# Improved Air Quality and Children's Respiratory Health

## Does Cleaning the Air Lead to Better Health?

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**Department of Preventive Medicine**
**Keck School of Medicine of USC**
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# Our Path this Evening…

- The Children's Health Study
- Recent air quality trends
- How children's health changed as air quality changed

# Children's Health Study (CHS)

- A "10-year" health study (est. 1992)
  …going on 23 years now!

- Supported by:

California Environmental Protection Agency
Air Resources Board

NIEHS

South Coast AQMD

NATIONAL INSTITUTES OF HEALTH

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

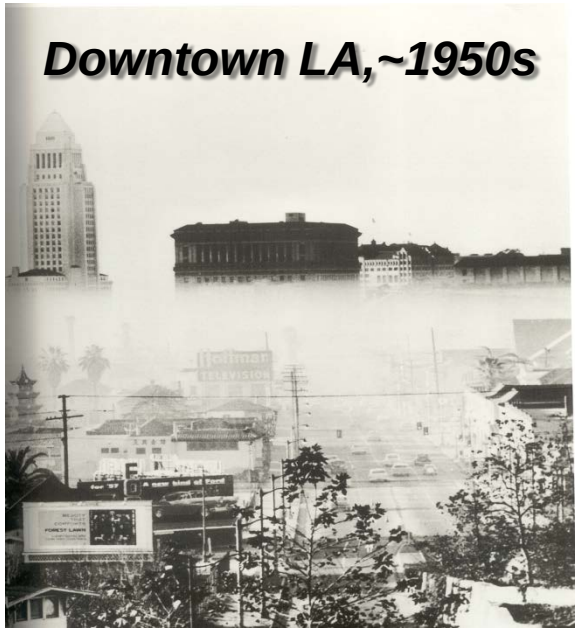
HEI

*The Hastings Foundation*

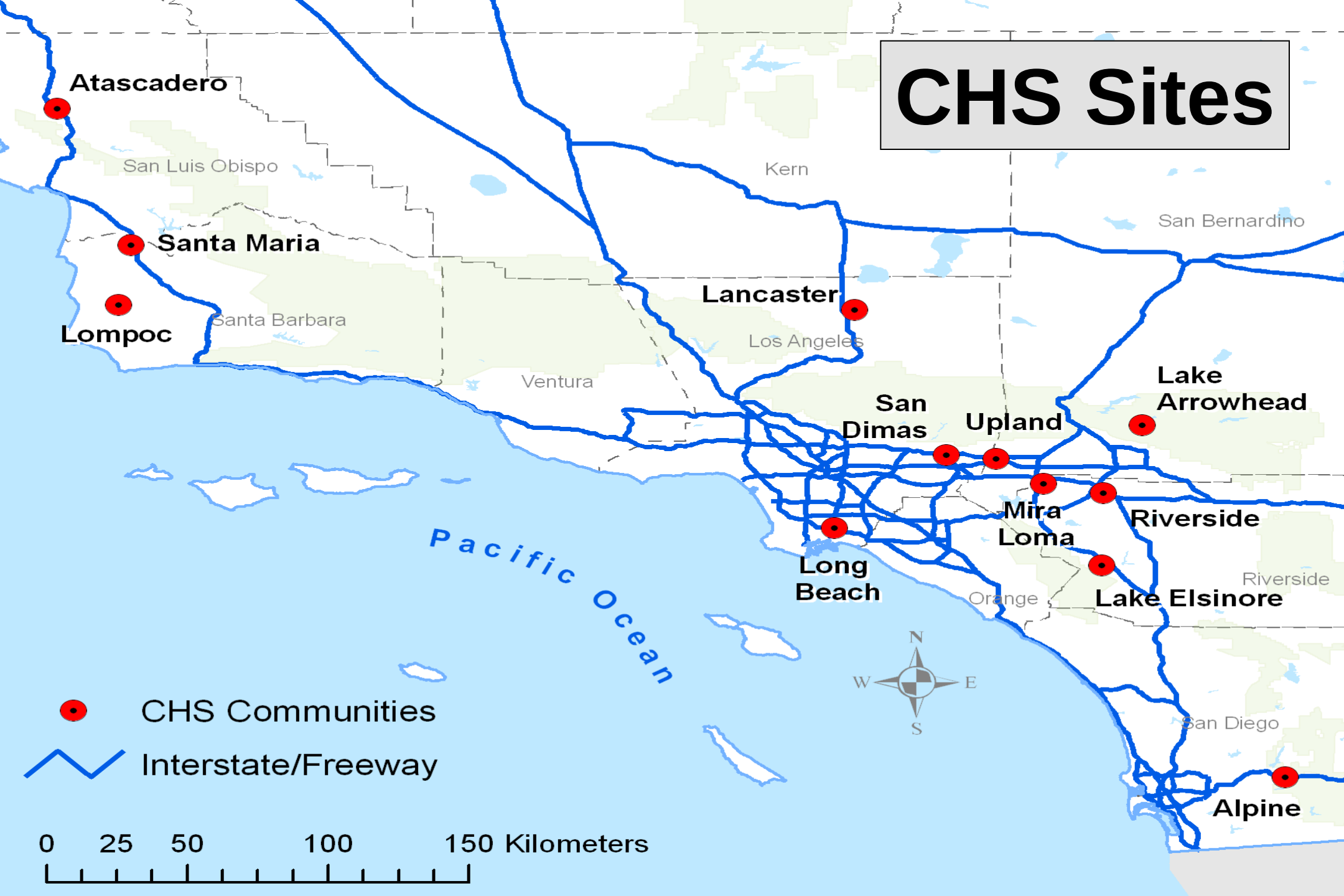
**Study participants and their families!**

# Primary goal of the CHS

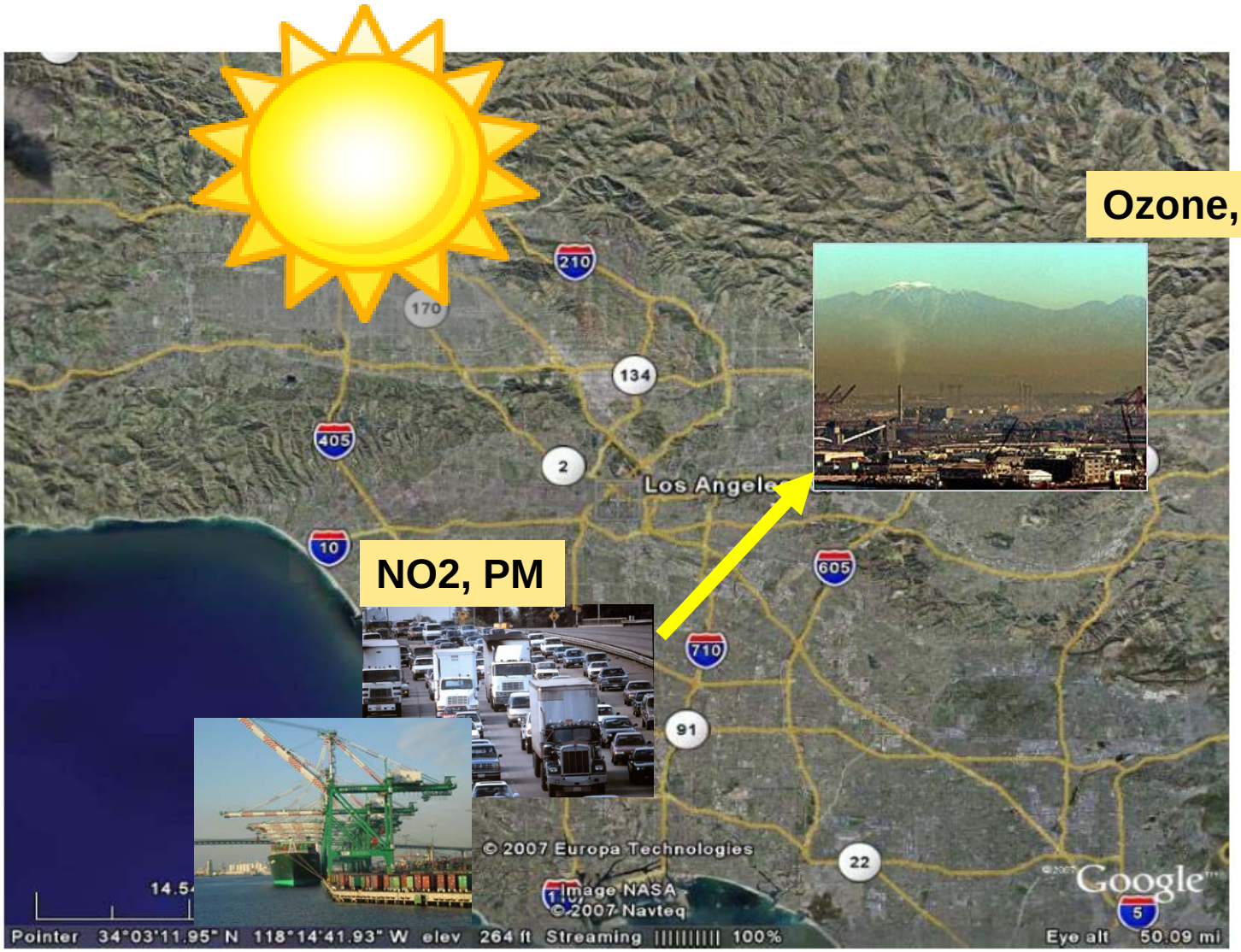
## Does outdoor air pollution cause *chronic* health effects?




- ↑ Asthma risk?
- ↓ Lung function growth?

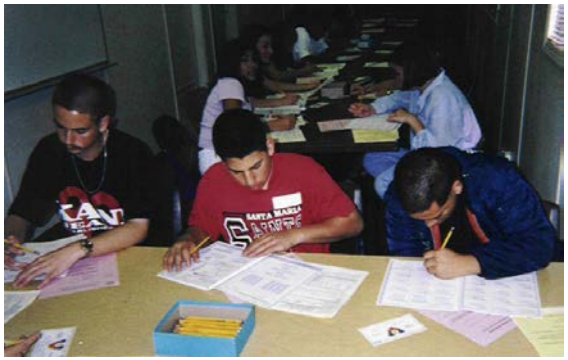


CHS Sites
Atascadero
San Luis Obispo
Santa Maria
Lompoc
Santa Barbara
Kern
Lancaster
Los Angeles
Ventura
San Bernardino
Lake Arrowhead
San Dimas
Upland
Mira Loma
Riverside
Long Beach
Orange
Lake Elsinore
Riverside
San Diego
Alpine
Pacific Ocean
N
W
E
S
CHS Communities
Interstate/Freeway
0 25 50 100 150 Kilometers

# Pollution in the L.A. Basin



# CHS Cohorts, By School Year & Class Grade

| Co-hort | N | '93 | '94 | '95 | '96 | '97 | '98 | '99 | '00 | '01 | '02 | '03 | '04 | '05 | '06 | '07 | '08 | '09 | '10 | '11 | '12 | '13 | '14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | School Year | | | | | | | | | | | | |
| A | 938 | 10 | 11 | 12 | | | | | | | | | | | | | | | | | | | |
| B | 937 | 7 | 8 | 9 | 10 | 11 | 12 | | | | | | | | | | | | | | | | |
| C | 1806 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | | | | | | | | | | | |
| D | 2081 | | | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | | | | | | | | |
| E | 5927 | | | | | | | | | | K | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| (ALL) | 11689 | | | | | | | | | | | | | | | | | | | | | | |



# Annual Lung Function Tests

## What do we collect?

- $FEV_1$ : How much air expired in 1 second
- FVC: Total amount of air expired

**These allow us to track lung growth over time**

# CHS Cohorts, By School Year & Class Grade

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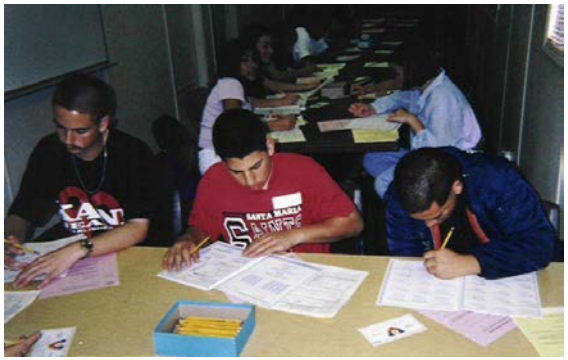
## Cohort C: Followed from 10 to 18 years of age



The NEW ENGLAND JOURNAL of MEDICINE

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

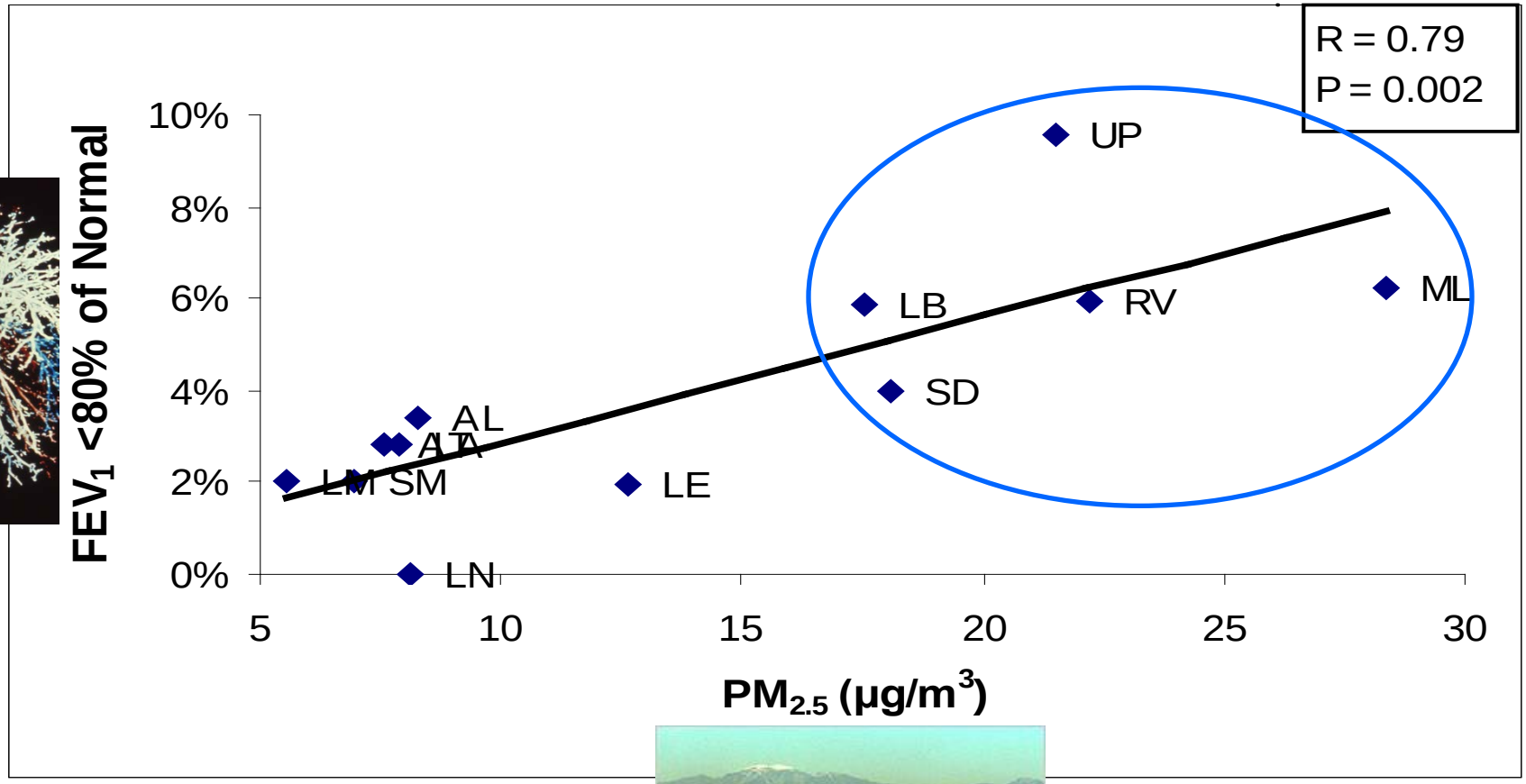
# The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age

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.

# Attained Lung Function

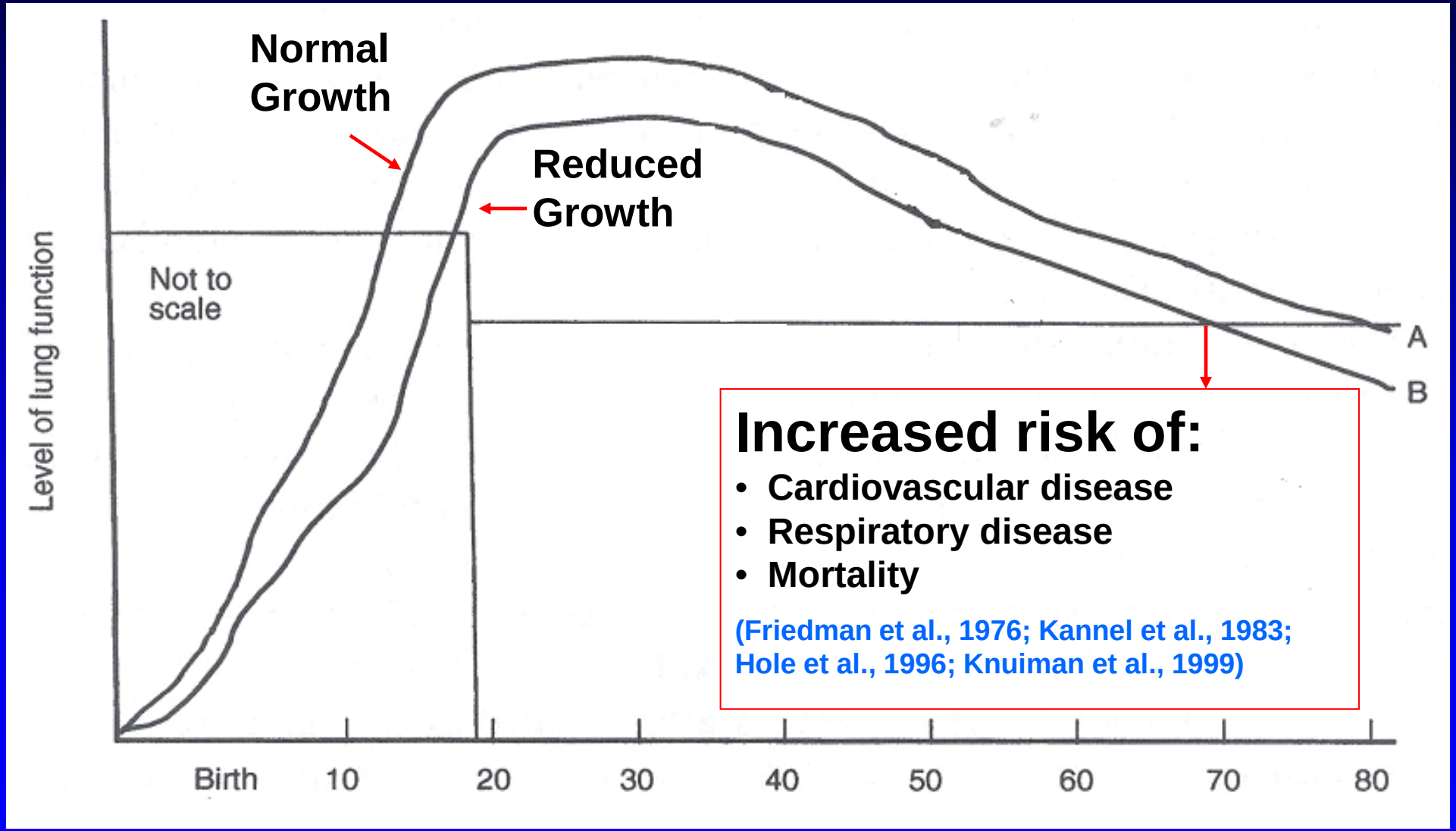
- What should lung function be at age 18?
  - Computed EXPECTED $FEV_1$ at age 18 based on sex, race/ethnicity, height, BMI, and asthma
- How does actual lung function compare to expected?
  - Computed OBSERVED/EXPECTED for each child
  - 'Low $FEV_1$' = OBSERVED/EXPECTED < 80%
- Is 8 years of breathing polluted air related to a greater chance of having clinically Low $FEV_1$?

# Abnormally Low Lung Function is More Likely in a Polluted Community




NEJM, 2004

# Why Is This Important?

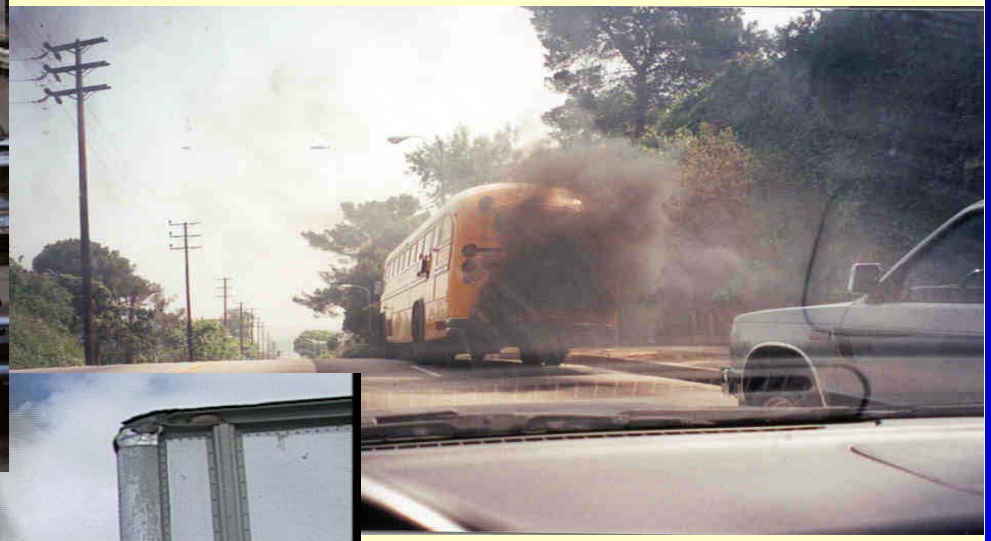



**Increased risk of:**

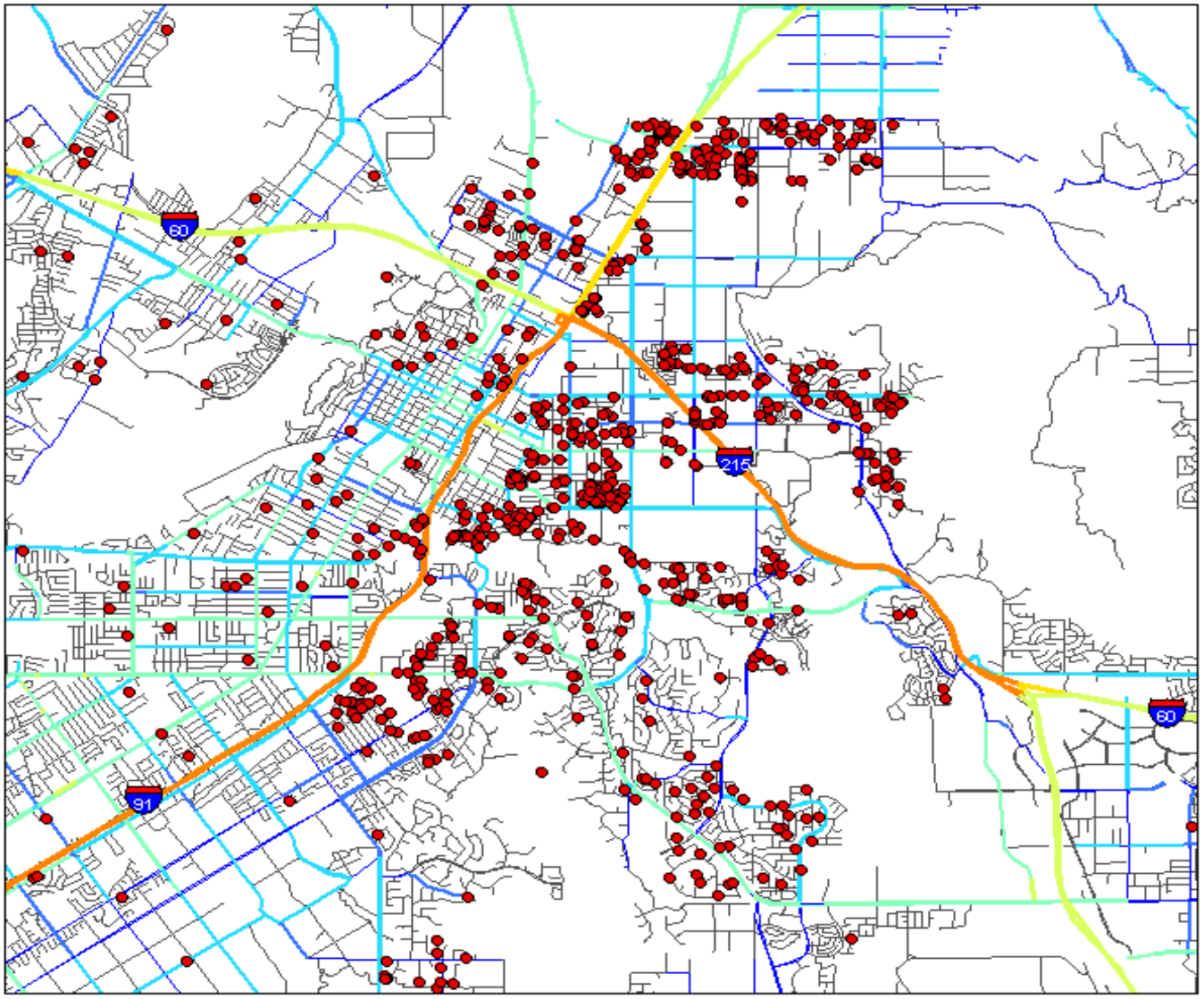
- **Cardiovascular disease**
- **Respiratory disease**
- **Mortality**

**(Friedman et al., 1976; Kannel et al., 1983; Hole et al., 1996; Knuiman et al., 1999)**

# What About Local Exposures?



# Riverside



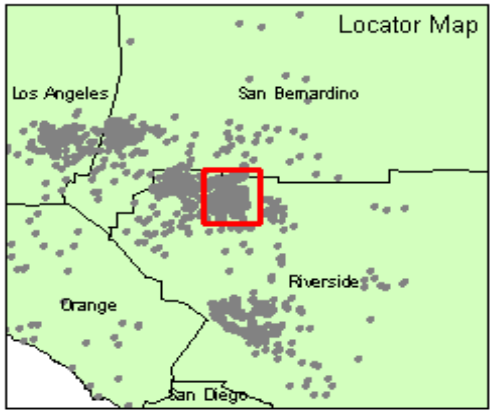

**Legend**

- 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



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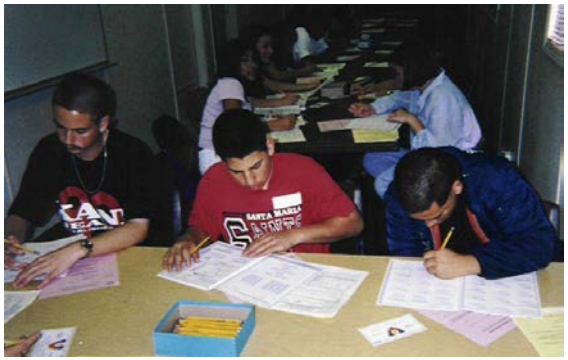
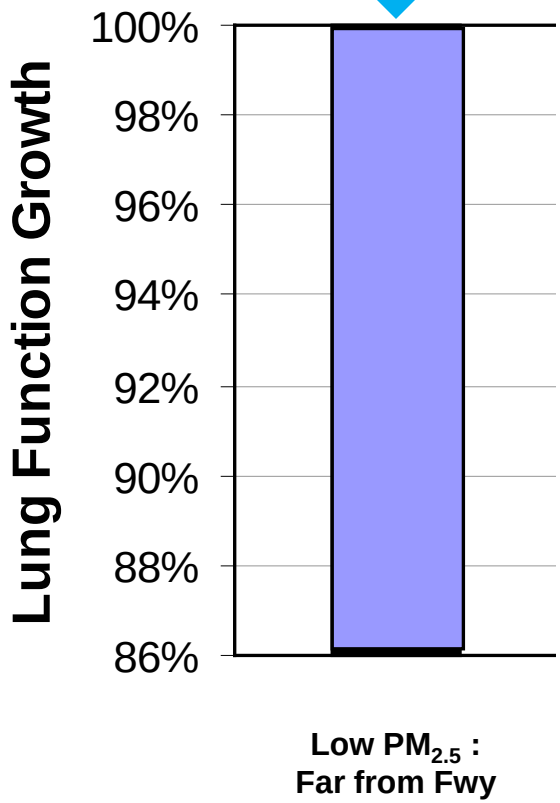
## Cohorts C & D: Followed for 8 years



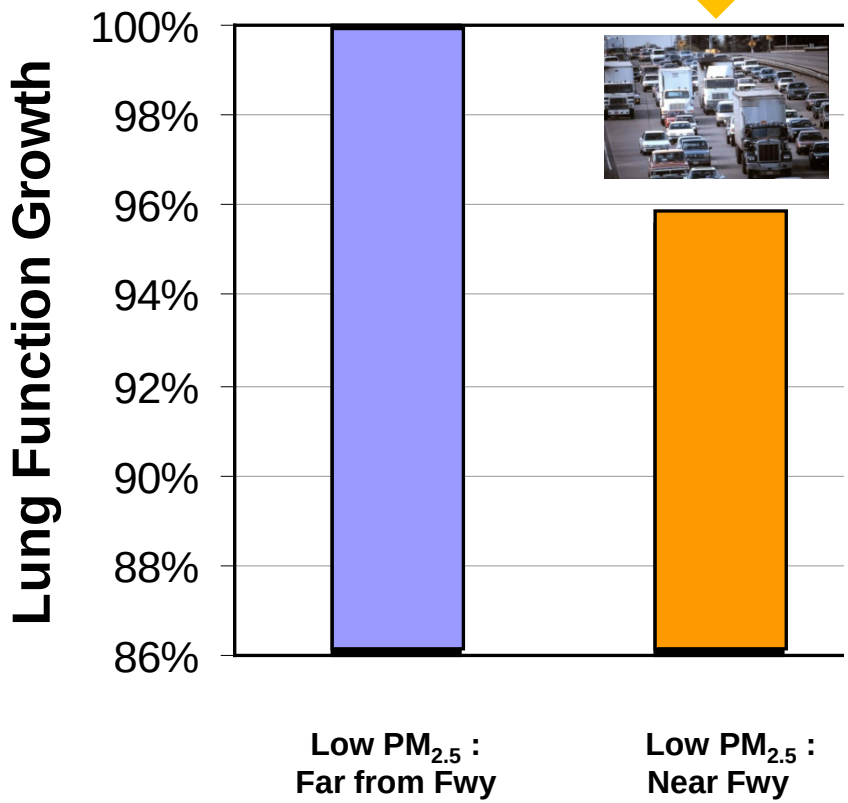
# Children living FAR FROM A FREEWAY in a LOW POLLUTION area have the best lung function




**Example: Santa Maria,**
**Far from Hwy 101**

**Regional $PM_{2.5}$ : Freeway Distance**

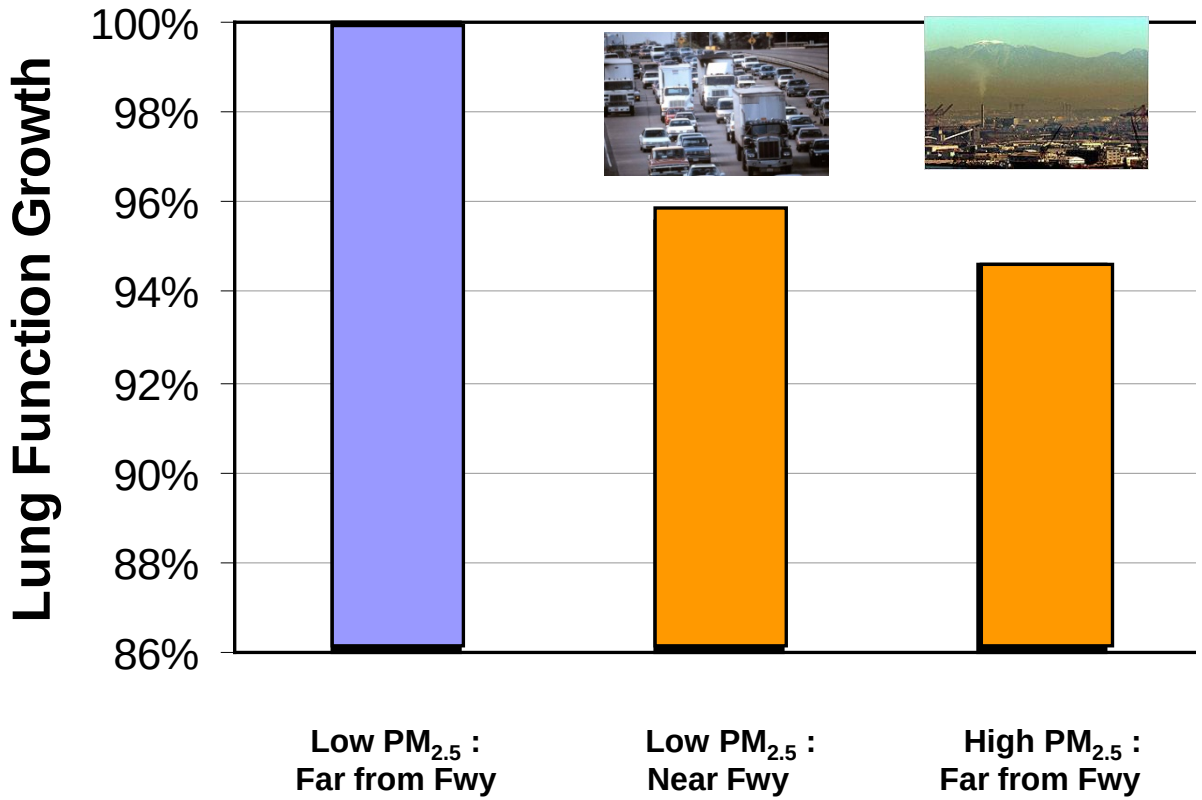
# Living NEAR A FREEWAY reduces lung function




**Example: Santa Maria, Close to Hwy 101**

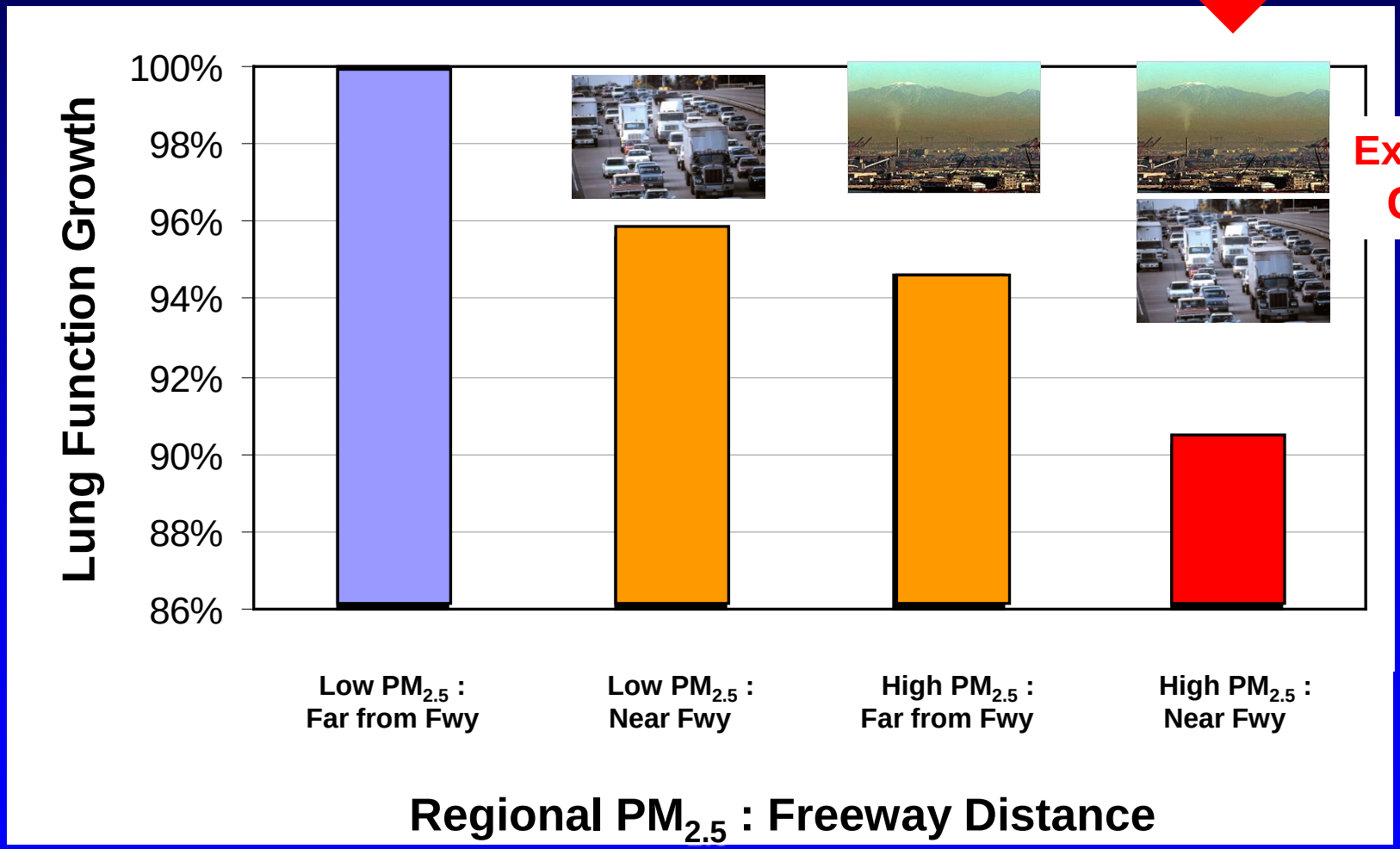
**Regional $PM_{2.5}$ : Freeway Distance**

# Living in a SMOGGY AREA reduces lung function




Example: Mira Loma, Far from 60 Fwy

# Living NEAR A FREEWAY in a SMOGGY AREA leads to the greatest reductions in lung function




Example: Mira Loma, Close to 60 Fwy

(Gauderman et al., Lancet, 2007)

**What if, over time,**

**the air got *cleaner* ?**

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 MARCH 5, 2015 VOL. 372 NO. 10

# Association of Improved Air Quality with Lung Development in Children

W. James Gauderman, Ph.D., Robert Urman, M.S., Edward Avol, M.S., Kiros Berhane, Ph.D., Rob McConnell, M.D., Edward Rappaport, M.S., Roger Chang, Ph.D., Fred Lurmann, M.S., and Frank Gilliland, M.D., Ph.D.

EDITORIAL

## Cleaner Air, Bigger Lungs

Douglas W. Dockery, Sc.D., and James H. Ware, Ph.D.

In the latter half of the 20th century, Los Angeles had, by many measures, higher levels of photochemical air pollutants than any other major city in the United States (Fig. 1). To address this problem, the California Air Resources Board and its partners became leaders in quantifying the growth in the children recruited in 1993,[2] 1997,[4] and 2003.[5]

The consistency of findings in the three separate cohorts is compelling. Moreover, the investigators sought to minimize the potential for confounding by controlling for known individual

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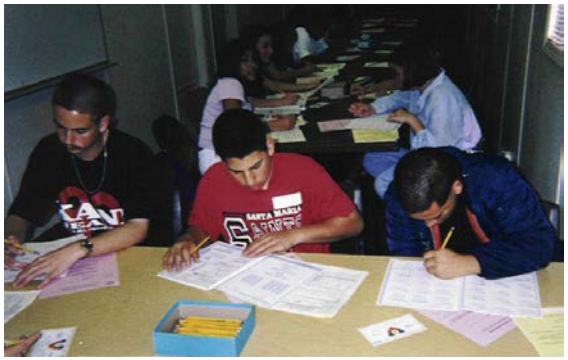
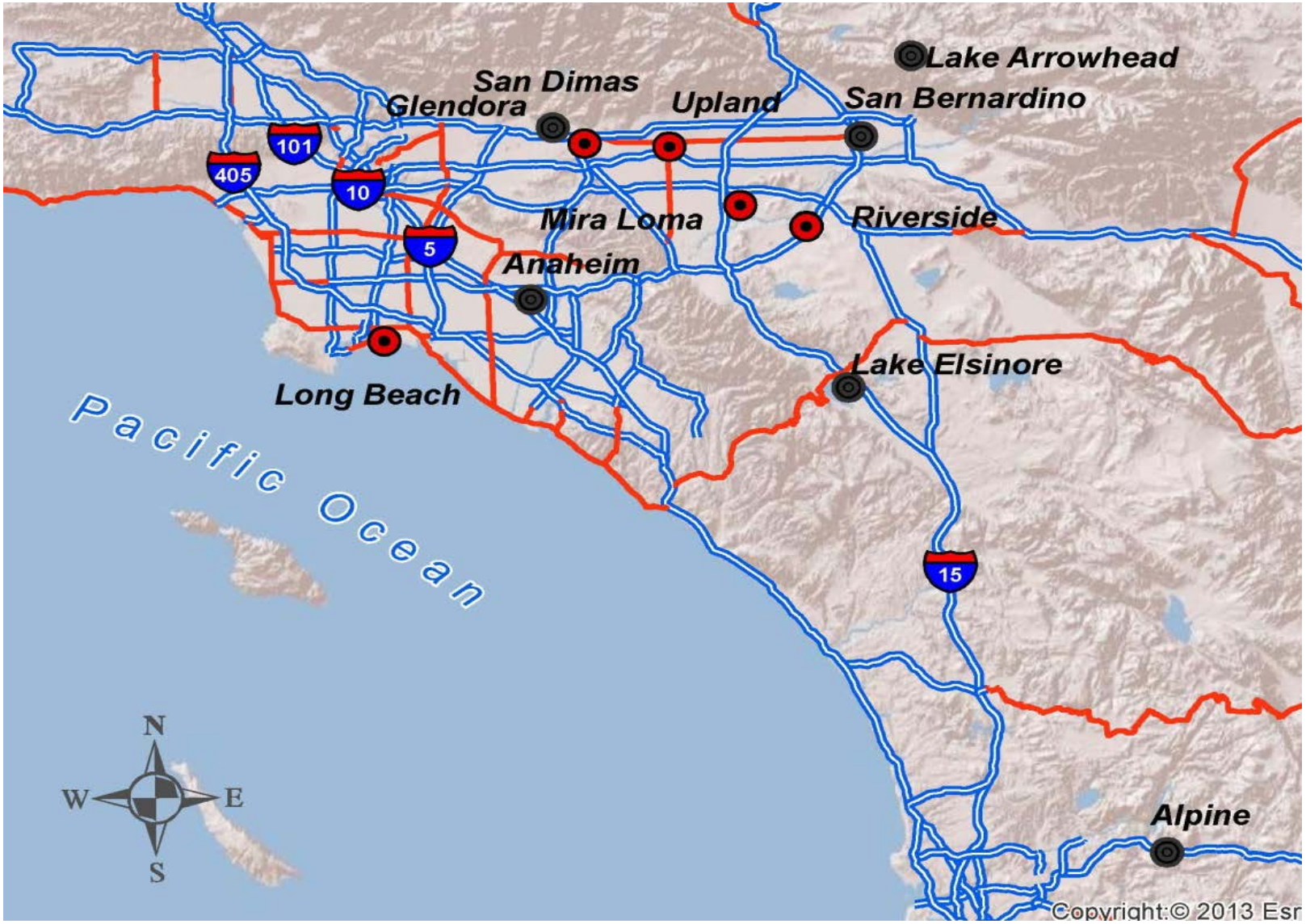
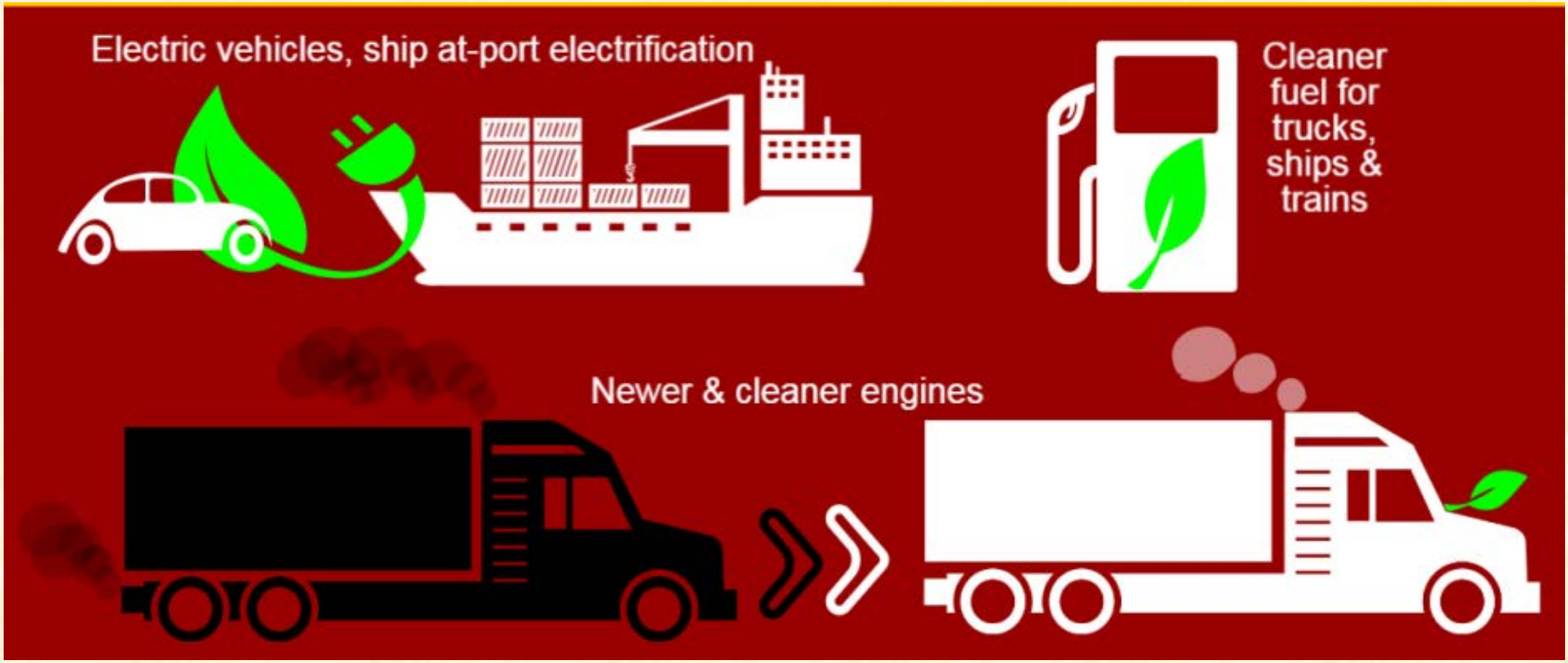
## <u>Overlap across cohorts</u>: 11 – 15 years of age on average



# Communities with health data from 1994 – 2011



# Policies over the past 20 years

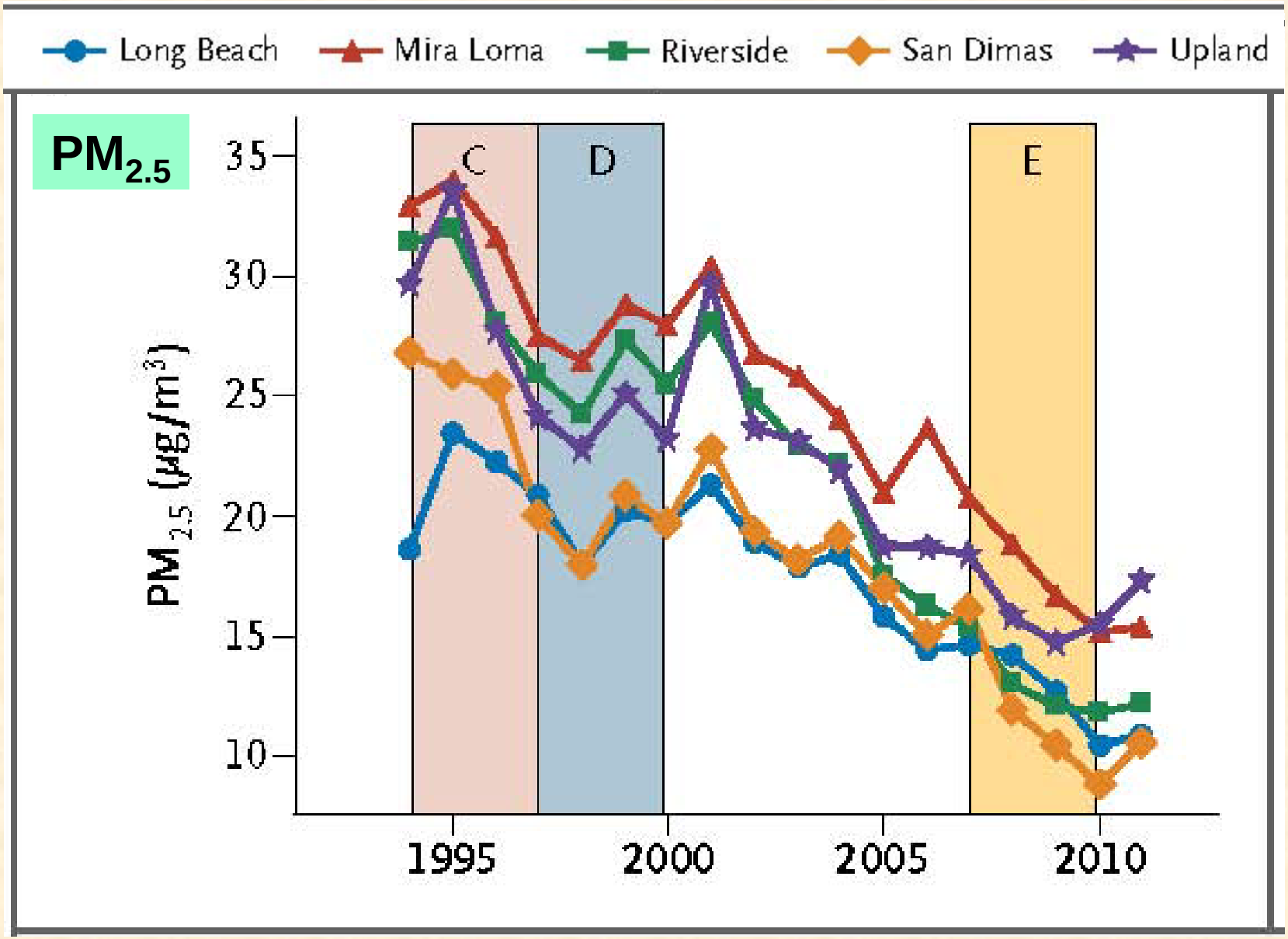



**… plus policies affecting stationary sources, off-road vehicles, …**

# Despite growth across the region…


**(1994 – 2011)**

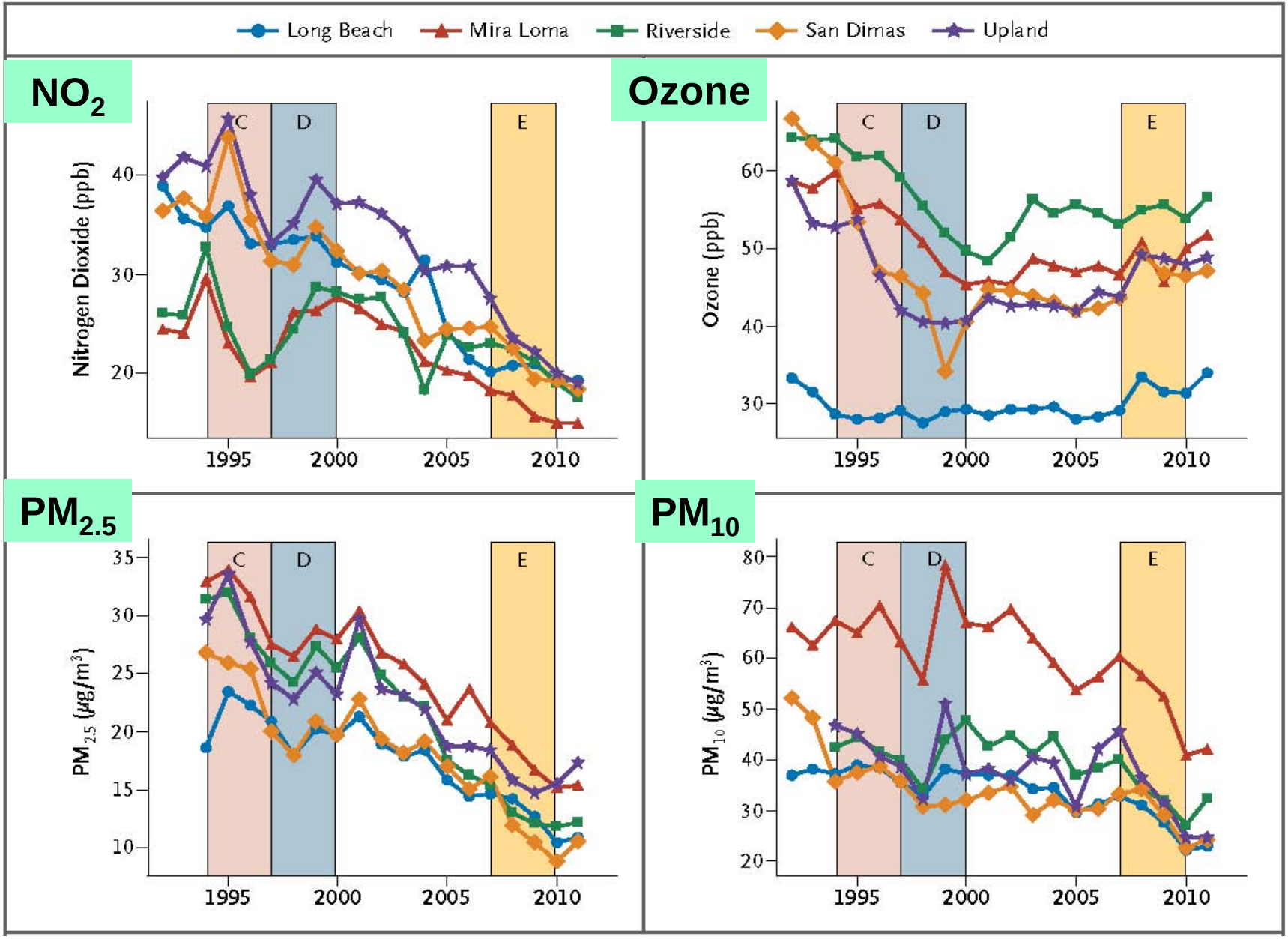
# … The Air Has Gotten Cleaner




**ML:**
**⬇ 43%**

**RV:**
**⬇ 55%**

# Exposure periods for CHS Cohorts C,D, & E



# Change in Exposure: Cohort C to E

**Supplemental Table S2:** Mean pollutant levels corresponding to the colored bands in Figure 1

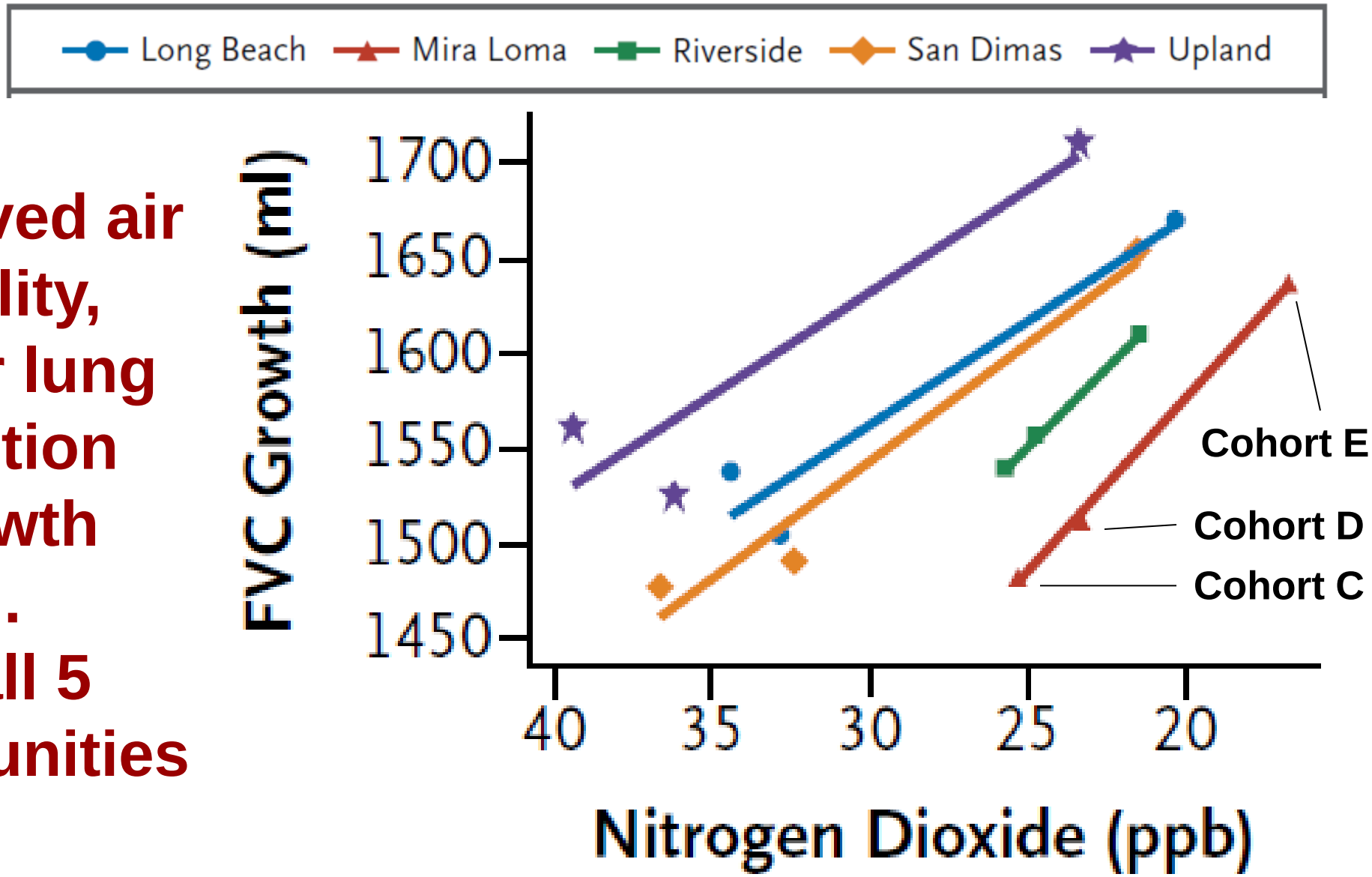
| Pollutant | Cohort | Years | Long Beach | Mira Loma | Riverside | San Dimas | Upland |
|---|---|---|---|---|---|---|---|
| $NO_2$ (ppb) | C | 1994-1997 | 34.4 | 23.3 | 24.7 | 36.6 | 39.4 |
| | D | 1997-2000 | 32.9 ( -4.5%) | 25.3 ( 8.5%) | 25.7 ( 4.0%) | 32.4 (-11.6%) | 36.2 ( -8.1%) |
| | E | 2007-2010 | 20.3 (-41.0%) | 16.7 (-28.3%) | 21.4 (-13.2%) | 21.5 (-41.3%) | 23.4 (-40.7%) |
| $O_3$ (10a-6p, ppb) | C | 1994-1997 | 28.6 | 56.2 | 61.9 | 52 | 48.8 |
| | D | 1997-2000 | 28.8 ( 0.7%) | 49.3 (-12.3%) | 54.1 (-12.5%) | 41.4 (-20.5%) | 40.9 (-16.1%) |
| | E | 2007-2010 | 31.4 ( 10.0%) | 48.4 (-13.9%) | 54.5 (-11.9%) | 46.6 (-10.5%) | 47.5 ( -2.6%) |
| $PM_{10}$ ($\mu g/m^3$) | C | 1994-1997 | 37.5 | 66.5 | 42.1 | 36.9 | 42.9 |
| | D | 1997-2000 | 35.9 ( -4.2%) | 66.0 ( -0.7%) | 41.5 ( -1.4%) | 32.5 (-12.0%) | 39.9 ( -7.1%) |
| | E | 2007-2010 | 28.4 (-24.2%) | 52.6 (-20.8%) | 33.4 (-20.7%) | 29.9 (-19.1%) | 34.7 (-19.2%) |
| $PM_{2.5}$ ($\mu g/m^3$) | C | 1994-1997 | 21.3 | 31.5 | 29.3 | 24.5 | 28.7 |
| | D | 1997-2000 | 19.7 ( -7.5%) | 27.6 (-12.2%) | 25.7 (-12.2%) | 19.6 (-19.9%) | 23.8 (-17.2%) |
| | E | 2007-2010 | 13.0 (-38.9%) | 17.8 (-43.3%) | 13.1 (-55.3%) | 11.9 (-51.6%) | 16.1 (-43.9%) |

Mean pollutant level over the indicated 4-yr period in each community (values in parentheses are the percent change compared to Cohort C)

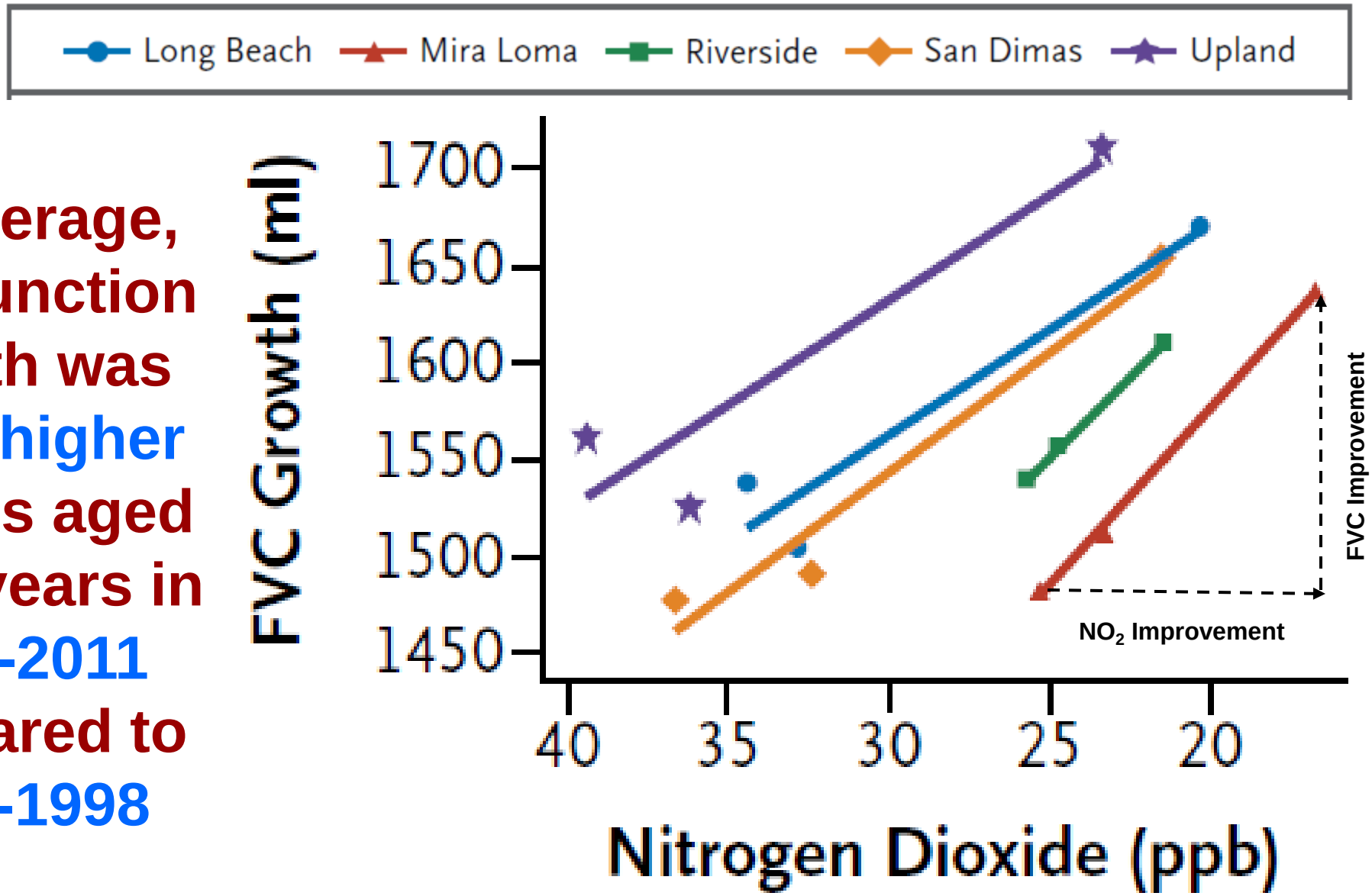
**Improved air quality, better lung function growth**

**…**

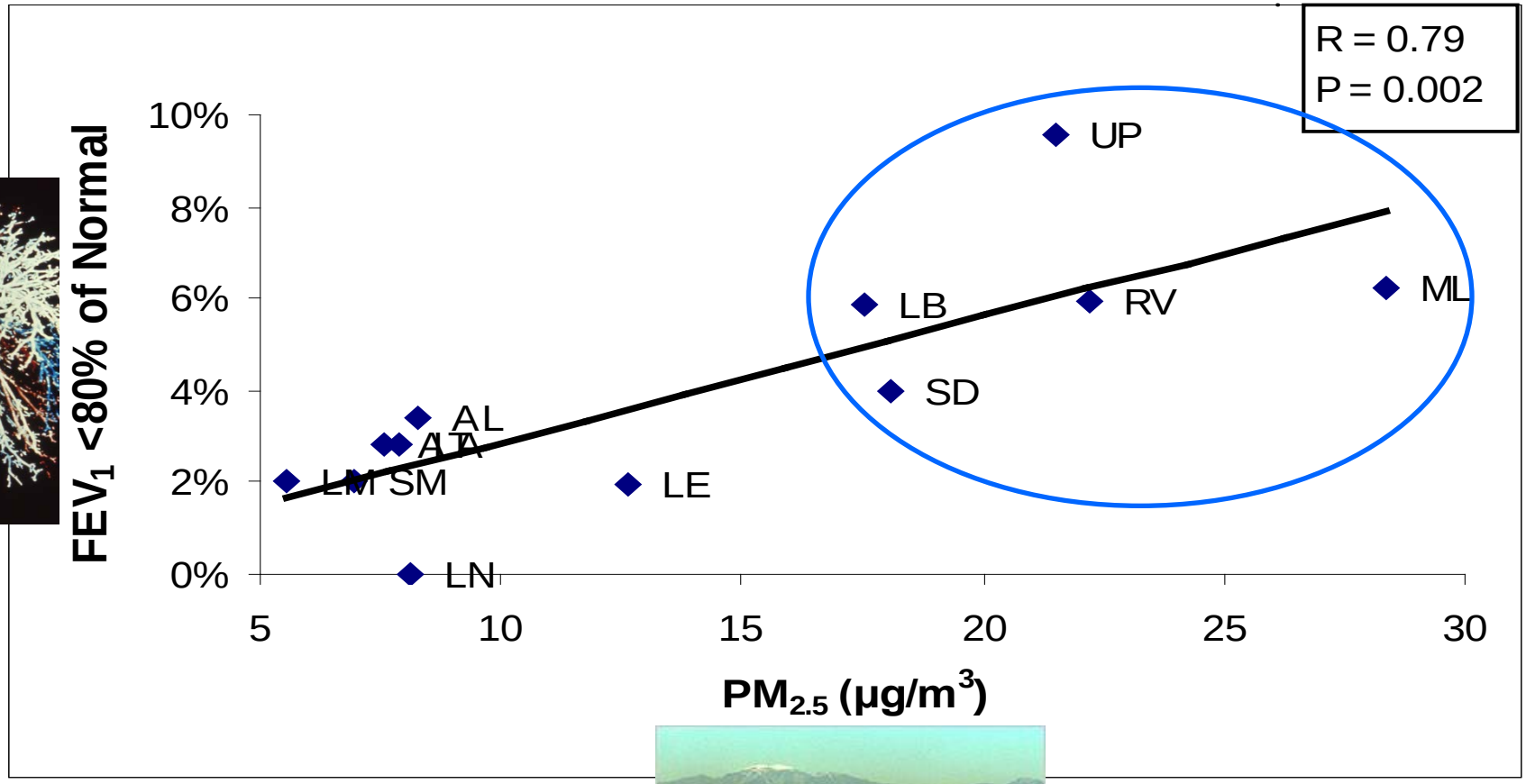
**In all 5 communities**



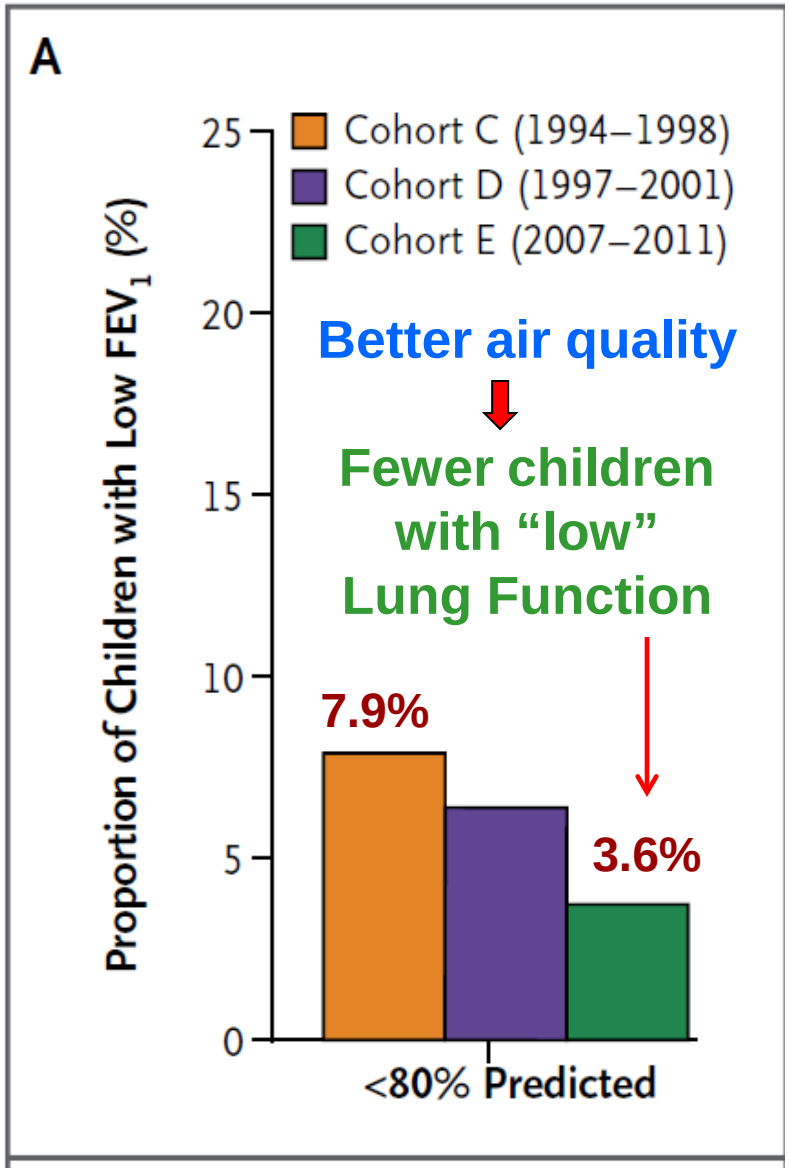
**On average, lung function growth was ~10% higher for kids aged 11-15 years in 2007-2011 compared to 1994-1998**



# Abnormally Low Lung Function is More Likely in a Polluted Community



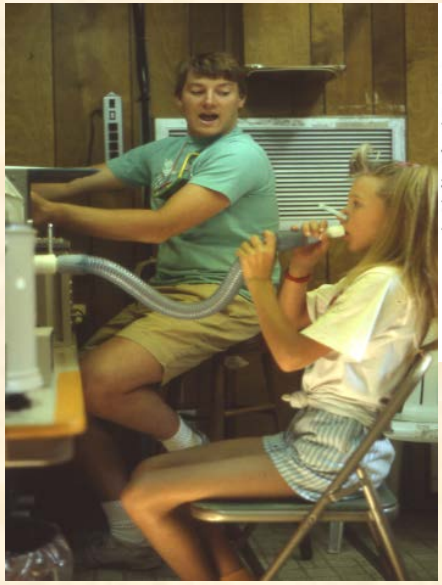

NEJM, 2004

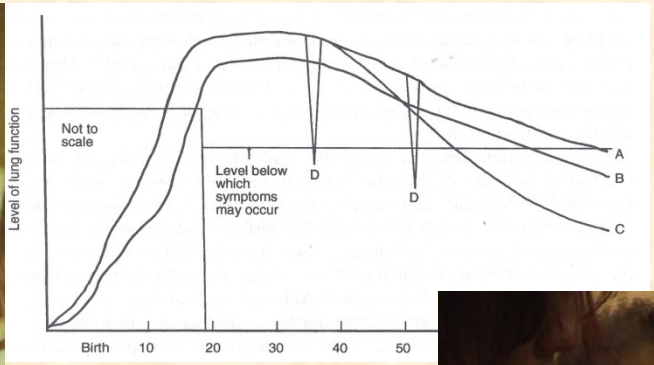

A
Cohort C (1994–1998)
Cohort D (1997–2001)
Cohort E (2007–2011)
Proportion of Children with Low FEV1 (%)
25
20
15
10
5
0
Better air quality
Fewer children with "low" Lung Function
7.9%
3.6%
<80% Predicted

NEJM, 2015

# Summary

- **Based on 20+ years of the CHS…**
  **Air pollution is associated with chronic health effects**






# Summary

- **Regional and local exposures are important**

# Summary

- **<u>Reductions</u> in air pollution are associated with measurable <u>improvements</u> in children's health**

# Summary

- **We <u>cannot</u> get complacent!**
  - **More cars, trucks, industry, population, etc. are projected**

# Summary

- **We <u>cannot</u> get complacent:**
  - **More cars, trucks, industry, population, etc. are projected**

**…but hard work to improve air quality pays off!**

# Questions?

JimG@usc.edu