Air Pollution and Children's Health

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Basic Questions

- What does air pollution do?
- What component is doing it?
- Who's it doing it to?
- How much does it take to do it?

Central Scientific Issues

- Exposure vs. Host Factors
  - Quantify contributions
- Reversibility
  - Continuum of acute→chronic
- Differentiating Association from Causation
  - Unraveling colinearity
  - Ecologic bias

Reason for Children's Health Study

- Are chronic respiratory effects caused by Southern California air pollution?

Regional Pollution

Local Pollution

The USC Children's Health Study

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Scott Zeger

The USC Children's Health Study

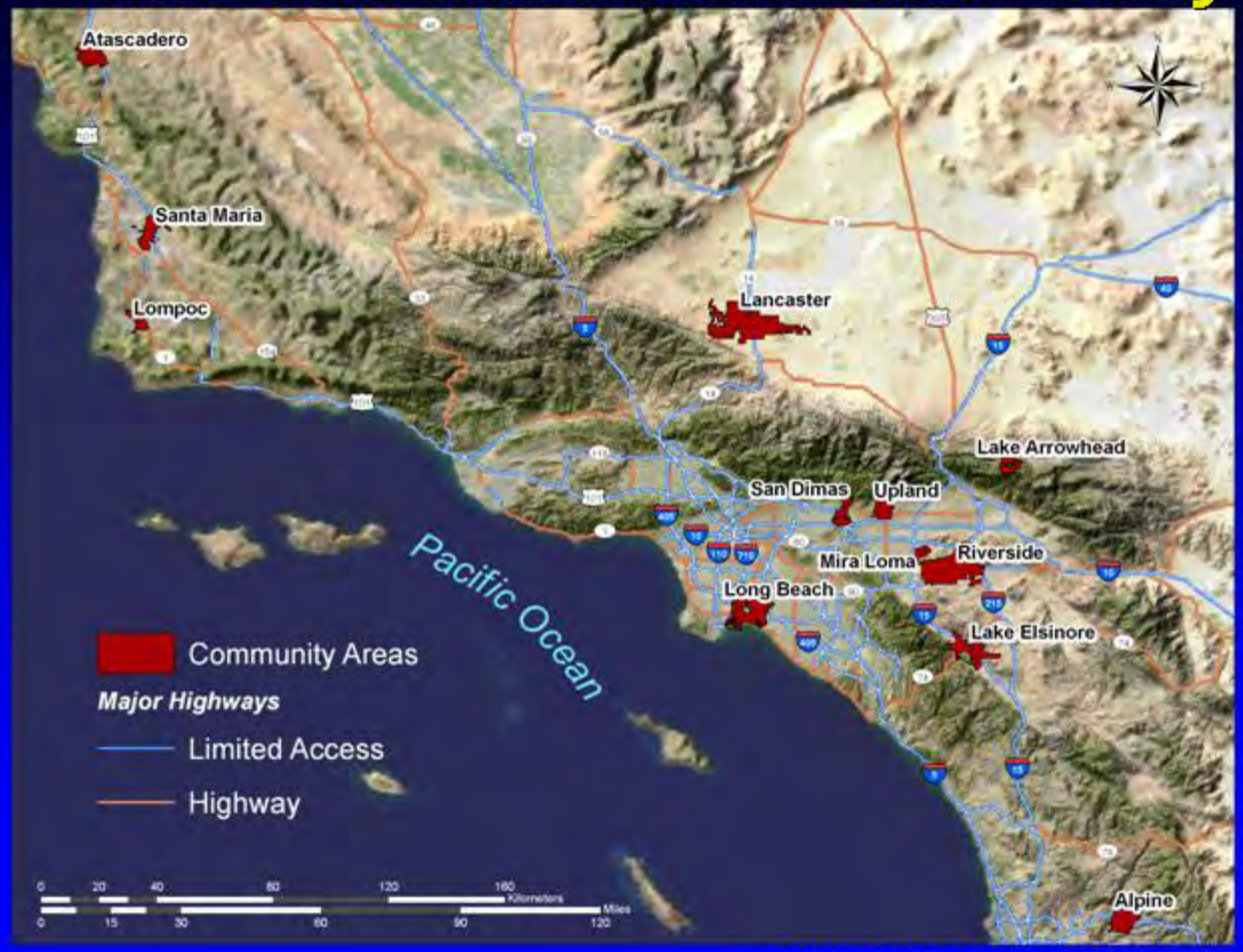
Funding:

California:	Air Resources Board
Federal:	NIEHS
	NHLBI
	EPA
Private:	Hastings Foundation

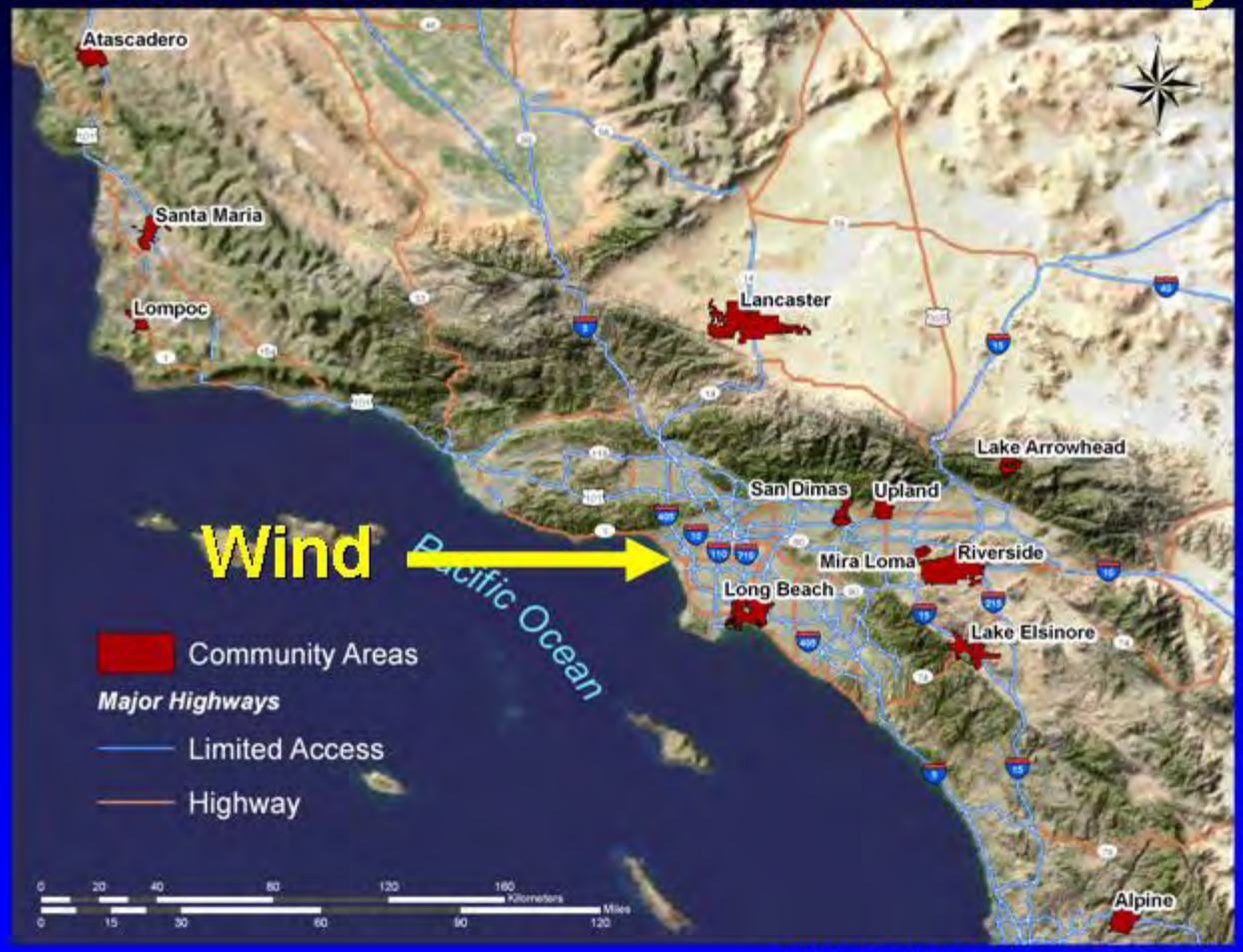
Children's Health Study Goals

- Is childhood exposure to ambient pollutants associated with:
  - Lung function development?
  - Chronic respiratory symptoms?
  - School absence?
  - Onset of asthma?

The USC Children's Health Study



The USC Children's Health Study



Southern California Children's Health Study
Ambient Air Quality Monitoring Sites.

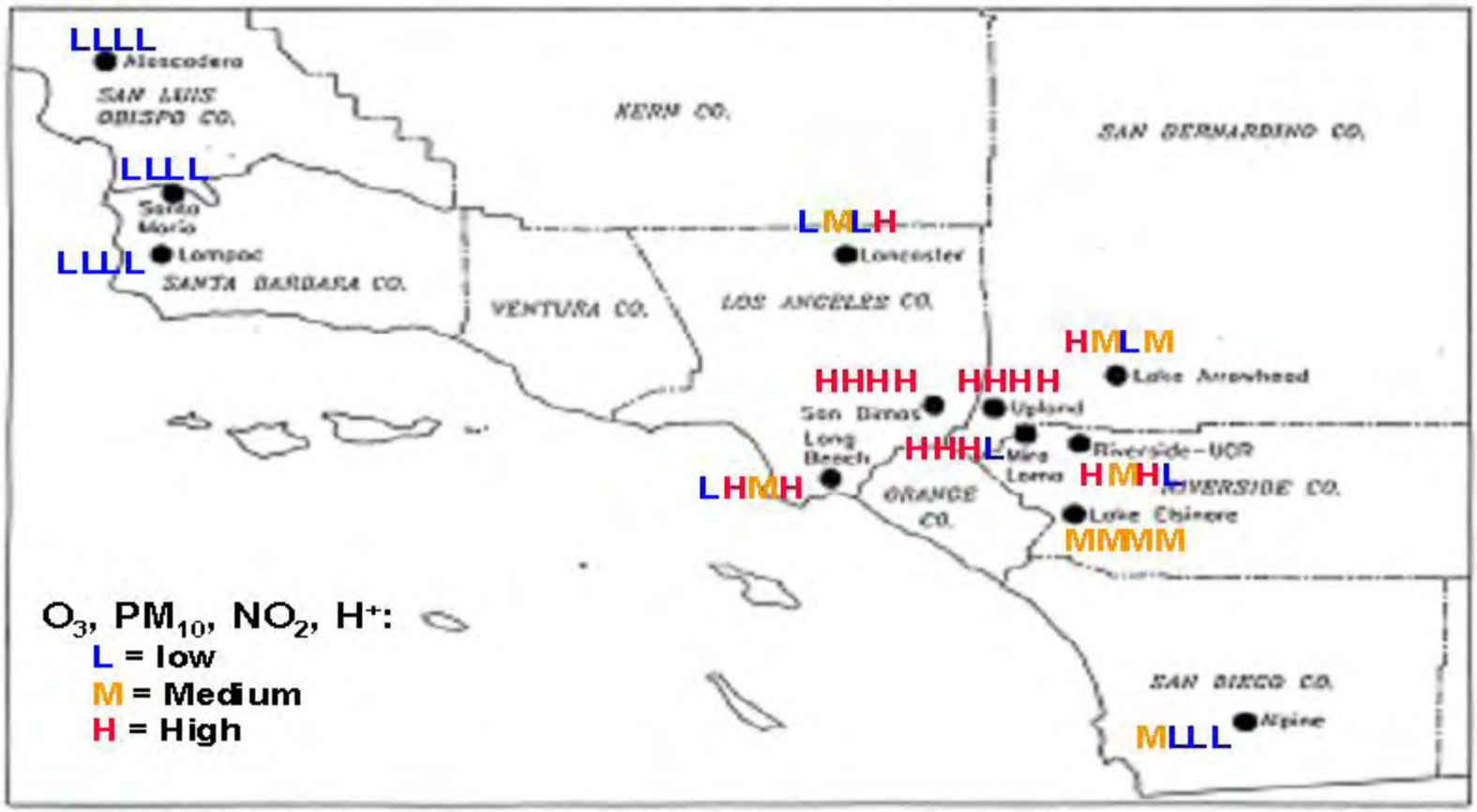


Figure 3-1. Locations of the ambient air monitoring sites.

Summary of Pollutants

- Continuous monitoring in each study community since 1994
  - Particulate Matter: PM_{10}, $PM_{2.5}$, EC, OC
  - Nitrogen Dioxide (NO_2)
  - Acid vapor: Primarily nitric acid
  - Ozone (O_3)

Elements of CHS

Exposure Assessment (Ambient)

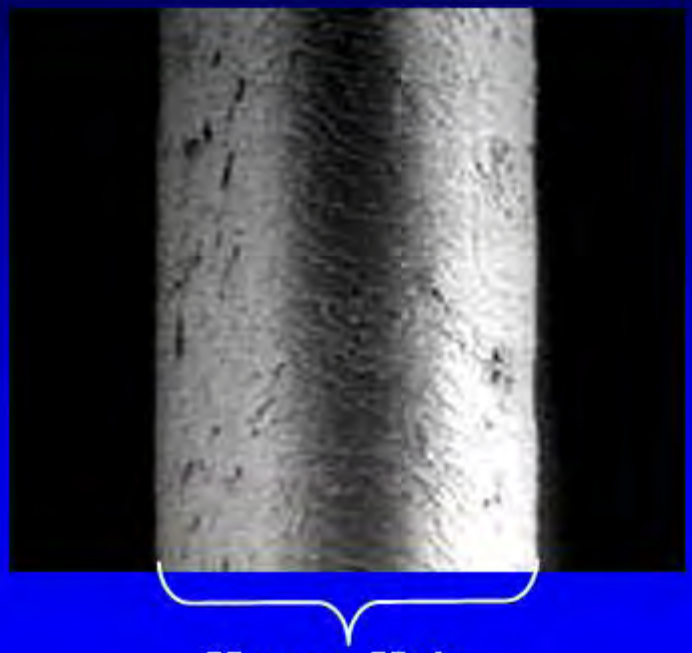
- One Station Per Community
  - Hourly O_3
  - Hourly NO_2
  - Hourly PM_{10}
  - Two week $PM_{2.5}$ mass and chemistry
  - Two week acid vapor

Elements of CHS

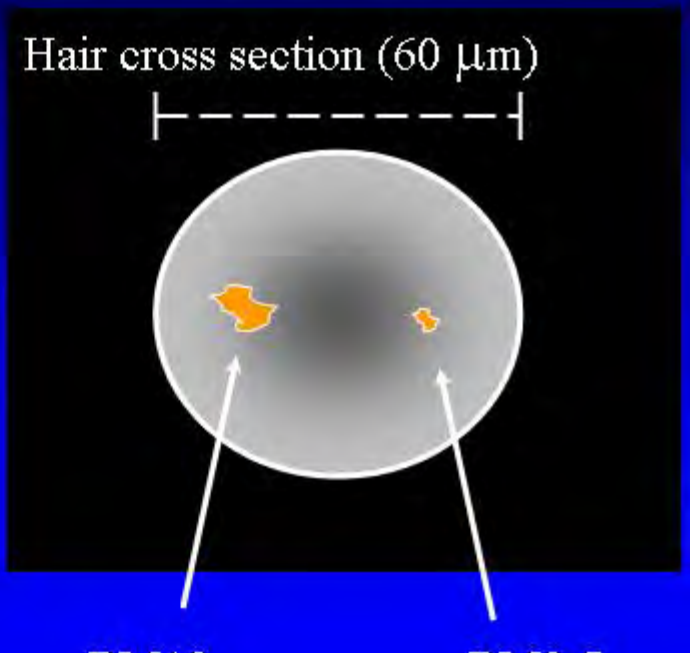
Exposure Assessment (→ Personal)

- Spatial activity
- Temporal activity
- Physical activity
- Residential history
- Microenvironmental sampling–I/O ratios
- Intra-community variation
- Exposure modeling

How Small is Particulate Matter?



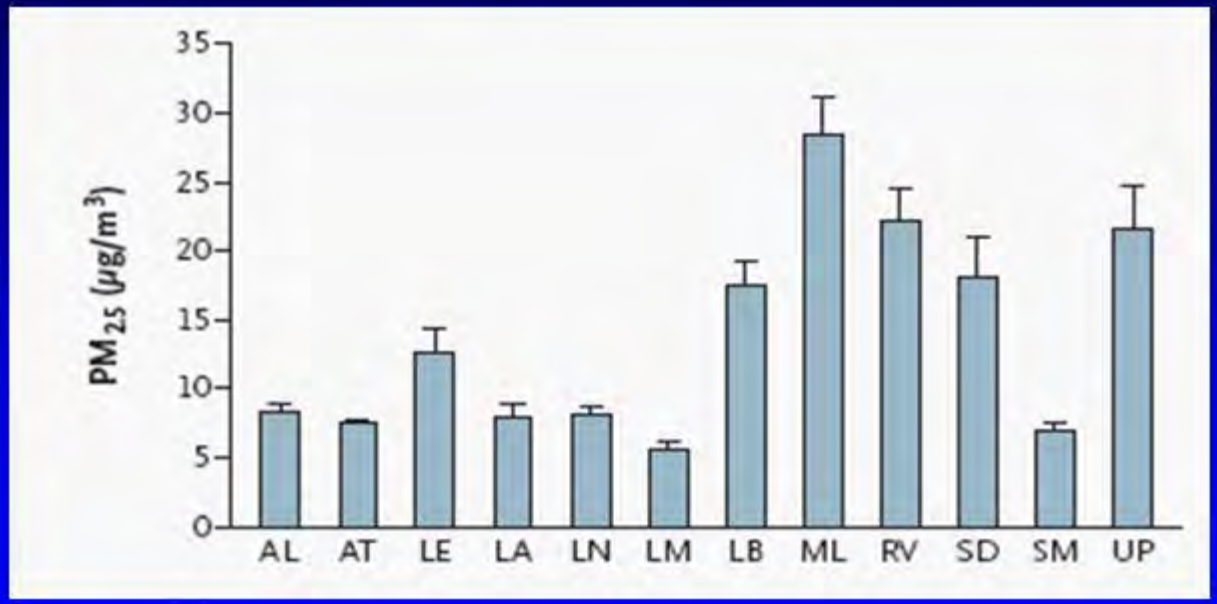
Human Hair
(60 µm diameter)



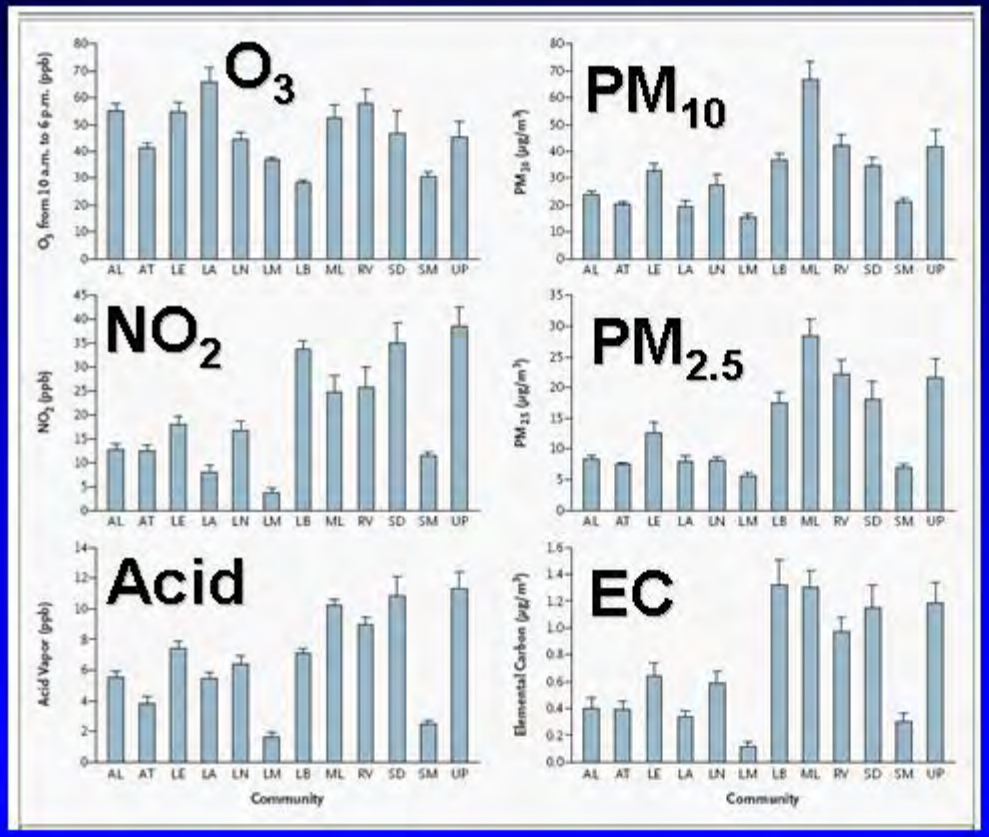
PM10
(10 µm)

PM2.5
(2.5 µm)

Mean $PM_{2.5}$ levels, 1994-2000

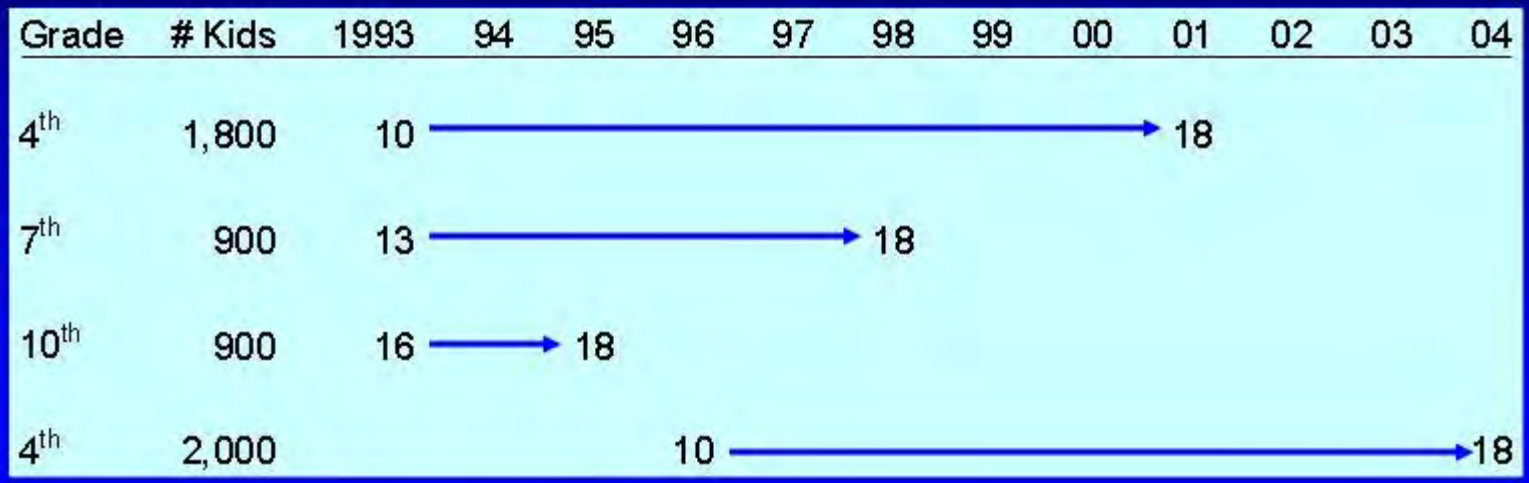


Mean pollutant levels, 1994-2000



Southern California has the full range of most pollutants found in the U.S.

Child Groups Studied and Their Ages Each Year



Children's Health Study Goals

- Is childhood exposure to ambient pollutants associated with:
  - Lung function development?
  - Chronic respiratory symptoms?
  - School absence?
  - Onset of asthma?

Elements of CHS

3 Health Outcomes

1. Pulmonary Function Tests (PFT)

   Volume & flows assessed annually

2. Questionnaire-based

Conditions	Symptoms
Asthmatic	Wheeze
Bronchitis	Cough
Pneumonia	Sputum

3. School absence monitoring

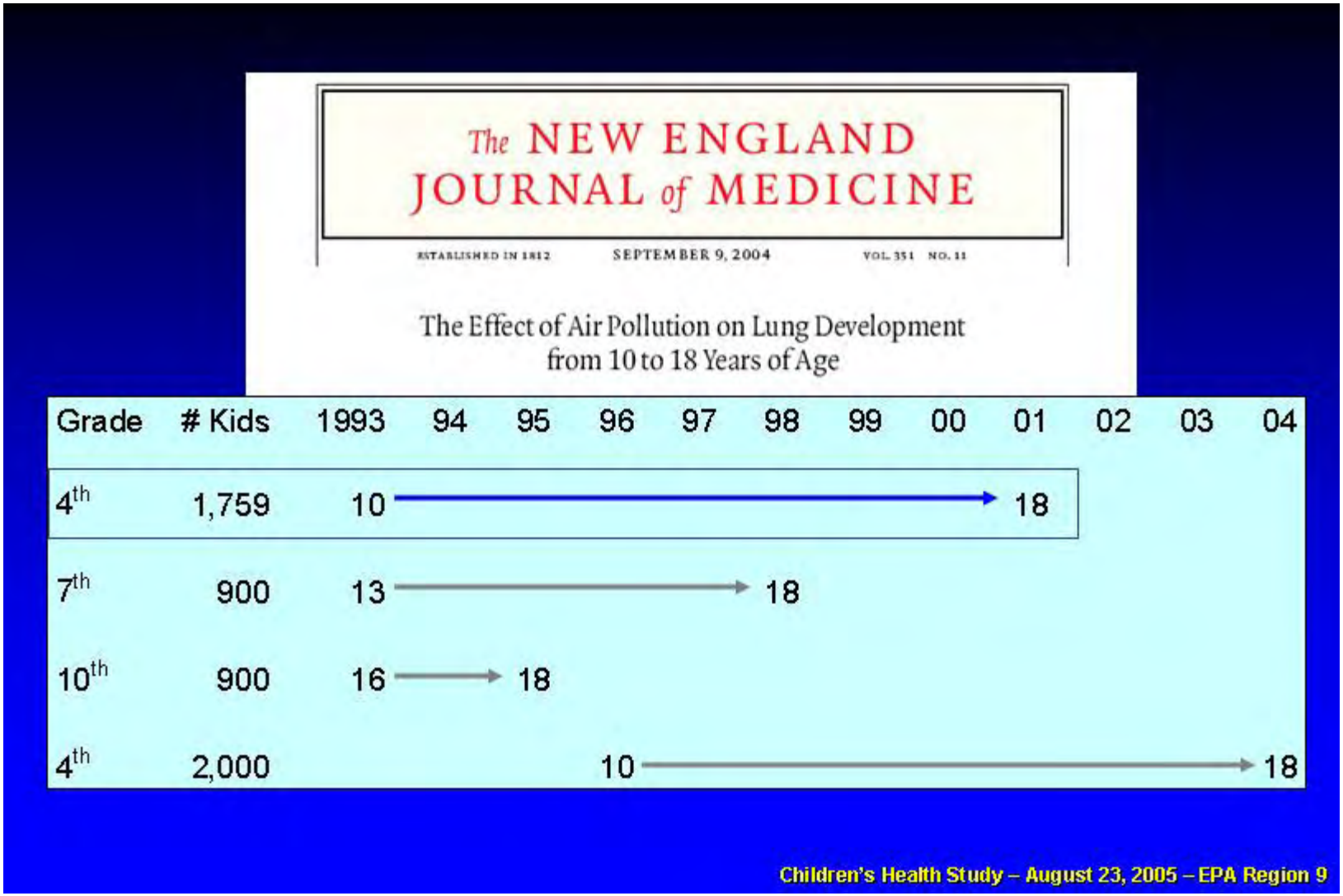
The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 SEPTEMBER 9, 2004 VOL. 351 NO. 11

The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age

W. James Gauderman, Ph.D., Edward Avol, M.S., Frank Gilliland, M.D., Ph.D., Hita Vora, M.S., Duncan Thomas, Ph.D., Kiros Berhane, Ph.D., Rob McConnell, M.D., Nino Kuenzli, M.D., Fred Lurmann, M.S., Edward Rappaport, M.S., Helene Margolis, Ph.D., David Bates, M.D., and John Peters, M.D.

ABSTRACT


The NEW ENGLAND JOURNAL of MEDICINE
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The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age
Grade # Kids 1993 94 95 96 97 98 99 00 01 02 03 04
4th 1,759 10 18
7th 900 13 18
10th 900 16 18
4th 2,000 10 18
Children's Health Study – August 23, 2005 – EPA Region 9

Annual lung function testing

4th grade through 12th

FEV_1: Volume of air exhaled in 1 second

Additional Data...

Active smoking?

Height?

Asthma?

Gas stove?

Respiratory illness?

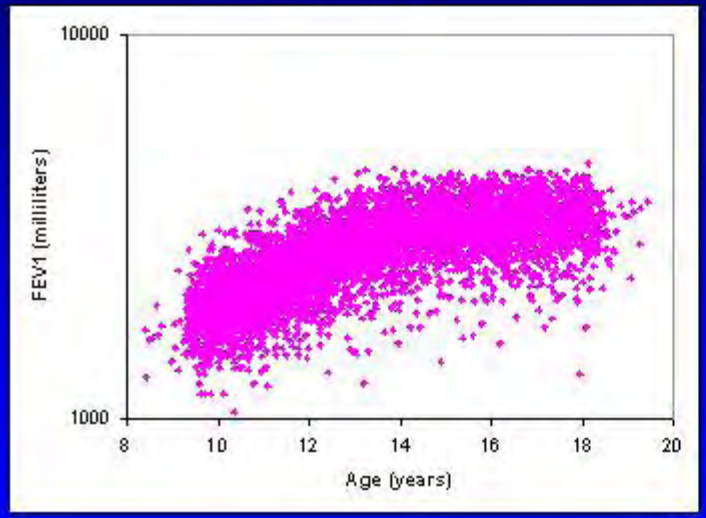
Passive Smoking?

Diet

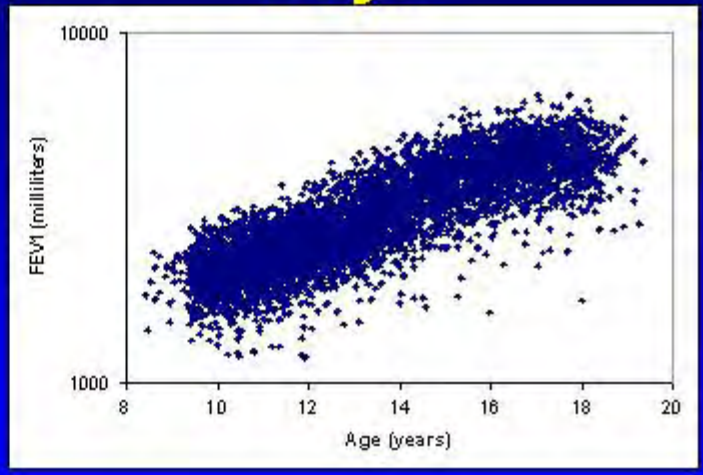
DNA

FEV_1 Growth Over 8 Years

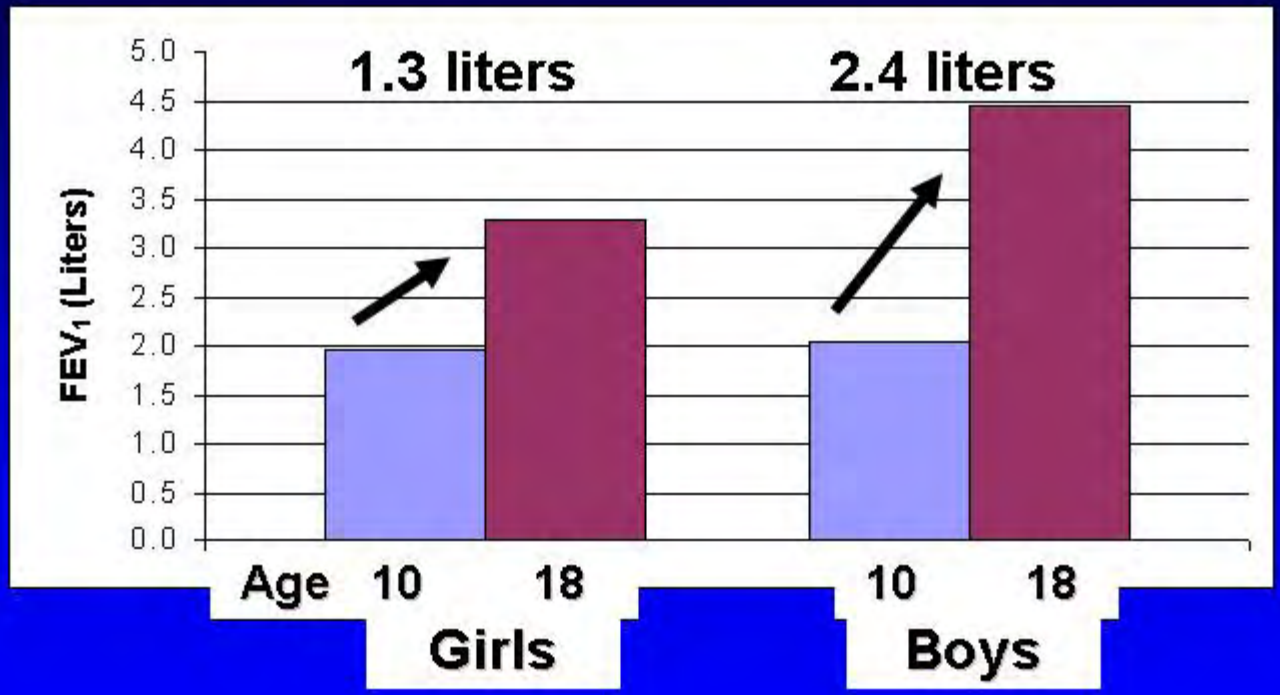
Girls



Boys



Average FEV_1 in Girls and Boys



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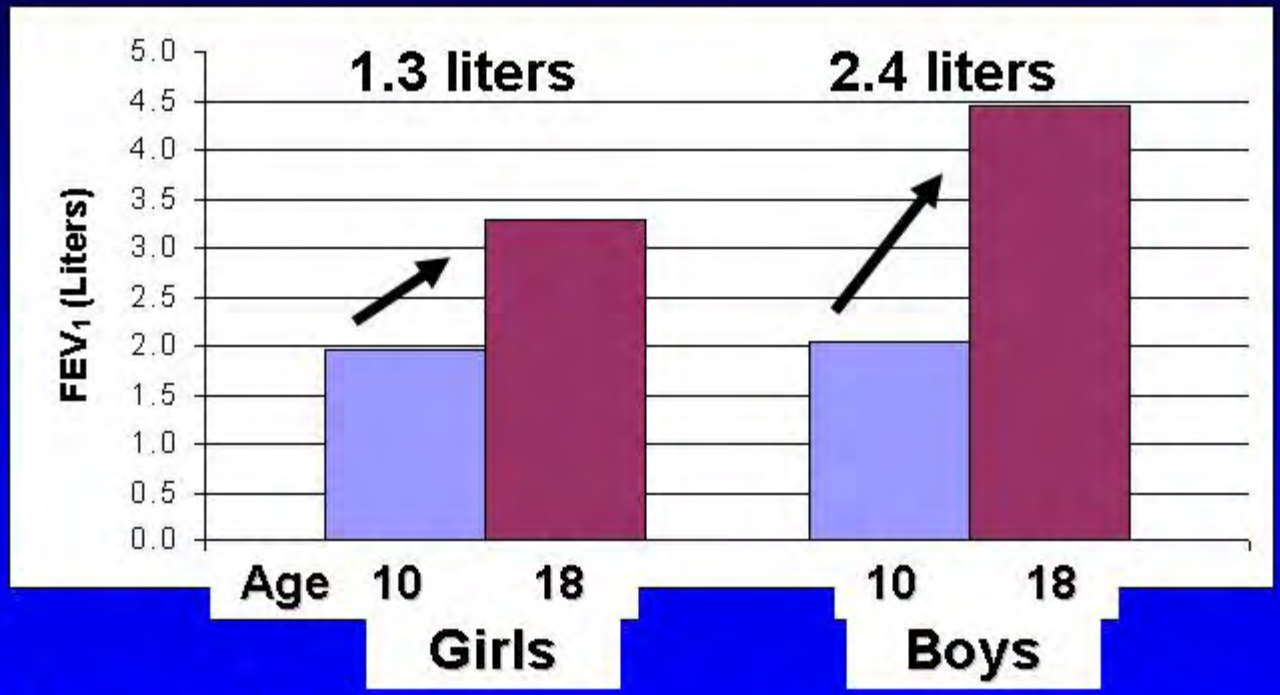
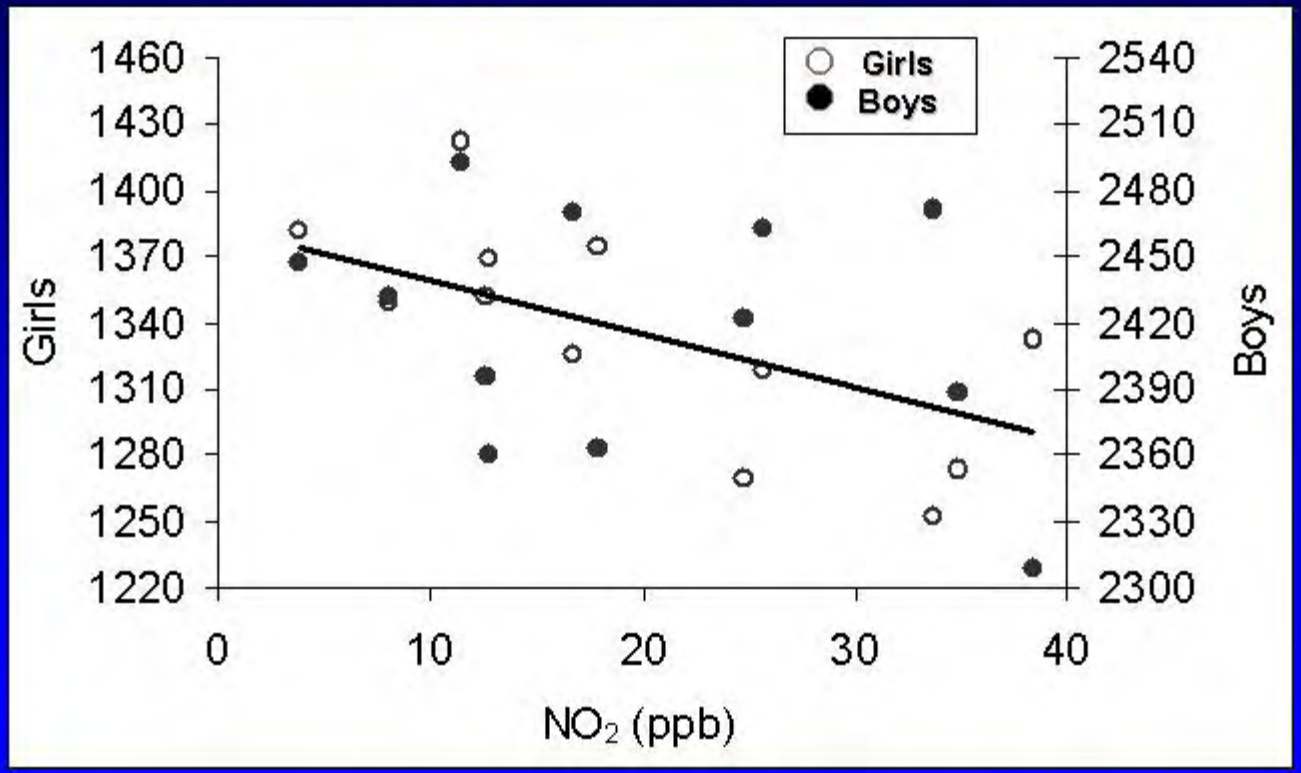


Key Question: Does 8-year growth vary across communities with respect to pollution?

Yes, Pollution Slows Lung Function Growth



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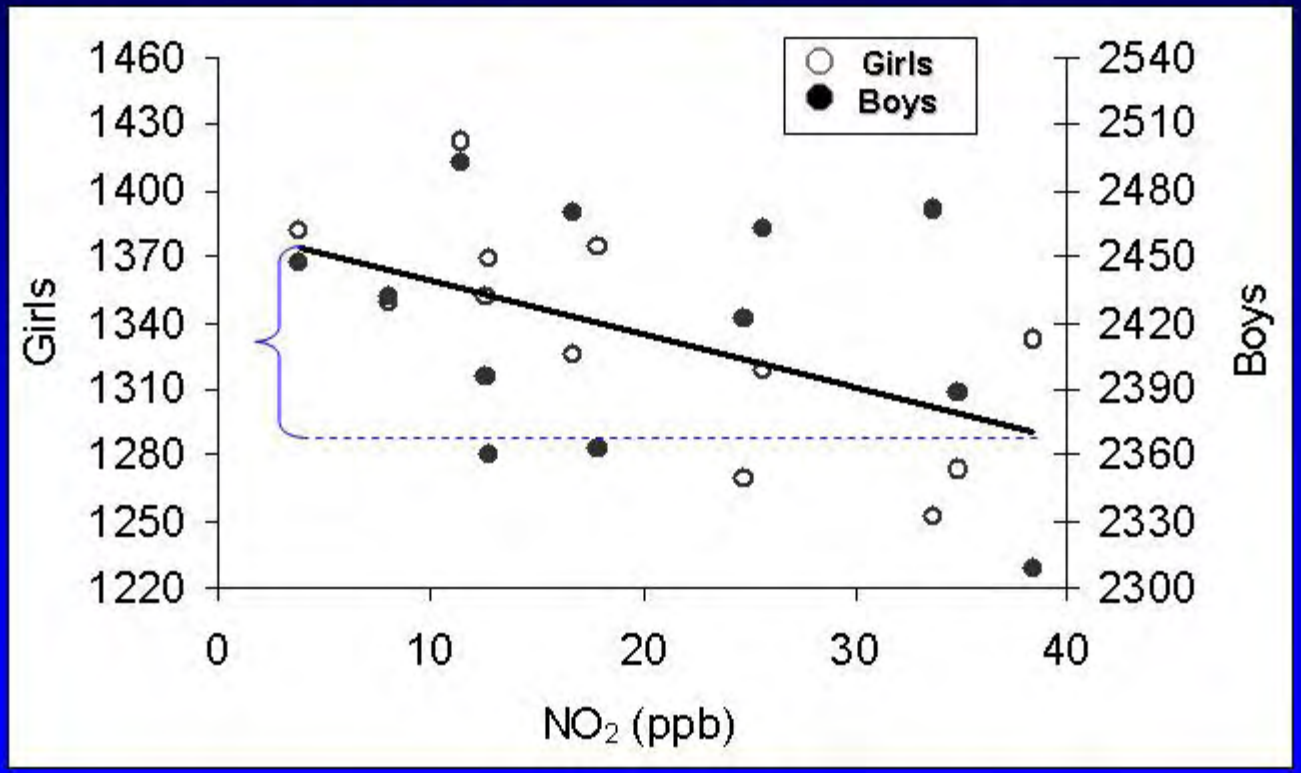
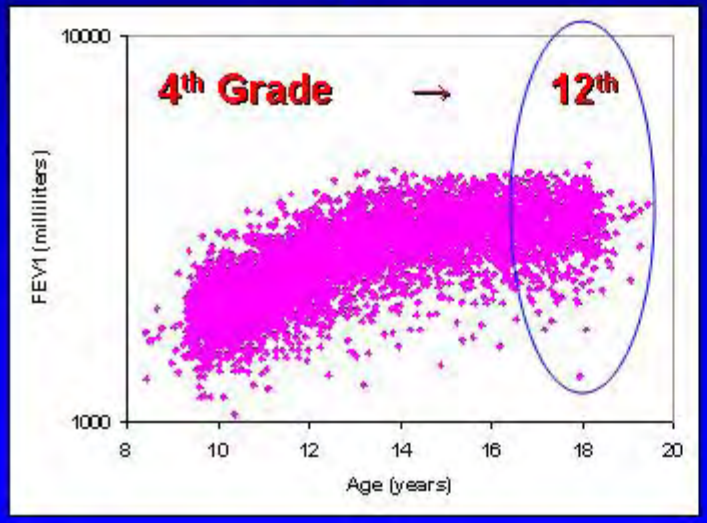


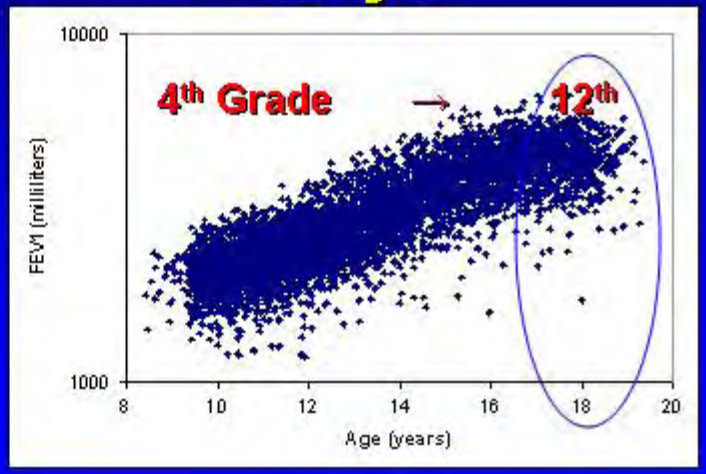
Deficit in growth: What does it mean?

- Clinically significant deficits at age 18?
  - FEV_1 below 80% of normal?

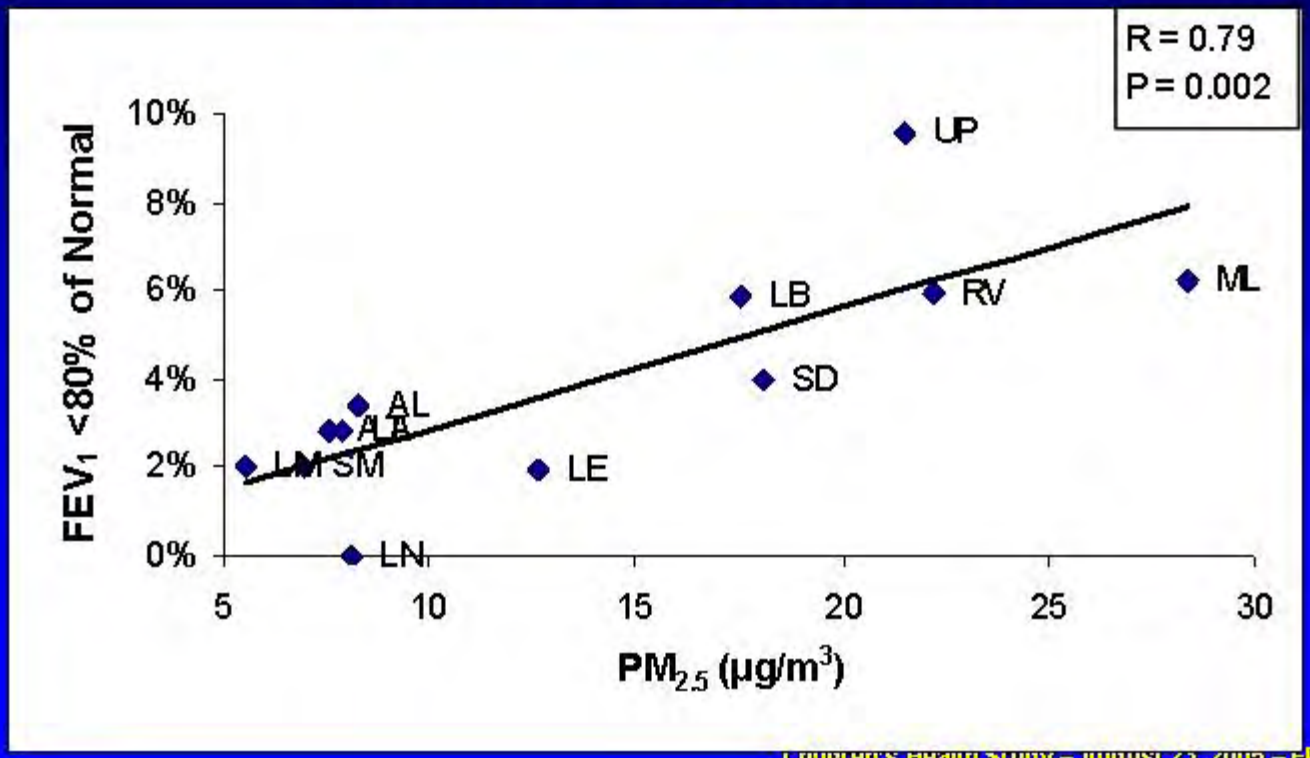
Girls



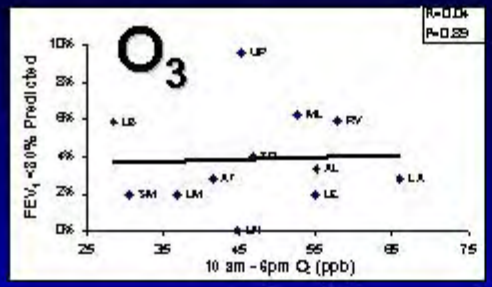
Boys

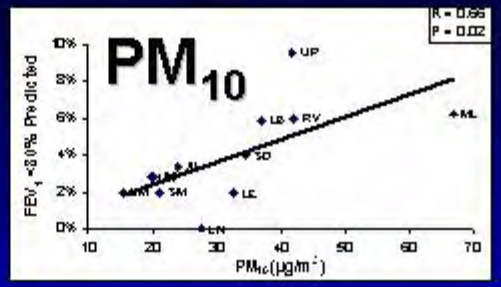


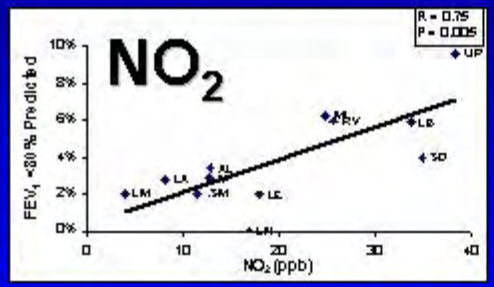
18-year-olds living in polluted communities are 4 to 5 times more likely to have abnormal lung function.

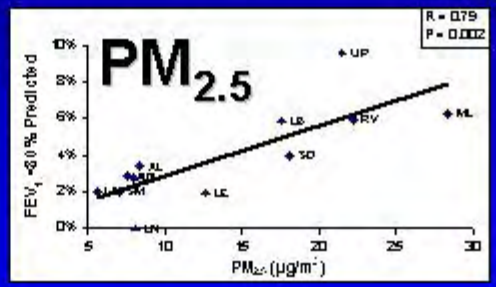


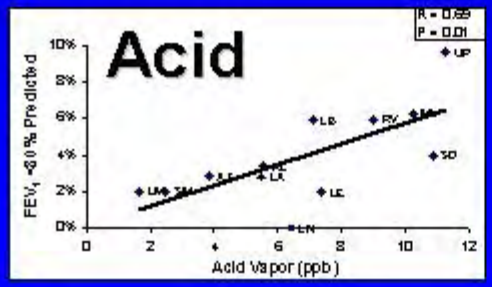
Low Lung Function Associated w/ Many Pollutants

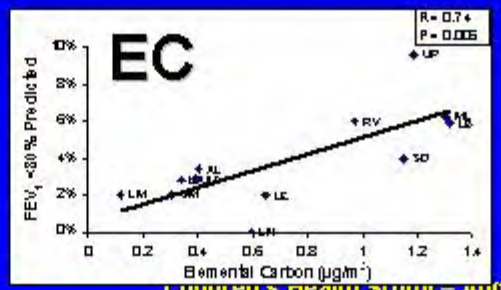












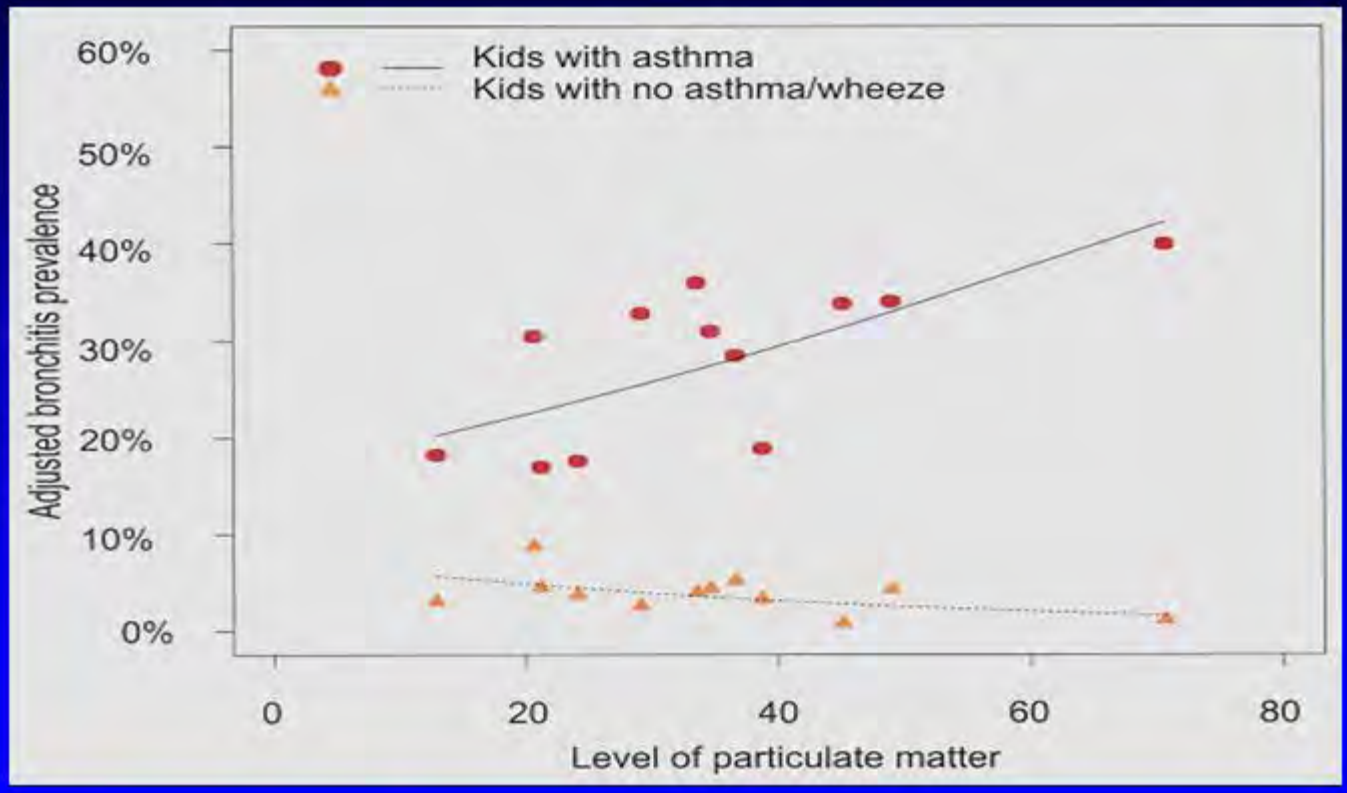
Other studies of lung function and pollution

- Longitudinal studies (growth)
  - Young children in Poland (Jedrowski et al., 1999)
  - Young children in Austria (Horak et al., 2002)
- Cross-sectional studies
  - 6-cities study (Dockery et al., 1989)
  - 24-cities study (Raizenne et al., 1996)
  - NHANES II (Schwartz, 1989)

Children's Health Study Goals

- Is childhood exposure to ambient pollutants associated with:
  - Lung function development?
  - Chronic respiratory symptoms?
  - School absence?
  - Onset of asthma?

PM_{10} and Bronchitis in Asthmatics



(McConnell, et al., 1999; see also McConnell et al., 2003)

Children's Health Study Goals

- Is childhood exposure to ambient pollutants associated with:
  - Lung function development?
  - Chronic respiratory symptoms?
  - **School absence?**
  - Onset of asthma?

Ozone and School Absence

- 20 ppb increase in O_3 was associated with an 83% increase in school absence due to acute respiratory disease (Gilliland et al., 2001)
- Large economic impact of pollution-related absences (Hall and Lurmann, 2003)

Children's Health Study Goals

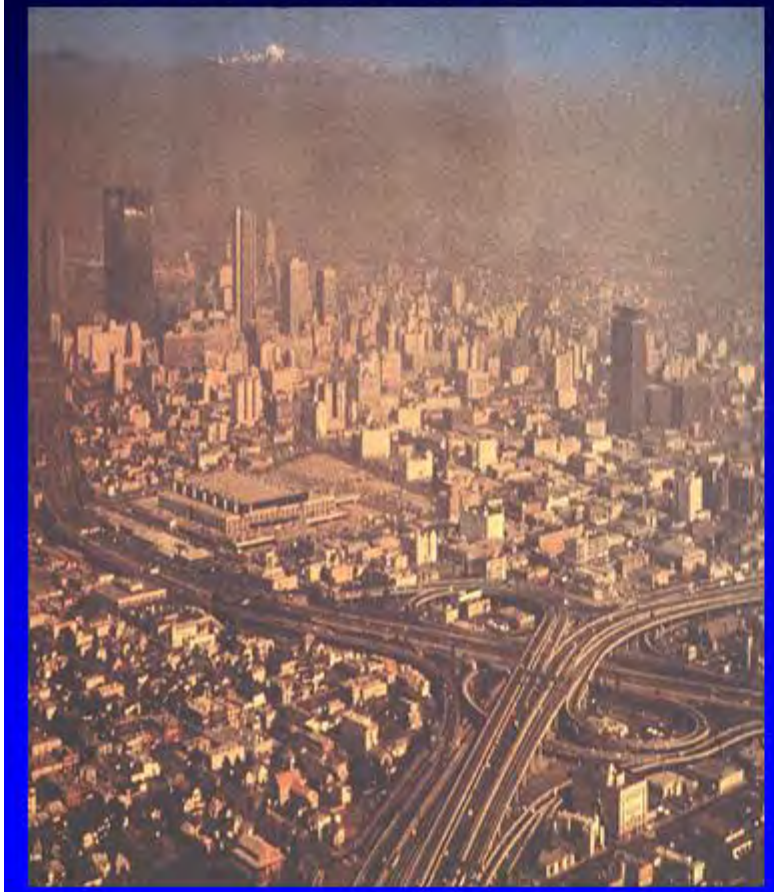
- Is childhood exposure to ambient pollutants associated with:
  - Lung function development?
  - Chronic respiratory symptoms?
  - School absence?
  - Onset of asthma?

Ozone and New-onset Asthma

Sports	Low O_3 Towns # asthma	RR	High O_3 Towns # asthma	RR
0	58	1.0	46	1.0
1	50	1.3	40	1.3
2	20	0.8	16	1.3
≥3	9	0.8	20	3.3

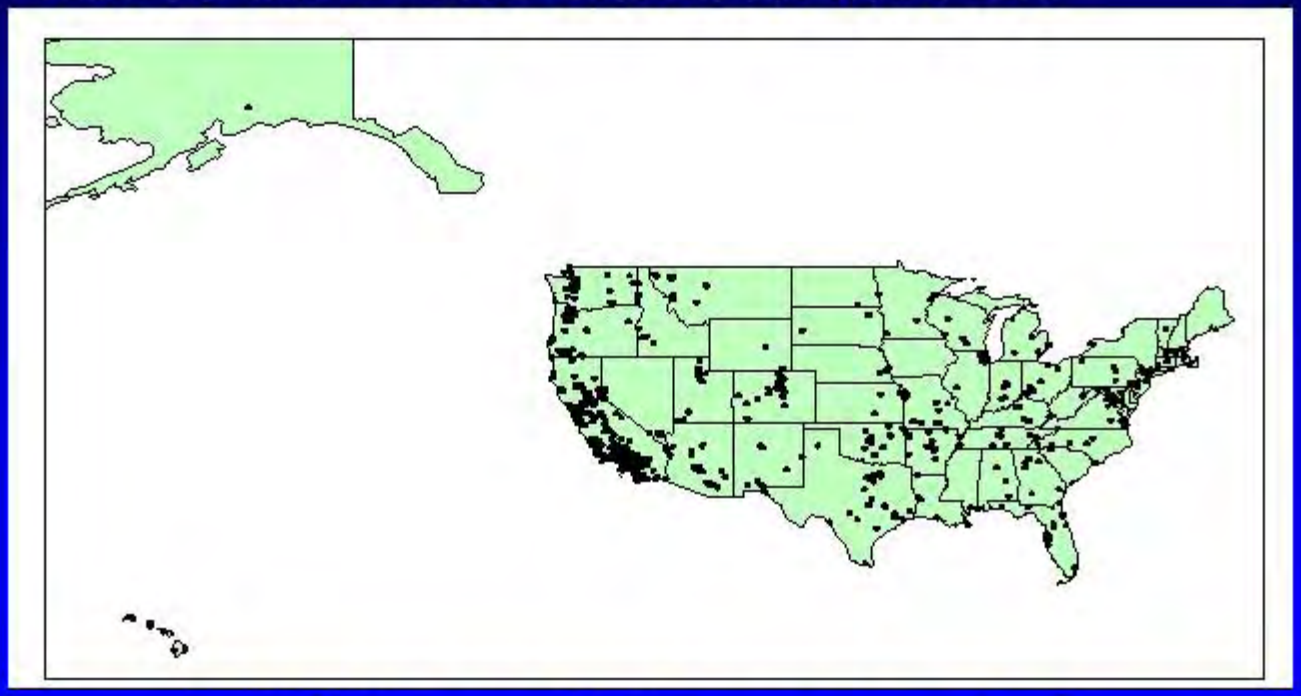
(McConnell et al., 2002)

Will Reductions in Pollution Improve Health?



CHS Movers Study

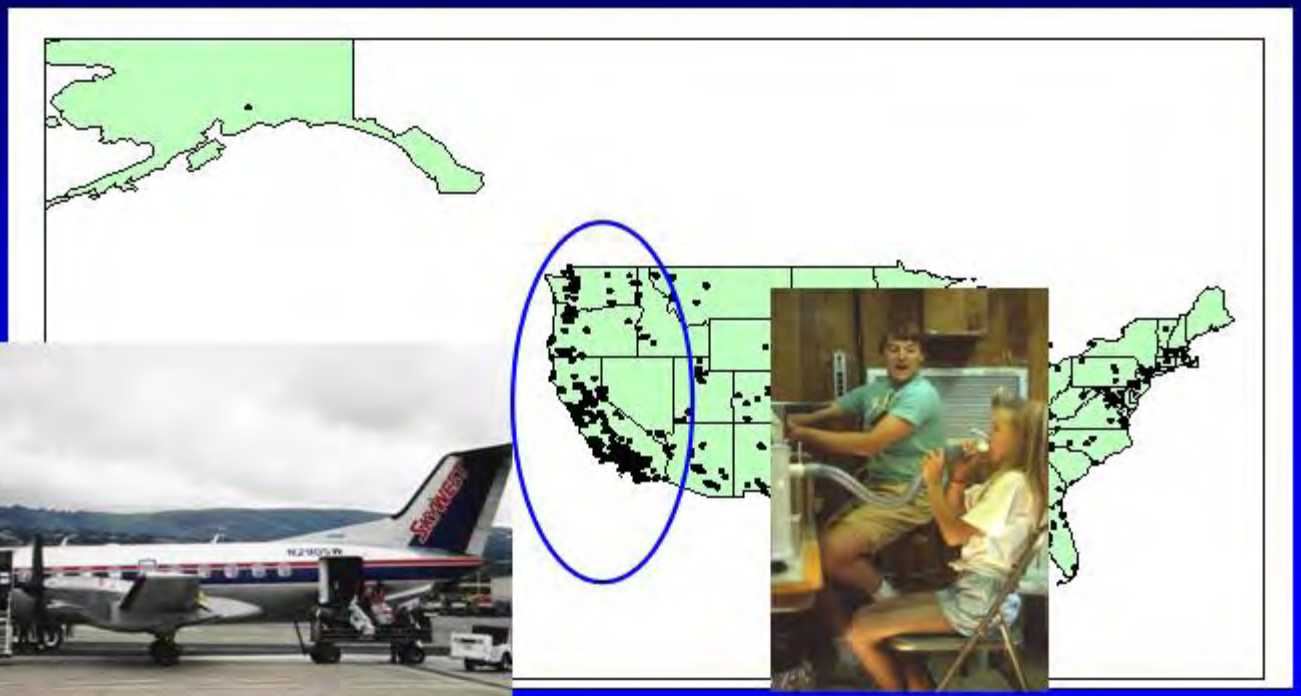
Where have CHS children moved?



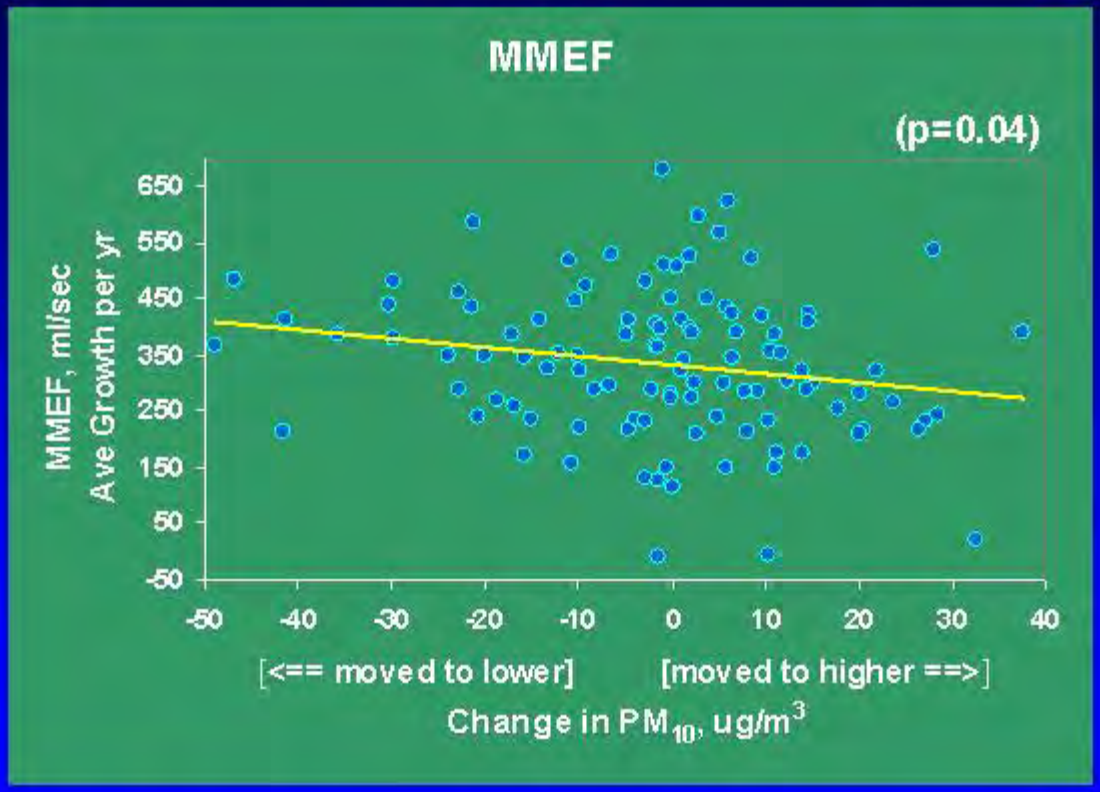
Some to higher pollution, some to lower

CHS Movers Study

We tested lung function of 110 movers in the western U.S.



Lung Function Growth in Movers



(Avol et al., 2001)

Air Pollution and Health

- High pollution communities vs. low pollution
  - Lower lung function
  - Increased symptoms
  - Increased asthma

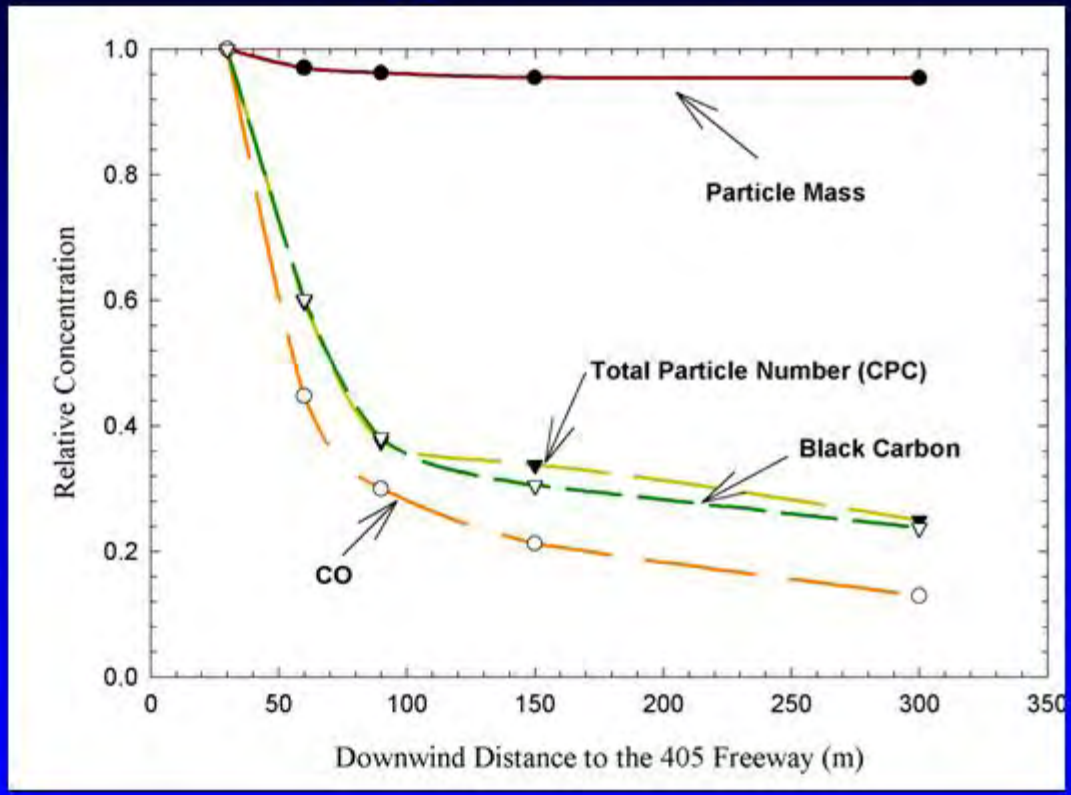
What About Local Exposures?

Local Exposures

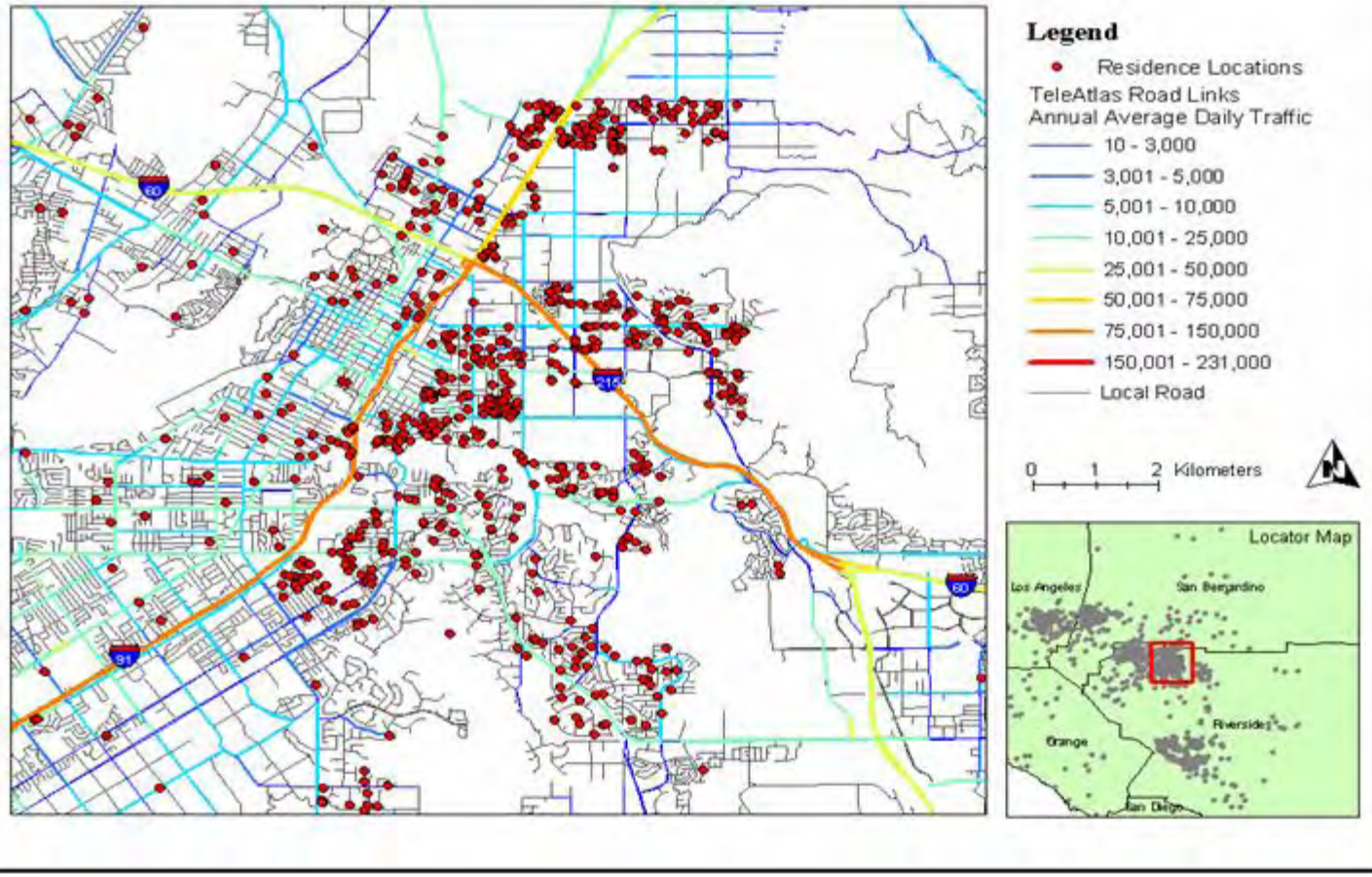
- Several studies in Europe linking traffic exposure to respiratory symptoms
- S.F. bay area study relating pollution exposure at schools to symptoms (Kim et al. 2004)
- We studied residential NO_2, traffic, and asthma (Gauderman et al., *Epidemiology*, in press)

PM Dynamics

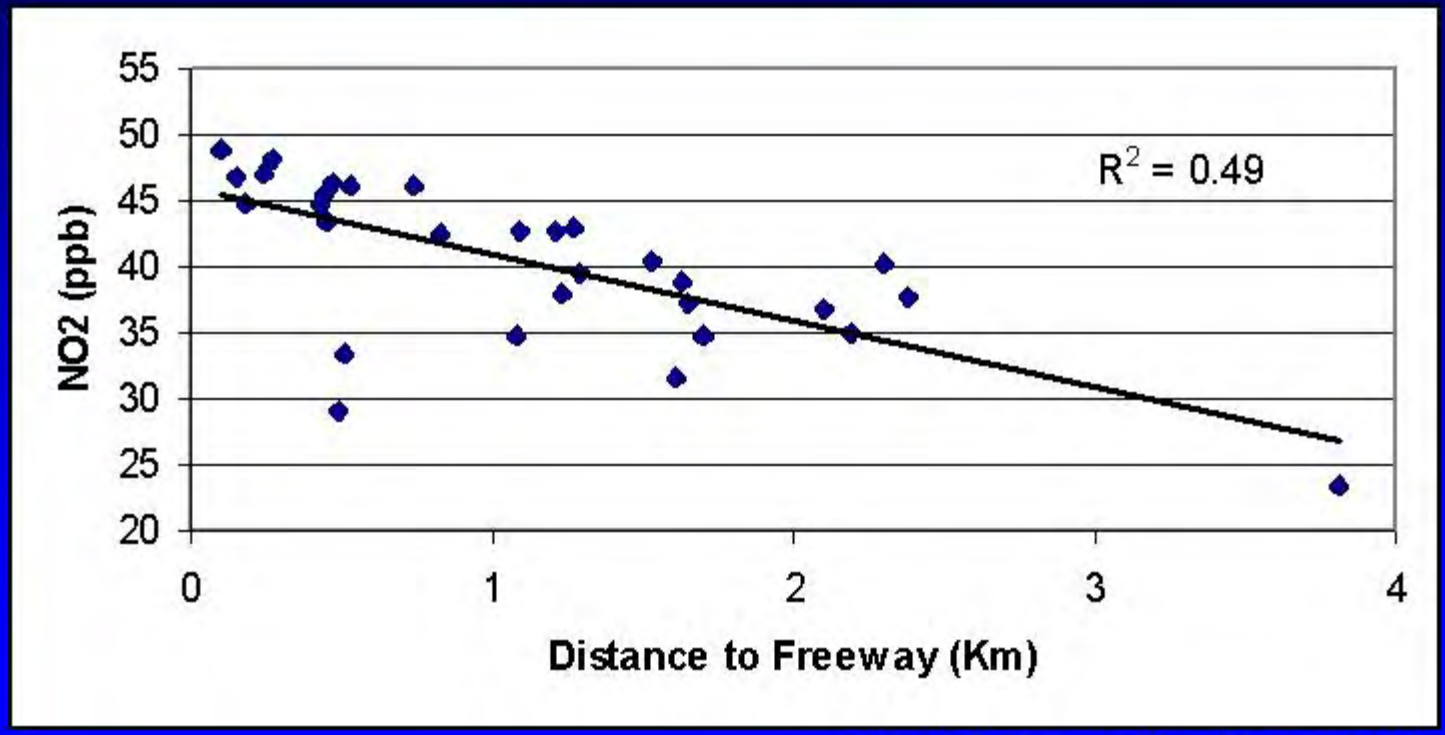
- Fine particles, CO, and roadside distance



Riverside


Legend
Residence Locations
TeleAtlas Road Links
Annual Average Daily Traffic
10 - 3,000
3,001 - 5,000
5,001 - 10,000
10,001 - 25,000
25,001 - 50,000
50,001 - 75,000
75,001 - 150,000
150,001 - 231,000
Local Road
0 1 2 Kilometers
Locator Map
Los Angeles
San Bernardino
Riverside
Orange
San Diego
60
215
91

Measured NO_2 vs. Distance to Freeway (Riverside)



How Do NO_2 and Traffic Correlate with Asthma Prevalence?

Exposure metric	Odds Ratio per IQR	
	OR[a]	(95% C.I.)
Measured NO_2	1.83	(1.04, 3.21)
Distance to Freeway	1.89	(1.19, 3.02)

Gauderman at al., *Epidemiology*, in press

What Have We Learned About What Pollutant "Causes" What Outcomes?

OZONE

- School absence for acute respiratory disease
- Asthma medication
- Exercise and asthma incidence

What Have We Learned About What Pollutant "Causes" What Outcomes?

NO_2, PM, Acid*

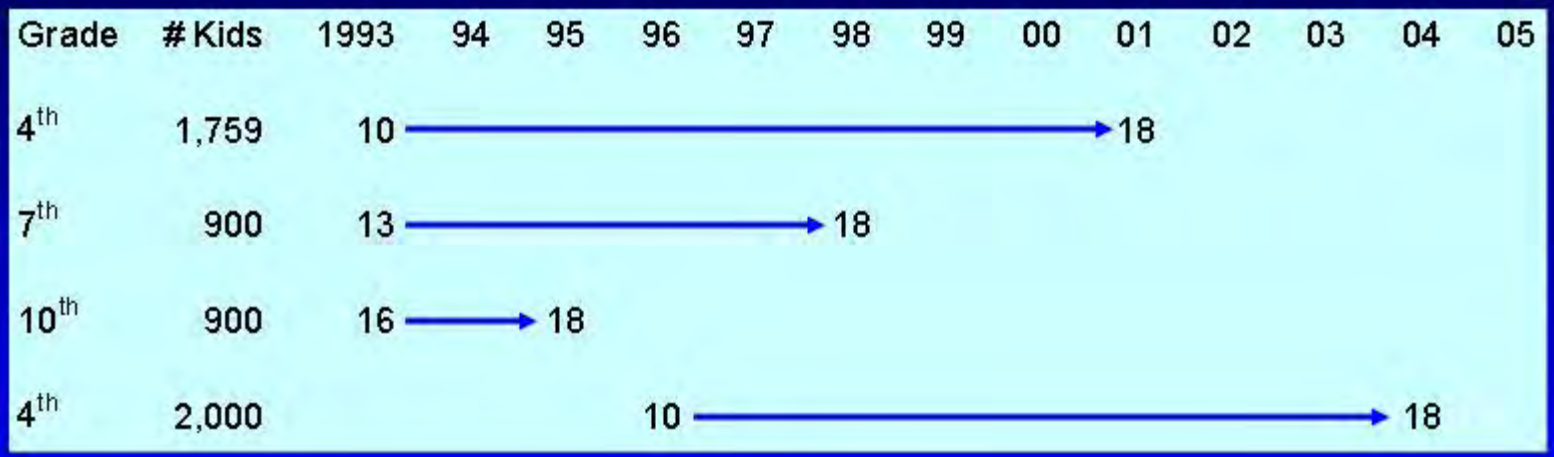
Part of correlated package of pollutants

- Chronic bronchitis in asthmatics
- Slowed lung growth
- Asthma prevalence
- Clinically significant lung impairment

* possibly stronger for slowed lung growth

CHS: Ongoing Studies

(Funding: NIEHS, NHLBI, EPA)



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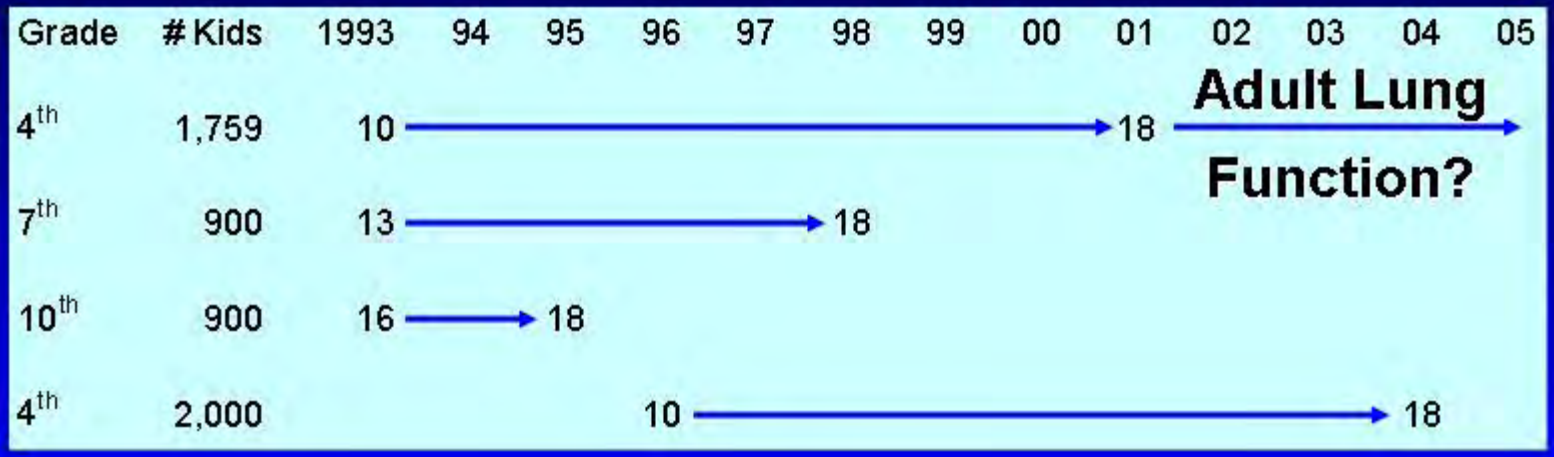

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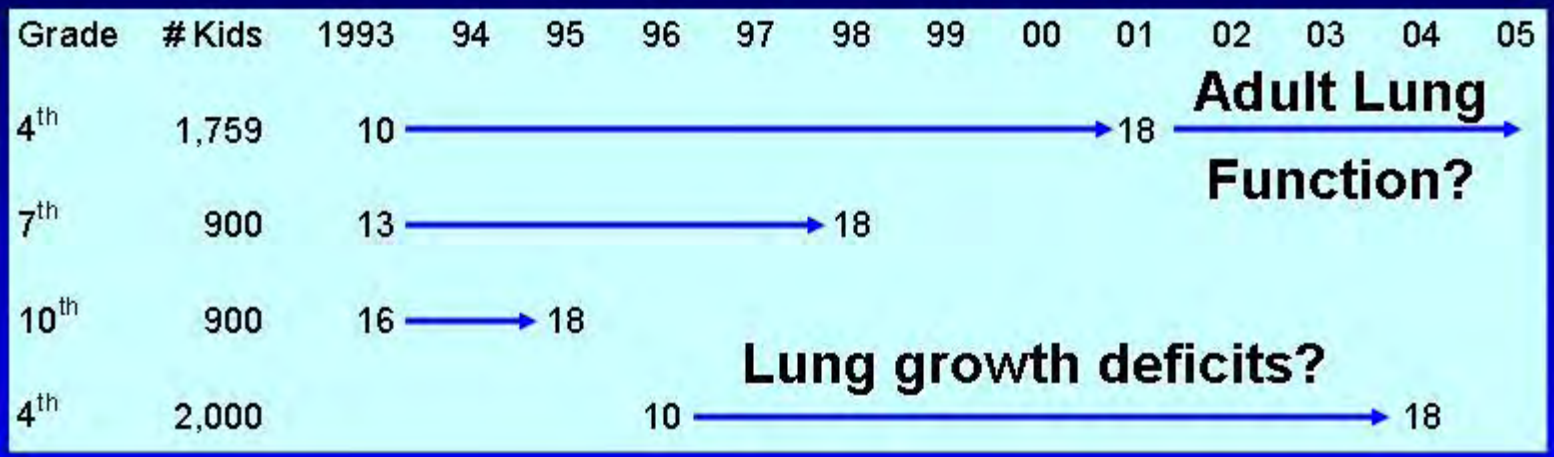

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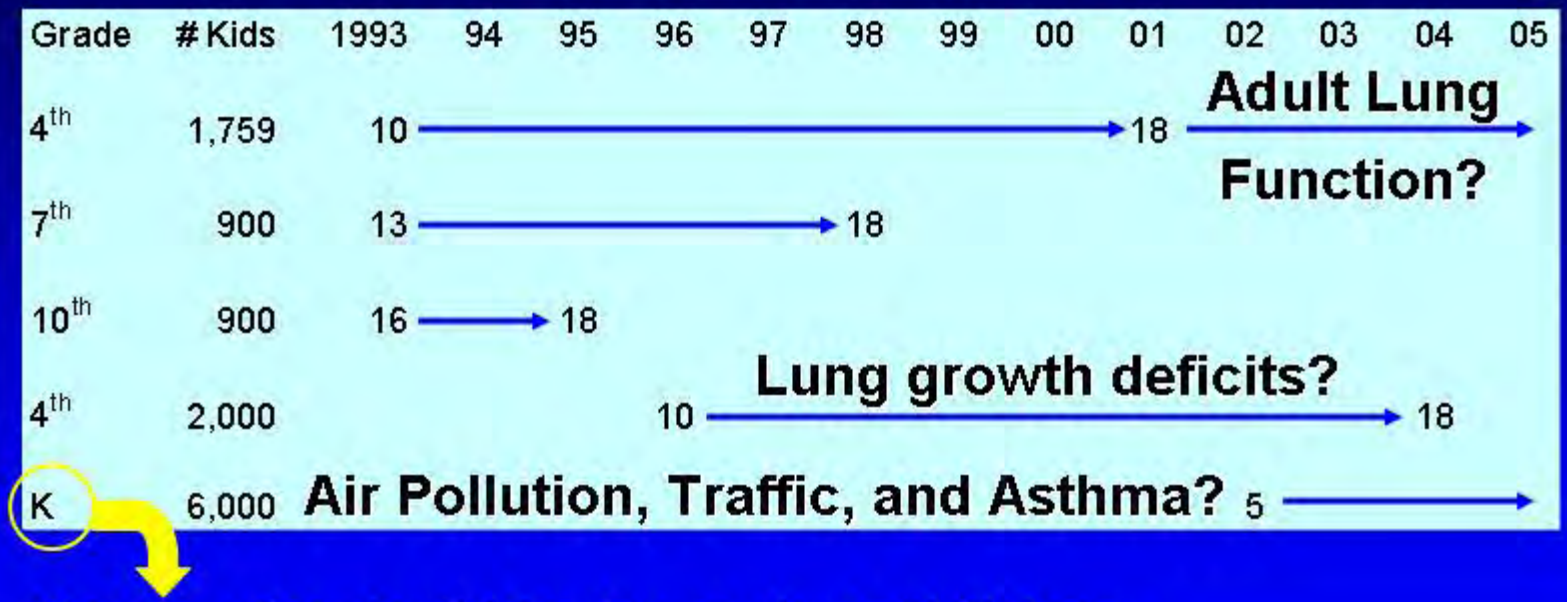
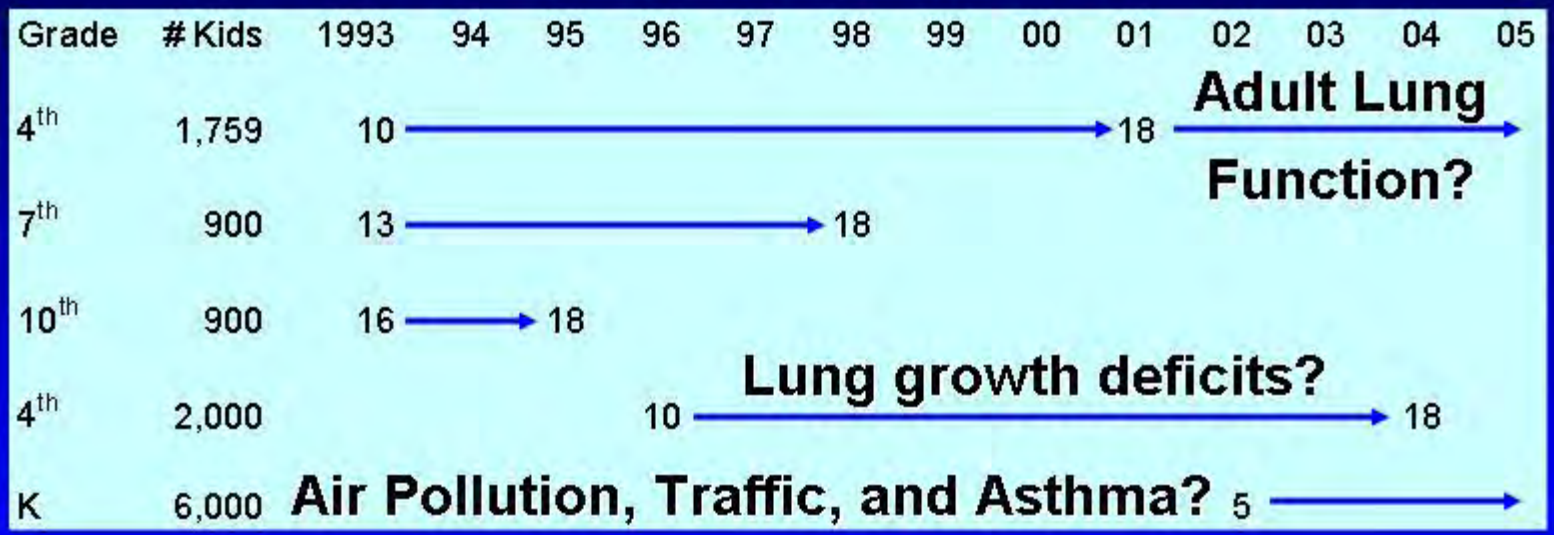


New cohort of kindergarten children

CHS: Ongoing Studies

(Funding: NIEHS, NHLBI, EPA)



Genetics: Do genes affect above relationships?

Summary

- Air pollution associated with acute *and* chronic effects

- Regional and local pollution are important

- Health effects at pollution levels that meet current US/EPA standards

Summary

- Reductions in air pollution should lead to measurable improvements in children's health