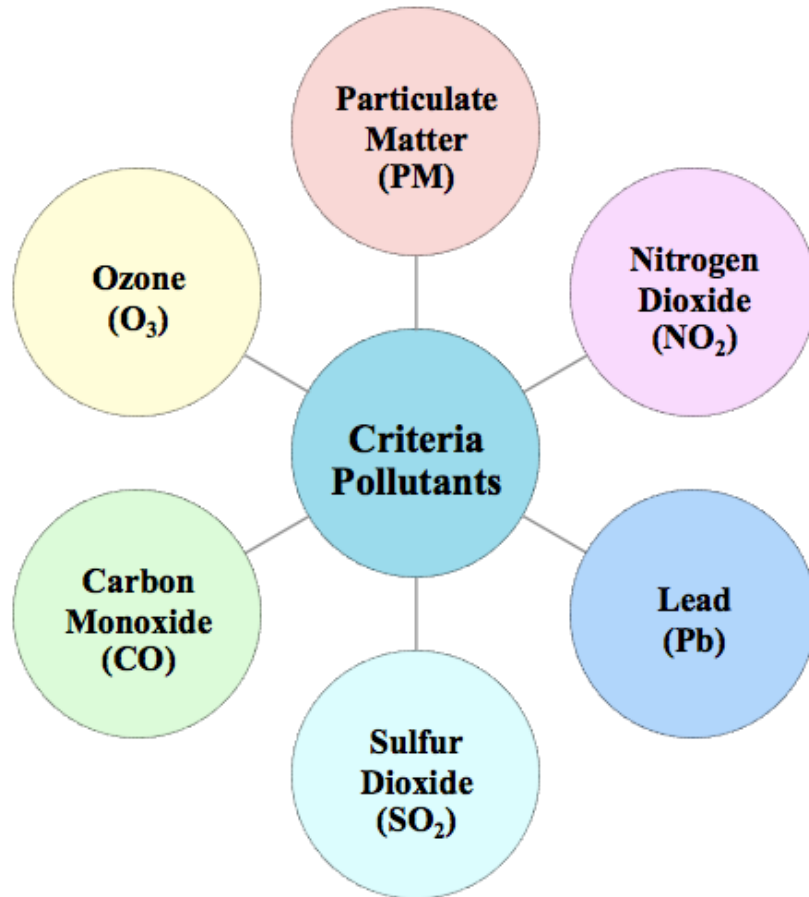


Image courtesy of the U.S. EPA





Cars and Trucks



Power Plants



Forest Fires

Fine and Coarse  
Particles Can Be Emitted  
Directly or Formed in the  
Air from Gases



Non-Road Vehicles



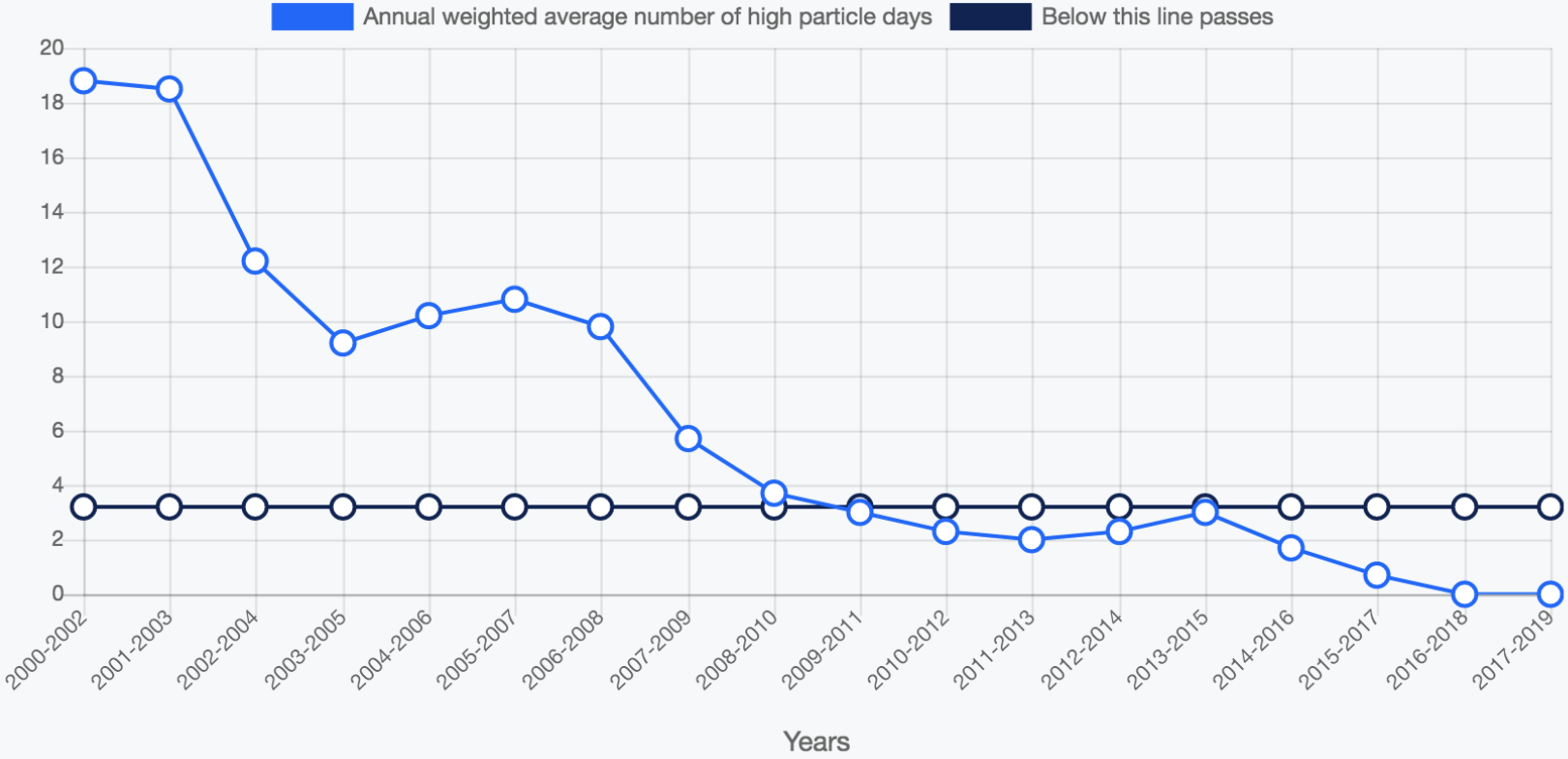
Heavy Duty Diesel Engines



Wood-Burning Stoves

# State of the Air

## Philadelphia



Particle Pollution 24-hour



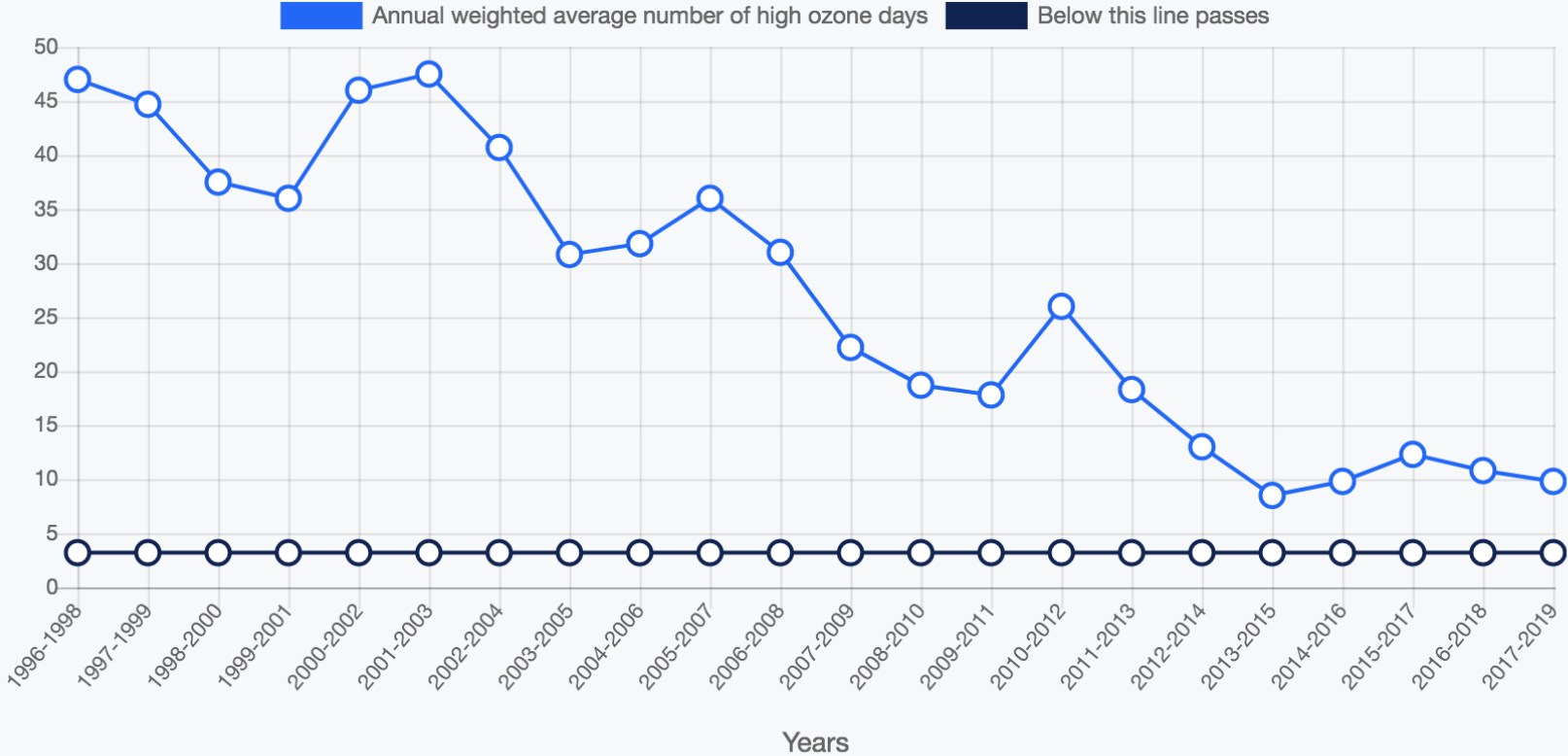
Particle Pollution Annual





# State of the Air

## Philadelphia

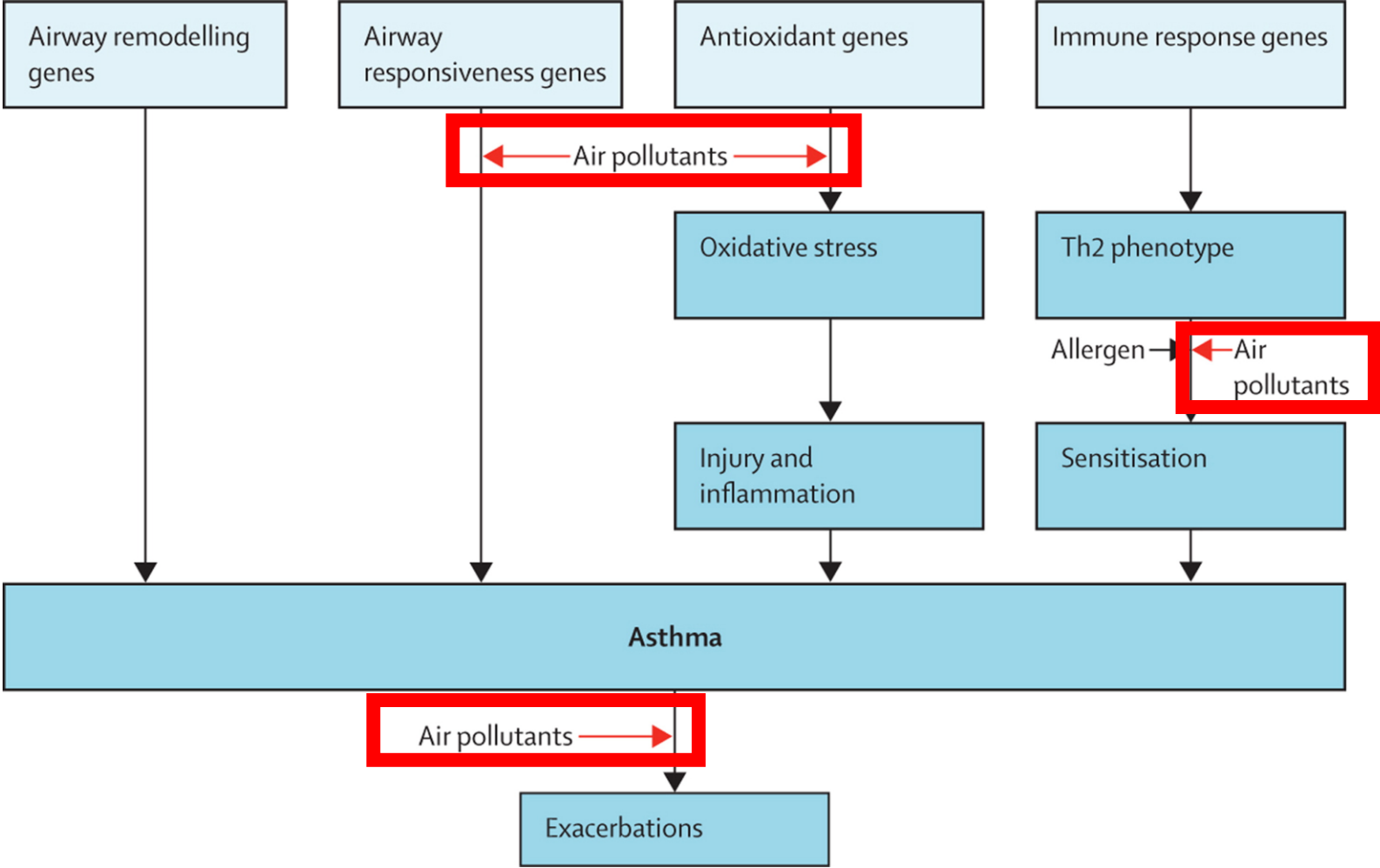


**What do we know about  
air pollution exposure  
and childhood asthma?**





# Air pollution exposure and asthma



# Long-term Exposure to Air Pollution is a Cause of Childhood Asthma

## Epidemiologic Evidence

- **Strong evidence** for childhood asthma and long-term air pollution especially TRAP (NO<sub>2</sub> and BC)

## Mechanistic Evidence

- Support for **biological plausibility**
- Air pollution, especially PM<sub>2.5</sub> and O<sub>3</sub> causes airway remodeling and increased incidence/severity of asthma-like phenotypes

## Clinical Considerations

- Air pollution causes lung function deficits, airway remodeling and other clinical parameters considered in the diagnosis of asthma
- Air pollution is a clinically plausible contributor to development and diagnosis of asthma

## Workshop Conclusions

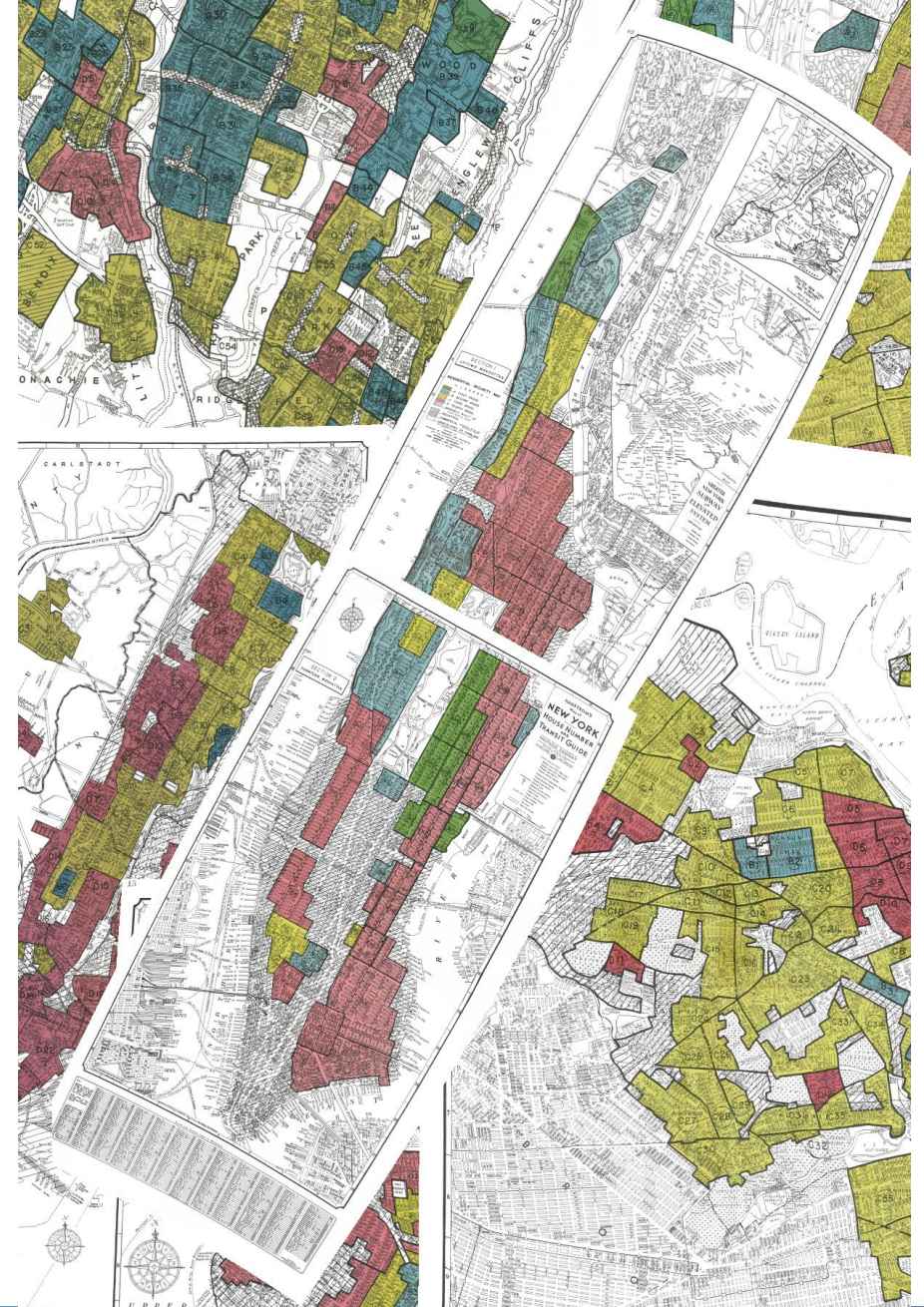
- Epidemiological and toxicological evidence convincingly indicate a causal induction of new childhood asthma by long-term outdoor air pollution exposure



# Historical Redlining

In the 1930s the Home Owners' Loan Corporation (HOLC) used maps to distinguish perceived risk for mortgage lending based on factors including racial composition

Discriminatory practices have perpetuated racial segregation, poverty, and influenced where highways and other point pollution sources were placed

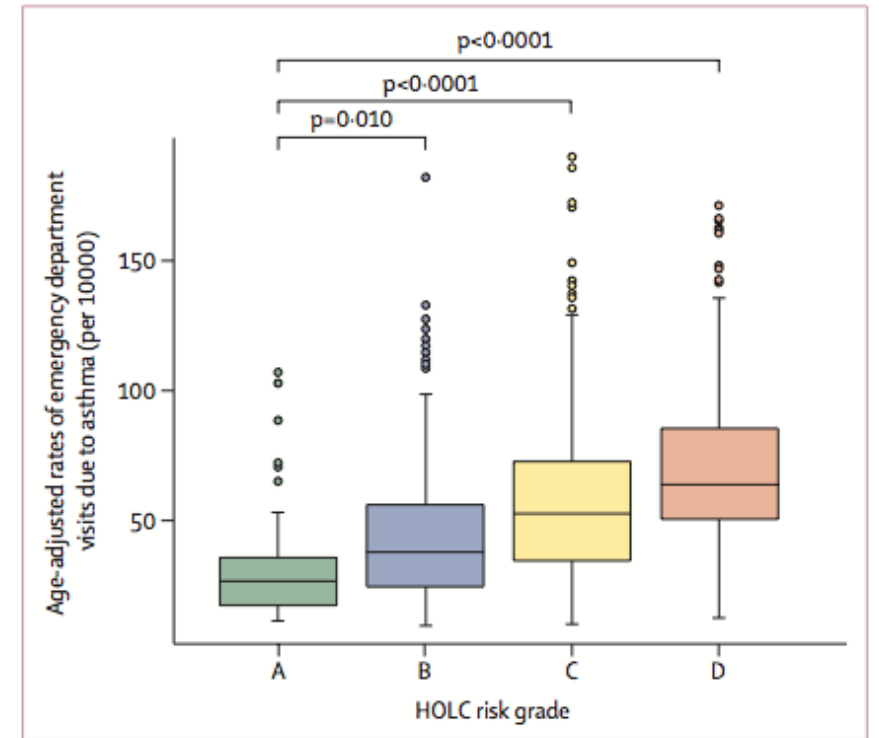


# Pollution and Asthma ED visits are Highest in Historically Redlined Neighborhoods

	Grade A (n=64)	Grade B (n=241)	Grade C (n=719)	Grade D (n=407)	p <sub>trend</sub>
Percentage Hispanic	10.9% (8.8)	27.6% (27.3)	46.5% (28.1)	55.5% (30)	<0.0001
Percentage non-Hispanic Asian	12.2% (12.2)	15.8% (17.4)	14.9% (17.0)	12.9% (14.9)	0.070
Percentage non-Hispanic Black	6.2% (16.1)	8.5% (16.2)	10.1% (12.5)	10.9% (13.7)	0.021
Percentage non-Hispanic White	67.1% (22.6)	44.8% (28.4)	25.9% (26.6)	18.3% (21.9)	<0.0001
Percentage other	3.5% (1.0)	3.1% (1.5)	2.4% (1.5)	2.2% (1.6)	<0.0001
Percentage of poverty*	15.6% (9.4)	29.7% (17.2)	47.3% (19.9)	51.9% (19.9)	<0.0001
Mean PM <sub>2.5</sub> (µg/m <sup>3</sup> )	11.1 (1.6)	11.0 (1.6)	11.5 (1.4)	11.4 (1.6)	0.0003
Mean diesel PM (kg/day)	22.6 (14.3)	27.8 (16.2)	29.8 (15.9)	39.7 (23.5)	<0.0001

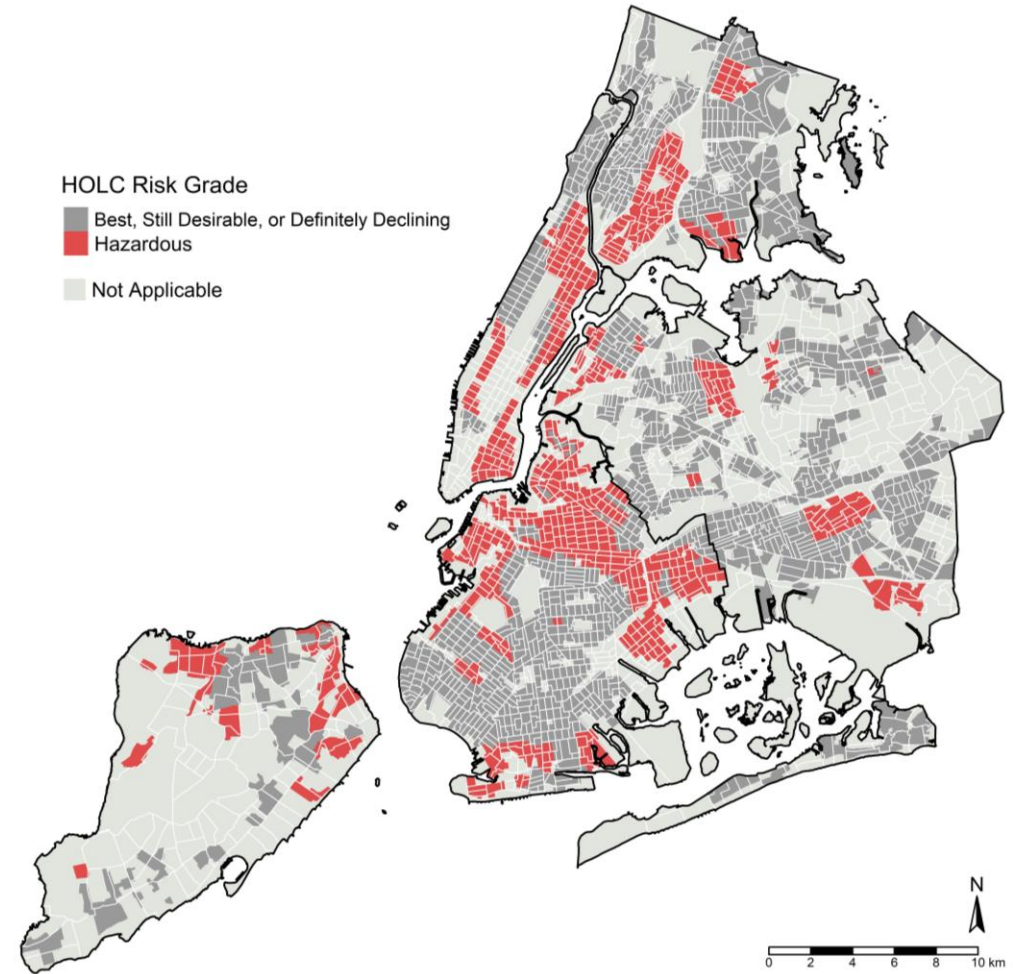
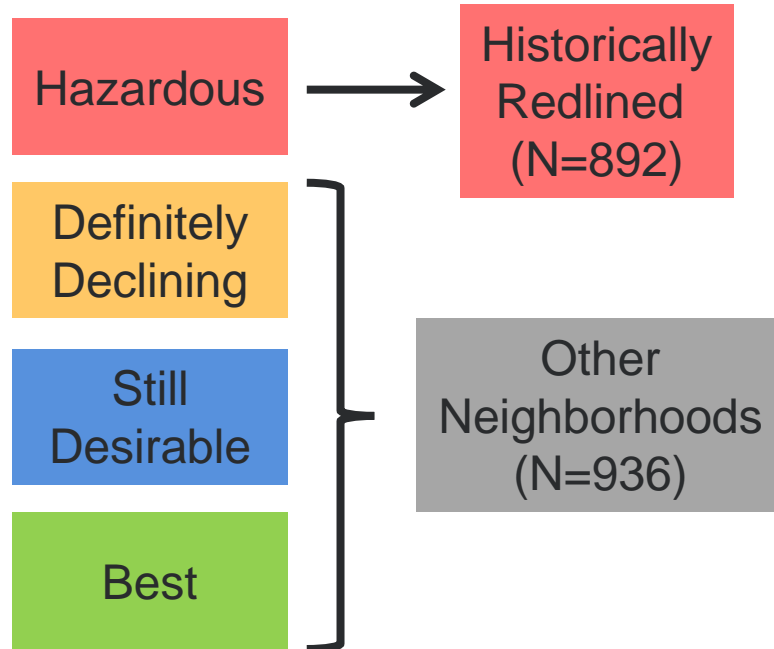
Data are mean (SD); n indicates the number of census tracts. HOLC=Home Owners' Loan Corporation. PM=particulate matter. \*Defined by the percentage of the population living below two-times the federal poverty level.

**Table 1: Socio-demographic and air pollution characteristics of census tracts by previous HOLC risk grade**



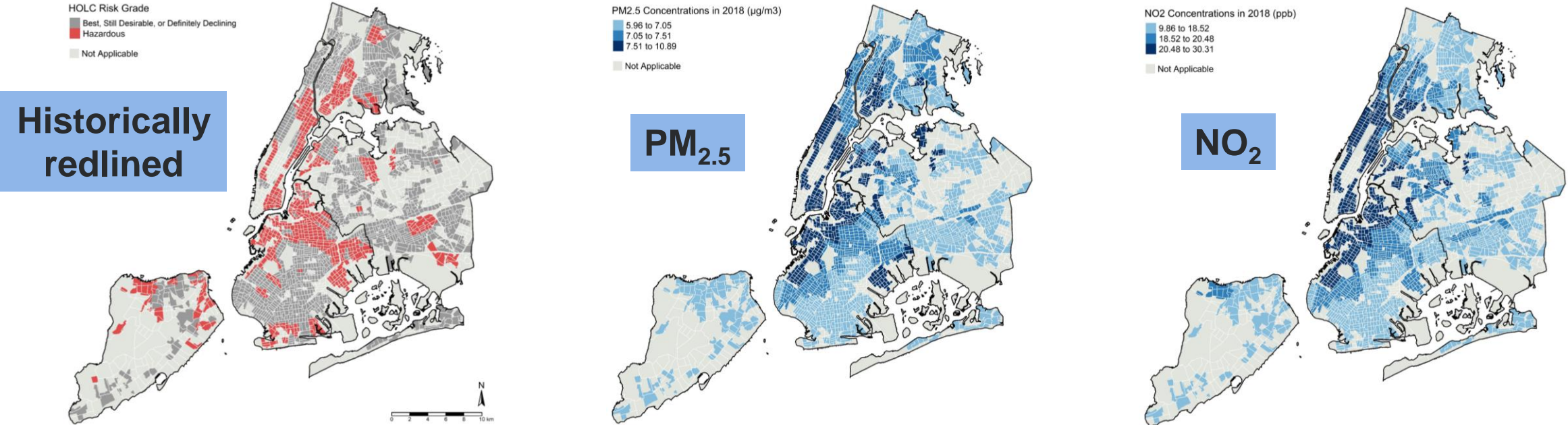


# Redlined Neighborhood Classification in NYC



Historical redlining data source:  
Mapping Inequality Project (<https://dsl.richmond.edu/panorama/redlining>)

# Pollution Concentrations are Higher in Historically Redlined Compared to Other Neighborhoods in NYC



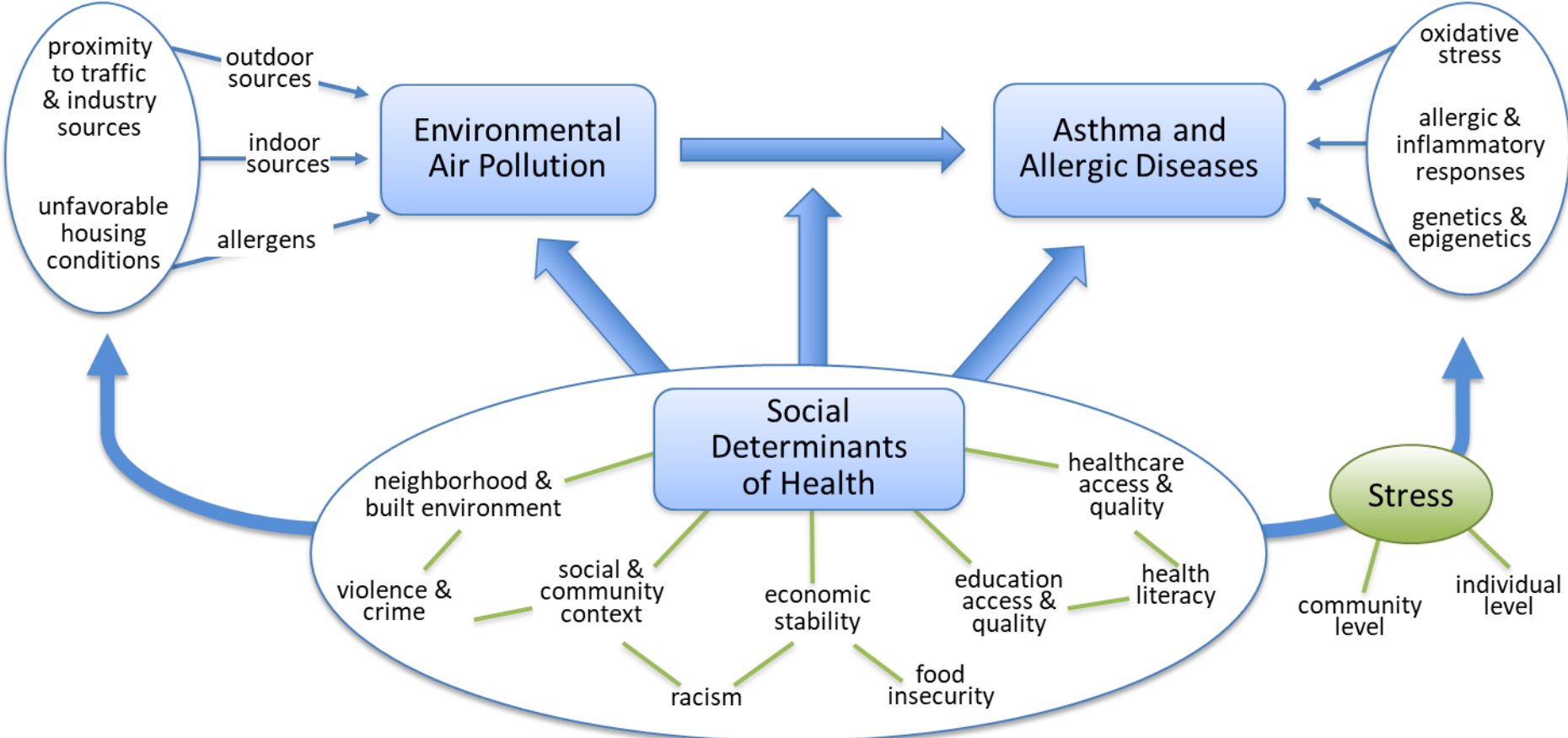


# Association of early-life pollution exposure and childhood asthma by neighborhood poverty

US national survey of 4,535 children <13 years old with exposures measured at birth addresses

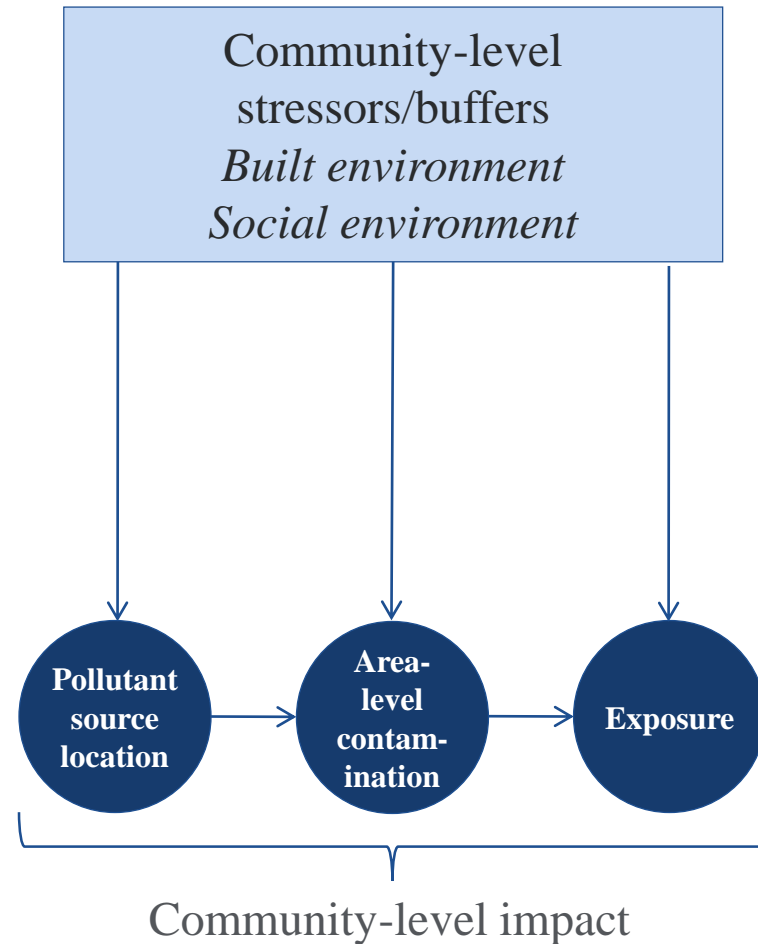
	<10% NH Poverty		10%–20% NH Poverty		>20% NH Poverty	
	(N = 1634)		(N = 1391)		(N = 1465)	
	OR	95% CI	OR	95% CI	OR	95% CI
Early-life NO <sub>2</sub> exposure	1.20	(0.93–1.58)	<b>1.26</b>	(1.02–1.57)	<b>1.31</b>	(1.08–1.60)
Early-life PM <sub>2.5</sub> exposure	1.20	(0.90–1.61)	1.24	(0.92–1.68)	<b>1.35</b>	(1.03–1.78)

# Complex interactions between air pollution exposure, social determinants of health, and asthma

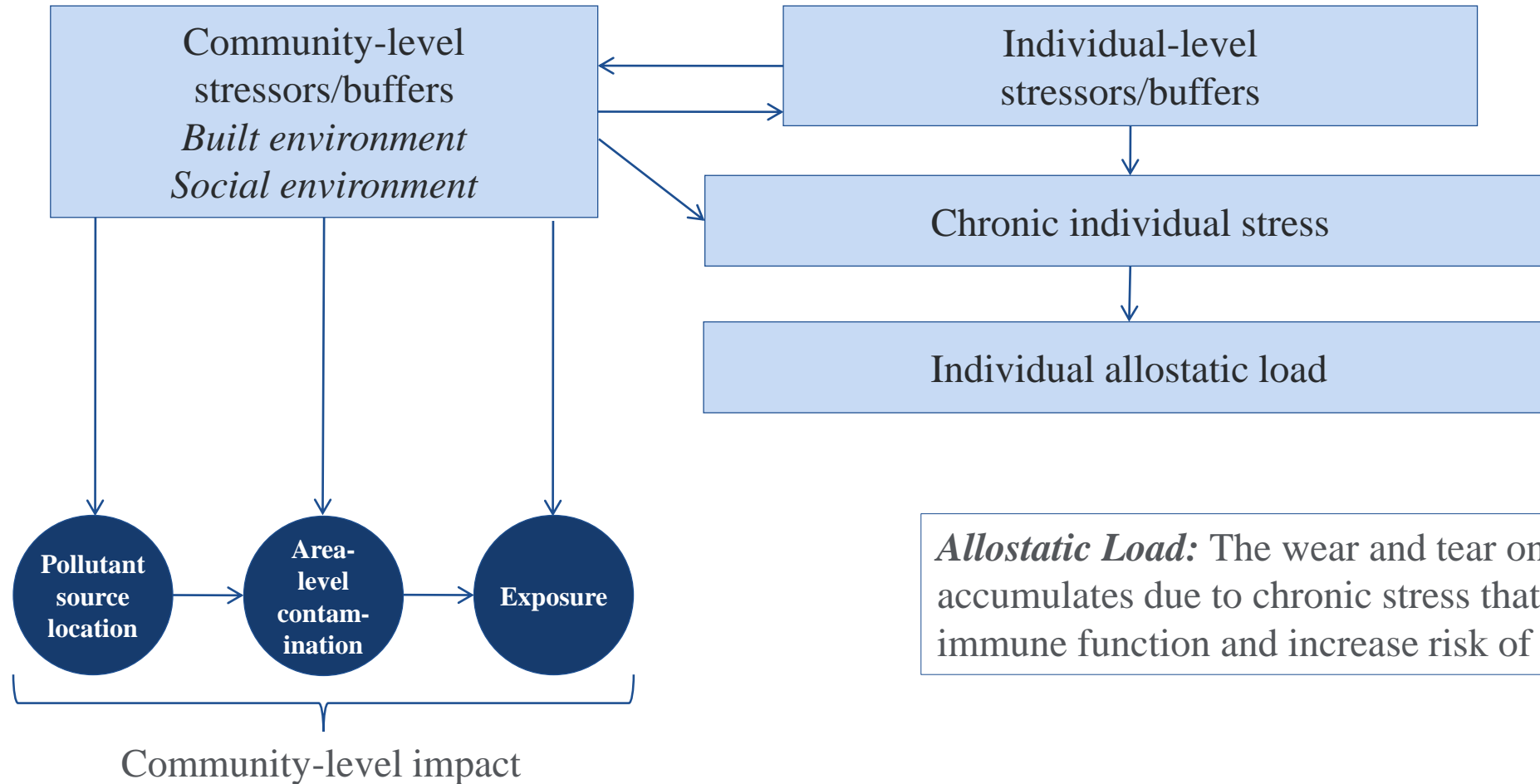




# Interplay of community and individual stressors shaping environmental susceptibility



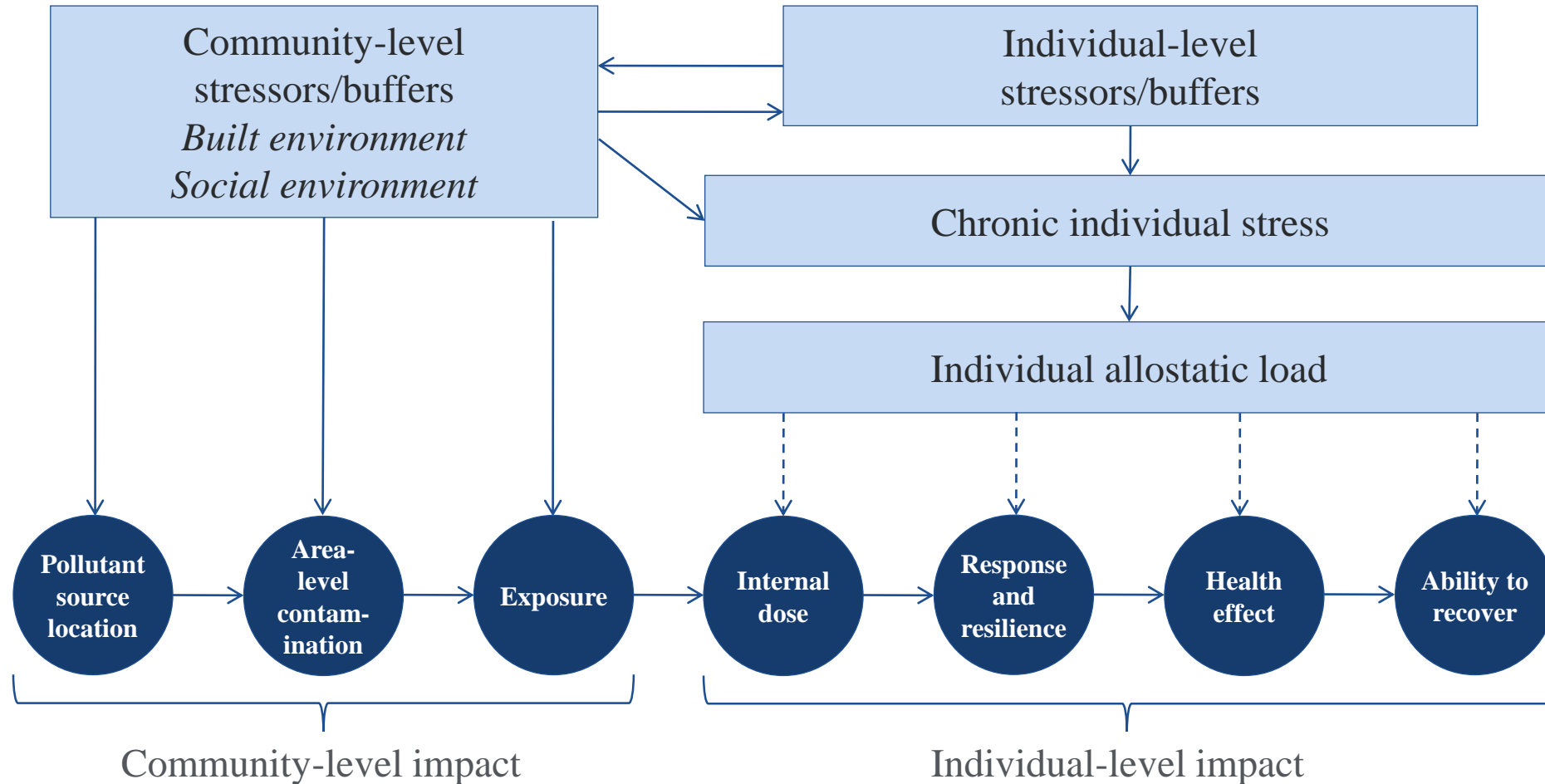
# Interplay of community and individual stressors shaping environmental susceptibility



***Allostatic Load:*** The wear and tear on the body that accumulates due to chronic stress that may suppress immune function and increase risk of disease



# Interplay of community and individual stressors shaping environmental susceptibility

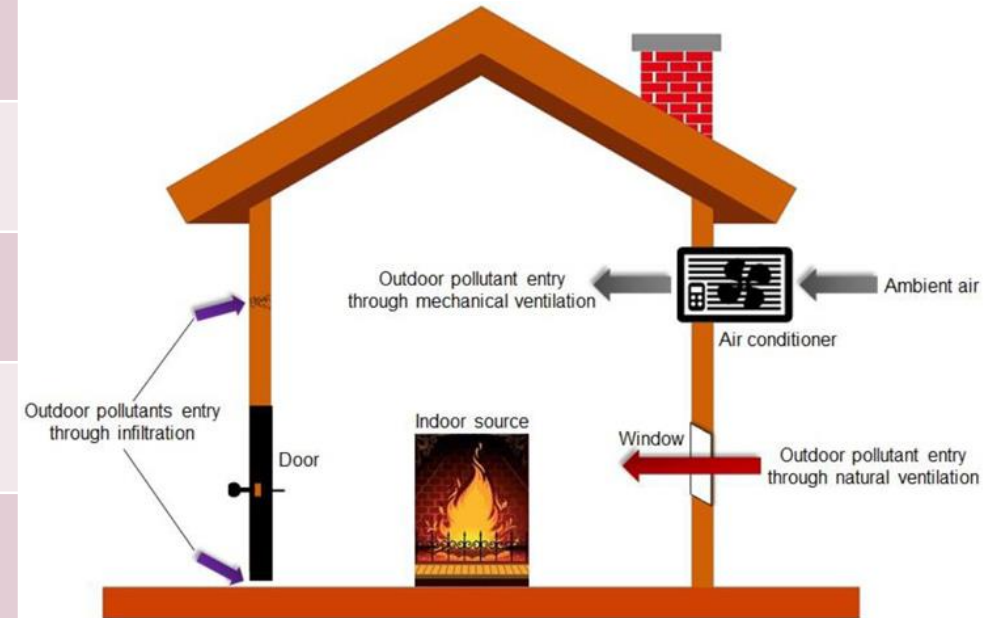


# How are children exposed to air pollution in the school environment?



# Common Indoor Sources of Pollution

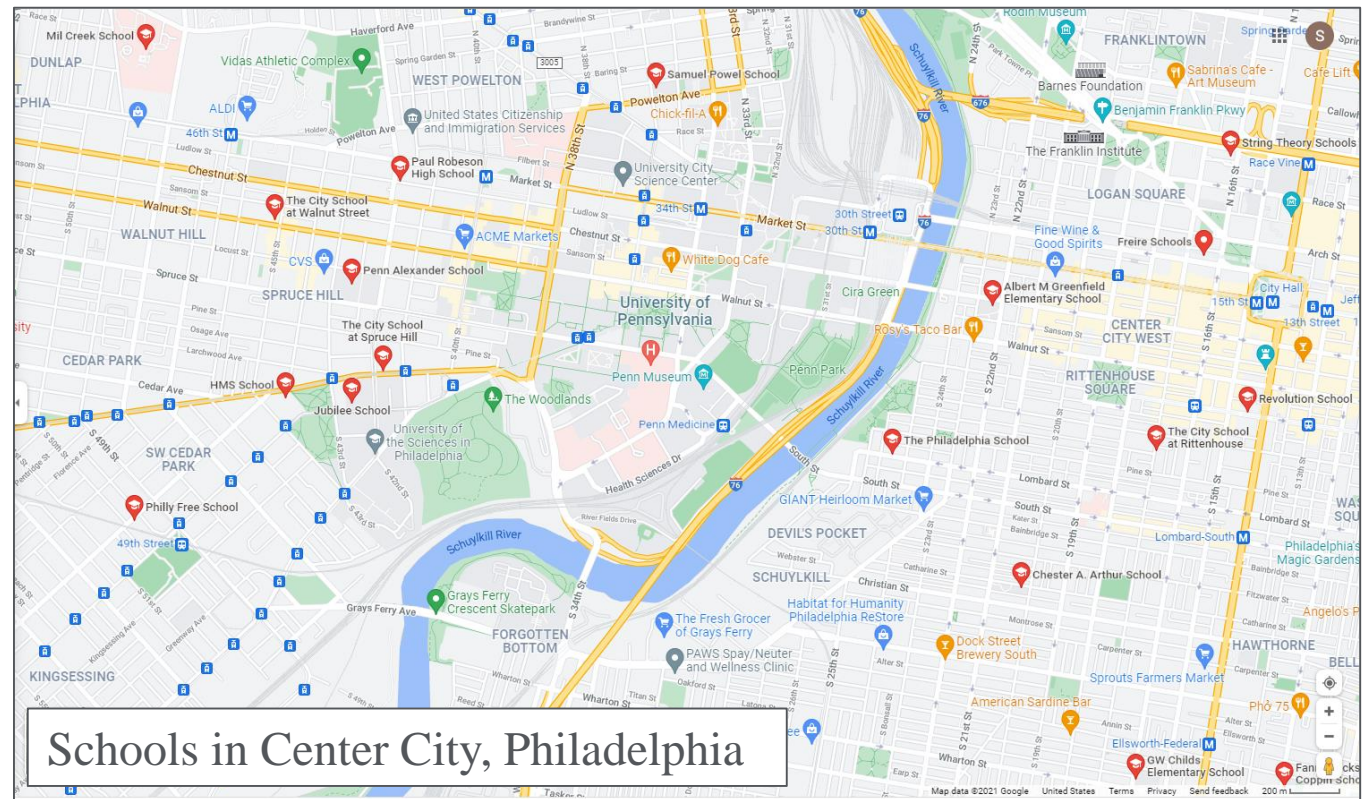
Pollutant	Sources
PM	Cooking stoves, fireplaces, smoking, <b>outdoor air</b>
SO <sub>2</sub>	Cooking stoves, fireplaces, <b>outdoor air</b>
NO <sub>2</sub>	Cooking stoves, fireplaces, <b>outdoor air</b>
CO	Cooking stoves, fireplaces, water heater, <b>outdoor air</b>
Ozone	Air cleaning device with high voltage, <b>outdoor air</b>



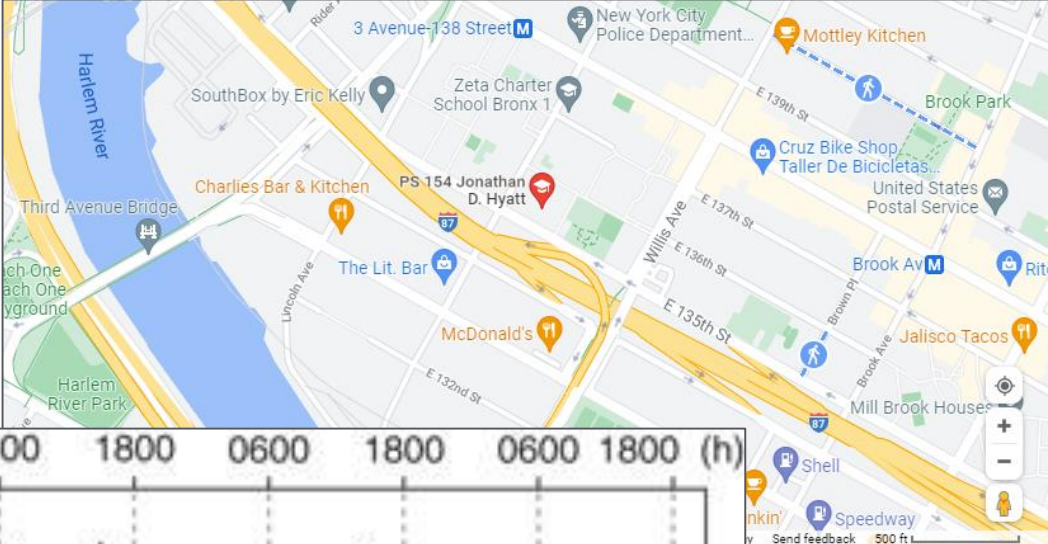


# Schools are often located near major roadways

- 114,644 US public and private schools grades pre K - 12 (2005-06)
- 3.2 million children (6.2%) attended schools within 100 meters of a major roadway
- Schools serving predominately Black students were 18% more likely to be near a major roadway



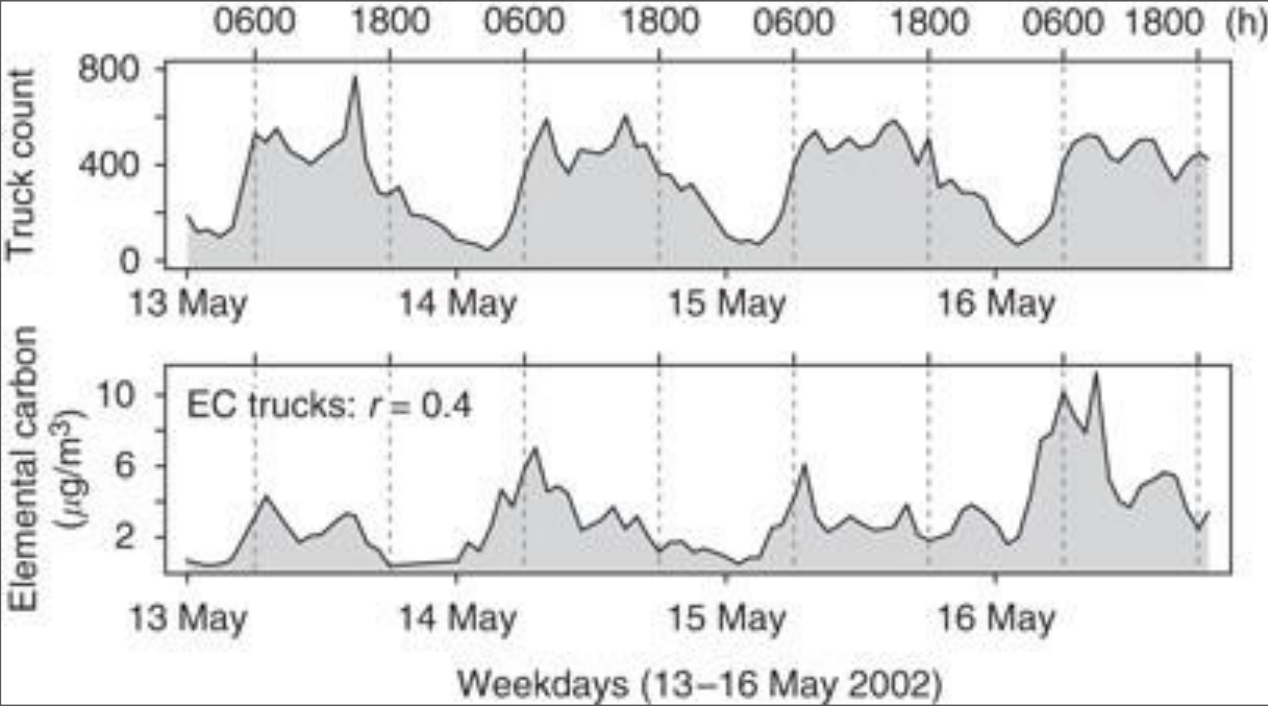
# Outdoor pollution at Bronx, NY school closely related to highway truck traffic counts



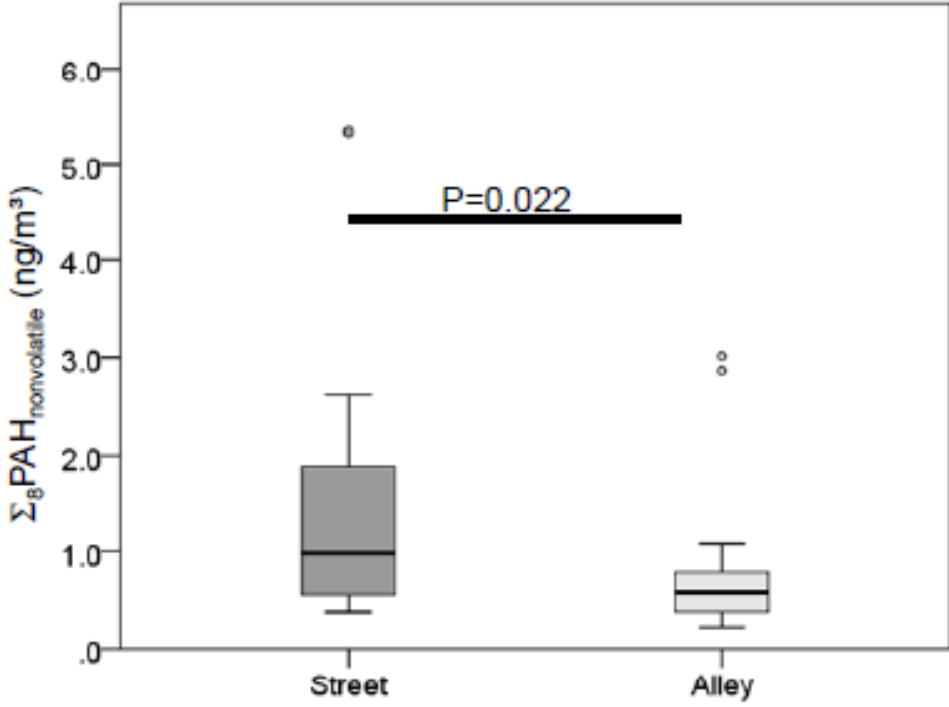
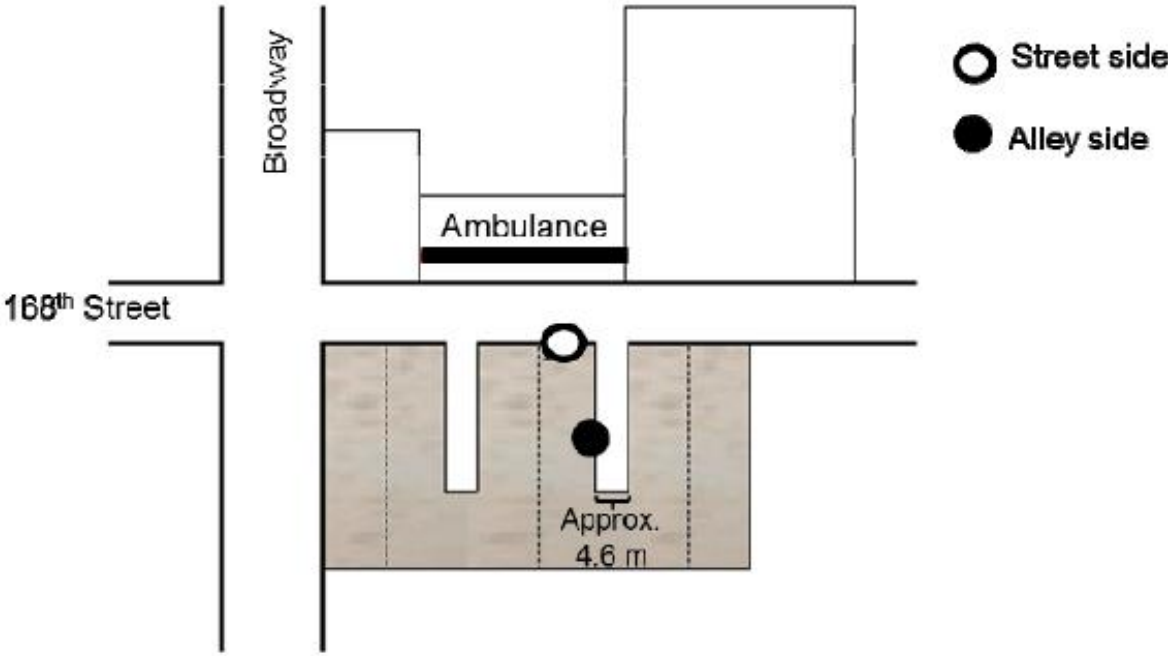
Truck traffic counts

School-site elemental carbon (EC) concentrations

Highest peaks early morning rush hour traffic



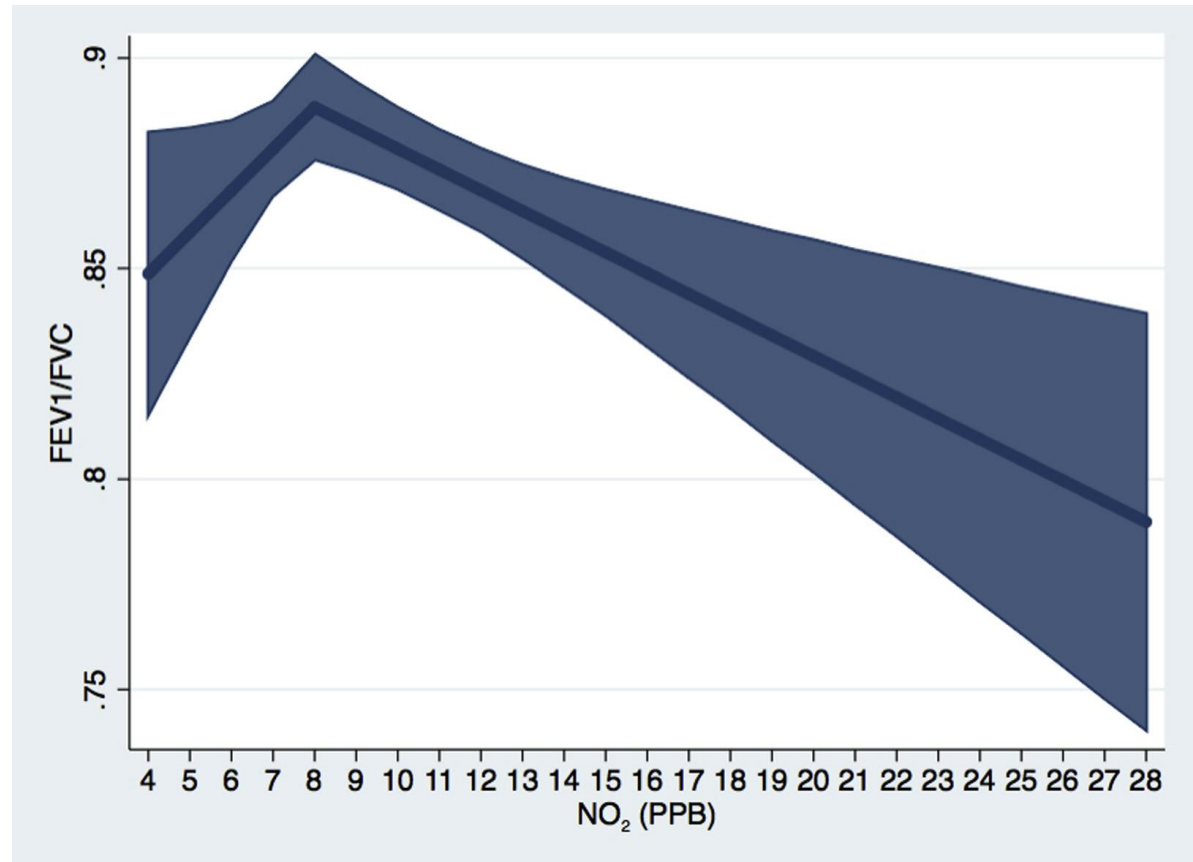
# Pollution exposure is higher adjacent to a street compared to near an alley





# School Inner City Asthma Study - Boston

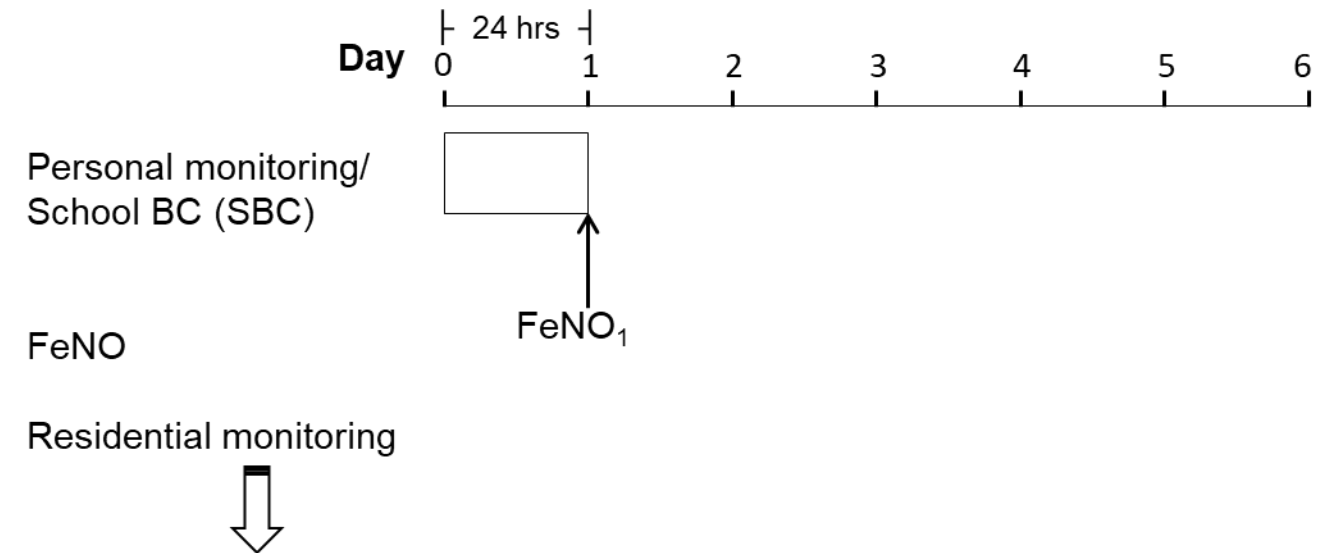
- 188 children ages 4-13 years (34% Black, 36% Hispanic, 18% Mixed race, 4% White)
- NO<sub>2</sub> measured in the classrooms for 1-week, twice per year
- Lung function measured during that same week



# Personal Pollution Monitoring in NYC Schools

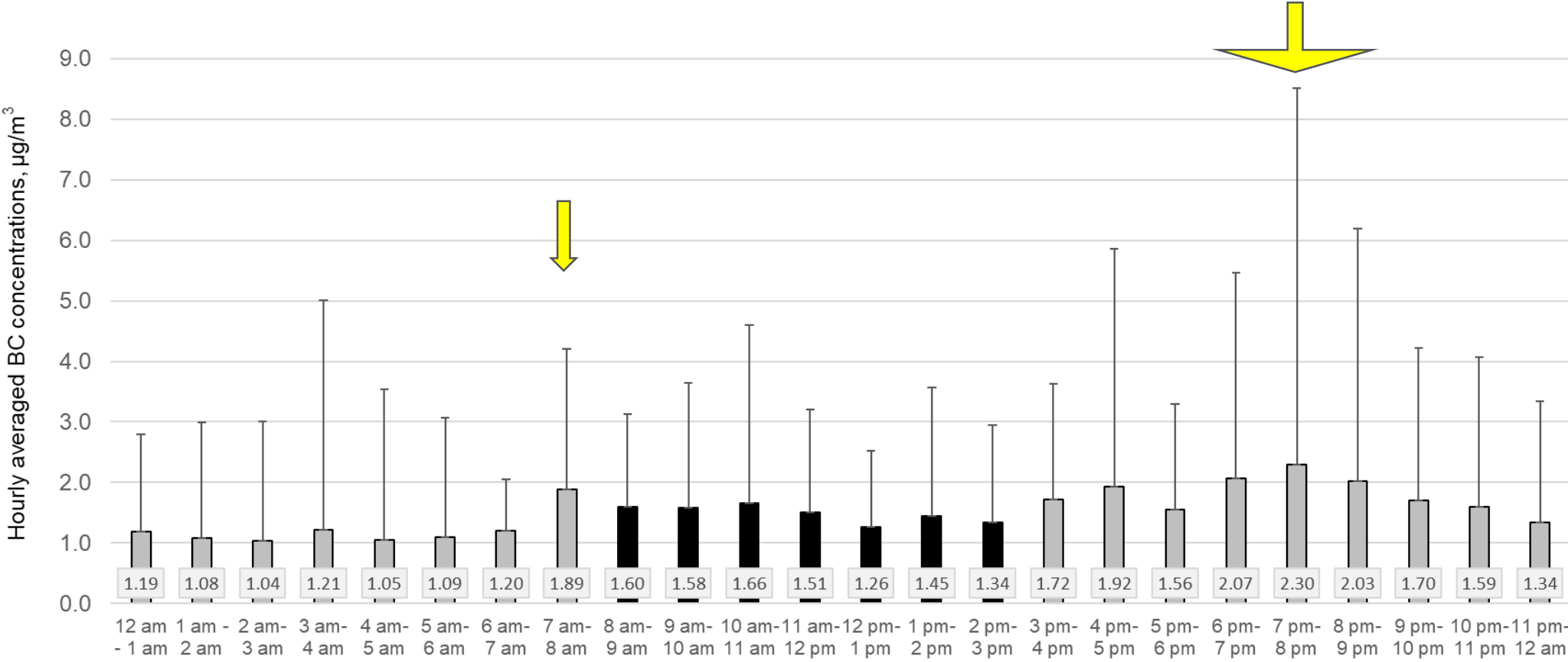
- 114 children ages 1-14 years (61% Dominican, 39% Black)
- Personal Black Carbon monitors for two 24-hr periods, 5 days apart
- Airway inflammation measured after pollution monitoring

## A. Time 1



## B. Repeated 6 months later (Time 2)

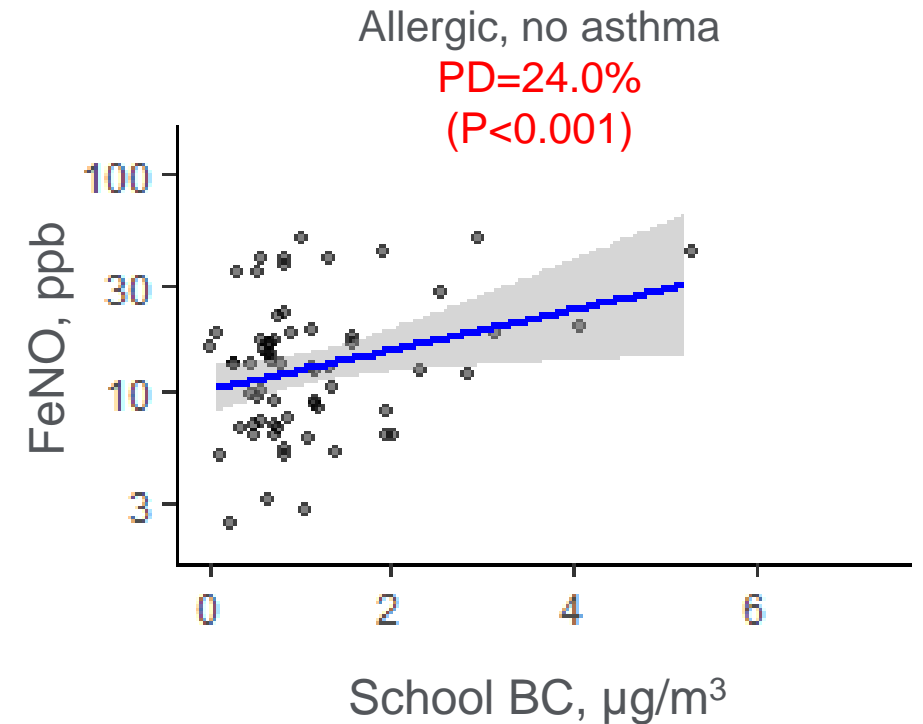
# Highest Personal BC Pollution Exposure Before School and in the Evenings





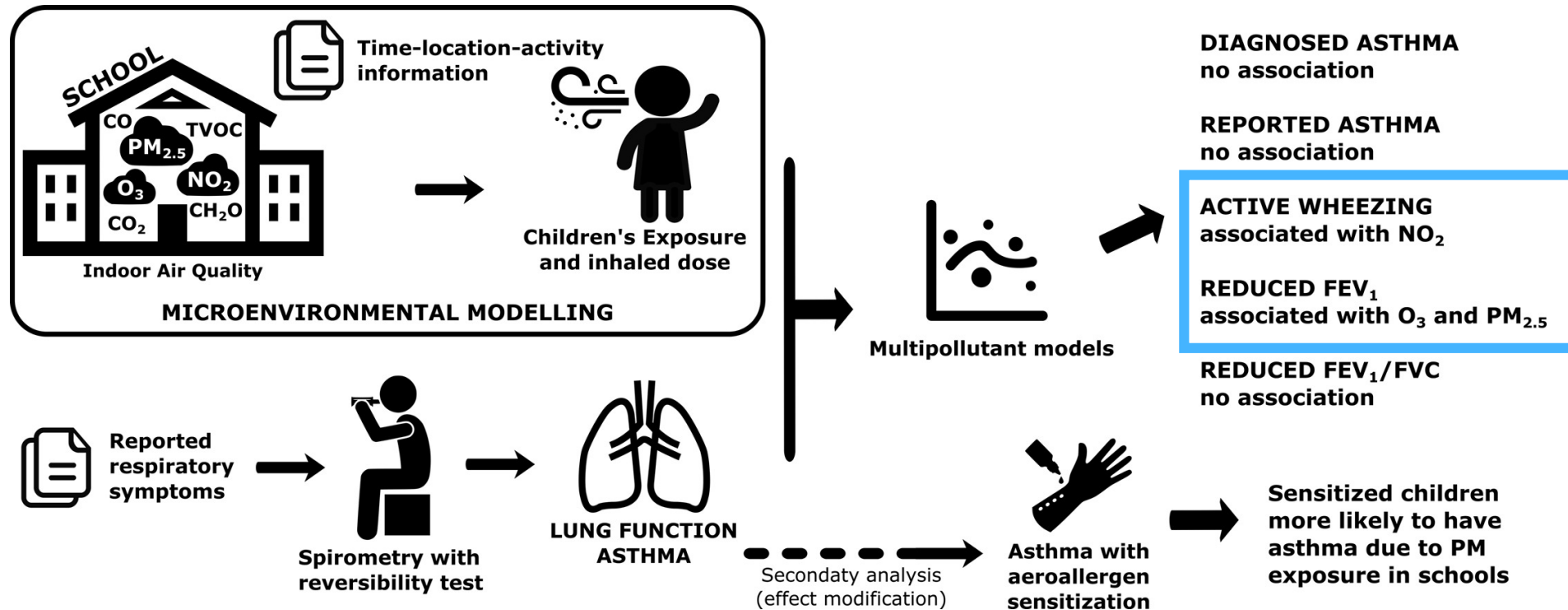
# Personal exposure to BC during school associated with increased airway inflammation

	% difference	95% CI	p-value
School BC	7.47%	1.31, 13.9	0.02
Commute BC	6.82%	0.70, 13.3	0.03
Non-school BC	1.92%	-1.09, 5.13	0.22
Residential BC	-0.50%	-9.88, 9.75	0.92

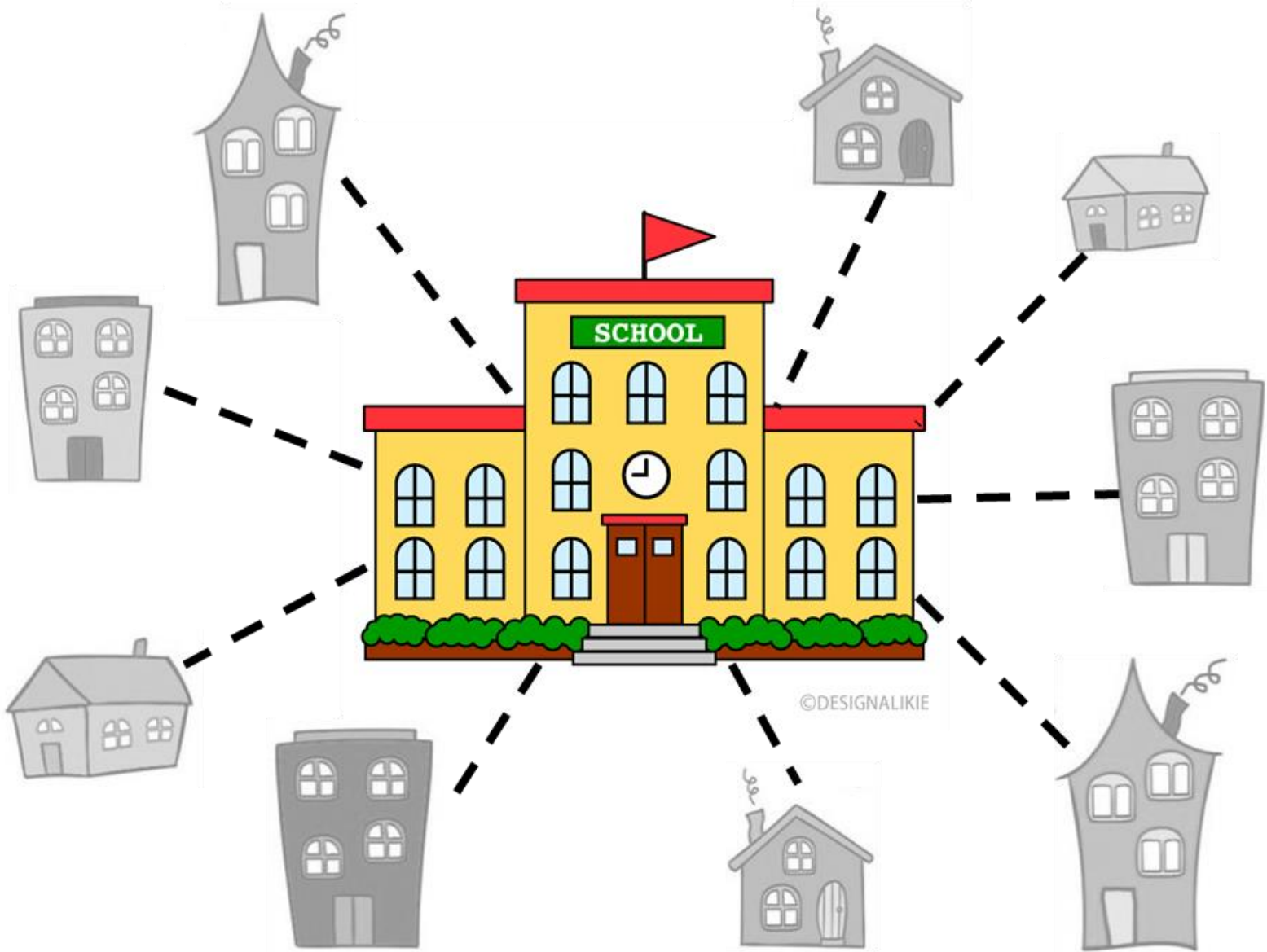


# Indoor air pollution in nursery and primary schools in Portugal associated with asthma outcomes

648 pre-school and 882 primary school children in Portugal



# School vs. Home Environmental Exposures and Respiratory Outcomes



**ECHO**

Environmental influences  
on Child Health Outcomes

A program supported by the NIH





# What measures can be taken to reduce air pollution in the school environment?



# Philadelphia school district to install new air purifiers despite concerns from air quality specialist

By Neena Hagen | Jul 21, 2021, 7:07pm EDT

Chalkbeat

PHILADELPHIA

f t REPUBLISH



Philadelphia school officials believe the new \$4.5 million air and surface purifiers are safe for students when district plans to install 9,500 devices by the end of the month.

| WHYY

Wirecutter



## Let's clear the air on air purifiers and COVID

By

The News & Observer

t f e r

UPDATED SEPTEMBER 20, 2021 9:17 AM



Photo: Tim Heffernan

## Can HEPA Air Purifiers Capture the Coronavirus?

UPDATED NOVEMBER 18, 2020 We've updated this guide to reflect [current understanding about airborne transmission](#).

# High Efficiency Particulate Air (HEPA) Filter



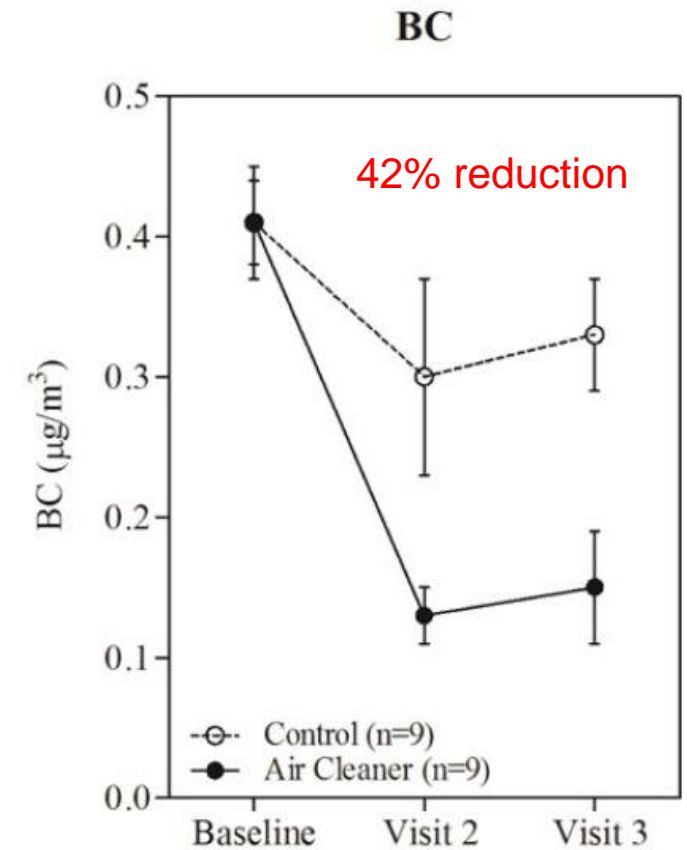
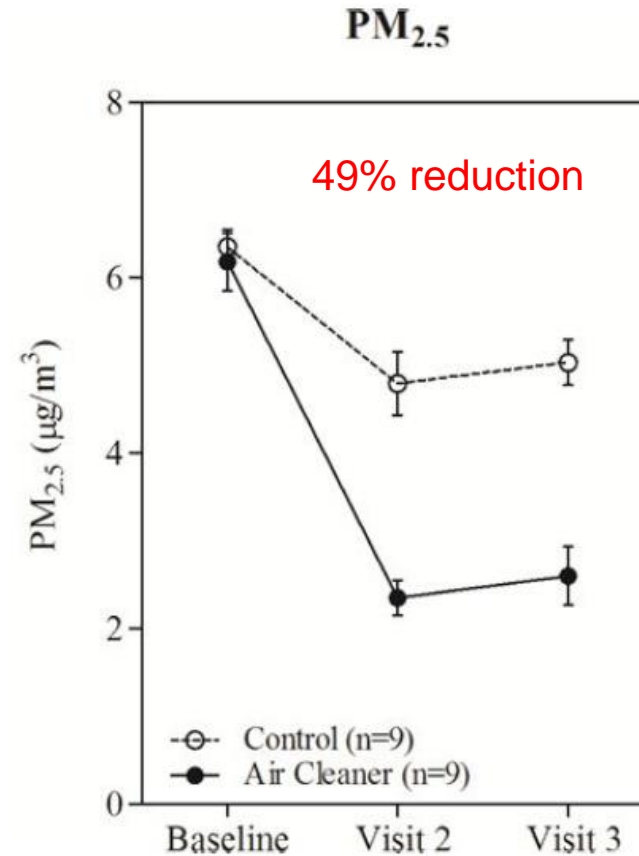


# HEPA filters in Boston classrooms reduced pollution concentrations

25 children with asthma, age 6-10 years (60% Black, 24% Hispanic)

9 intervention (air cleaner with HEPA filter) and 9 control classrooms over 6 months

Modest improvements in lung function and asthma symptoms in intervention compared to control groups

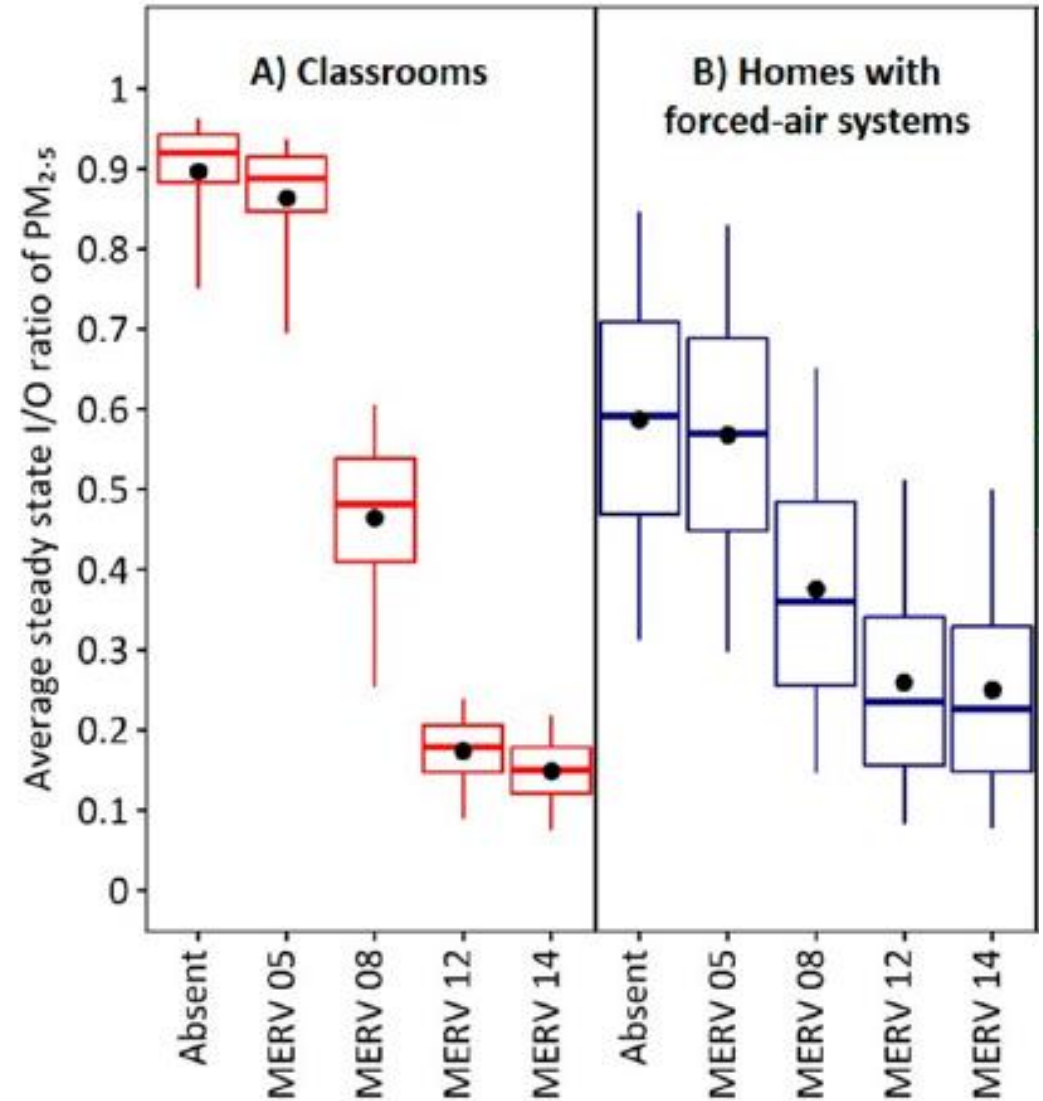


# Enhanced filters in schools and homes to reduce indoor exposure to pollution in Detroit

Estimated indoor  $PM_{2.5}$  in 290 schools in Detroit

More efficient filters in schools would reduce asthma-related health burden (decreased asthma symptom days)

MERV: minimum efficiency reporting value  
(HEPA = MERV  $\geq 17$ )



# Unflued gas heater replacement in Australian schools associated with improved respiratory outcomes

8 intervention schools (n=45), 10 control schools (n=73)

Replacement of gas heaters with either flued or electric heaters

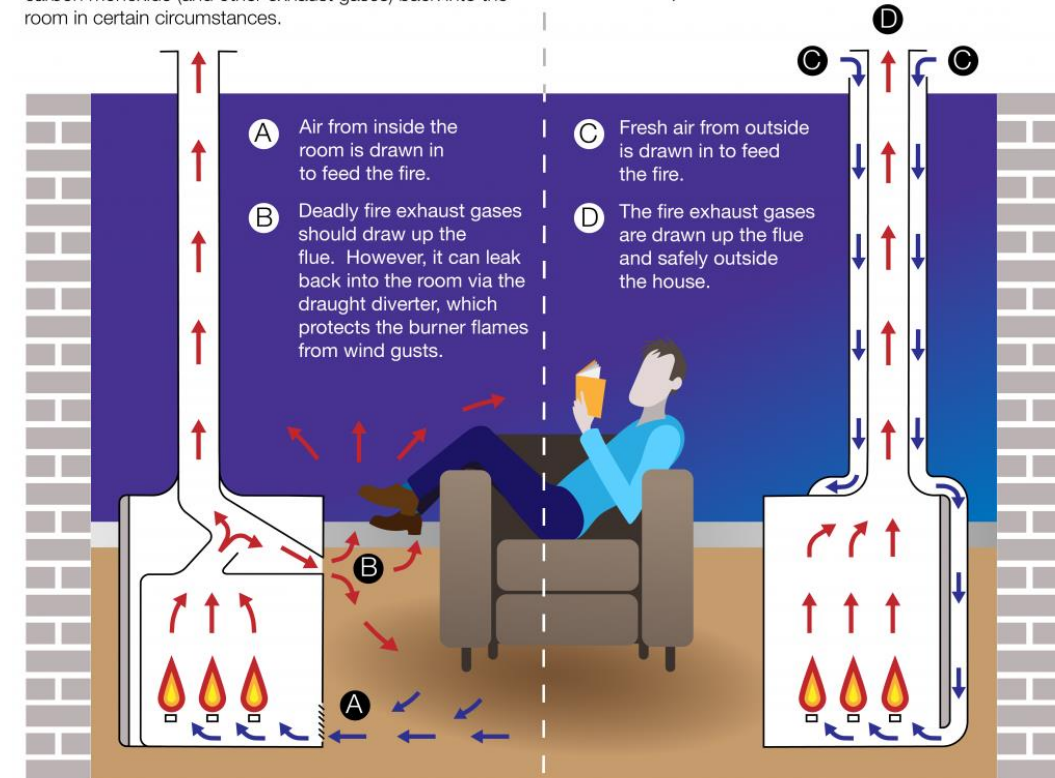
Mean NO<sub>2</sub> levels: 15.5 (6.6) ppb vs. 47.0 (26.8) ppb

	% Difference	RR [95% CI]
Daytime difficulty breathing	59%	0.41 [0.07, 0.98]
Nighttime difficulty breathing	68%	0.32 [0.14, 0.69]
Chest tightness	55%	0.45 [0.25, 0.81]
Daytime asthma attacks	61%	0.39 [0.17, 0.93]

## OPEN-FLUED HEATERS

Draw air from the room to feed the fire.

Inadequate ventilation and use of exhaust fans can draw carbon monoxide (and other exhaust gases) back into the room in certain circumstances.



## ROOM SEALED HEATERS

Draw air from outside the house to feed the fire.

As they are sealed, exhaust gases are drawn up the flue and dispersed outside.



# Air Quality Flag Program

**GOOD**

**MODERATE**

**UNHEALTHY**  
for Sensitive Groups

**UNHEALTHY**

**VERY UNHEALTHY**

**Raise a flag  
to show the  
air quality forecast  
in your area.**

Learn more at:  
[airnow.gov/flag](http://airnow.gov/flag)



It's a great day to be active outside!

It's a good day to be active outside.

It's OK to go outside and be active for recess or PE class. For longer activities, take it a little easier.

Take it a little easier if you do any outside activities

It's a good day to play inside.

## Go for 60!

CDC recommends 60 minutes or more of physical activity each day.

## Watch for symptoms!

Coughing or shortness of breath are signs to take it easier. Air pollution can make asthma symptoms worse and trigger attacks.

## Take it easier.

Take some breaks. Do less intense activities like walking instead of running when it's an orange or red day.

## Plan ahead for ozone.

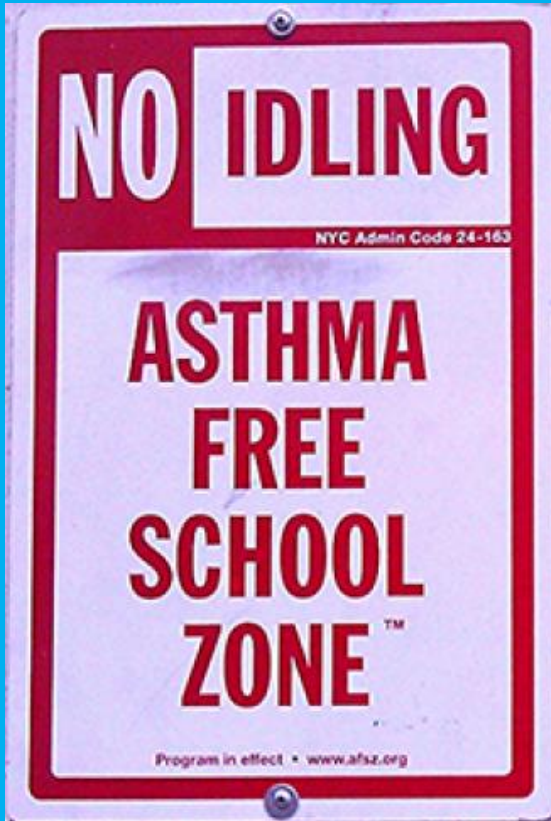
There is less ozone in the morning, so do intense activities in the morning on ozone air pollution days.



EPA-456/H-15-001  
September 2015

[www.airnow.gov/flag](http://www.airnow.gov/flag)





## Around Schools...

- Ask bus driver and carpool drivers to turn off their engines if parked more than 30 seconds.
- Play or exercise as far as possible from busy roads.
- Check the Air Quality Index daily or download the mobile app at [www.airnow.gov](http://www.airnow.gov).

Philadelphia  
Cloudy

Now	5PM	6PM	6:47PM	7PM	8PM	9PM
73°	73°	72°	Sunset	70°	70°	66°

50% 50%

Wednesday		72	54
Thursday		66	52
Friday		70	48
Saturday		73	48
Sunday	30%	73	57
Monday		68	57
Tuesday		68	55
Wednesday	30%	72	55
Thursday	30%	72	57

Today: Cloudy currently. The high will be 75°. Partly cloudy tonight with a low of 59°.

AIR QUALITY AQI (US)

### 75 – Moderate

More data from BreezoMeter >



# Take home messages

1. *What do we know about air pollution exposure and childhood asthma?*
  - Air pollution causes asthma and worsens asthma symptoms
2. *How are children exposed to air pollution in the school environment?*
  - The predominant source of indoor air pollution in school is from outdoor sources, particularly traffic related pollution
3. *What measures can be taken to reduce air pollution in the school environment?*
  - Air filtration devices that include HEPA filters can reduce air pollution in classrooms along with education programs such as the Air Quality Flag Program



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**ASPIRE!**

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