Moderate to vigorous physical activity levels negatively correlate with traffic related air pollutants in children with asthma attending a school near a freeway

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Air Pollution

- 43.5 million exposed to traffic pollution in the U.S. [1,2]
- More likely to affect those in underserved communities
- Abundant evidence of adverse health effects [3-5]

1. Li et al. 2011
2. Raysoni et al. 2013
3. Greenwald et al. 2013
4. Zora et al. 2013
5. Sarnat et al. 2012

Heavy Traffic Air Pollution

- Associations in asthmatic children [6]
  - ↑ Airway inflammation
  - ↓ Lung function
- Schoolchildren living 30-300 meters from a major roadway [7]
  - ↑ Arterial stiffness
  - ↓ Academic performance
  - ↑ Absenteeism
  - ↑ Clinical symptoms

6. Raysoni et al. 2011
7. Staniswalis et al. 2009

Exposure to air pollutants and physical activity

- The benefits of physical activity are essential for overall health[8]

- Outdoor activities (walking, jogging, dancing)
  - ↓ Risk of cardiovascular disease
  - ↓ Metabolic syndrome[9]

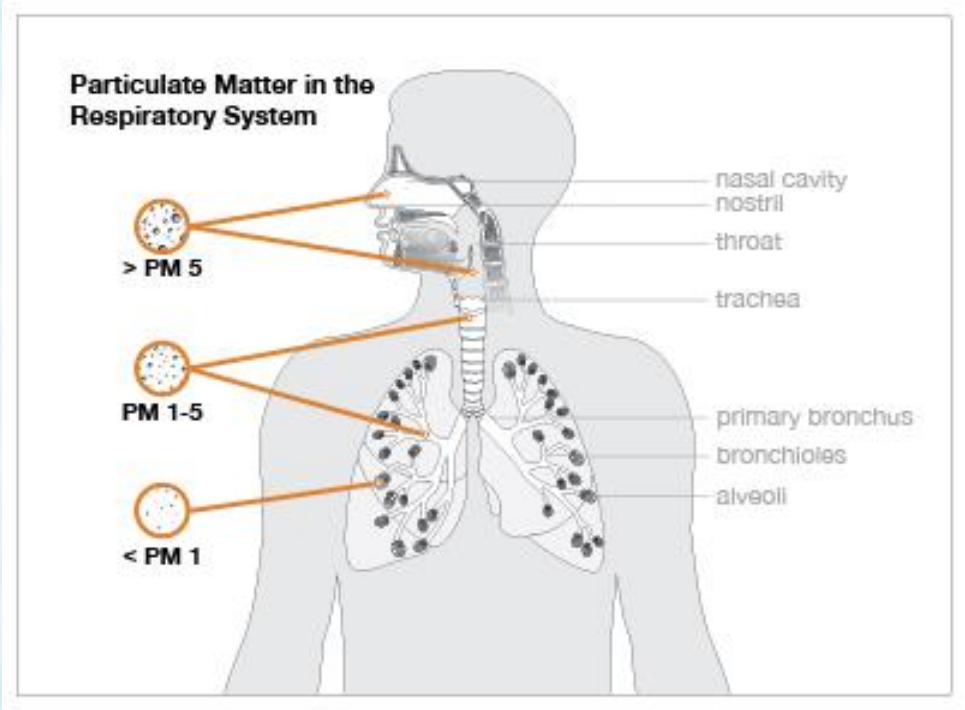
- Outdoor physical activity exposes people to air pollutants (might lead to)
  - ↑ Cardiovascular or respiratory diseases [10-13]

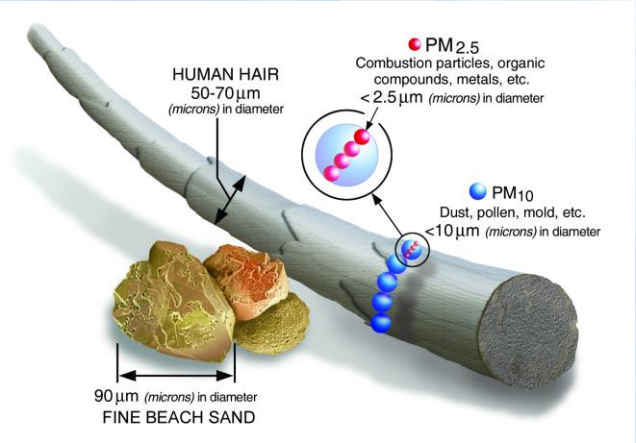
8. Janssen et al. 2010
9. Raysoni et al. 2013
10. Greenwald et al. 2013
11. Zora et al. 2013
12. Sarnat et al. 2012

Exposure to air pollutants and physical activity

- Physical activity:
  - ↑ respiratory intake
  - ↑ deposition of air pollutants in the lungs[14]

- Exercise: exposure or inhalation to air pollutants
  - ↓ performance[15]
  - ↓ lung function[16]



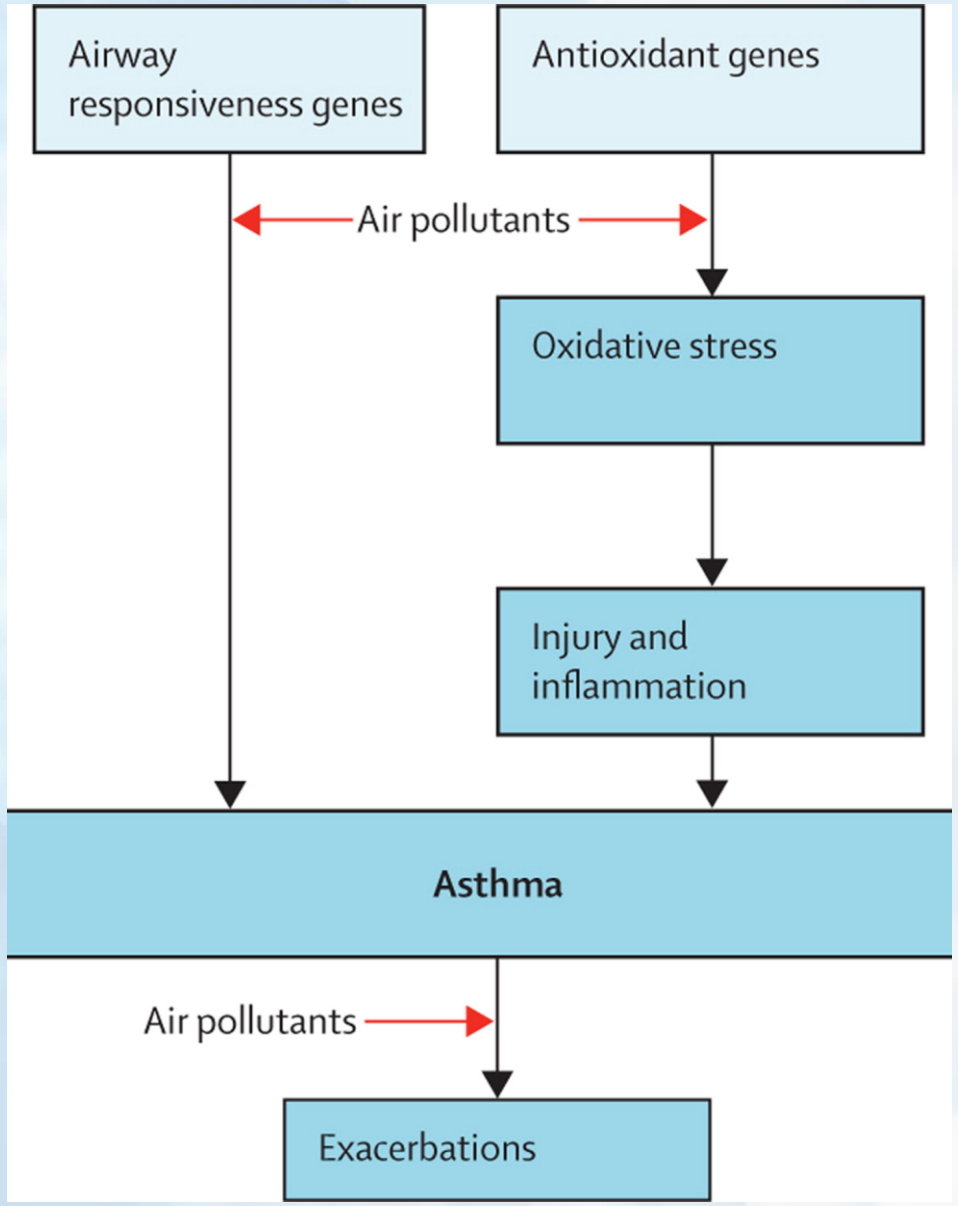


14. Giles et al. 2014
15. Rundell et al. 2008
16. Cutrufello. 2012

Particulate matter images retrieved from http://aurametrix.weebly.com/topics/particulate-matter

Effects on Asthma

- People with asthma may have
  - ↓ physical activity
    - avoid aerobic fitness
    - concerns of triggering asthma symptoms[17-18]
- In a polluted environment
  - ↑ risk of having an asthma attack[10]
  - ↑ lung pathologies[14]
- Health habits → young age
  - Emphasize physical activity with asthma patients[19]

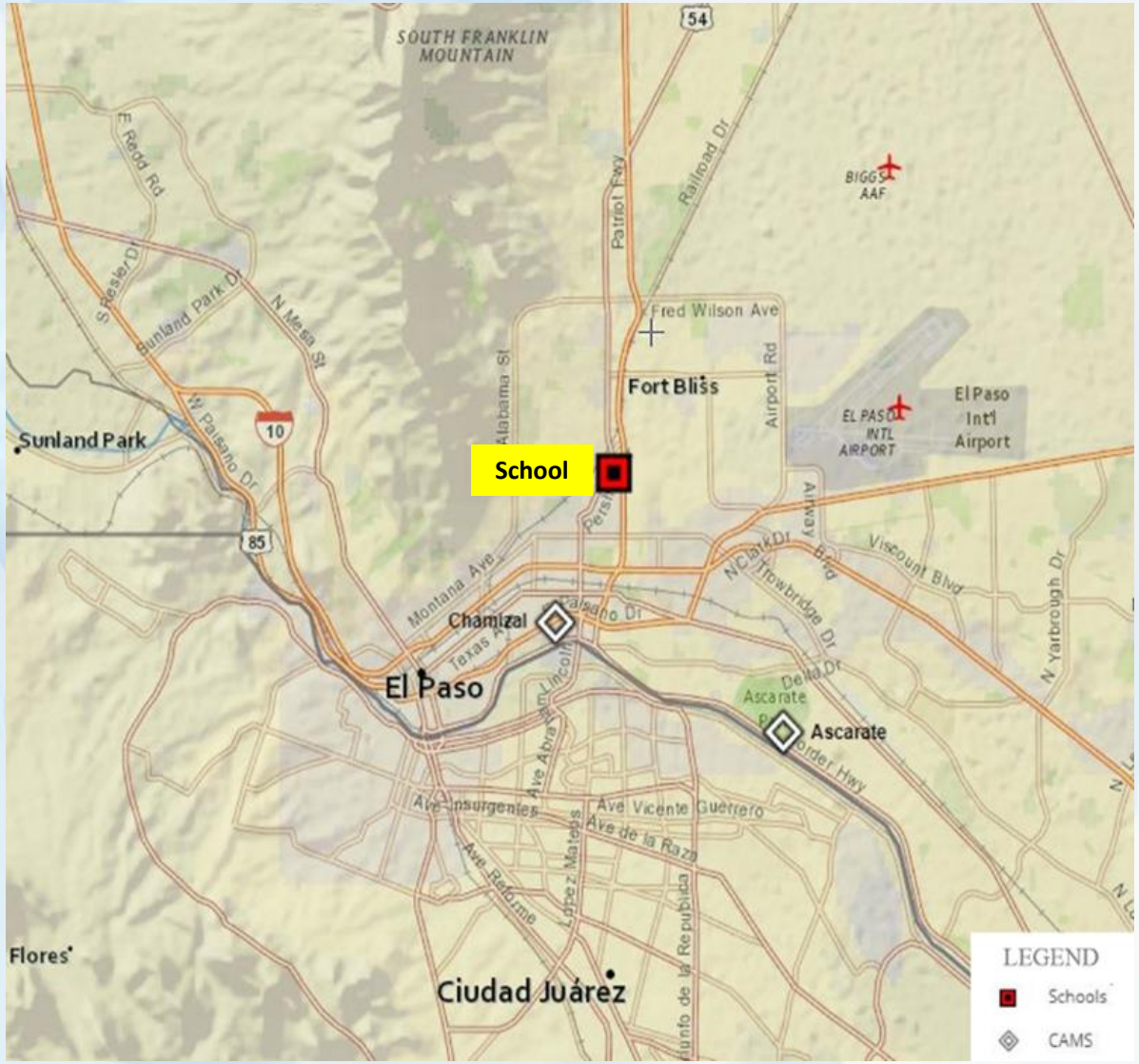


Mechanistic framework for air pollution effects in asthma retrieved from https://www.sciencedirect.com/science/article/pii/S0140673614606176

17. Mälkiä et al. 1998
18. Garfinkel et al.1992
10. Sharman et al 2004
14. Giles et al al. 2014
19. Mancuso et al. 2006

Data Collected for the Study

- Study period: 10 weeks from Oct. - Dec. 2017
- Air quality data at elementary school
  - $PM_{2.5}$, PM_{10}, NO_2 and ozone.
- Health measurements Physical Activity by Accelerometer
    - 1 day/week, during school hours
    - n=12, ages 6-12



Physical Activity Monitor

- Movement in three axis
- % time spent on moderate to vigorous physical activity (MVPA), light activity, and sedentary activity
  - MVPA : brisk walking, jogging, and playing active sports
  - Light : slow walking, playing instruments
  - Sedentary: sitting, lying down

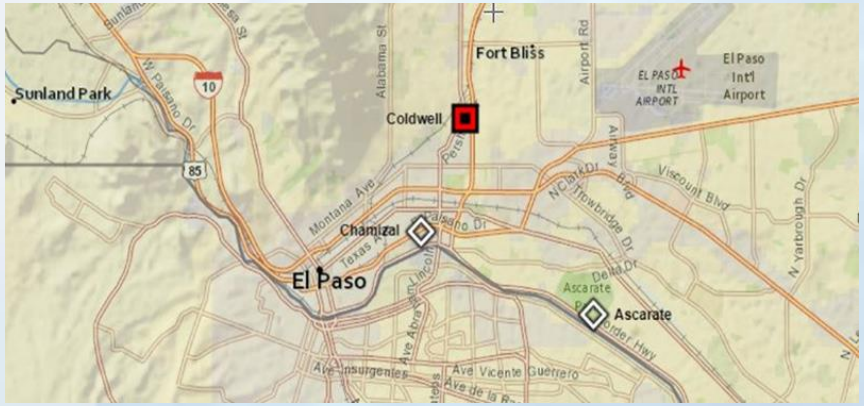
Statistical Analysis

- Summary statistics of air pollution metrics ($PM_{2.5}$, PM_{10}, NO_2, O_3)
- Pollutant averaged with exposure periods (24-, 48-, 72-, 96-hr)
- Summary statistics of physical activity outcomes
- Correlation analyses with physical activity monitoring
- Longitudinal analyses using GEE models with assumptions of:
  - subject-specific cluster, and
  - exchangeable correlation structure for the repeated measures of data

Subject Characteristics

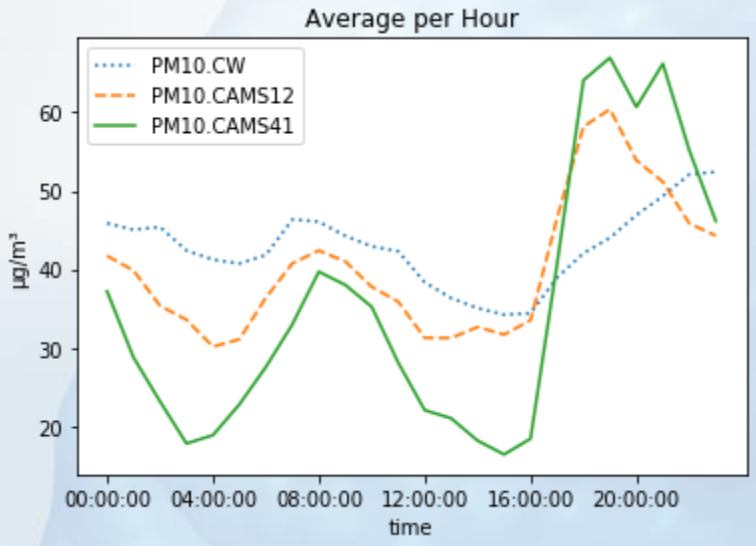
n=12 children	mean ± sd	range
Age (yrs)	8.3 ± 1.5	6-10
Height (in)	54.3 ± 4.4	(46.3-70.0)
Weight (lb)	76.3 ± 27.3	(45.8-134)
BMI (kg/m^2)	17.9 ± 5.0	(12.3-27.8)
BMI (%ile)	49.8 ± 41.2	(0-99.4)
Physical Activity (%, N=102 measures)		
MVPA	63.4 ± 8.2	(30.4-77.7)
Light	10.1 ± 1.7	(7.1-14.4)
Sedentary	26.5 ± 7.9	(13.7-61.7)

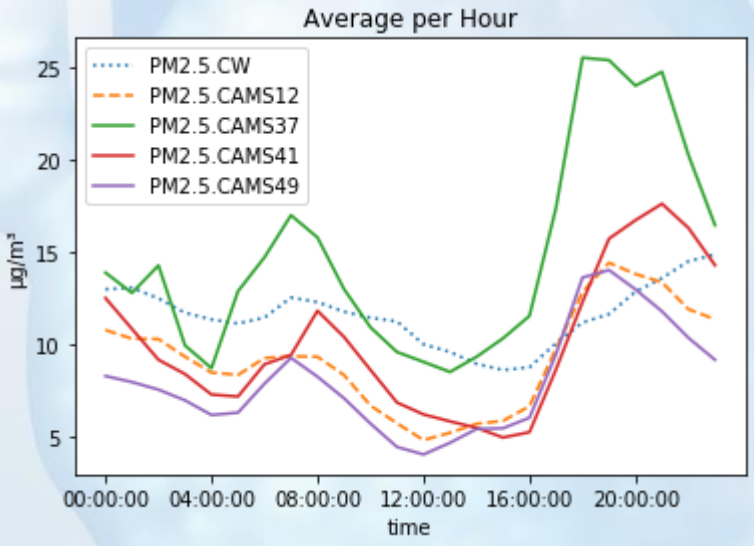
School and ambient pollutant metrics

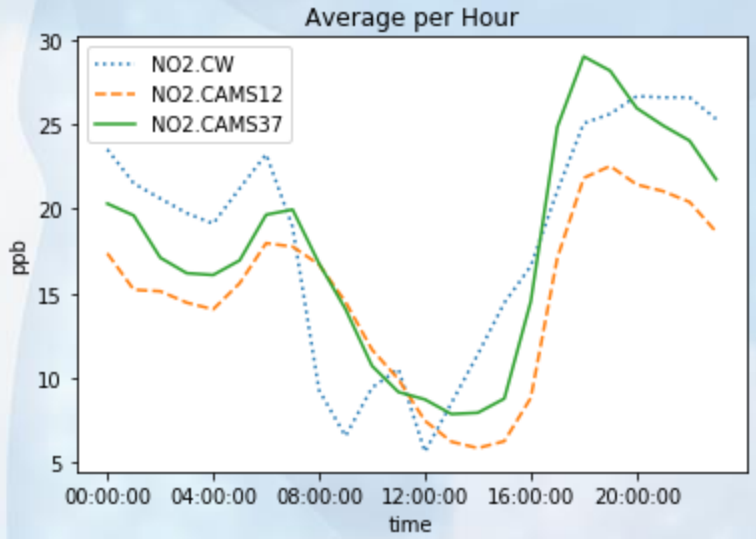


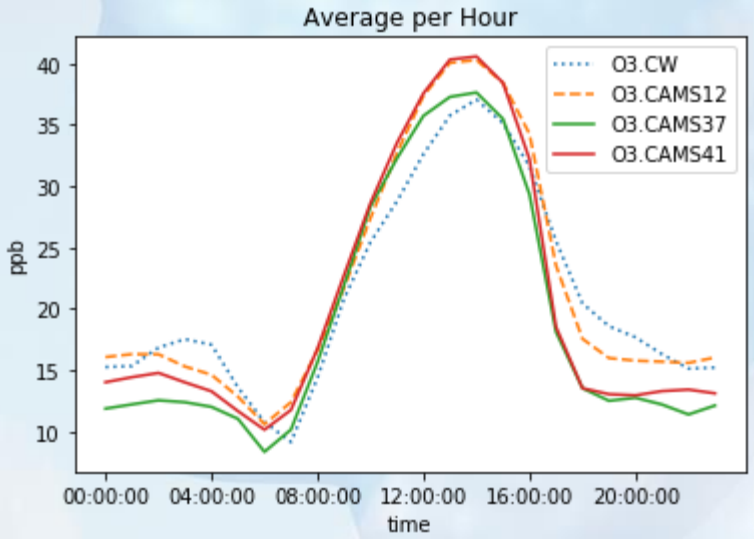
	24-hr	48-hr	72-hr	96-hr	96-hr (CAMS)
$PM_{2.5}$ (µg/m³)					
Mean	**12.52**	**11.73**	**11.48**	**12.16**	**10.17**
SD	3.71	2.40	1.88	2.80	5.25
PM_{10} (µg/m³)					
Mean	**45.30**	**43.05**	**42.55**	**44.94**	**36.89**
SD	17.36	12.47	8.70	9.13	12.43
NO_2 (ppb)					
Mean	**17.63**	**18.20**	**18.40**	**18.94**	**17.90**
SD	6.06	3.25	3.06	3.72	5.11
O_3 (ppb)					
Mean	**21.41**	**20.37**	**21.75**	**20.35**	**19.85**
SD	10.51	6.66	7.25	5.47	5.08

Diurnal trend during entire study period: school and El Paso CAMS stations









Interaction of physical activity rates per factor level

Subject-specific Factor	Frequency,% (n=12)		Physical activity MVPA	p-value*	Sedentary	p-value*
Sex						
Male	7	58%	65.8%	**0.001**	24.2%	**0.001**
Female	5	42%	60.0%		29.2%	
BMI category						
Underweight & Normal	8	67%	61.9%	**0.010**	28.4%	**< 0.001**
Overweight & Obese	4	33%	66.5%		22.6%	
Father with Asthma	3	25%	60.9%	**0.041**	28.8%	**0.032**
No	9	75%	64.3%		25.7%	
Siblings with Asthma	6	50%	61.2%	**0.005**	28.8%	**0.001**
No	6	50%	65.6%		24.1%	
Having Eczema	3	25%	66.8%	**0.012**	23.2%	**0.011**
No	9	75%	62.2%		27.7%	

Subject-specific Factor	Frequency,% (n=12)		Physical activity MVPA	p-value*	Sedentary	p-value*
Health Insurance Coverage(n=11)						
Medicaid	6	55%	66.5%	**0.003**	23.9%	**0.039**
Private	5	45%	61.2%		27.9%	
Smoking (outside of household)	2	17%	59.9%	**0.013**	29.9%	**0.010**
No	10	83%	64.2%		25.7%	
Cooking Fuel						
Electric	1	8%	68.7%	**0.035**	22.7%	0.127
Gas	11	92%	62.9%		26.8%	
Leukotrieneblockers (LB)	7	58%	66.4%	**< 0.001**	23.7%	**< 0.001**
No	5	42%	59.4%		30.3%	
Long-acting bronchodilators and inhaled corticosteroids (LABAIC)	2	17%	68.1%	**0.012**	22.0%	**0.013**
No	10	83%	62.6%		27.2%	
Nasal corticosteroids (NC)	4	33%	66.8%	**0.003**	23.4%	**0.007**
No	8	67%	61.7%		28.0%	

**p*-value for mean difference in physical activity between factor levels using Kruskal-Wallis test.

There were no significant interactions found for mother with asthma; father, mother, or sibling with hay fever; allergic phenotype (air or food); caretaker education level; Short Acting Beta Agonist (SABA); Inhaled Corticosteroids (IC); Systemic Corticosteroids (SC).

Associations between MVPA and sedentary activity

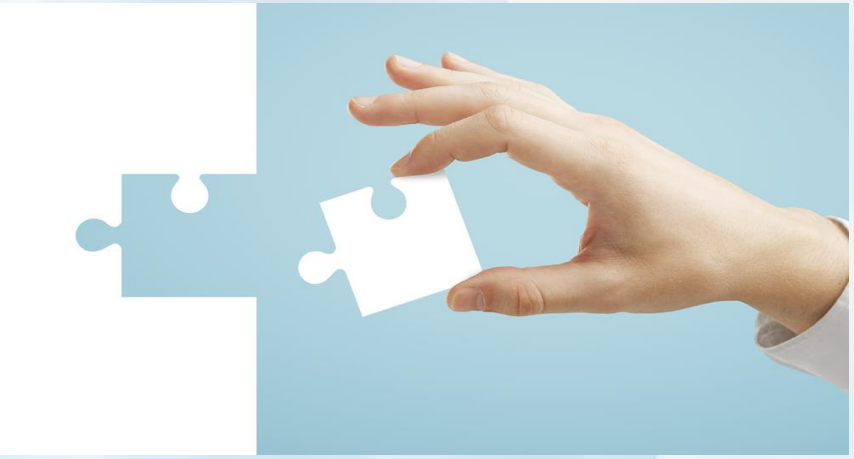
Pollutant		IQR	MVPA				Sedentary			
			% Change in PA per IQR change in pollutant	95% C.I.		p value	% Change in PA per IQR change in pollutant	95% C.I.		p value
				lower	upper			lower	upper	
$PM_{2.5}$	72-hr	3.11	**-1.71%**	**-2.95%**	**-0.46%**	**0.007**	**1.43%**	**0.24%**	**2.61%**	**0.018**
	96-hr	4.07	**-3.45%**	**-5.00%**	**-1.90%**	**< 0.001**	**3.43%**	**1.78%**	**5.09%**	**< 0.001**
	96-hr CAMS	5.22	**-3.86%**	**-6.12%**	**-1.59%**	**0.001**	**4.04%**	**1.71%**	**6.37%**	**0.001**
PM_{10}	72-hr	11.93	**-1.32%**	**-2.24%**	**-0.39%**	**0.005**	**1.00%**	**0.09%**	**1.91%**	**0.031**
	96-hr	9.56	**-1.59%**	**-2.37%**	**-0.81%**	**< 0.001**	**1.51%**	**0.69%**	**2.34%**	**< 0.001**
	96-hr CAMS	16.84	**-2.87%**	**-4.65%**	**-1.08%**	**0.002**	**3.07%**	**1.19%**	**4.95%**	**0.001**
NO_2	72-hr	2.76	-0.60%	-1.30%	0.11%	0.098	0.66%	-0.06%	1.38%	0.075
	96-hr	4.96	**-1.35%**	**-2.62%**	**-0.09%**	**0.036**	**1.52%**	**0.25%**	**2.79%**	**0.019**
	96-hr CAMS	5.19	**-0.78%**	**-1.53%**	**-0.04%**	**0.040**	0.63%	-0.12%	1.38%	0.099
O_3	72-hr Max $O_3$8hr	9.94	**-3.99%**	**-6.35%**	**-1.63%**	**0.001**	**4.62%**	**2.15%**	**7.08%**	**< 0.001**
	72-hr	12.32	-0.66%	-2.33%	1.01%	0.437	1.41%	-0.37%	3.19%	0.120
	96-hr	8.57	-0.33%	-1.81%	1.15%	0.661	0.49%	-1.05%	2.04%	0.530
	96-hr CAMS	7.50	-0.04%	-1.51%	1.43%	0.955	0.24%	-1.34%	1.82%	0.766

Summary

- 96-hr average concentration of pollutants was higher than CAMS stations
- 96-hr $PM_{2.5}$, PM_{10}, and NO_2 negatively correlate with MVPA
- 96-hr $PM_{2.5}$, PM_{10}, and NO_2 positively correlate with sedentary activity
- GEE models account for individual factors
- For O_3 the use of maximum values had a significant association

Discussion

- First study to characterize associations of traffic air pollutants with physical activity in children with asthma *using objective measures of physical activity*
- On-site school monitoring reveals a *relatively* higher level of exposure than CAMS locations



Recommendations

- Placement of natural barriers to mitigate air pollutants (intercept particulate matter)[20]
- Policy changes
  - Add on-site air quality monitoring at schools near high-traffic roads. Use data to inform:
    - Outdoor activity schedule
    - Transportation-to-school policies (decrease vehicle idling at drop off and pick up, increase active transportation, etc.)
  - Future school sites ensure outdoor activity space by being away from high-traffic roads

20. Currie et al. 2008

Acknowledgements

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The contents of this presentation are solely the responsibility of the authors and do not necessarily represent the official views of the U.S. DOT.

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Thank you !