BAQS: Windsor, Ontario Exposure Assessment Studies - Update

October 2008

Detroit, Michigan

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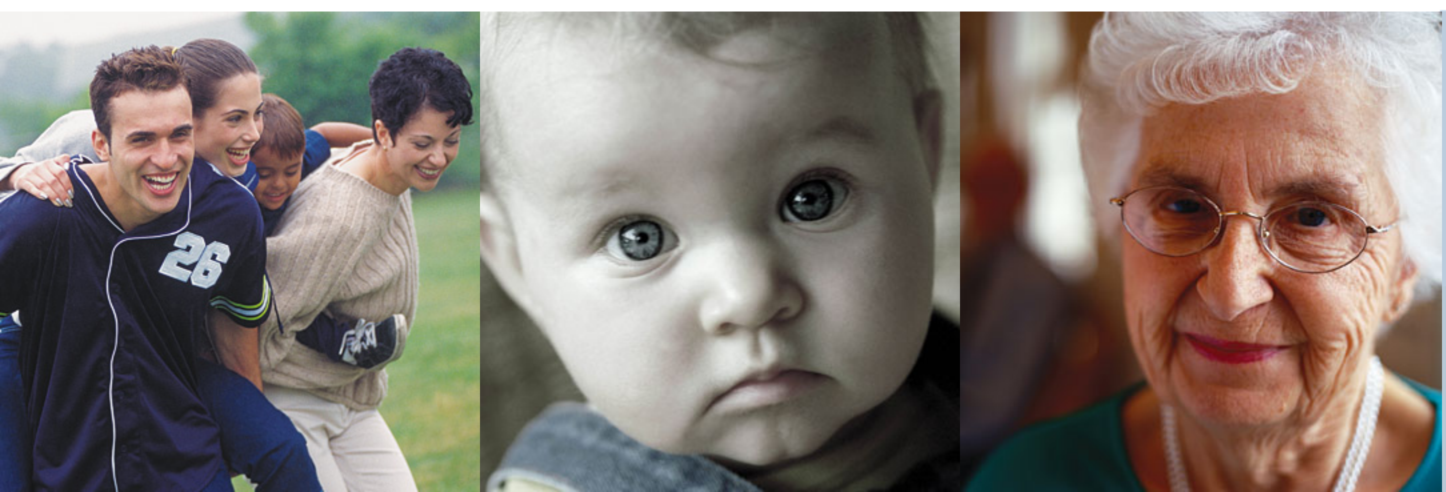
Air Health Science Division



Canada

INTRODUCTION

Spatial Studies

- 2004
- 2005
- 2006

Personal Exposure Assessments

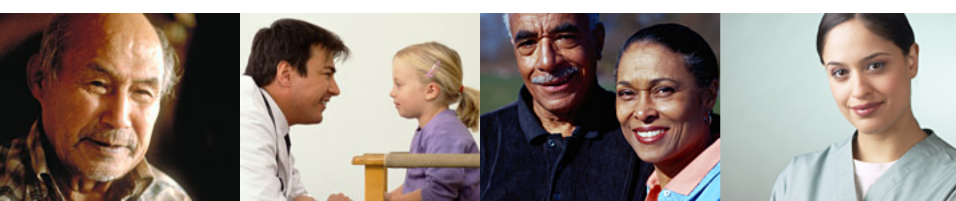
- 2005 – Healthy Adults
- 2006 – Asthmatic Children

Respiratory Health Effects

- 2004 – Survey
- 2005 – Cross Sectional Lung Function
- 2005 – Longitudinal Lung Function

Cardiovascular Health Effects

- 2005 – Diabetics
- 2007 – Seniors



STUDY DESIGN - Spatial

Integrated 2-week sampling sessions

- 4 seasons in each of 2004, 2005 and 2006

150 sampling sites

- between 1 and 8 seasons at each site (typically 50 sites per year)

<u>Pollutants</u>

NO_2 – Ogawa (2004)

$PM_{2.5}$ – PEM 1.8 LPM; Abs Coeff. – smokestain reflectance of $PM_{2.5}$

$PM_{2.5\text{-}10}$ – Harvard Cascade Impactor

Acid vapour (acetic, formic, nitric) – filter pack

Volatile Organic Compounds (VOCs) – 3M Badge (2004)

Polycyclic Aromatic Hydrocarbons (PAH) – URG pesticide sampler

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Intra-urban variability of air pollution in Windsor, Ontario—Measurement and modeling for human exposure assessment ☆

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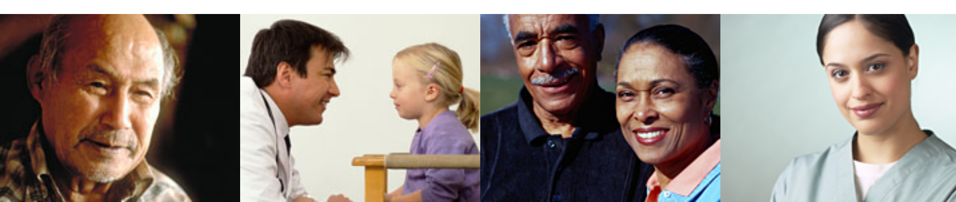


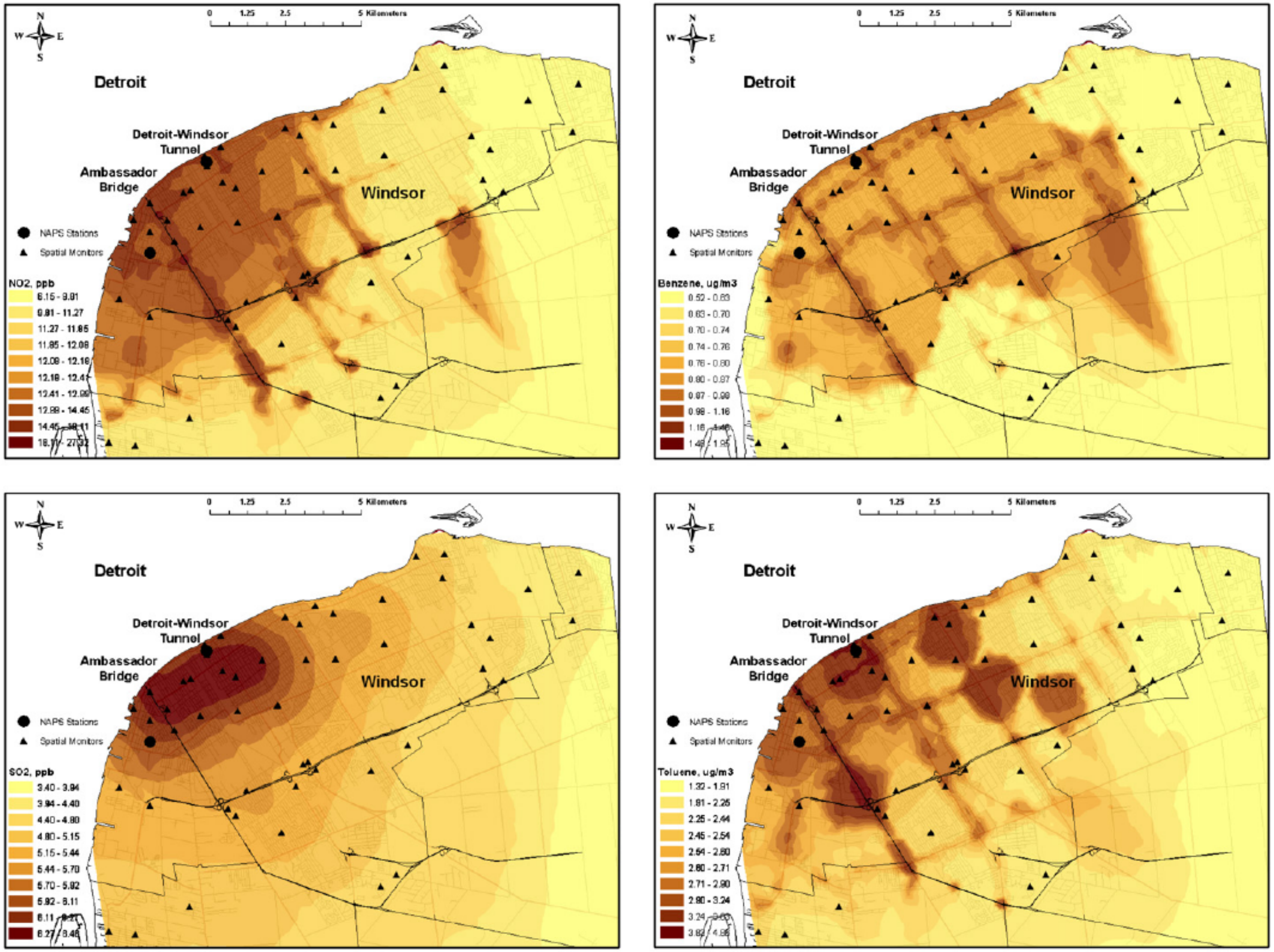
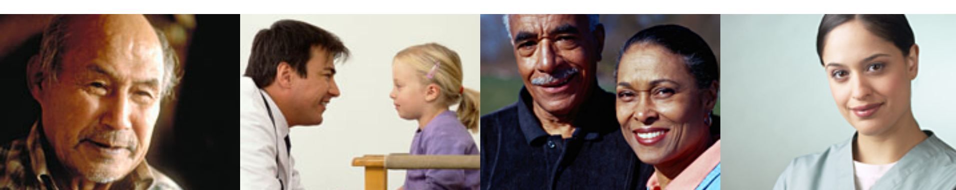
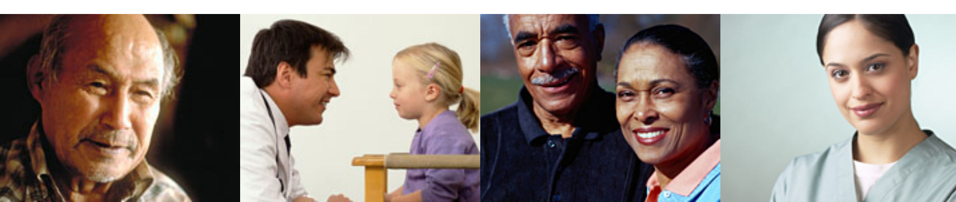


Fig. 1. Land-use regression maps for NO_2, SO_2, benzene, and toluene.



Association between ambient pollutants and land-use variables: multiple linear regression models using the 'maximum R^2 improvement' technique

	Variable				
	Unit	β	Std. error	t-Value	P-value
NO_2, R^2 is 0.77					
Intercept		14.8573	0.44027	33.75	<.0001
Distance to Ambassador Bridge	km	−0.49270	0.05501	−8.96	<.0001
Length of Expressways and Highways within 50 m	km	38.46239	6.83256	5.63	<.0001
Length of major roads within 100 m	km	5.60590	1.61525	3.47	0.0011
SO_2, R^2 is 0.69					
Intercept		5.9519	0.35173	16.92	<.0001
Distance to Ambassador Bridge	km	−0.14850	0.02897	−5.13	<.0001
Dwelling density within 1500 m	dwellings/km^2	0.0005	0.00022	2.29	0.0263
Detroit SO_2 emission point sources within 3000 m		0.6089	0.22133	2.75	0.0083
Benzene, R^2 is 0.73					
Intercept		0.5246	0.03980	13.18	<.0001
Length of major roads within 100 m	km	0.81248	0.16644	4.88	<.0001
Length of expressways and primary highways within 50 m	km	2.46169	0.67963	3.62	0.0007
Detroit VOC emission point sources within 4000 m		0.1861	0.04277	4.35	<.0001
Windsor VOC emission point sources within 3000 m		0.2716	0.04407	6.16	<.0001
Toluene, R^2 is 0.46					
Intercept		2.9685	0.26646	11.14	<.0001
Distance to Ambassador Bridge	km	−0.09604	0.03129	−3.07	0.0035
Length of major roads within 200 m	km	0.67806	0.34554	1.96	0.0554
Length of primary highways within 100 m	km	2.49724	1.13792	2.19	0.0330
Windsor VOC emission point sources within 1000 m		0.8264	0.28675	2.88	0.0059



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Establishing the spatial variability of ambient nitrogen dioxide in Windsor, Ontario

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Winter 2004
NO_2 LUR INCLUDED TRAFFIC COUNT DATA
R^2 = 0.88

PROXIMITY TO MAJOR ROADS (≤300m vs. ≥ 300m)

- NO_2 concentrations: 15.0 (5.5) ppb vs 12.9 (5.0) ppb

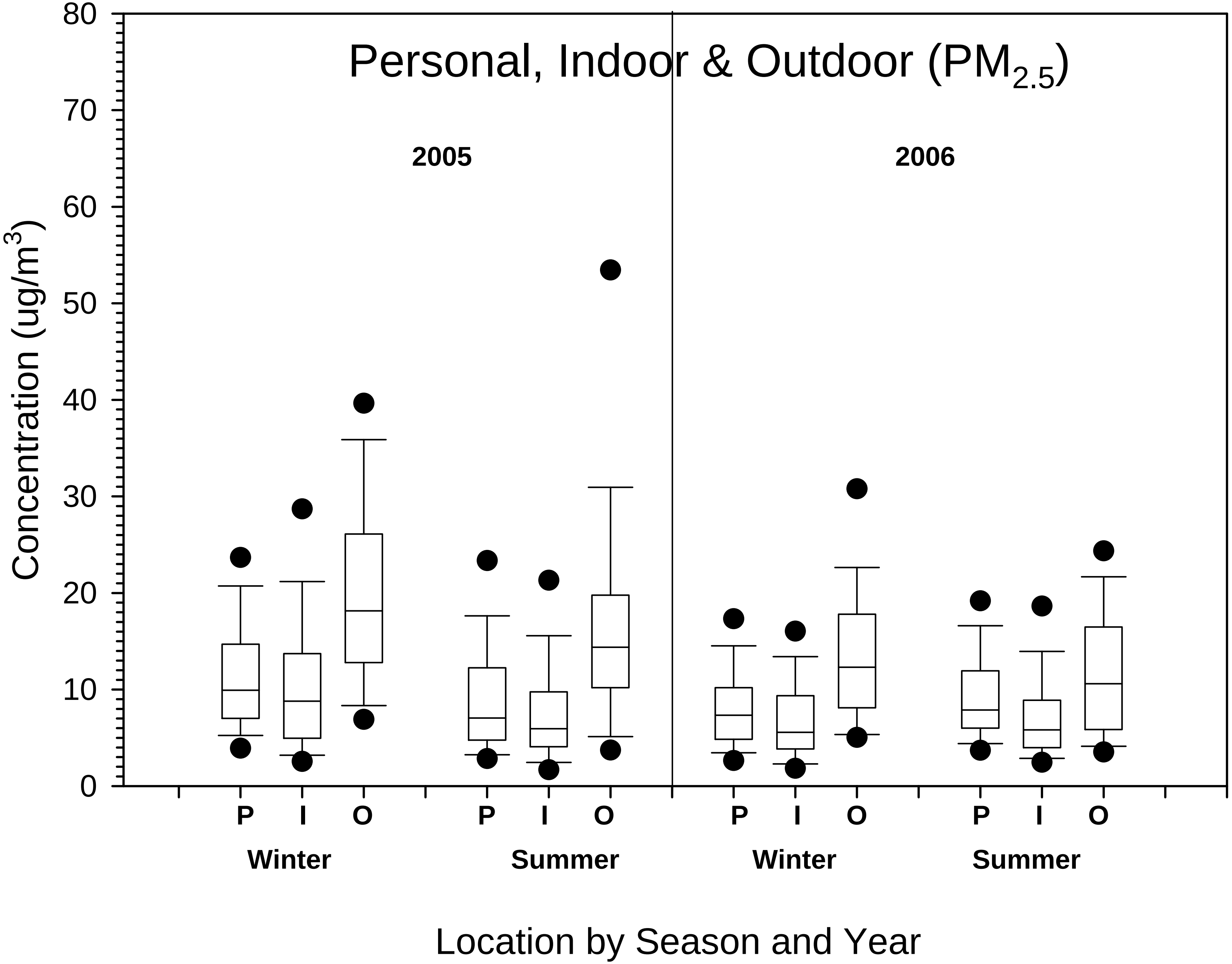
- Significant associations between:
  - NO_2 and $PM_{2.5}$: 0.18 vs 0.40
  - NO_2 and Abs Coeff: 0.23 vs 0.49
  - NO_2 and Benzene: 0.34 vs 0.39
  - NO_2 and PAH: 0.40 vs non-significant

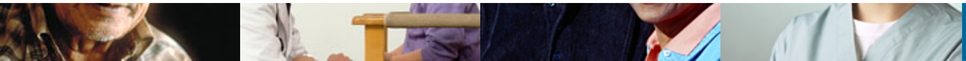
FUTURE PLANS – Spatial

- Investigate associations between NO_2 and other geographic predictors using similar distances from sources
- Incorporate traffic count and vehicle fleet data to identify if diesel vehicles are responsible for these associations
- Undertake further spatial data collection in other locations to investigate whether these associations can be reproduced

STUDY DESIGN - Personal Exposure Assessment

- 48 Healthy adults (2005)
- 51 asthmatic children aged 10 – 13 years (2006)
- Two seasons (5 x days winter and summer) for a total of 10 days of repeated measures for each individual
- Children completed peak flow measurements
- Personal monitoring 24 hour average exposures to:
  - $PM_{2.5}$, EC, NO_2 and O_3
- Indoor & outdoor measures for the same pollutants were collected
- Continuous $PM_{2.5}$ pDR (personal 2006), Dust Traks (indoor & outdoor)
- Self-reported daily activities and symptoms (2006), housing characteristics, and proximity to sources were collected


Personal, Indoor & Outdoor (PM2.5)
2005
2006
Concentration (ug/m3)
0
10
20
30
40
50
60
70
80
P
I
O
P
I
O
P
I
O
P
I
O
Winter
Summer
Winter
Summer
Location by Season and Year



Peak Flow Results: FEV_1

		Per IQR increase of PM2.5				
		Estimate	LCI95	UCI95	StdErr	Probt
	Averaging time lag					
Winter (Jan -March)	Past 0- 4 hours	0.016	-0.016	0.048	0.017	0.335
	Past 0- 8 hours	-0.011	-0.044	0.022	0.017	0.521
	Past 0- 12 hours	-0.021	-0.063	0.021	0.022	0.329
	Past 0- 24 hours	-0.020	-0.079	0.038	0.030	0.495
Summer (July - Aug)	Past 0- 4 hours	0.003	-0.014	0.021	0.009	0.724
	Past 0- 8 hours	-0.001	-0.024	0.021	0.011	0.922
	Past 0- 12 hours	-0.004	-0.025	0.017	0.011	0.702
	Past 0- 24 hours	-0.008	-0.032	0.016	0.012	0.509

Using a mixed model with random intercept and fixed slope.

Associations were adjusted for personal past 24-hour mean temp & RH, day of week, season, use of SABA/ICS

Symptoms results

		Winter			Summer		
Symptom	Time	OR	LowerCL	UpperCL	OR	LowerCL	UpperCL
Cough	Past 0-4 Hr	**1.19**	**1.03**	**1.37**	0.97	0.86	1.10
	Past 0-8 Hr	1.16	0.98	1.36	0.95	0.82	1.10
	Past 0-12 Hr	**1.42**	**1.09**	**1.84**	0.95	0.79	1.13
	Past 0-24 Hr	1.13	0.96	1.33	0.94	0.74	1.18
Wheeze	Past 0-4 Hr	0.65	0.42	1.00	0.59	0.33	1.05
	Past 0-8 Hr	0.72	0.46	1.12	0.61	0.35	1.05
	Past 0-12 Hr	0.70	0.43	1.15	**0.52**	**0.31**	**0.87**
	Past 0-24 Hr	0.60	0.26	1.38	**0.32**	**0.16**	**0.64**
Tight chest	Past 0-4 Hr	1.08	0.91	1.29	0.93	0.75	1.16
	Past 0-8 Hr	1.02	0.80	1.29	0.87	0.67	1.12
	Past 0-12 Hr	1.00	0.71	1.41	0.83	0.61	1.13
	Past 0-24 Hr	1.01	0.77	1.33	**0.55**	**0.32**	**0.97**
Difficulty breathing	Past 0-4 Hr	1.01	0.89	1.15	1.01	0.92	1.11
	Past 0-8 Hr	1.00	0.86	1.15	1.00	0.91	1.11
	Past 0-12 Hr	0.95	0.74	1.22	0.98	0.85	1.13
	Past 0-24 Hr	1.04	0.92	1.17	0.86	0.55	1.34

Conclusions

- Only a small number of children required the use of any asthma medications
- Peak flow meters are not as sensitive as spirometry
- Symptoms data indicate an increase in cough with increased exposure to $PM_{2.5}$
    - Self reported data
- Less $PM_{2.5}$ variability over a 5 day period especially when it is a regional pollutant for this city

Future Plans – Lung health & personal monitoring

- Separate the $PM_{2.5}$ exposures into ambient and indoor source fractions
  - Ambient sourced PM has been implicated in greater impacts upon health
- Investigate relationship between respiratory health and other pollutants included in the study
- Investigate personal, indoor and outdoor air pollution sources and exposures with health effects
- Plan future studies using spirometry and longer time periods of exposure

2004: SURVEY RESULTS

The adjusted OR comparing the highest to the lowest roadway density quintiles, were statistically significant for:

- Wheeze 1.23 (95%CI 1.07-1.41) ($p=0.004$),
- Wheeze with dyspnea 1.27 (95%CI 1.05-1.52) ($p=0.013$)

No associations with cough, chest illness or asthma.

Roadway density expressed as a continuous variable:

- Asthma OR 1.08 (95%CI 1.012-1.149) for 0.6km increase in roadway density within 200m of home address

Accepted in J.Occupational & Environmental Monitoring

2005: CROSS SECTIONAL LUNG HEALTH

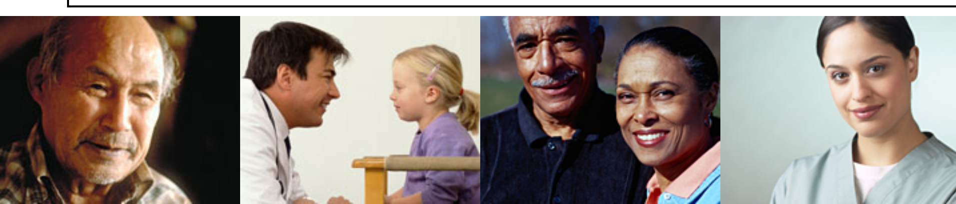
- Each kilometer of roadway (local, major, highway) within 200m radius of the home resulted in an increase in eNO of 10.1% ($p=0.002$)
  - Each kilometer of local roadway within a 200m radius of the home was associated with a 6.8% increase in eNO ($p=0.045$)

- Associations between roadway density, and both FEV_1 and FVC were negative but not statistically significant at $p < 0.05$

- Each µg/m^3 increase in $PM_{2.5}$ using fixed site data was associated with a 3.9% increase in eNO ($p=0.058$) and 0.70% decrease in FVC expressed as a percentage of predicted ($p=0.39$)

- From LUR estimates of NO_2, SO_2, black smoke and coarse PM there were positive but non-significant associations with eNO

doi:10.1289/ehp.10943 (available at http://dx.doi.org/)
Online 1 August 2008 (Environmental Health Perspectives)

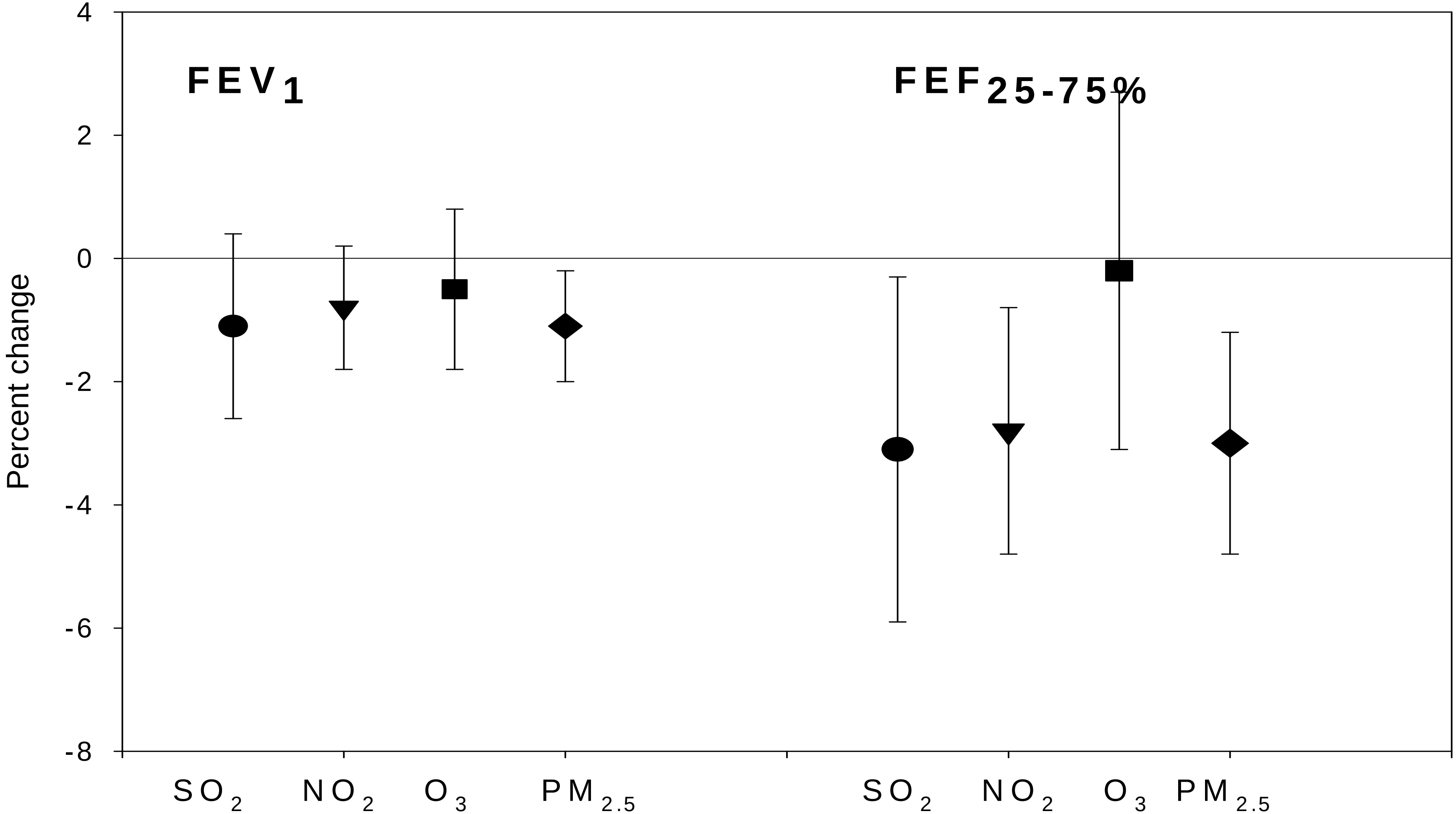


STUDY DESIGN – 2005 Longitudinal

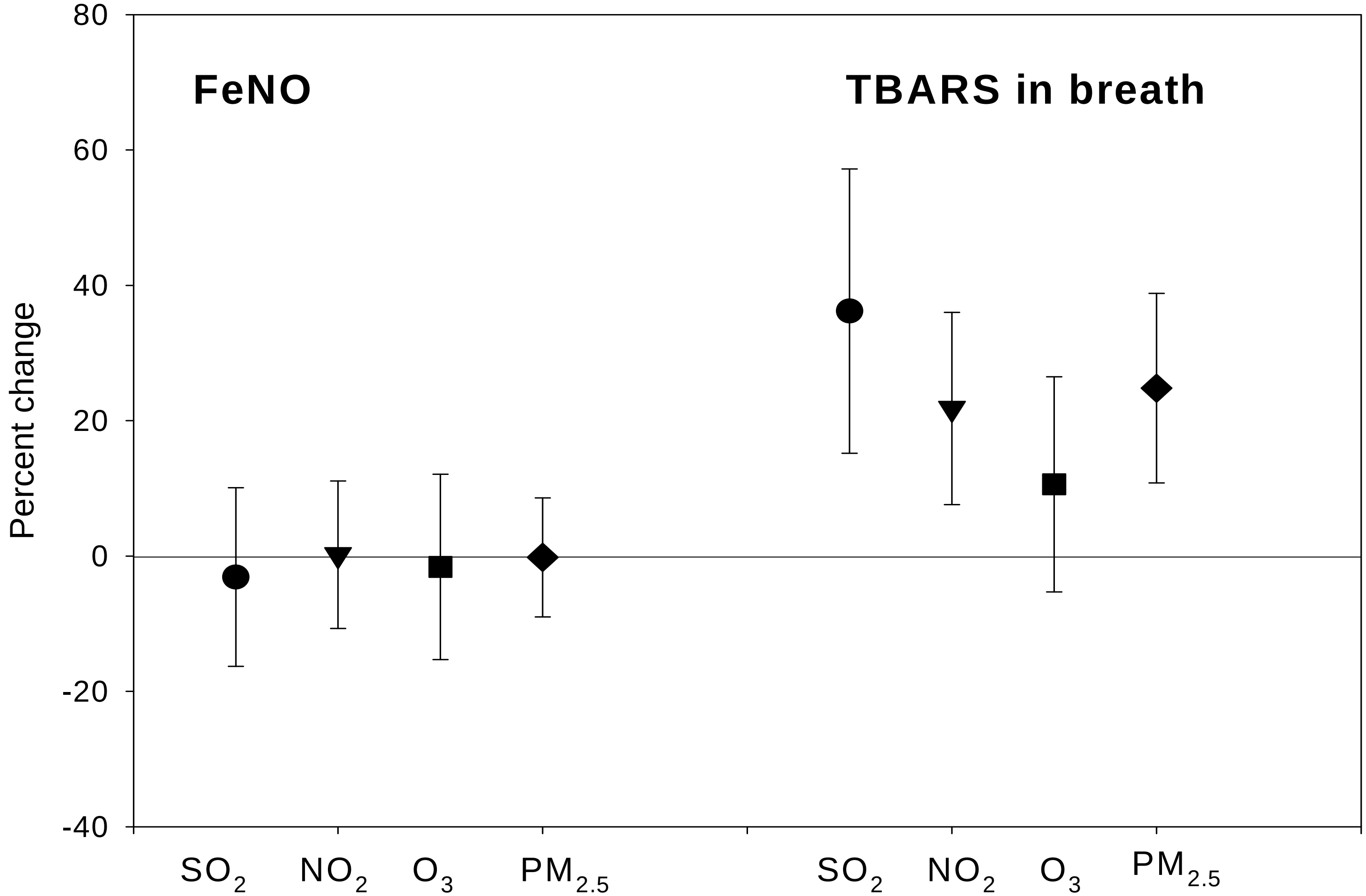
- **Participants:** 182 asthmatic children, ages 9-14
- **Health tests:** once weekly, for 4 weeks
  - Spirometry
  - Exhaled NO (FeNO)
  - Exhaled breath condensate to determine TBARS, 8-isoprostane, and IL-6
- **Air Monitoring:** Daily SO_2, NO_2, O_3, $PM_{2.5}$ from two stations
- **Statistical analyses:** Mixed-effects regression models, adjusting for confounding of weather, season, asthma medications, co-pollutants.

Revisions under review in Environmental Health Perspectives

PULMONARY FUNCTION



INFLAMMATION AND OXIDATIVE STRESS



Influence of Personal Exposure to Particulate Air Pollution on Cardiovascular Physiology and Biomarkers of Inflammation and Oxidative Stress in Subjects With Diabetes

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JOEM, Vol 49:No.3 (March 2007)

SUMMARY OF FINDINGS

Air pollution (Personal PM_{10}):

- Elevated blood pressure
- Elevated heart rate
- Reduced basal arterial diameter and flow
- Elevated oxidative stress
- CV medications seem to help reduce the risk of PM

Data analysis on seniors' health study is underway

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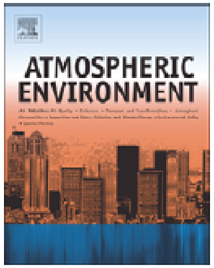

Predicting personal exposure of Windsor, Ontario residents to volatile organic compounds using indoor measurements and survey data

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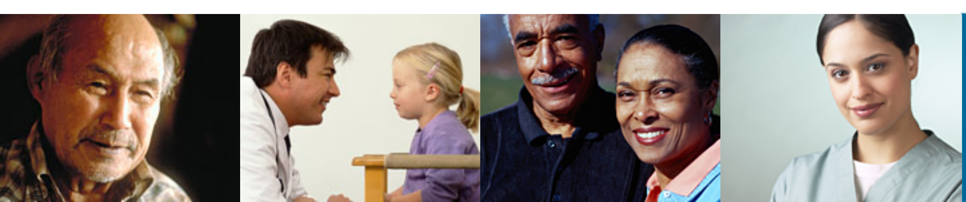


PLANNED / IN PROGRESS MANUSCRIPTS

Factors influencing the correlations between nitrogen dioxide and other ambient airborne pollutants across four seasons in Windsor, Ontario

Indoor and outdoor sources of continuous $PM_{2.5}$ personal monitoring and lung health of asthmatic children

Factors influencing the infiltration of $PM_{2.5}$ mass and its components in Windsor, Ontario residences

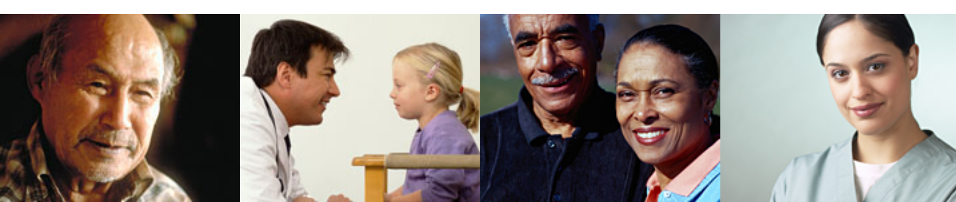
Factors influencing infiltration of particulates into residences

An Analysis of $PM_{2.5}$ Sampler Inter-Comparisons Performed in Exposure Assessment Studies by Health Canada

Predicting personal exposures for children and adults

Air pollution exposure and senior’s cardiovascular health effects

Oxidative stress and exposures to transition metals: Asthmatic children's lung health effects



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Robert Dales – Health Canada
Raymond Poon – Health Canada
Ling Liu – Health Canada
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Ron Williams – US EPA
Lucas Neas – US EPA
Mike Wolfson - HSPH
Steve Ferguson – HSPH
Craig Fitzner – MDEQ
Lisa Baxter – US EPA
Alan Vette – US EPA

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City of Windsor, School boards
International Joint Commission