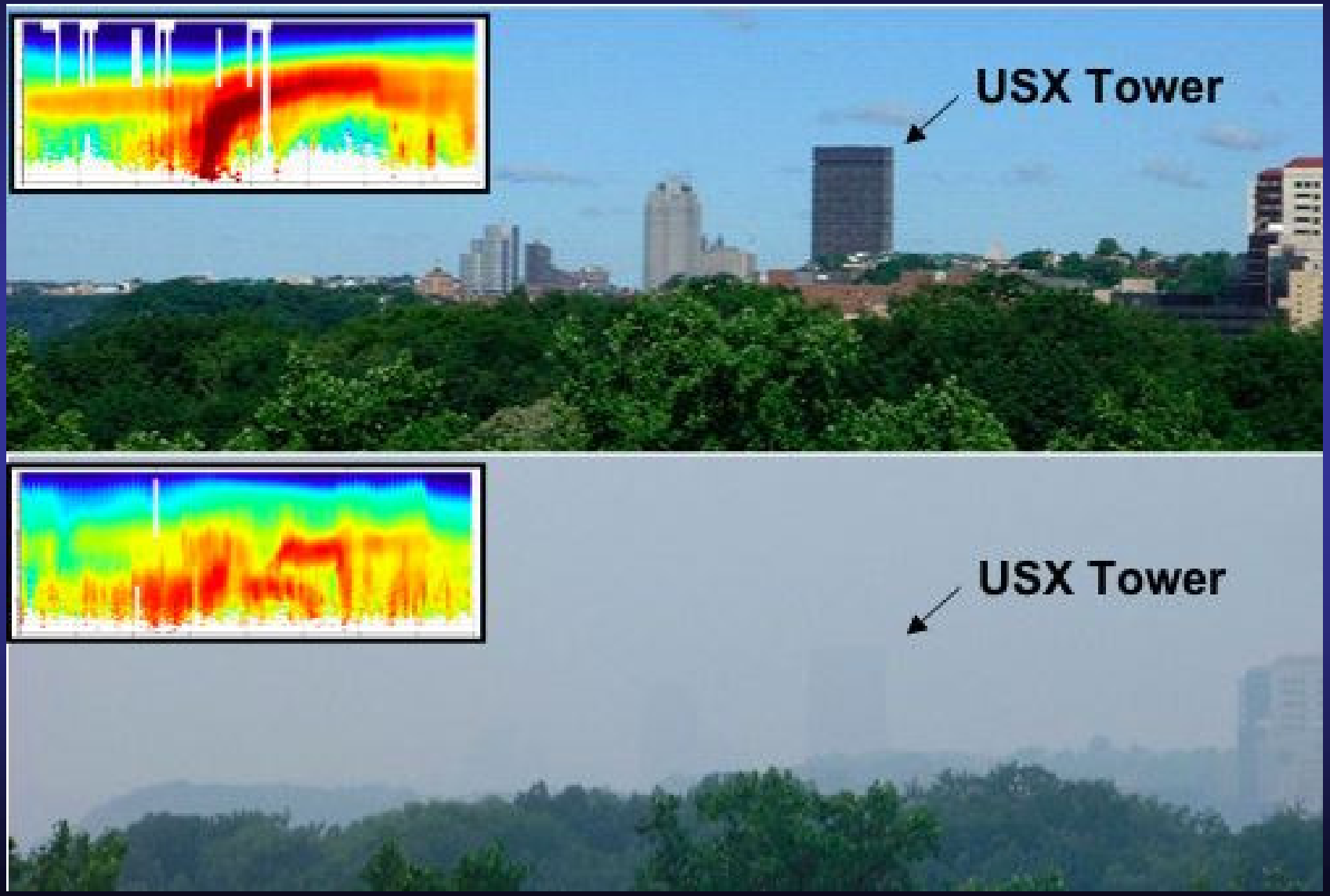
Air Pollution and the respiratory system

It matters who breathes it and where and you breathe,

perhaps more than *what you* breathe

Mexico City, 2001

The Center for Atmospheric Particle Studies



State of the Air: 2008 ALA, Short-term particle air pollution

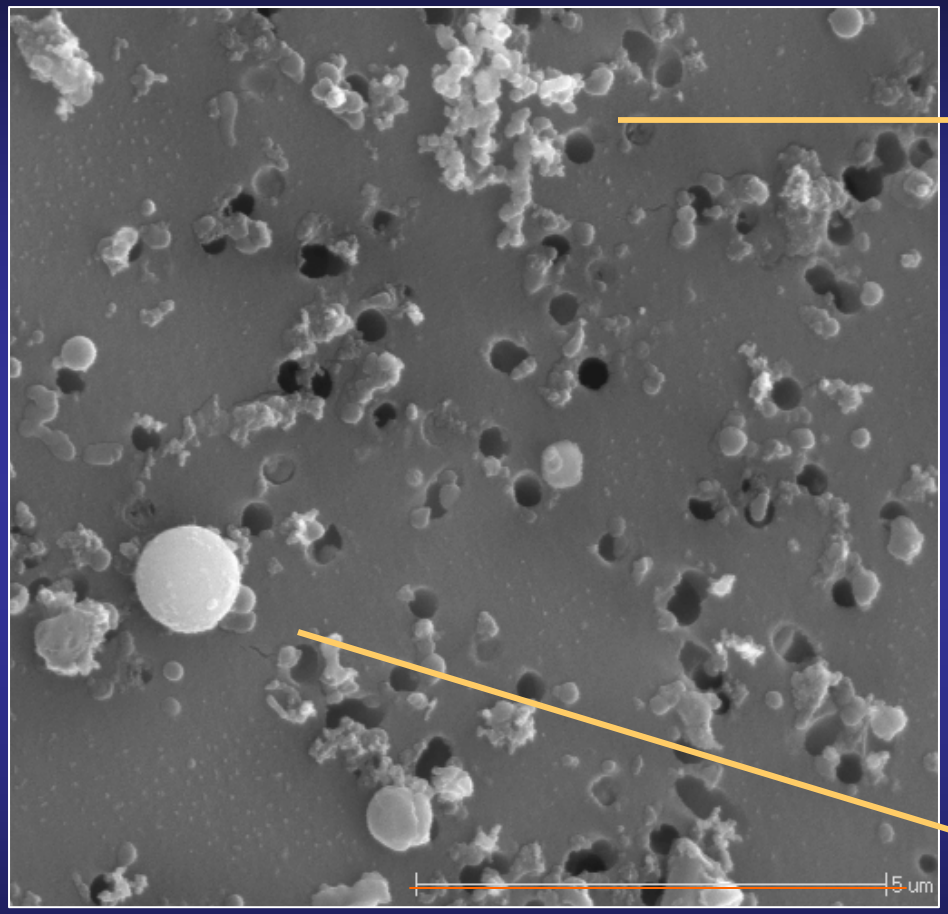
- **#1 Pittsburgh**
  #2 Los Angeles
  #3 Fresno
  #4 Bakersfield
  #5 Birmingham
  #6 Logan
  #7 Salt Lake City
  #8 Sacramento
  #9 Detroit
  #10 D.C./Baltimore

ALA most polluted cities 2009

- #1 Pittsburgh
  #2 Fresno
  #3 Bakersfield
  #4 Los Angeles
  #5 Birmingham
  #6 Salt Lake City
  #7 Sacramento
  #8 Logan
  #9 Detroit
  #9 Chicago

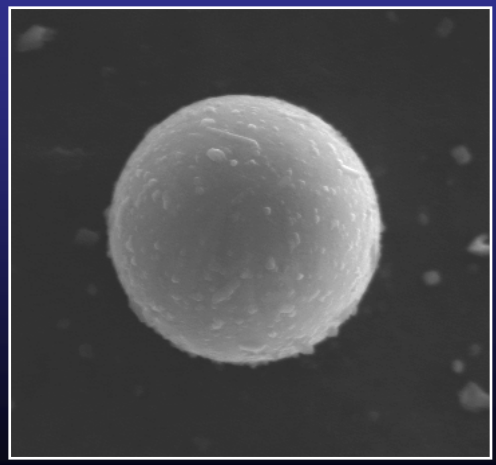
	Primary Standards		Secondary Standards	
Pollutant	**Level**	**Averaging Time**	**Level**	**Averaging Time**
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour (1)	None	
	35 ppm (40 mg/m^3)	1-hour (1)		
Lead	0.15 µg/m^3 (2)	Rolling 3-Month Average	Same as Primary	
	1.5 µg/m^3	Quarterly Average	Same as Primary	
Nitrogen Dioxide	0.053 ppm (100 µg/m^3)	Annual (Arithmetic Mean)	Same as Primary	
Particulate Matter (PM_{10})	150 µg/m^3	24-hour (3)	Same as Primary	
Particulate Matter ($PM_{2.5}$)	15.0 µg/m^3	Annual (4) (Arithmetic Mean)	Same as Primary	
	35 µg/m^3	24-hour (5)	Same as Primary	
Ozone	0.075 ppm (2008 std)	8-hour (6)	Same as Primary	
	0.08 ppm (1997 std)	8-hour (7)	Same as Primary	
	0.12 ppm	1-hour (8) (Applies only in limited areas)	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Mean)	0.5 ppm (1300 µg/m^3)	3-hour (1)

PM < 2.5 Ambient Sample – Field Image

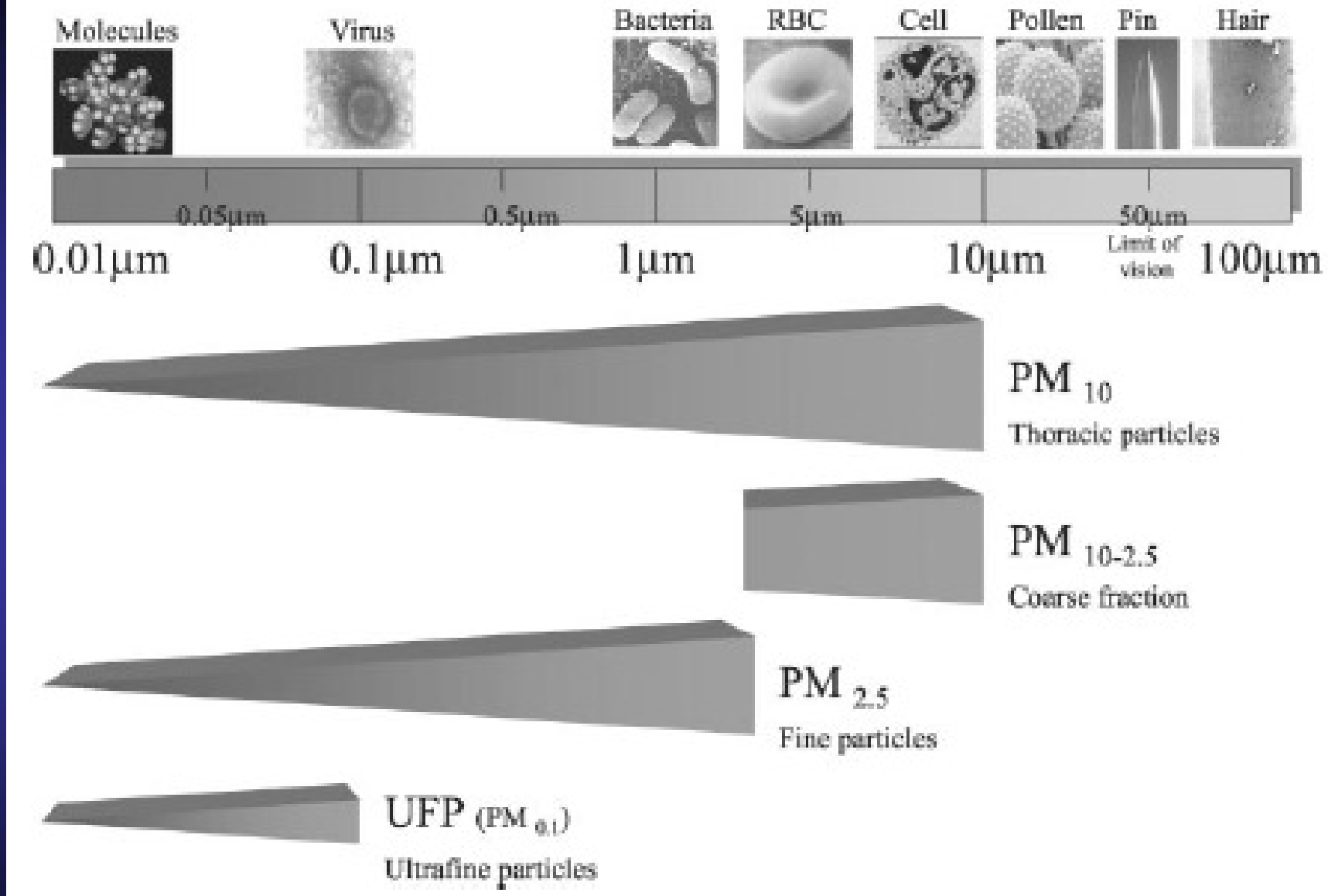


Mexico City sample
Courtesy of Judith Chow PhD
The Desert Research Institute, Reno Nevada

Fossil Fuel Combustion



Coal Combustion



AHA, Particulate Matter and Cardiovascular Disease, Circulation

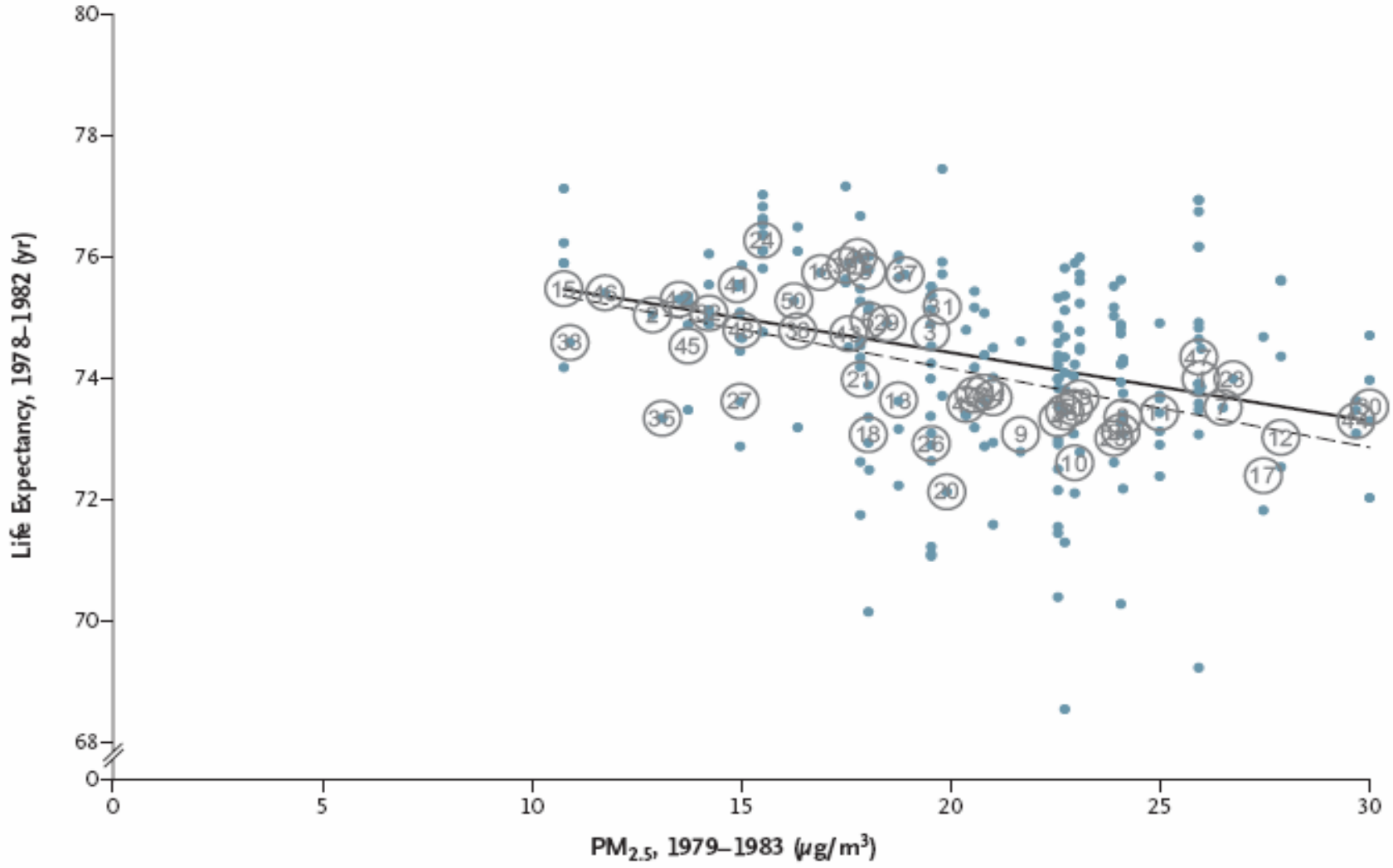


Figure 2. Cross-Sectional Life Expectancies for 1978–1982, Plotted against $PM_{2.5}$ Concentrations for 1979–1983.
Dots and circles labeled with numbers represent population-weighted mean life expectancies at the county level and the metropolitan-area level, respectively. The solid and broken lines represent regression lines with the use of county-level and metropolitan-area–level observations, respectively. The metropolitan areas are coded by number as

Dockery and Pope NEJM, January 22, 2009

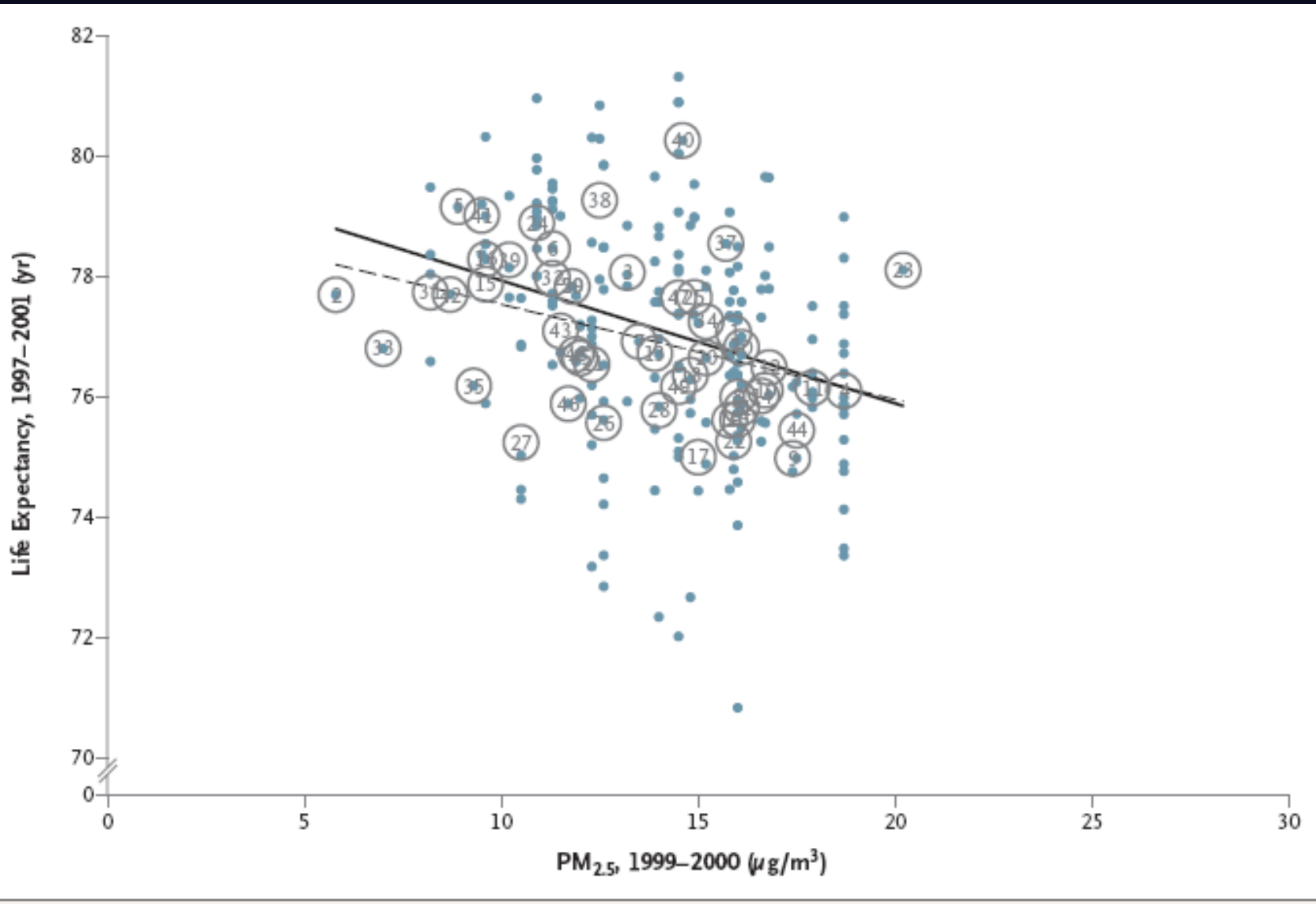


Figure 3. Cross-Sectional Life Expectancies for 1997–2001, Plotted against $PM_{2.5}$ Concentrations for 1999–2000.

Dots and circles labeled with numbers represent population-weighted mean life expectancies at the county level and the metropolitan-area level, respectively. The solid and broken lines represent regression lines with the use of county-level and metropolitan-area–level observations, respectively. The metropolitan areas are coded by number as

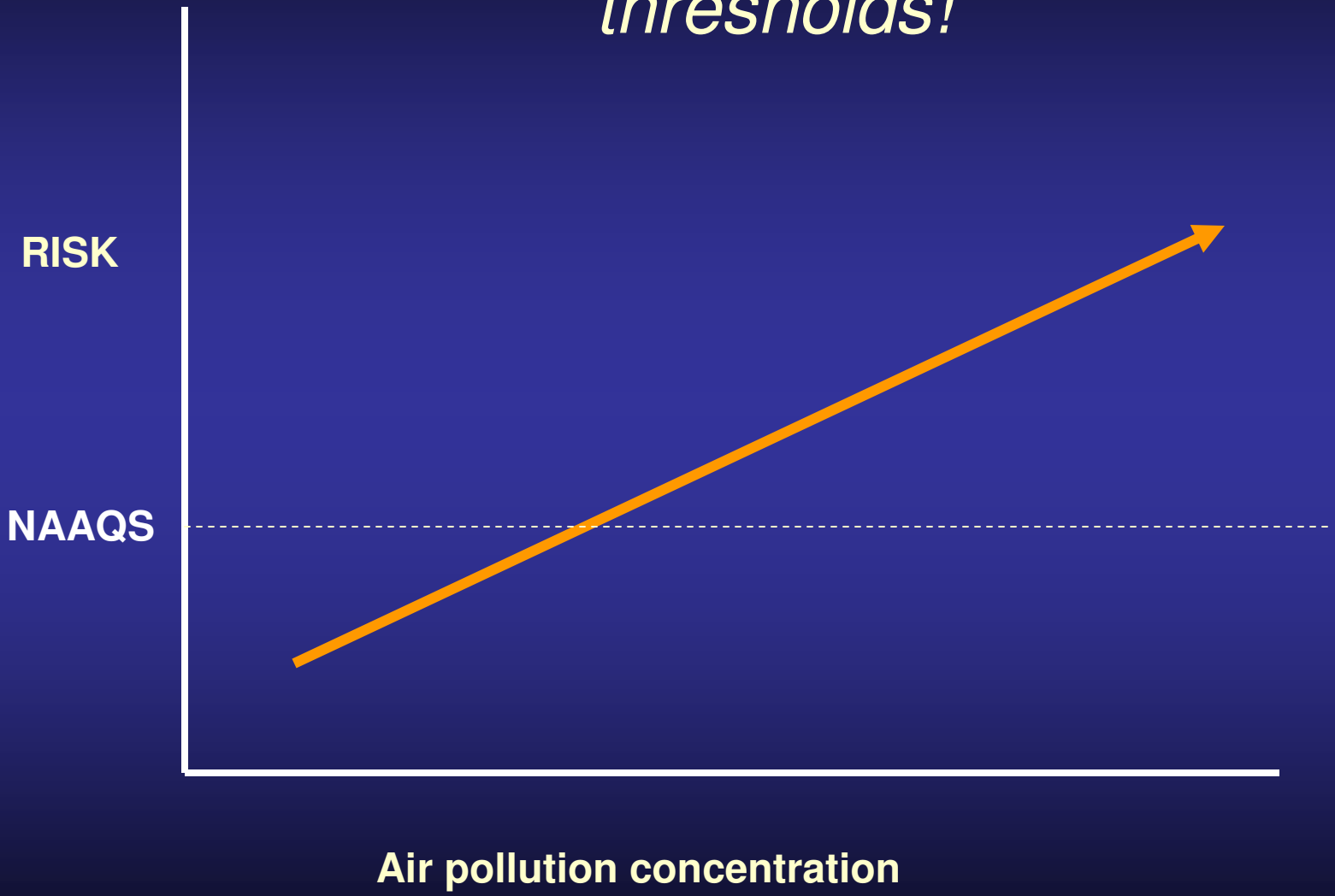
Things we know

- Increase frequency and severity of respiratory symptoms
- Increased healthcare utilization
  - Hospitalizations
  - Emergency room visits
  - Loss of work/school days
  - Increased rates of lower and upper respiratory tract infections
  - Increased mortality rates

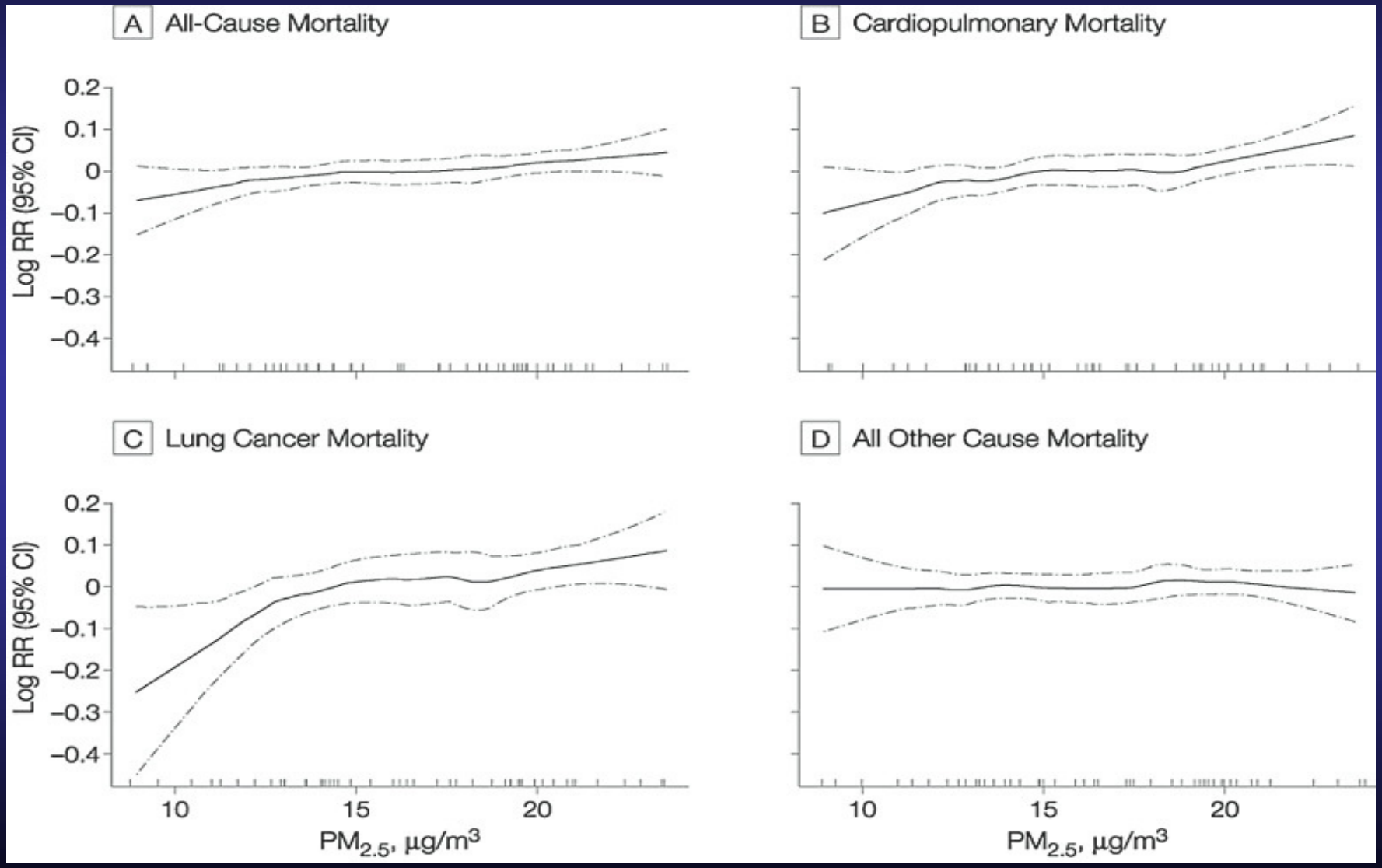
Things we have recently learned

- Mechanisms
  - Airway inflammation
  - Chronic effects
  - Asthma incidence
  - Susceptibility: Genetic and individual factors
- Traffic, the only threshold?
- Reducing the exposure, reducing the health burden

In epidemiologic studies of air pollution levels and health outcomes, *there are no thresholds!*

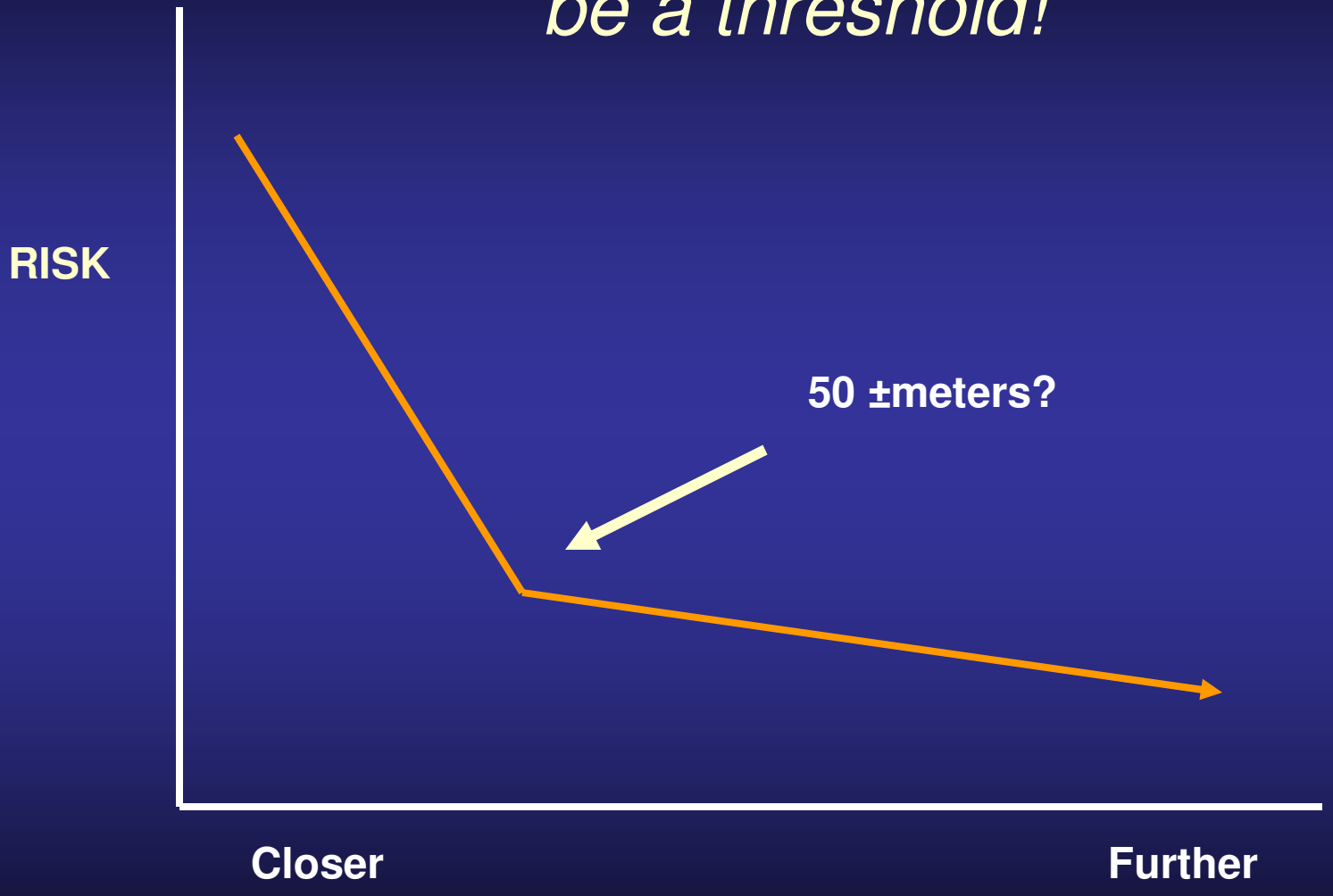


$PM_{2.5}$ exposure – relative risk relationship

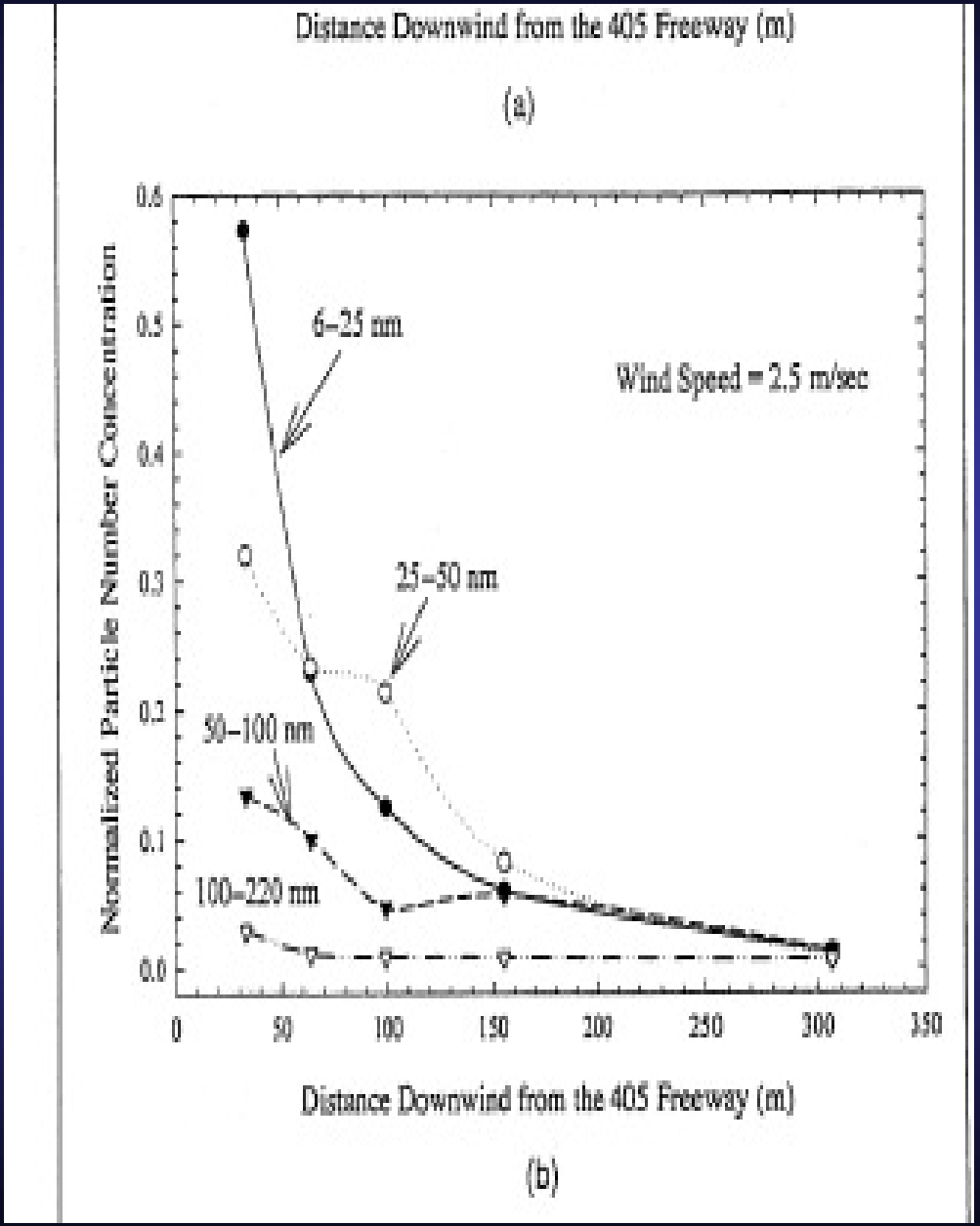


Pope et al, JAMA 2002

In epidemiologic studies of traffic-related emissions and health outcomes, *there may be a threshold!*



Near the road, particle exposure is unique



JAMWA, Sept 2002

$PM_{2.5}$ dispersion from a major road

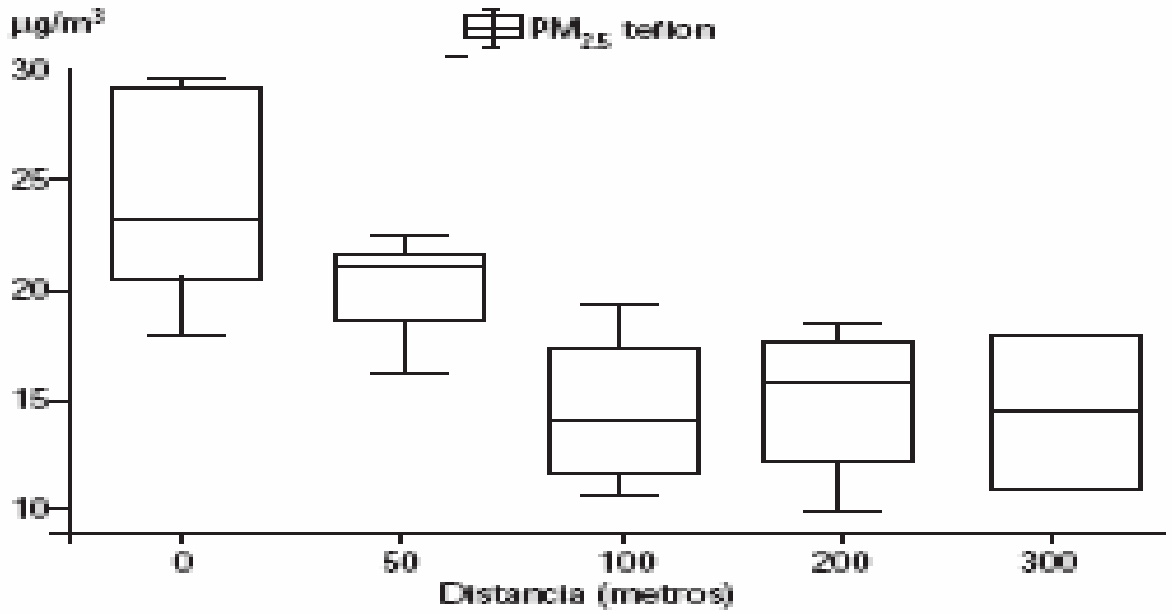
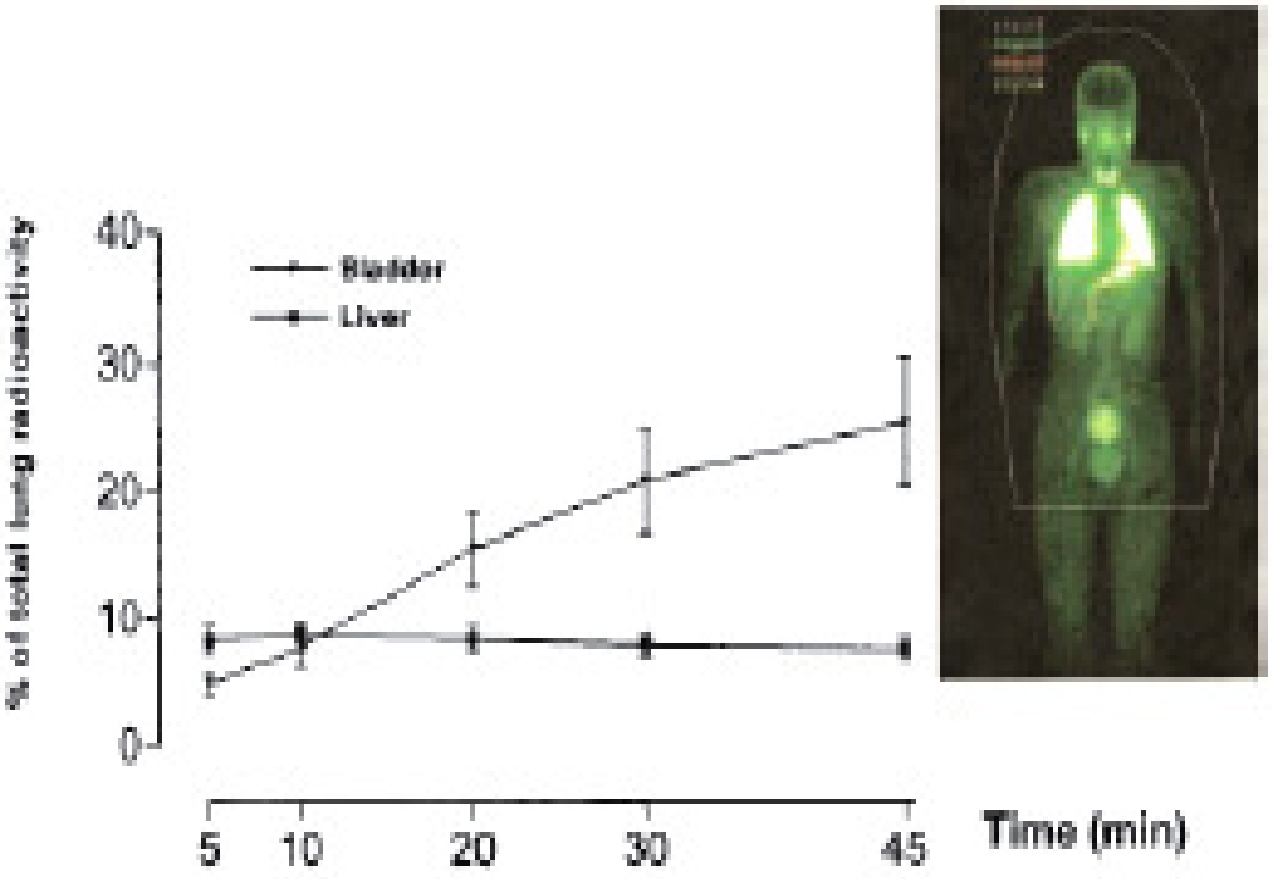


FIGURA 1. CONCENTRACIONES DEL $PM_{2.5}$ A DIFERENTES DISTANCIAS. CIUDAD JUÁREZ, MÉXICO, 2002

At 100 m distance from the avenue, PM2.5 levels decreased by 9.5 microg/m3 (40.6%) when compared to median levels registered on the avenue. The results showed a highly significant negative correlation between PM2.5 measurements and the distance from the avenue (r=-0.70, n=20 and p=0.0005).

Cortez Lugo et al. Salud Publica Mex. 2004 Nov-Dec;46(6):534-7.

Passage of Inhaled Particles Into Human Circulation



Circulation. 2002;105:411-414.

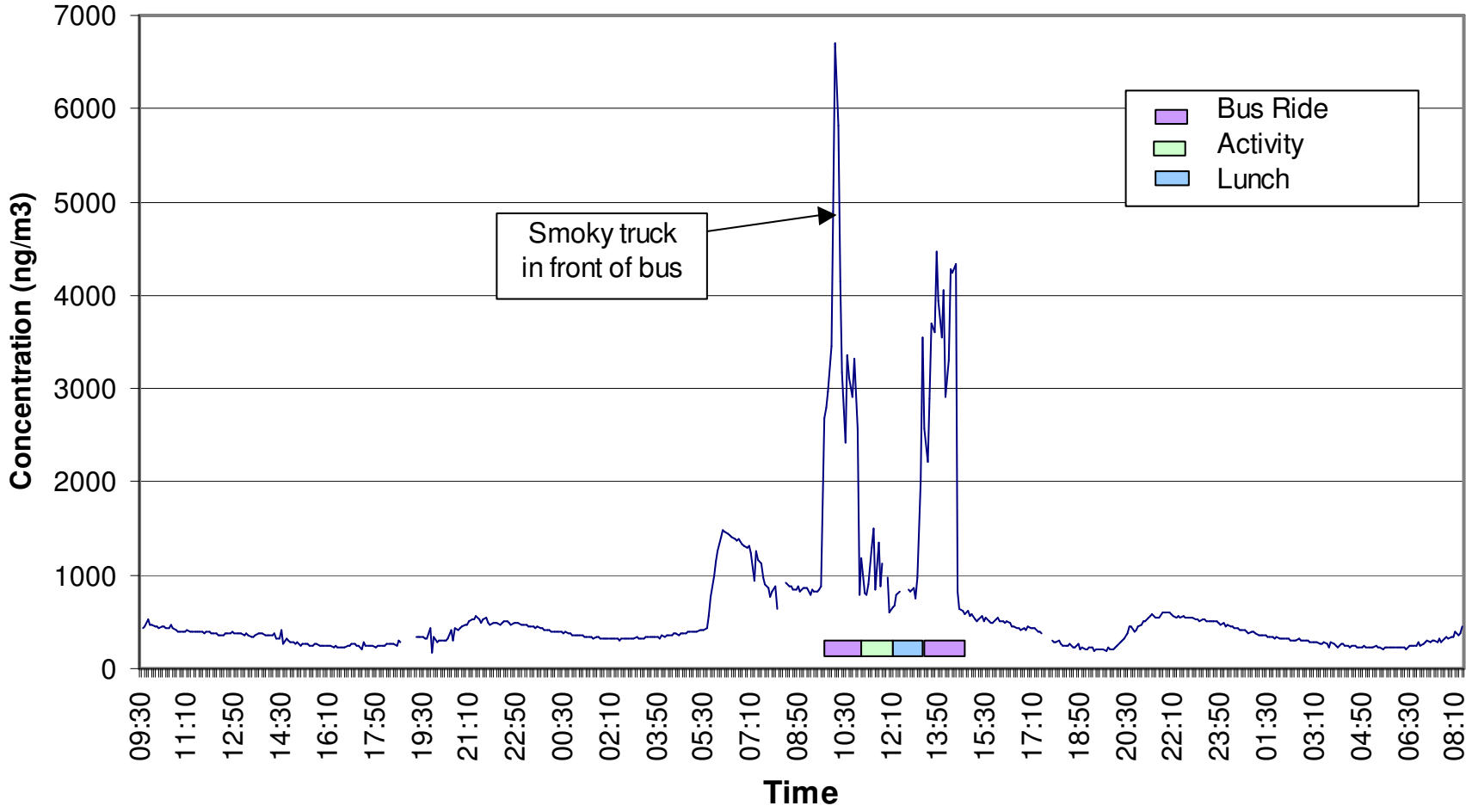
Inhaled ultrafine particles PM < 1.0 μm

^{99m}Tc-labeled

Radioactivity was detected in blood at 1 minute

T_{max} between 10 and 20 minutes maintained 60 mins

Atlanta: Black Carbon Data
May 27-29, 2002



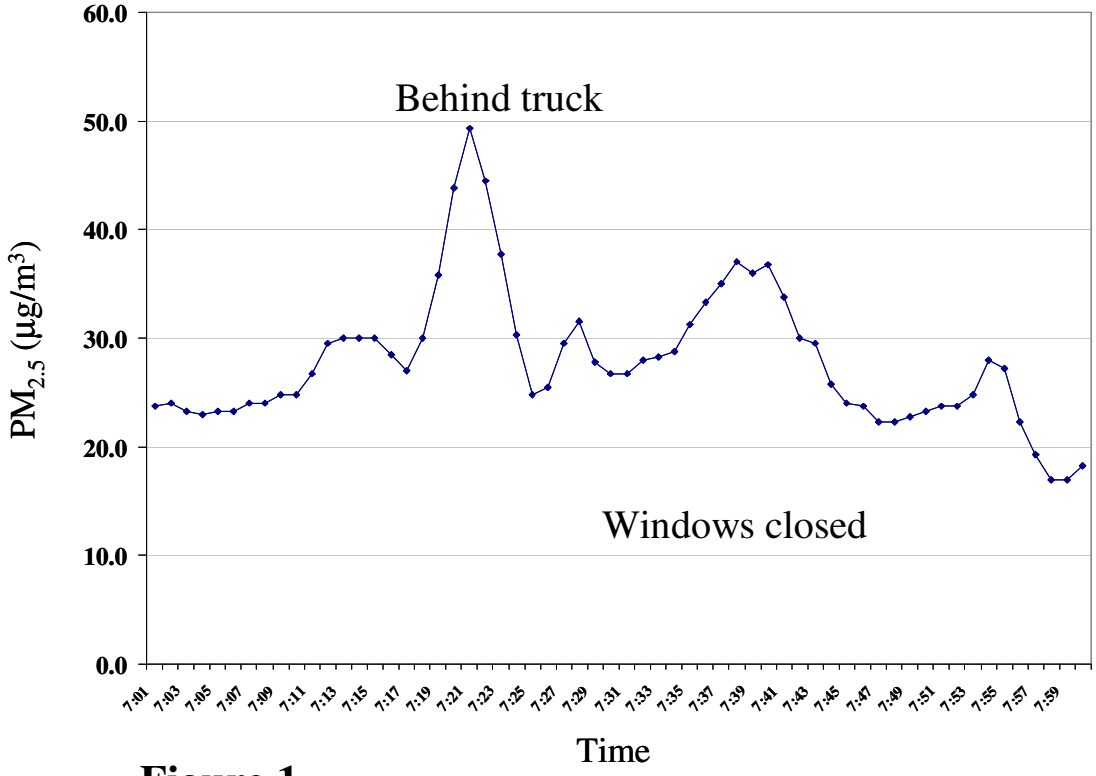
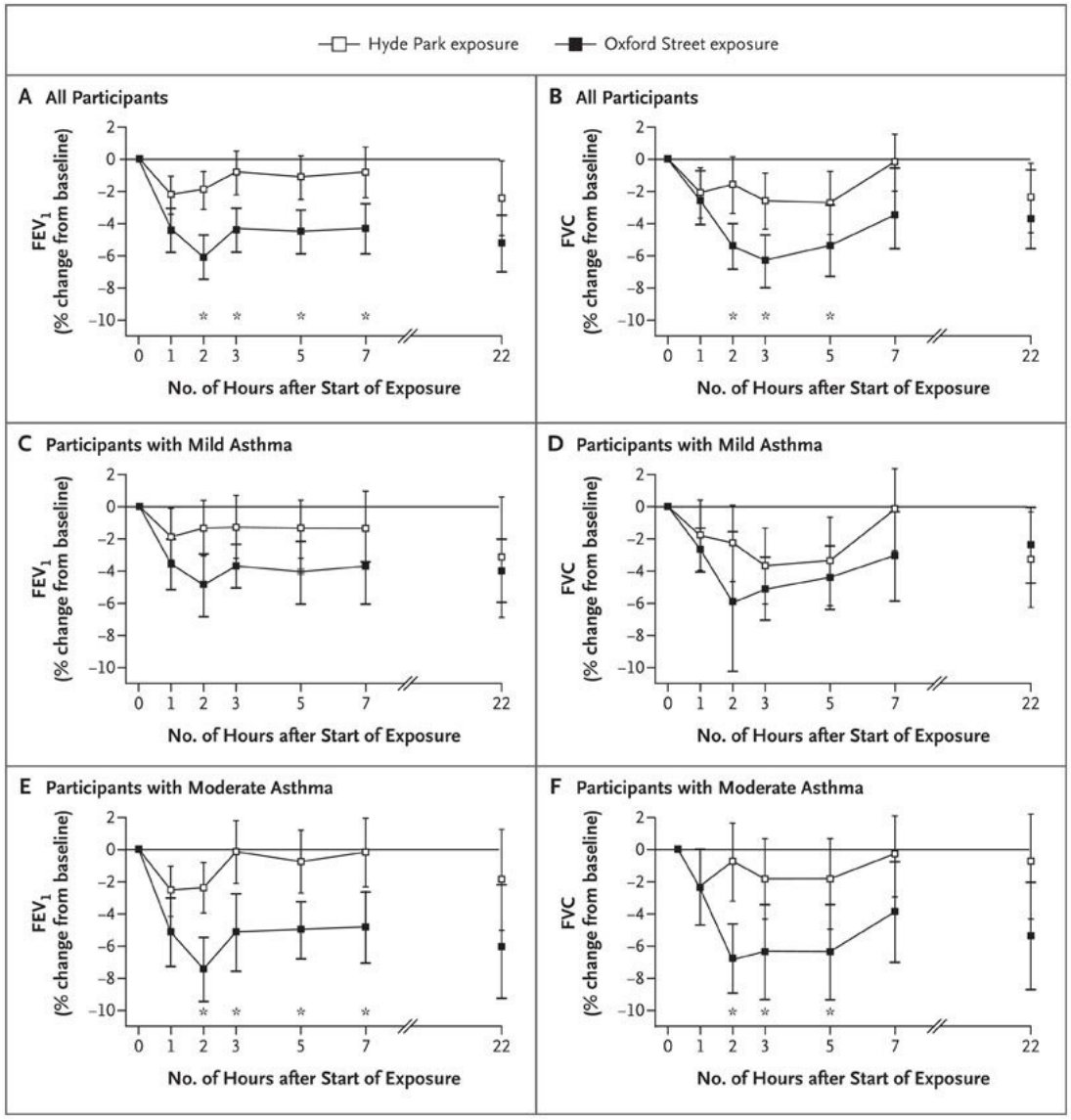


Figure 1.

Figure 1, for example, shows typical results from an hour-long commute (7am–8am), (mean in-vehicle PM2.5: 27 mg/m3; maximum: 49 mg/m3; concurrent ambient PM2.5: 11.7 mg/m3).


Welcome to the United States
Bienvenidos a los Estados Unidos

Mean Percent Changes in FEV1 and FVC during and after Exposure on Oxford Street and in Hyde Park



McCreanor J et al. N Engl J Med 2007;357:2348-2358

The NEW ENGLAND JOURNAL of MEDICINE

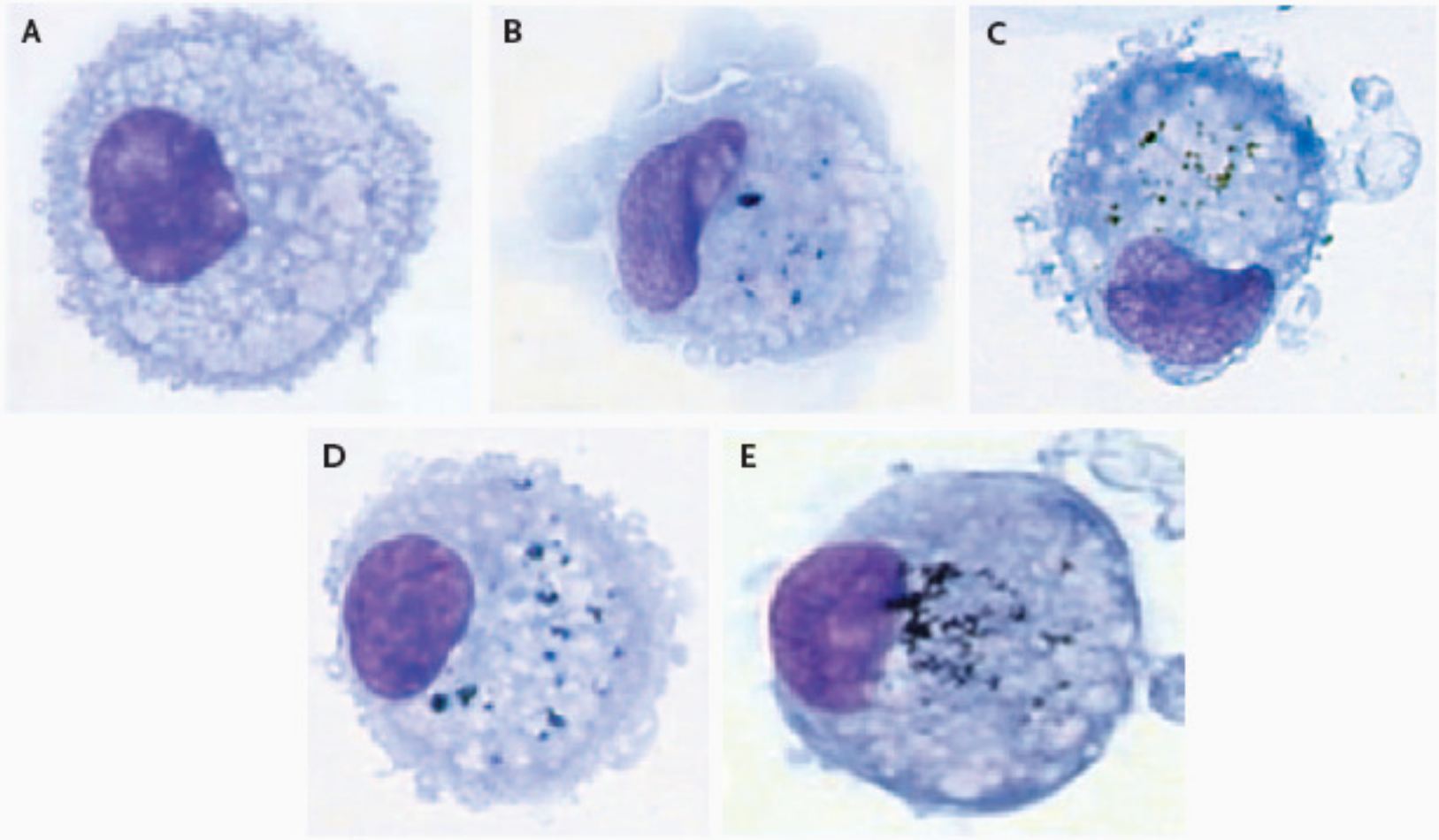


Figure 1. Representative Images of Carbon in Airway Macrophages from Healthy Children.

Panel A shows a macrophage with no carbon. Increasing levels of carbon are shown in Panels B through E. Airway macrophages were obtained from sputum, stained with Diff-Quik, and viewed with an oil-immersion lens. For each child, the area occupied by carbon in 100 randomly selected airway macrophages was determined by means of image analysis, and the median area (in square microns) per cell was calculated.

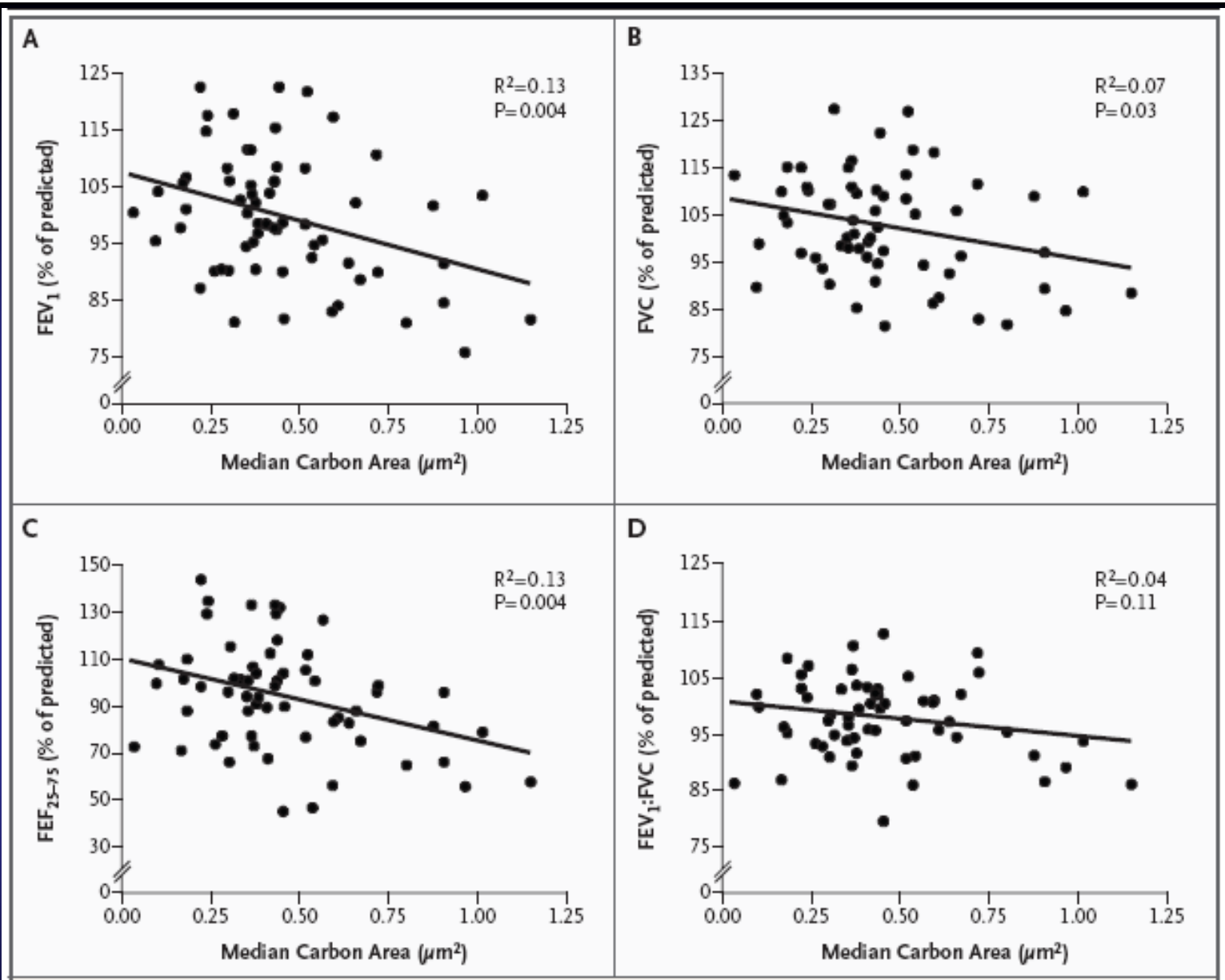


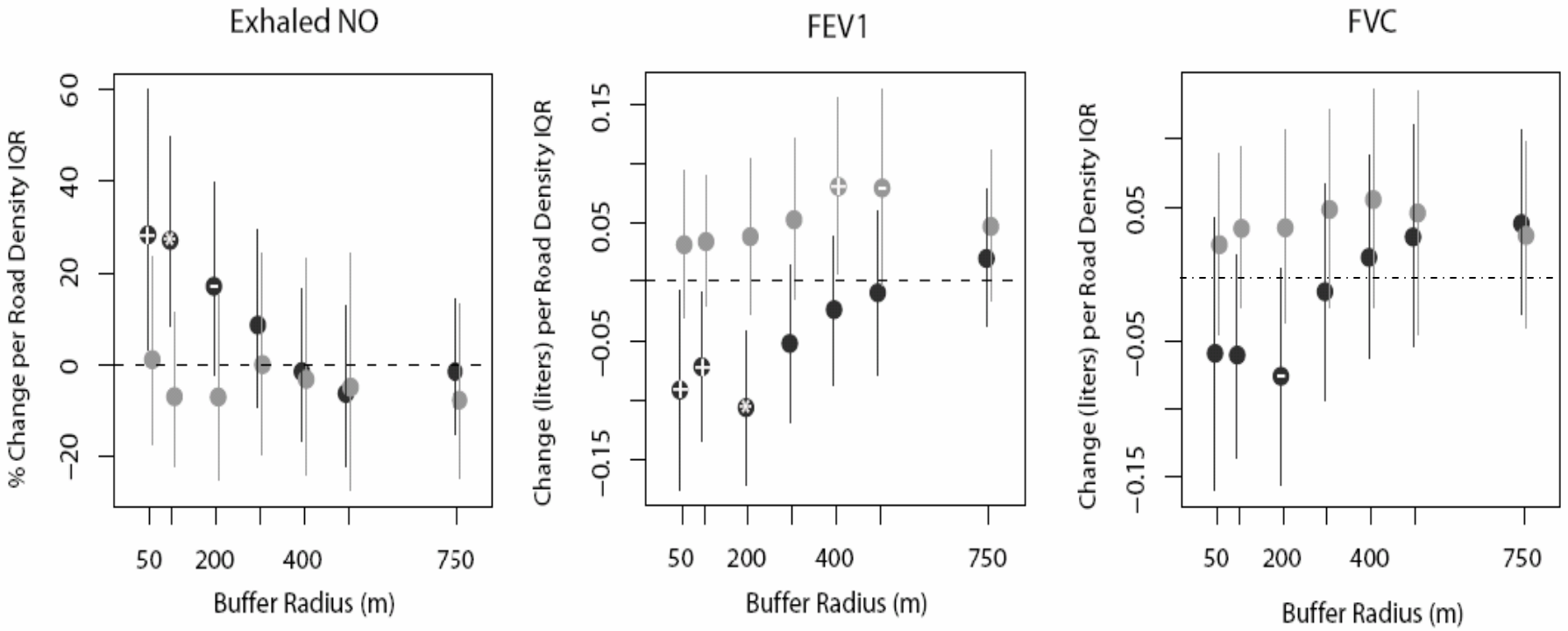
Figure 2. Associations between Carbon in Airway Macrophages and Lung Function in Healthy Children.

The 95 percent confidence intervals from the linear regression of these data and the Spearman's correlation coefficients are shown in Table 2. FEV_1 denotes forced expiratory volume in one second, FVC forced vital capacity, and FEF_{25-75} forced expiratory flow between 25 and 75 percent of the FVC.


Schools
Houses

Road density exposure at the homes

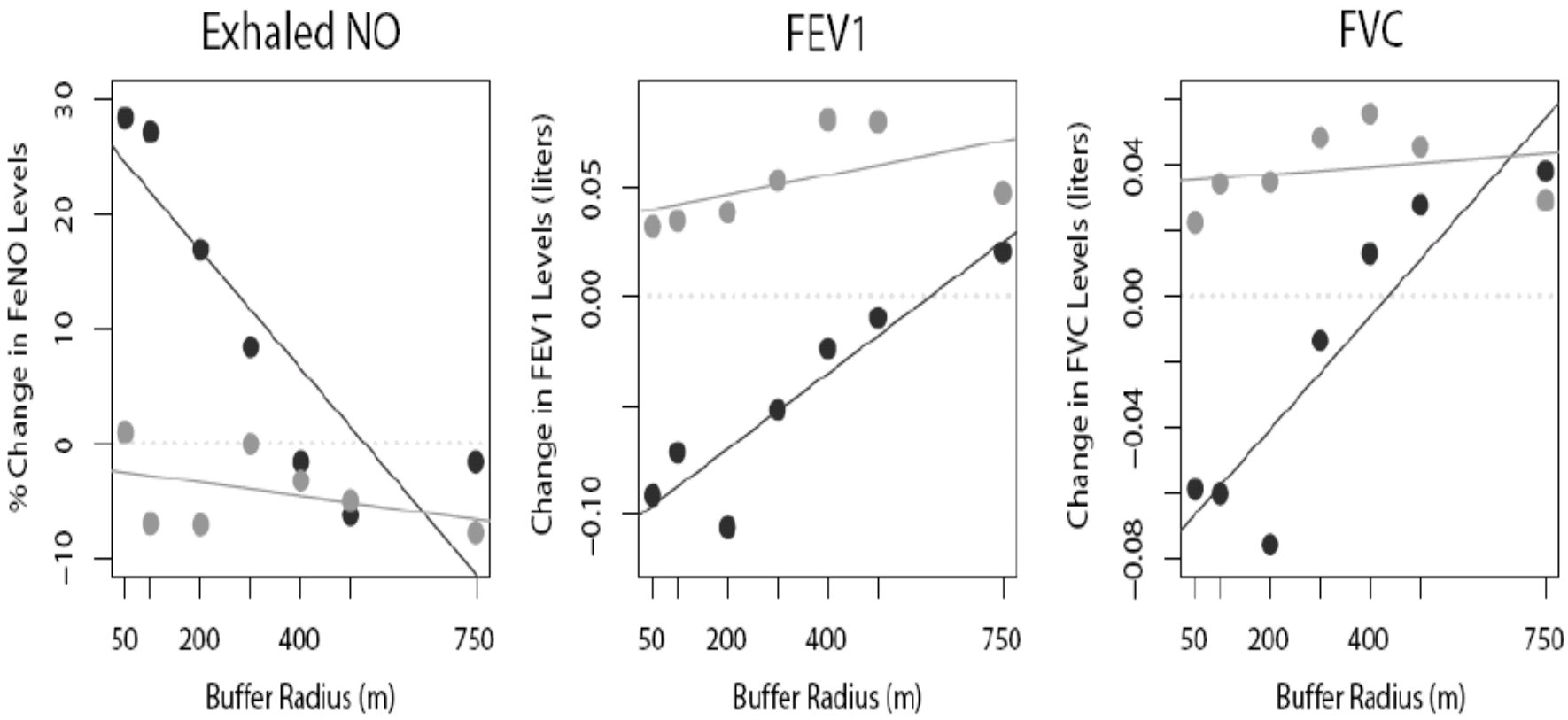
% Change in exhaled NO and lung volumes for an IQR increase in road density



Models were adjusted for sex, age, body mass index, day of the week, season, total number of years of maternal education, total number of years of paternal education and passive smoking

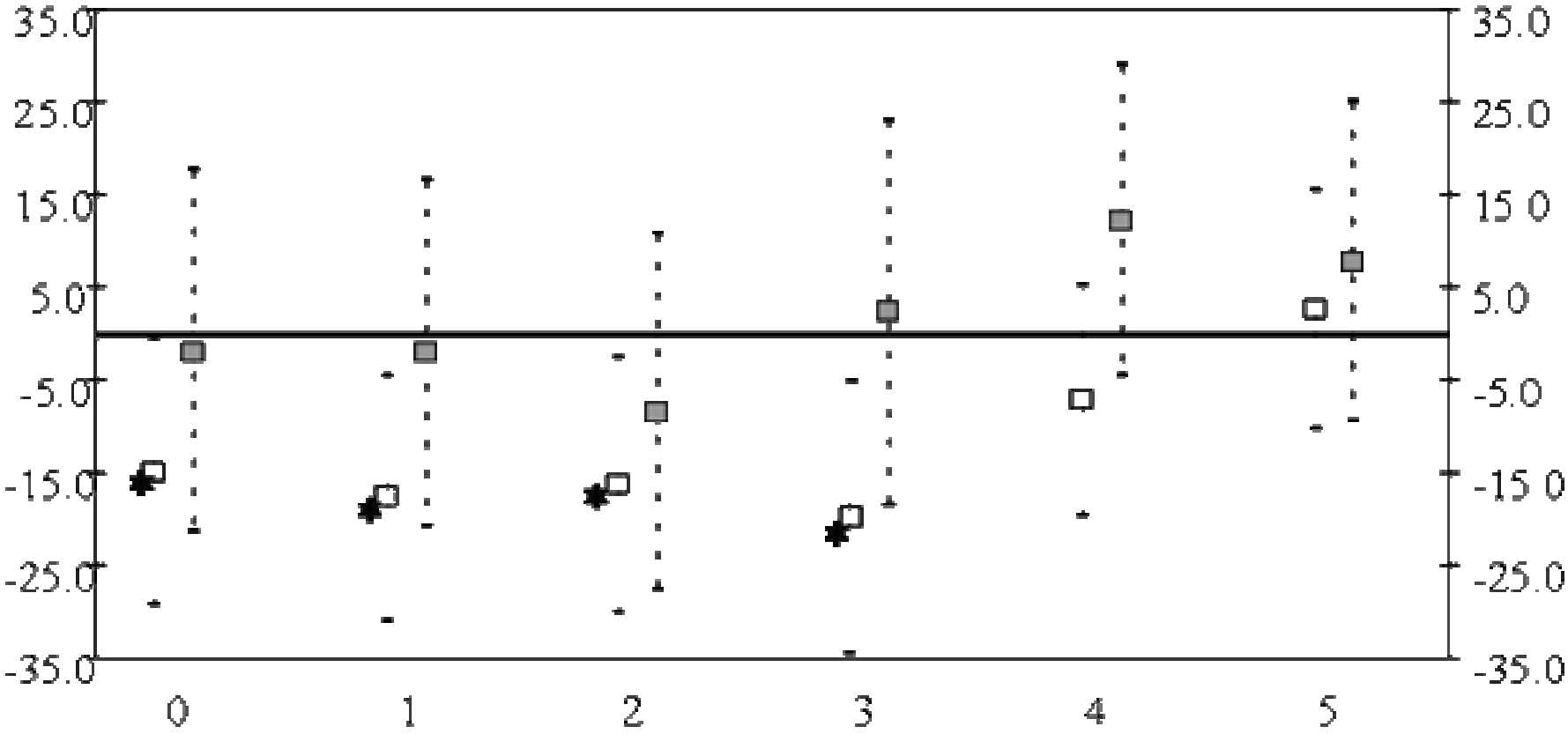
Holguin et al, Am J Resp Crit Care Med, 2007

Linear trend for road density exposure at the homes



Air pollution and treatment

Association between 10 ppb increase in NO_2 with FEV1% response to SABA

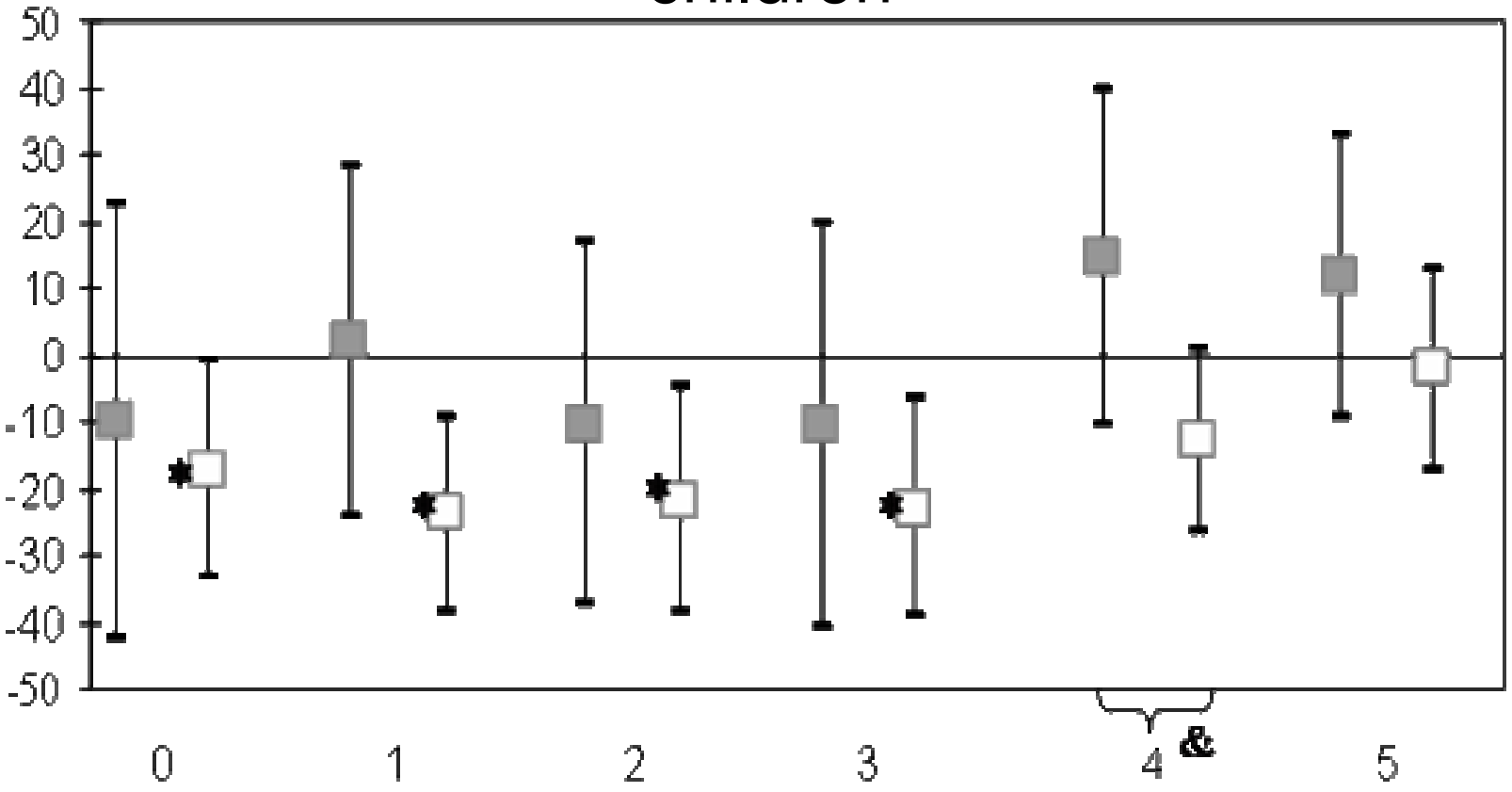


The models were adjusted for: gender, pets at home in the last 12 months, presence of mold in the home and maximum temperature.
Open Squares: FEV_1, dark squares: FVC

FVC FEV1

Hernandez – Cadena et al, Chest 2009

Association between a 10 ppb increase in NO_2 with FEV_1 % response to SABA in asthmatic children

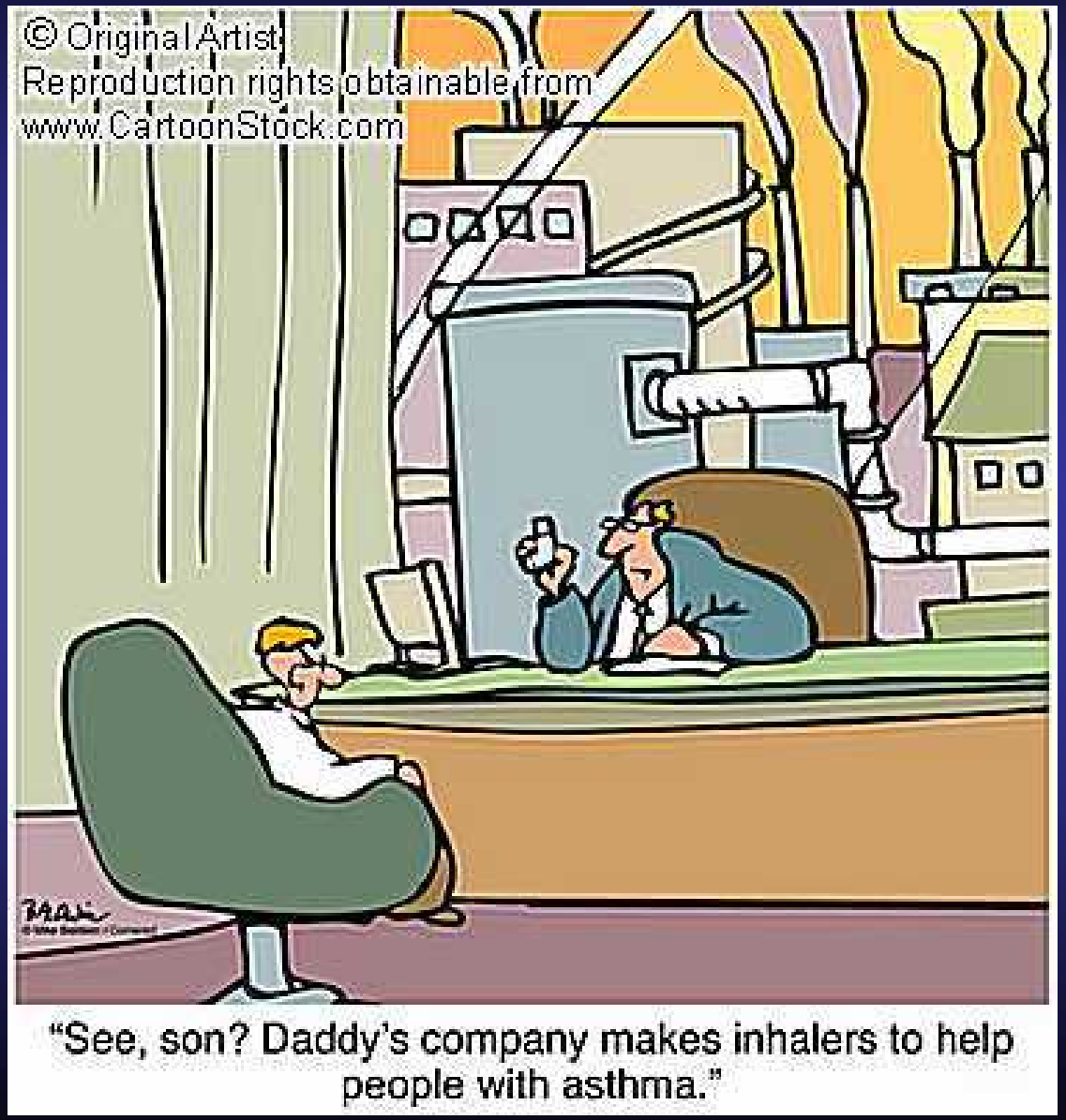


The models were adjusted for: gender, pets at home in the last 12 months, presence of mold in the home and maximum temperature. Open Squares: no ICS use, dark squares: ICS use

No IC IC

Hernandez Cadena et al, Chest 2009

Long term consequences



Asthma in exercising children exposed to ozone: a cohort study

	Low pollution communities (n=46)		High pollution communities (n=46)	
	Concentration (mean [SD])	Median (range)	Concentration (mean [SD])	Median (range)
Maximum 1-h ozone (ppb)	50·1 (11·0)	47·6 (37·7–67·9)	75·4 (6·8)	73·5 (69·3–87·2)
$Ozone_{10-14}$ (ppb)	40·0 (7·9)	40·7 (30·6–50·9)	59·6 (5·3)	56·9 (55·8–69·0)
24-h ozone (ppb)	25·1 (3·1)	25·1 (20·6–28·7)	38·5 (11·0)	33·1 (30·7–59·8)
PM_{10} (mg/m³)	21·6 (3·8)	20·8 (16·2–27·3)	43·3 (12·0)	39·7 (33·5–66·9)
$PM_{2·5}$ (mg/m³)	7·6 (1·0)	7·7 (6·1–8·6)	21·4 (6·0)	21·8 (13·5–30·7)
NO_2 (ppb)	10·8 (4·6)	12·1 (4·4–17·0)	29·2 (8·5)	29·5 (17·9–39·4)
Acid (ppb)	1·8 (0·7)	1·7 (0·9–2·6)	3·9 (0·7)	3·7 (3·3–4·9)

*These are the same six high and six low communities for PM_{10}, $PM_{2·5}$, NO_2, and acid, but not for other pollutants. Ppb=parts per billion; Acid=inorganic acid vapour.

Table 3: **4-year pollution concentrations in high and low pollution communities***

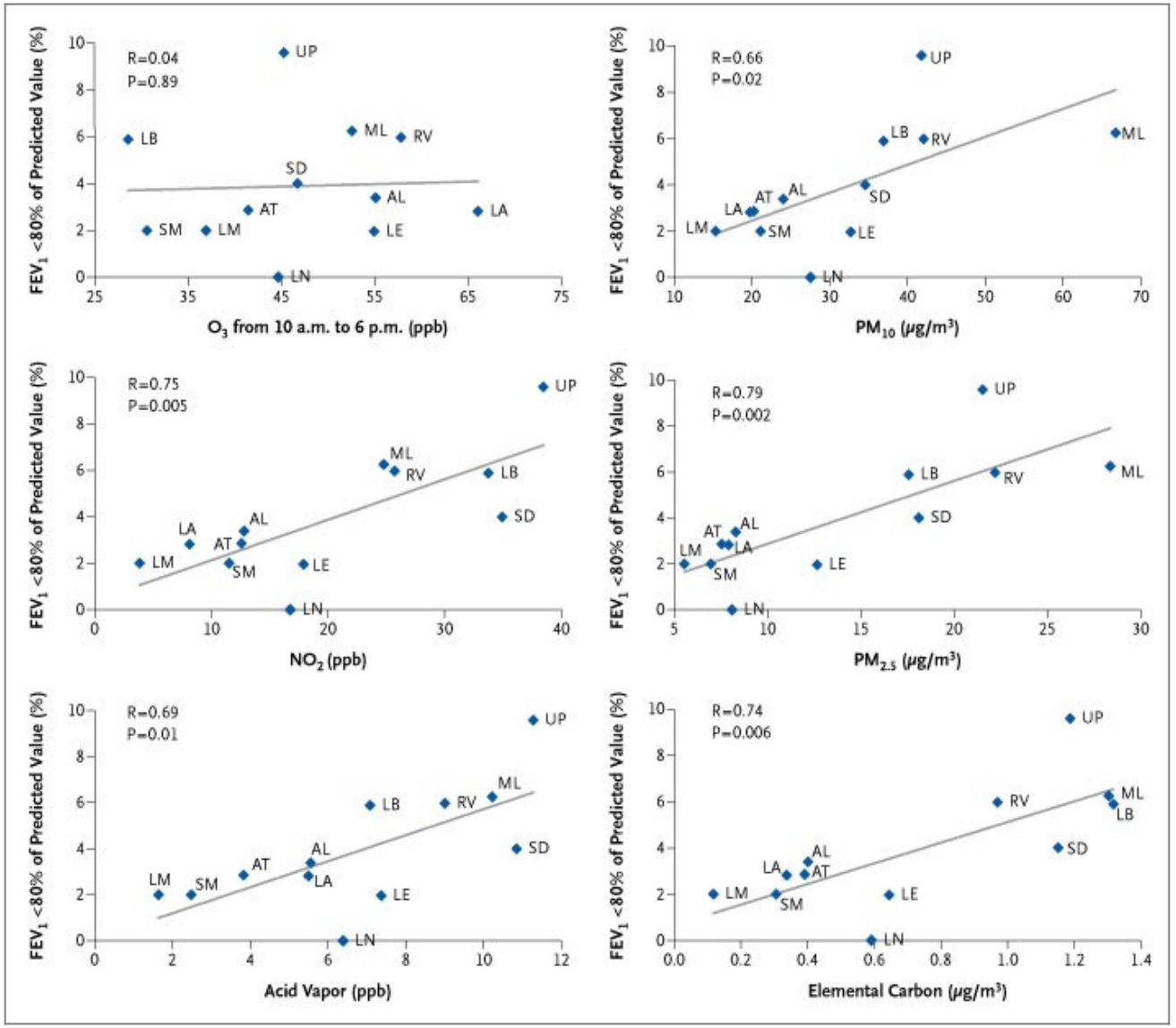
	Low PM communities		High PM communities	
	N (incidence)*	RR (95% CI)	N (incidence)*	RR (95% CI)
Number of sports played				
0	49 (0·023)	1·0	55 (0·021)	1·0
1	54 (0·032)	1·5 (1·0–2·2	36 (0·021)	1·1 (0·7–1·7)
2	22 (0·024)	1·2 (0·7–1·9	14 (0·018)	0·9 (0·5–1·7)
≥3	13 (0·033)	1·7 (0·9–3·2	16 (0·033)	2·0 (1·1–3·6)

PM=particulate matter; N=number of cases of asthma; RR=relative risk, adjusted for ethnic origin, and for stratified baseline hazards by sex and age group. *Denominator=person-years of follow-up.

Table 4: **Effect of number of team sports played on the risk of new asthma diagnosis in high and low PM (and other pollutant) communities**

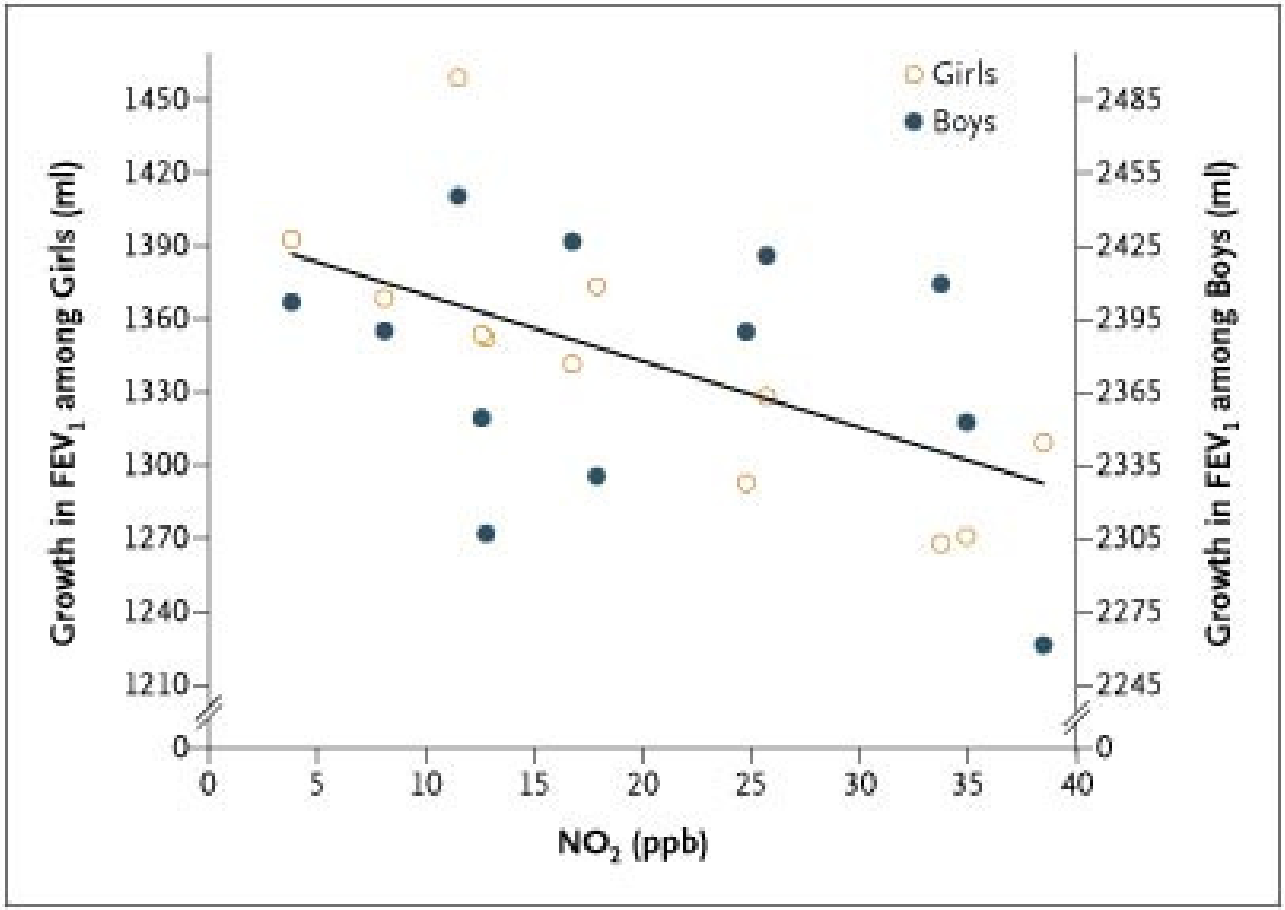
McConnell, Lancet 2002

Community-Specific Proportion of 18-Year-Olds with a FEV1 below 80 Percent of the Predicted Value Plotted against the Average Levels of Pollutants from 1994 through 2000



Gauderman W et al. N Engl J Med 2004;351:1057-1067

Community-Specific Average Growth in FEV1 among Girls and Boys During the Eight-Year Period from 1993 to 2001 Plotted against Average Nitrogen Dioxide (NO2) Levels from 1994 through 2000



Gauderman W et al. N Engl J Med 2004;351:1057-1067

Lung growth from most to least polluted

Table 3. Difference in Average Growth in Lung Function over the Eight-Year Study Period from the Lea

Pollutant	FVC		FEV_1	
	Difference (95% CI) *ml*	P Value	Difference (95% CI) *ml*	P Value
O_3				
10 a.m.–6 p.m.	–50.6 (–171.0 to 69.7)	0.37	–22.8 (–122.3 to 76.6)	0.62
1-Hour maximal level	–70.3 (–183.3 to 42.6)	0.20	–44.5 (–138.9 to 50.0)	0.32
NO_2	–95.0 (–189.4 to –0.6)	0.05	–101.4 (–164.5 to –38.4)	0.005
Acid vapor	–105.2 (–194.5 to –15.9)	0.03	–105.8 (–168.8 to –42.7)	0.004
PM_{10}	–60.2 (–190.6 to 70.3)	0.33	–82.1 (–176.9 to 12.8)	0.08
$PM_{2.5}$	–60.1 (–166.1 to 45.9)	0.24	–79.7 (–153.0 to –6.4)	0.04
Elemental carbon	–77.7 (–166.7 to 11.3)	0.08	–87.9 (–146.4 to –29.4)	0.007
Organic carbon	–58.6 (–196.1 to 78.8)	0.37	–86.2 (–185.6 to 13.3)	0.08

Environmental health is *complex*

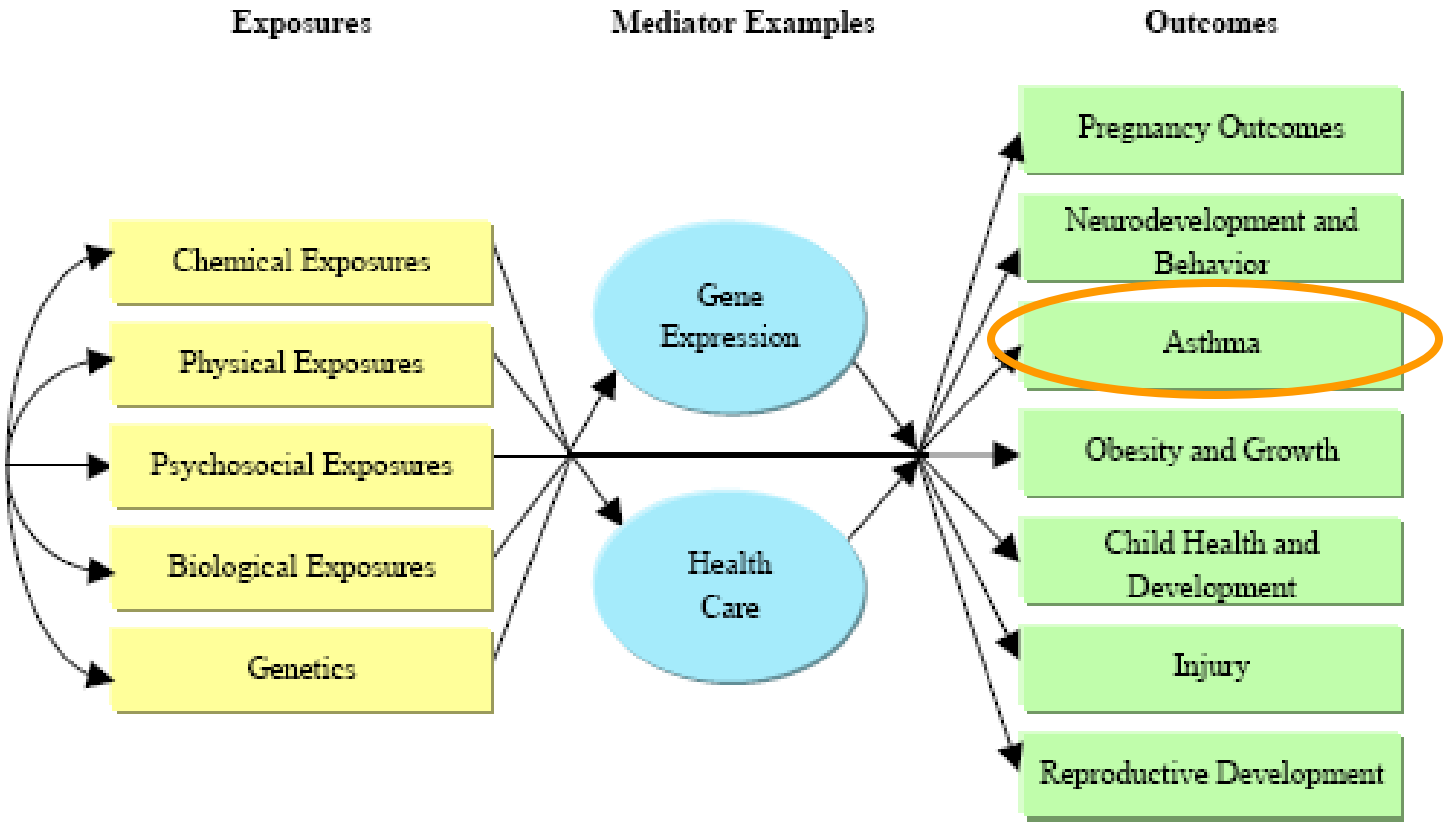


Figure 2-1. Conceptual Model of Exposures, Their Interactions, Examples of Mediators, and Outcomes

The National Children's Health study. http://www.nationalchildrensstudy.gov/

SES and susceptibility to exposures

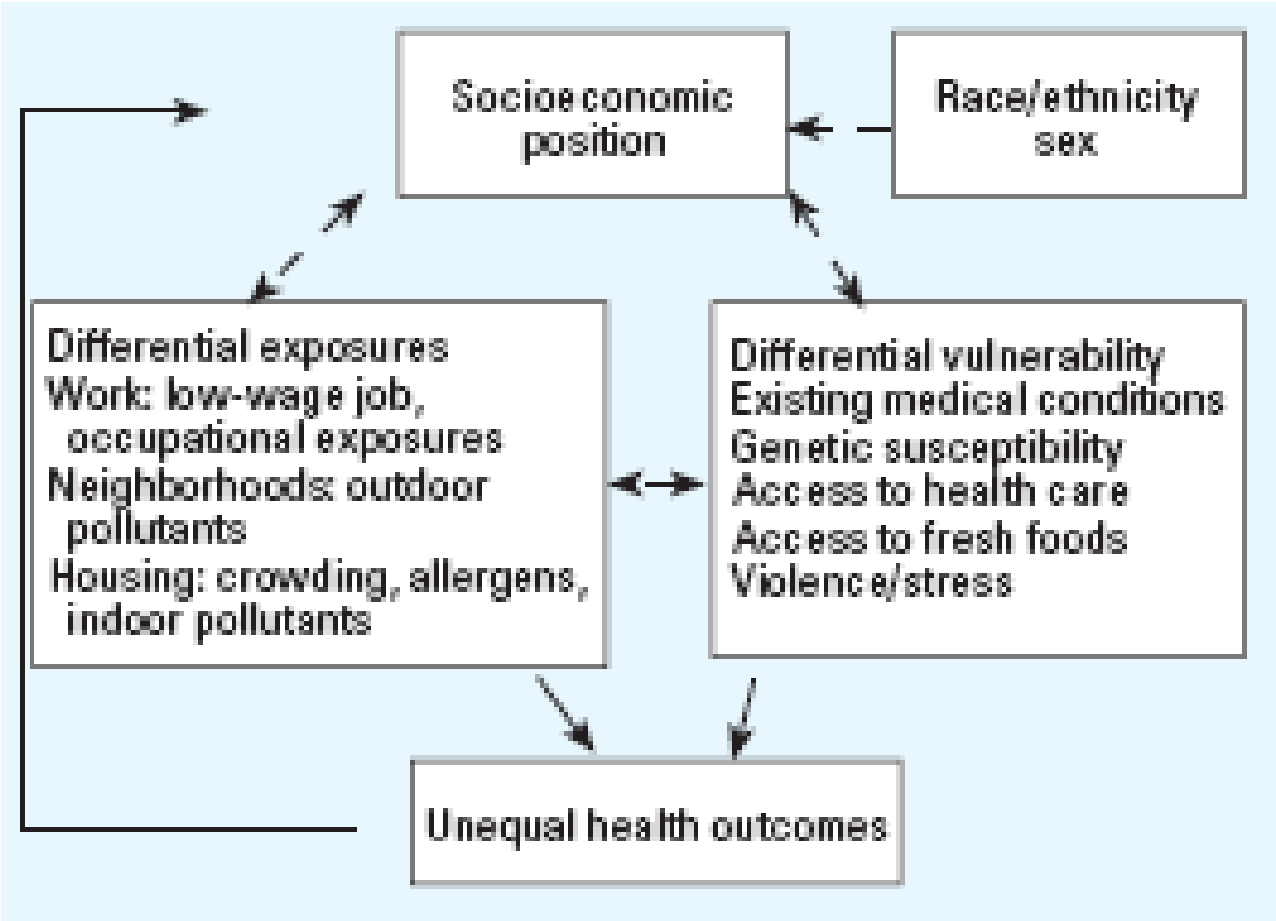
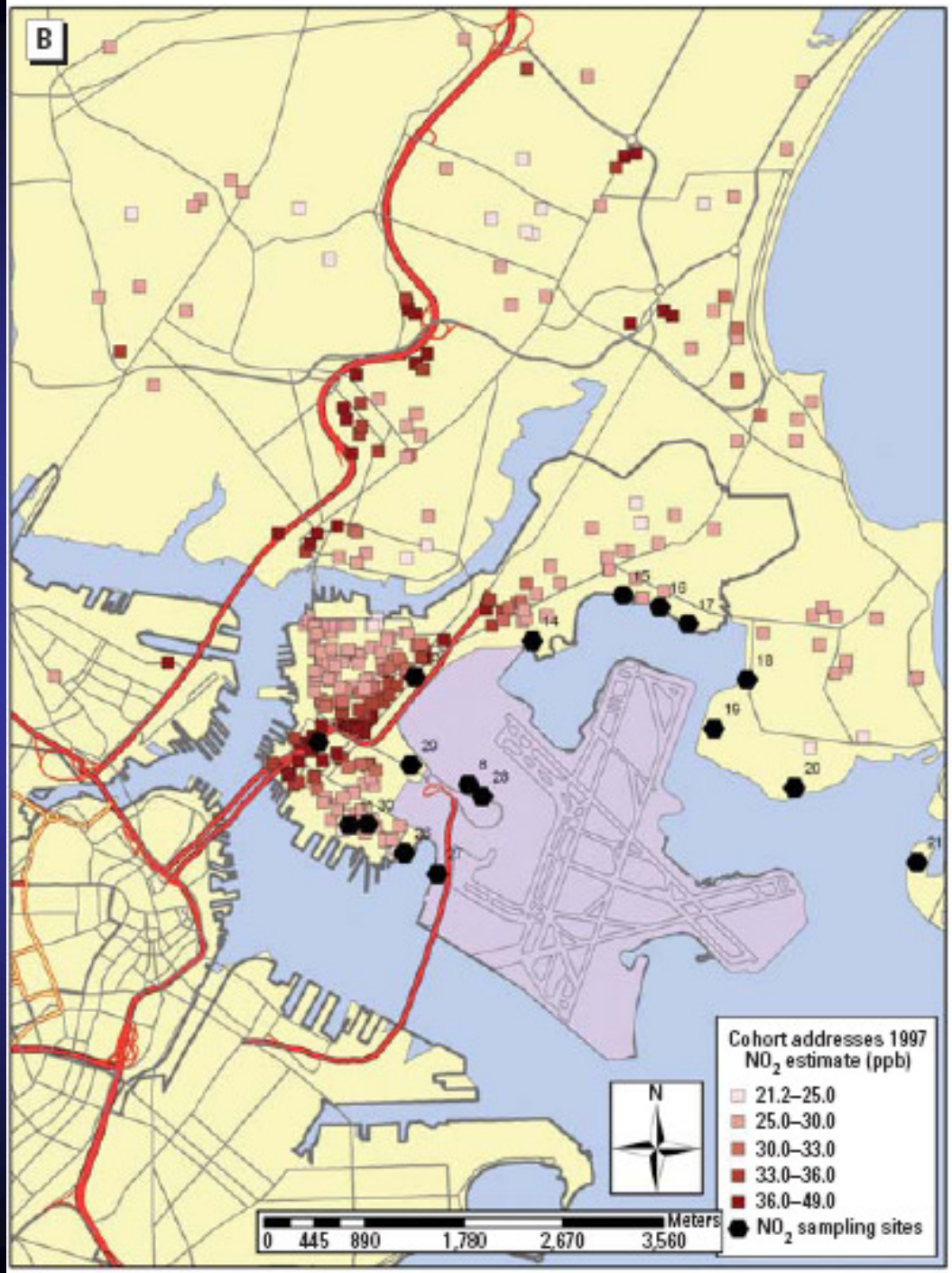


Figure 1. Potential pathways for SEP to increase susceptibility and exposure.

Mary O' Neill, EHP, 2006


B
Cohort addresses 1997
NO_2 estimate (ppb)
21.2–25.0
25.0–30.0
30.0–33.0
33.0–36.0
36.0–49.0
NO_2 sampling sites
N
0 445 890 1,780 2,670 3,560
Meters

Asthma, chronic NO_2 exposure and violence

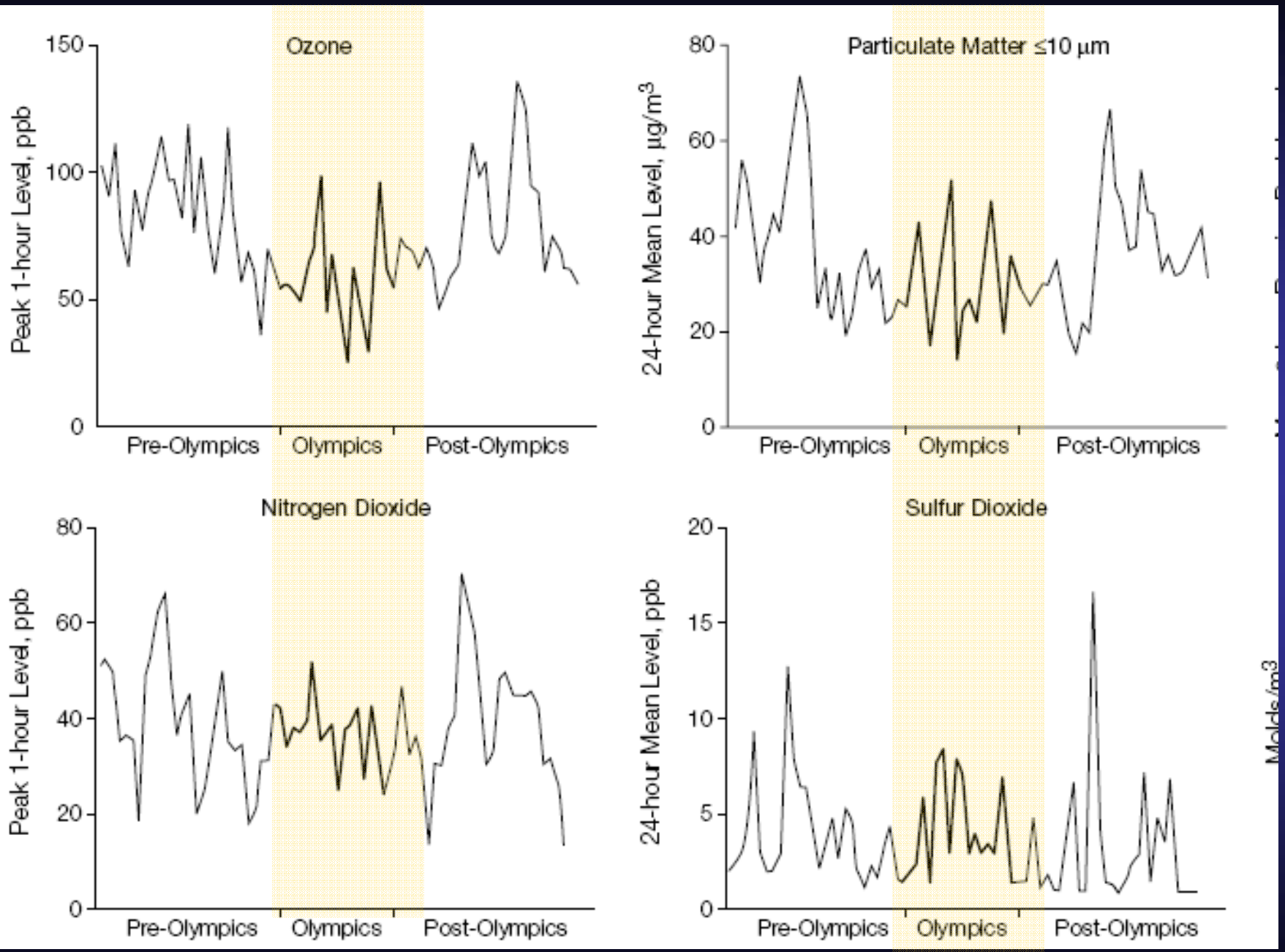
Table 4. Multivariate model for asthma diagnosis [OR (95% CI)].

	Full cohort	Lifetime residents
Maternal asthma (ever diagnosed)	1.31 (0.58–2.96)	0.89 (0.29–2.74)
In utero tobacco smoke exposure	1.07 (0.44–2.58)	1.87 (0.53–6.57)
Maternal smoking since birth	1.10 (0.70–1.72)	0.85 (0.45–1.63)
Less than high school education	1.14 (0.71–1.81)	1.12 (0.60–2.07)
Child's sex (female)	0.85 (0.54–1.34)	0.62 (0.34–1.14)
Child's age (≥ 7 years)	1.44 (0.90–2.33)	1.06 (0.56–2.00)
High ETV	0.89 (0.56–1.43)	1.10 (0.59–2.04)
NO_2 year of diagnosis: low ETV	0.99 (0.73–1.34)	0.85 (0.56–1.27)
NO_2 year of diagnosis: high ETV	1.63 (1.14–2.33)	2.40 (1.48–3.88)

ORs for NO_2 are associated with a 1-SD (4.3 ppb) increase.

Environmental Health Perspectives

What if we reduce emissions?



Freeman, M JAMA 2001

Less pollution, less asthma morbidity

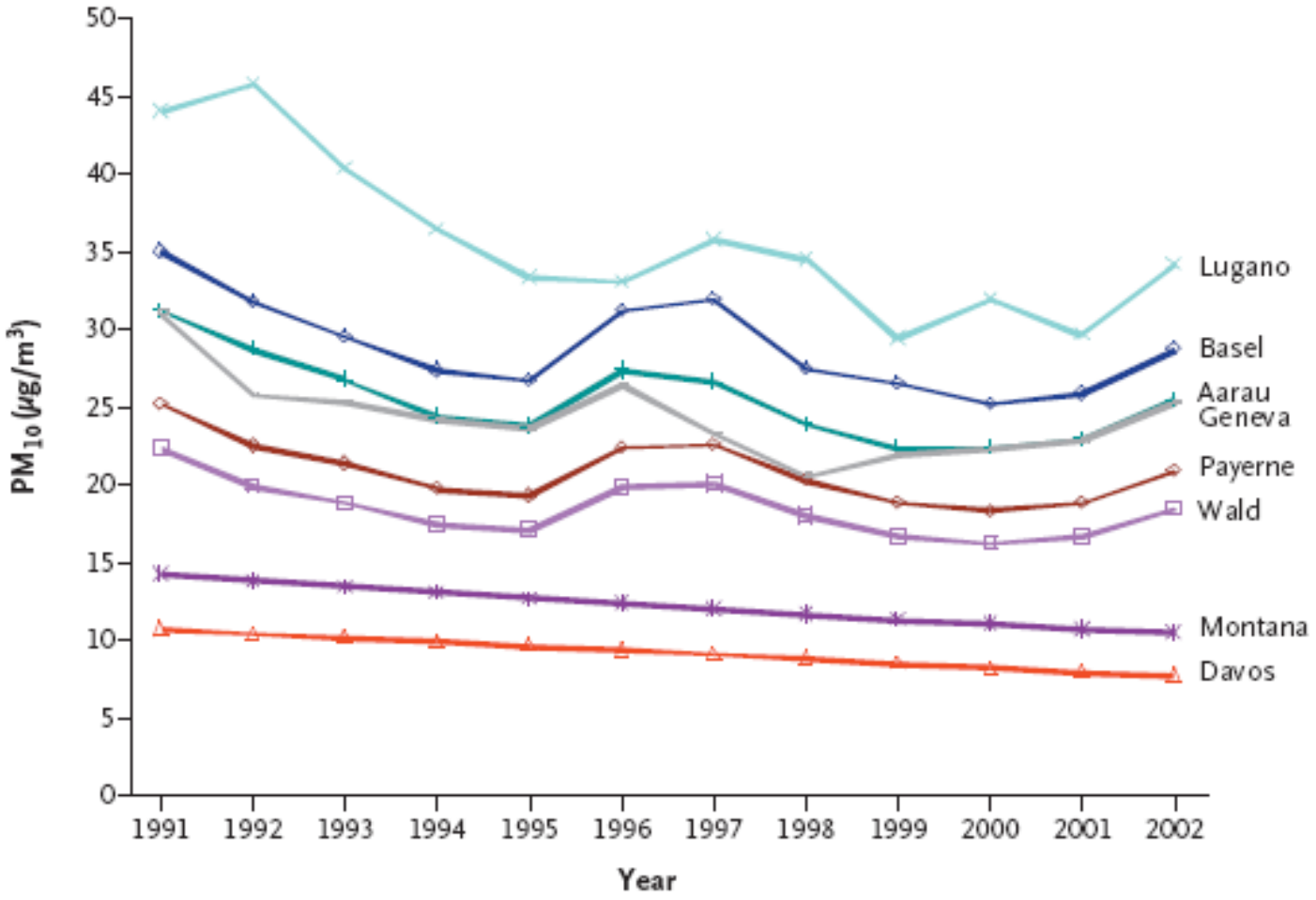
Table 2. Univariate and Adjusted Relative Risk of Acute Asthma Events During the 1996 Summer Olympic Games Compared With the 1996 Summertime Baseline Period*

Data Source	Univariate RR† (95% CI)	*P* Value	Adjusted RR‡ (95% Confidence Interval)	*P* Value
Georgia Medicaid claims file	0.61 (0.44-0.85)	.003	0.48 (0.44-0.86)	.005
Health maintenance organization	0.56 (0.31-1.02)	.06	0.58 (0.32-1.06)	.10
Pediatric emergency departments	0.91 (0.85-1.42)	.48	0.93 (0.71-1.22)	.69
Georgia Hospital Discharge Database	0.81 (0.54-1.23)	.34	0.71 (0.46-1.11)	.22

*RR indicates relative risk; CI, confidence interval. For definition of baseline period, see "Study Design" subsection of "Methods" section.
†Relative risk based on Poisson model (fraction of total acute care events with a primary diagnosis of asthma).
‡Time-series regression analysis was adjusted for day of week (weekday vs weekend) and minimum daily temperature (lagged 1 day to minimize serial correlation).

Freeman, M. JAMA 2001

Reduced Exposure to PM10 and Attenuated Age-Related Decline in Lung Function



Exposure on 9651 SAPALDIA participants. Estimates on the annual PM10 individual home outdoor exposure

NEJM, 2007

Reduced PM10, reduced lung function decline

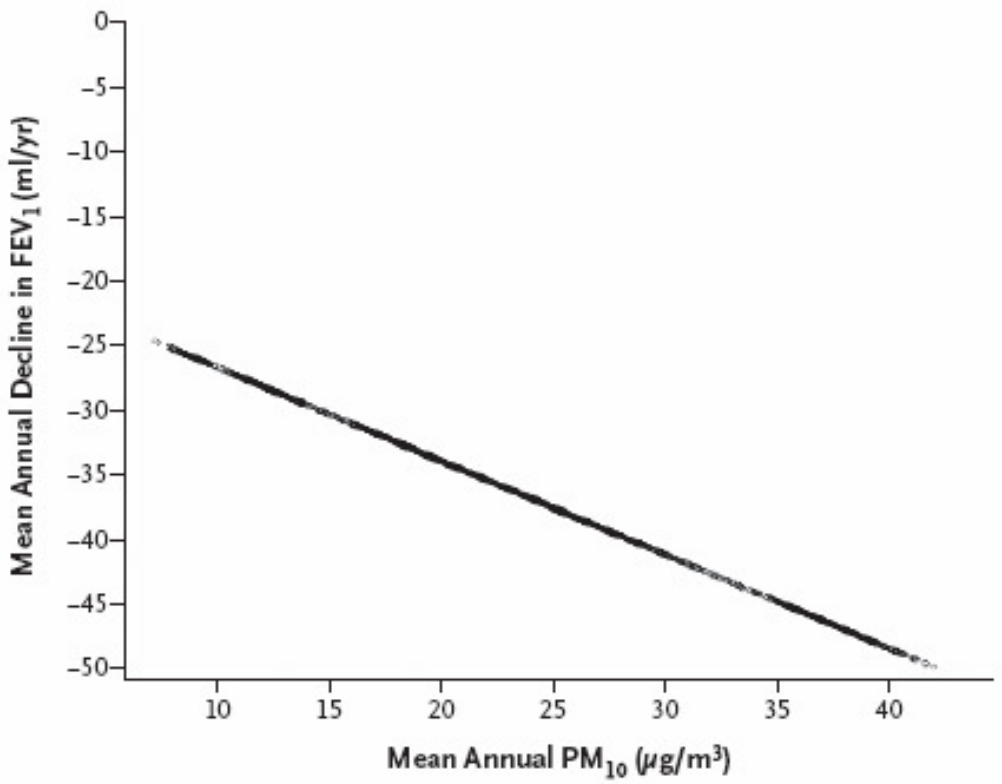


Figure 3. Estimated Effect of Interval Exposure between 1991 and 2002 (Expressed as Mean Annual PM_{10}) on Mean Annual Decline in FEV_1.

The mixed model was refitted with a penalized spline and the use of generalized cross-validation. Interval exposure has been converted to mean annual exposure during the interval for ease of interpretation. PM_{10} denotes particulate matter with an aerodynamic diameter of less than 10 μm, and FEV_1 forced expiratory volume in 1 second.

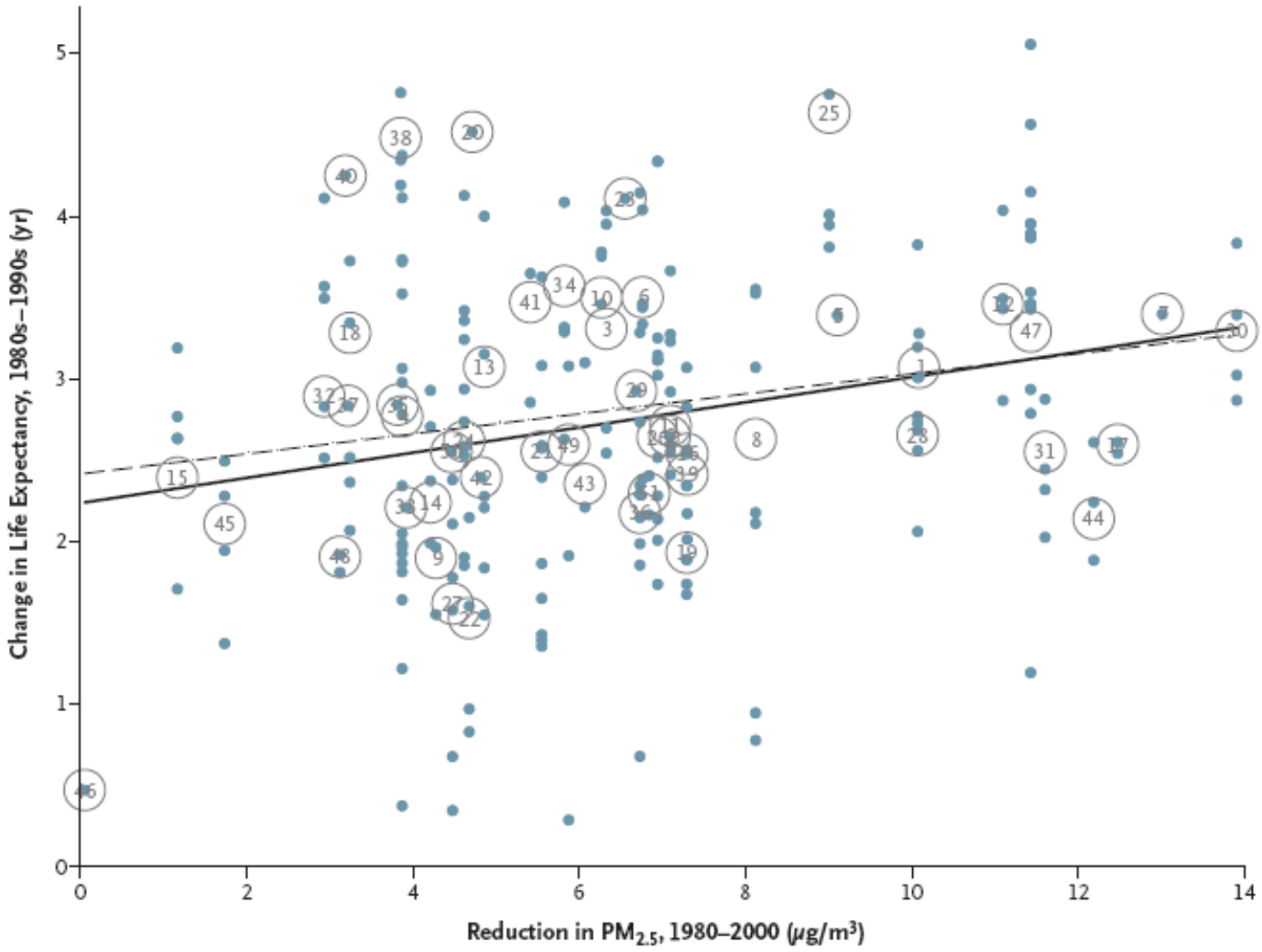
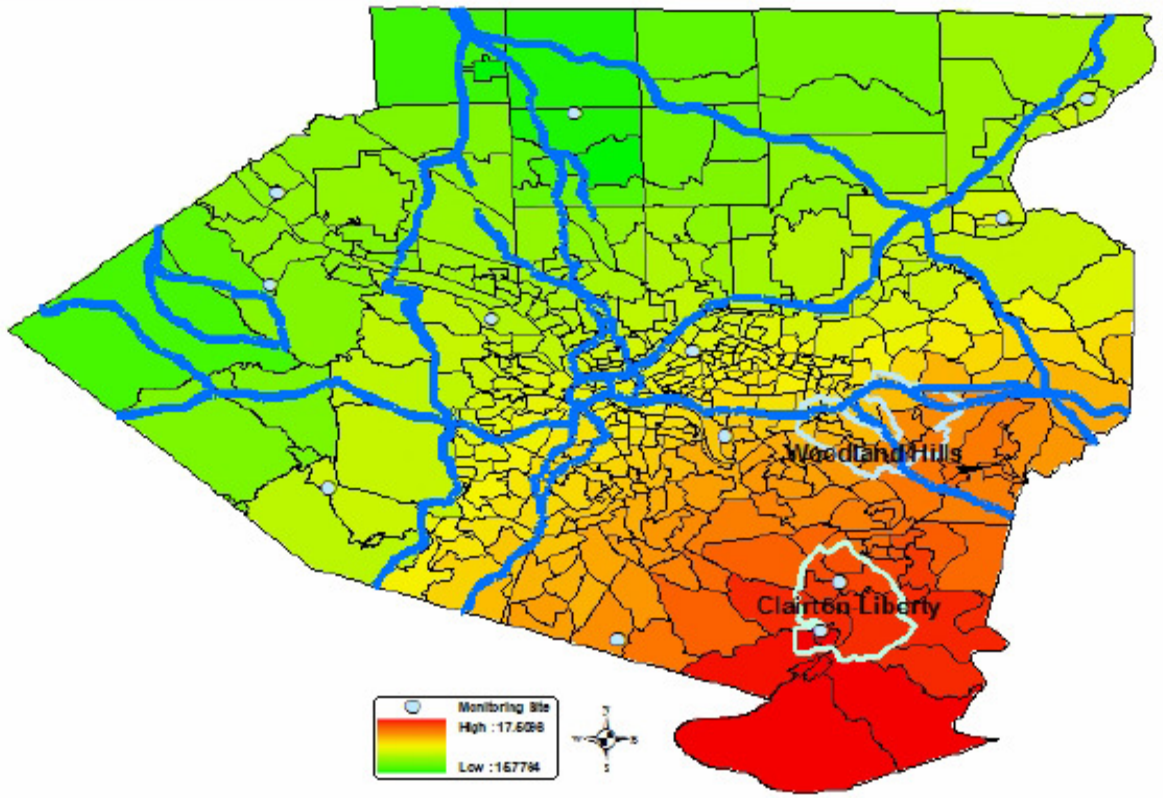


Figure 4. Changes in Life Expectancy for the 1980s–1990s, Plotted against Reductions in $PM_{2.5}$ Concentrations for 1980–2000.

A reduction of 10 μg per cubic meter in PM2.5 was associated with an increased life expectancy of 0.95±0.57 for the least-polluted areas and 0.57±0.26 year for other areas

Pediatric Environmental Medicine Center (PEMC) Portal

Woodland Hills and Clarton Liberty Communities



Announcements

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RSS Viewer

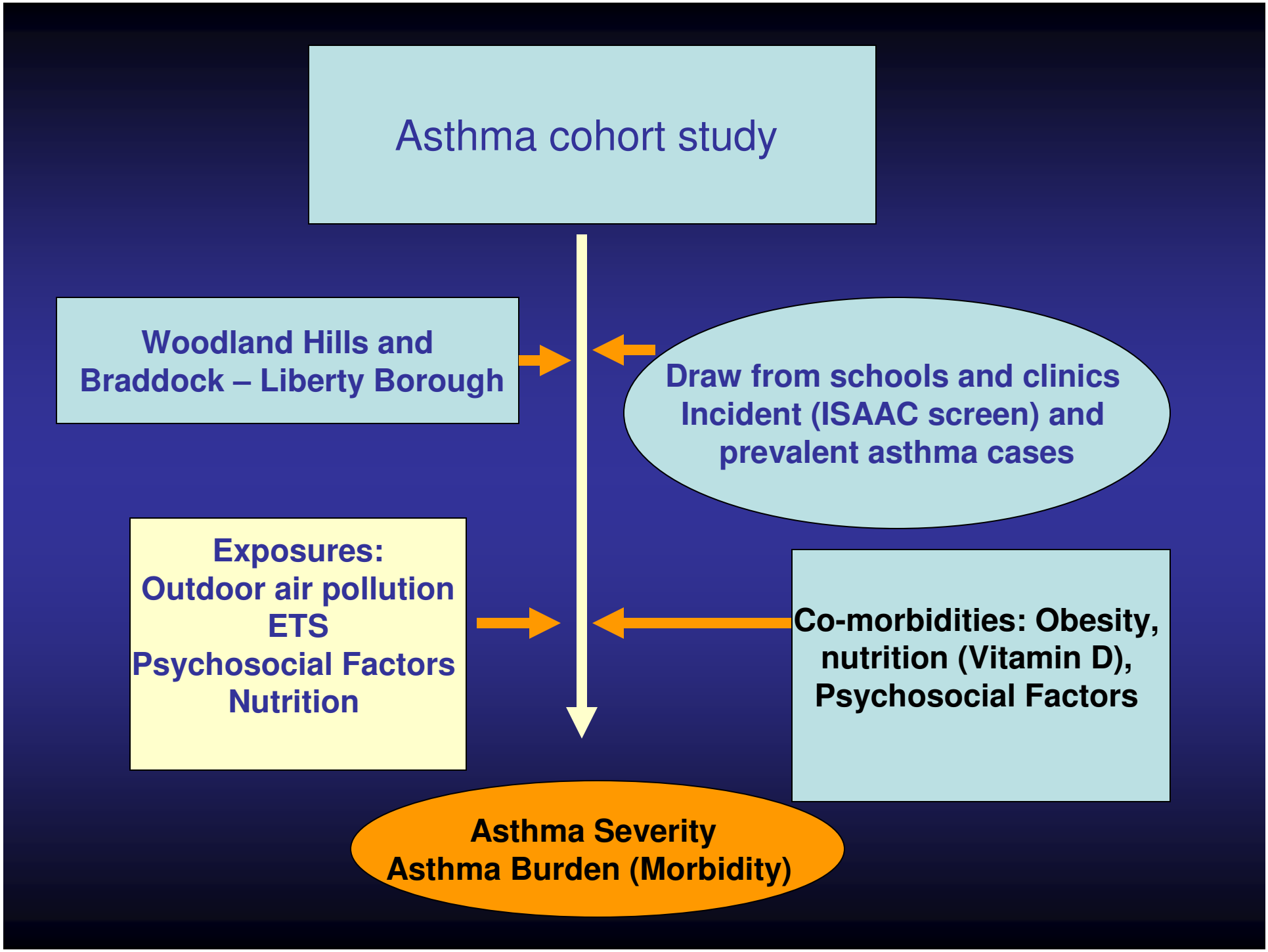
Environmental Health via MedWorm.com

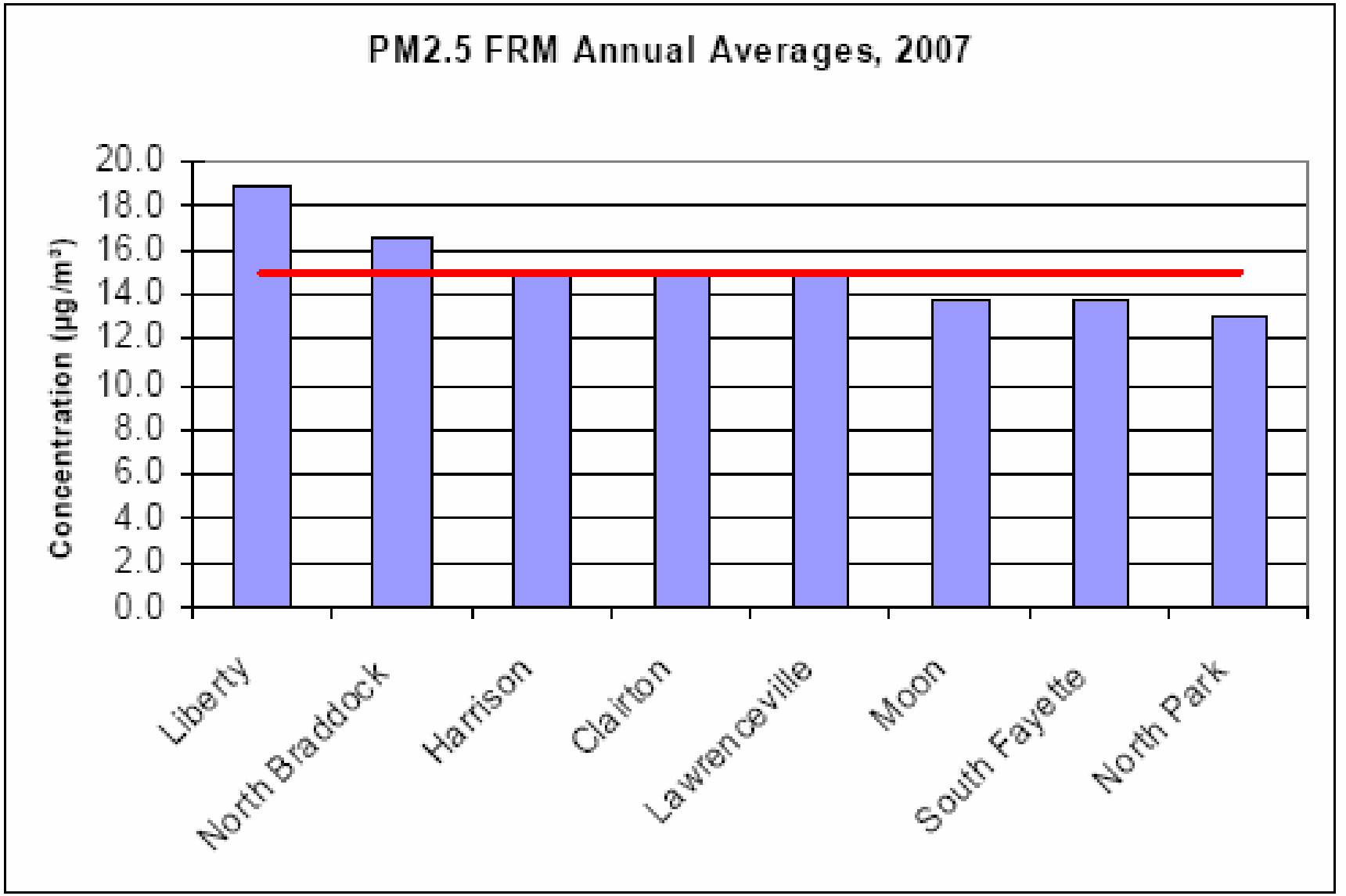
Gender and respiratory findings in workers occupationally exposed to organic aerosols: a meta analysis of 12 cross-sectional studies

Immune cell counts and risks of respiratory infections among infants exposed pre- and post-natally to organochlorine compounds: a prospective study

A framework for integrated environmental health impact assessment of systemic risks

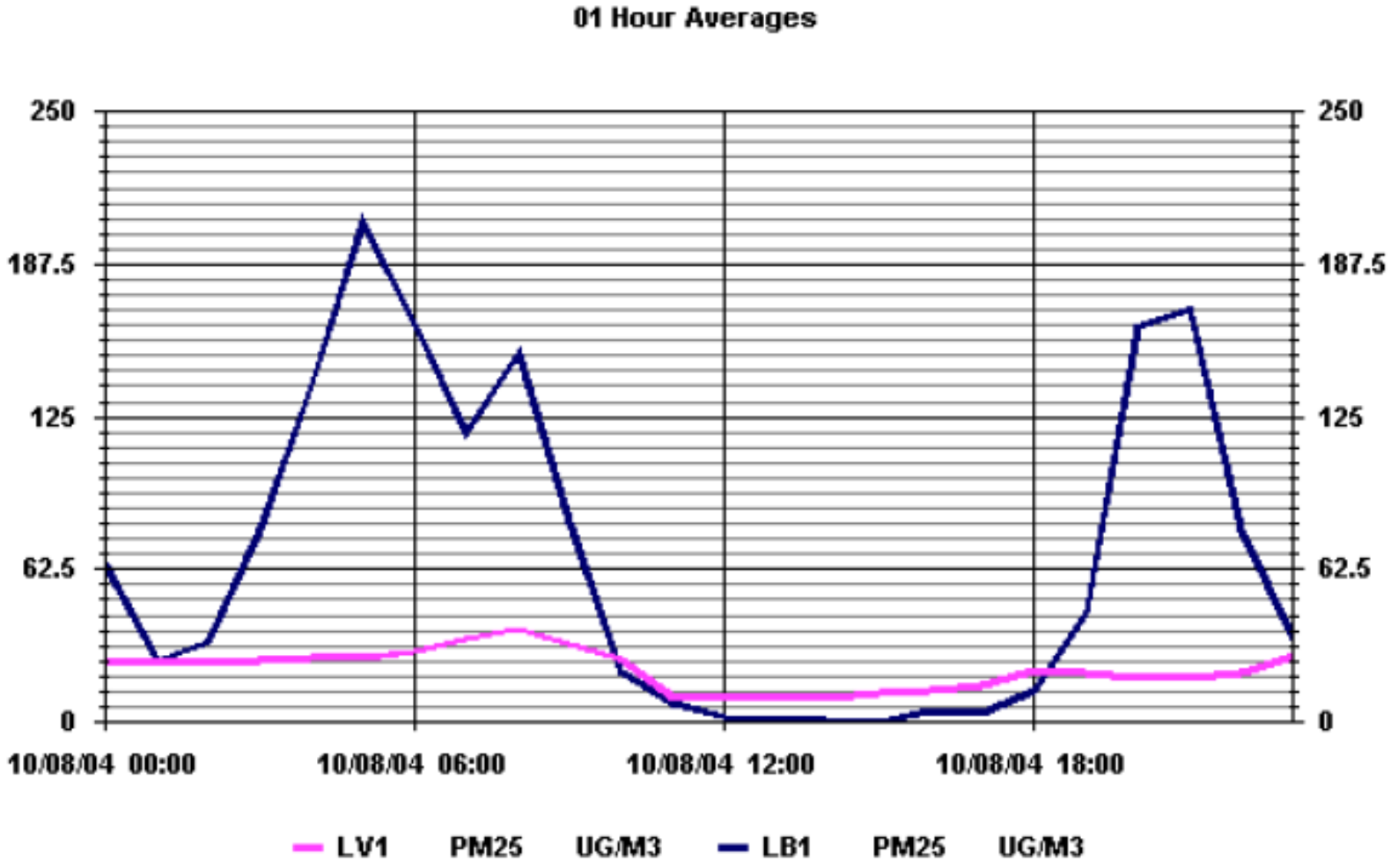
Site Users


Asthma cohort study
Woodland Hills and Braddock – Liberty Borough
Draw from schools and clinics Incident (ISAAC screen) and prevalent asthma cases
Exposures: Outdoor air pollution ETS Psychosocial Factors Nutrition
Co-morbidities: Obesity, nutrition (Vitamin D), Psychosocial Factors
Asthma Severity Asthma Burden (Morbidity)



Allegheny County Health Department http://www.achd.net/air/pubs/pdf/4q07aqreport.pdf

PM2.5 Influenced by Inversions at Liberty



US Steel Proposes $1B Investment In Clairton Plant

U.S. Steel is set to announce a major capital investment at Clairton Coke Works

Reuters, 2007

Collaborators & Partners

- CMU Civil Engineering
  - Center for Atmospheric Particles
- Robotics CMU, CREATE Laboratory
- Department of Psychology CMU and University of Pittsburgh
- Allegheny County Health Department
- G.A.S.P.
- S.H.I.P.
- CMH, University of Pittsburgh
- Heinz Foundation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