Improved Air Quality and Children’s Respiratory Health

Does Cleaning the Air Lead to Better Health?

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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:

Study participants and their families!

The Hastings Foundation
Primary goal of the CHS

Does outdoor air pollution cause *chronic* health effects?

- ↑ Asthma risk?
- ↓ Lung function growth?
Pollution in the L.A. Basin

Ozone, NO2, PM

NO2, PM
## CHS Cohorts, By School Year & Class Grade

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<th>Cohort</th>
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### Notes
- **Cohorts A to E** represent different groups of students.
- **School Year** and **Class Grade** are listed for each cohort.
Annual Lung Function Tests

What do we collect?

- **FEV₁**: 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 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

\[ \text{PM}_{2.5} (\mu g/m^3) \]

\[ \text{FEV}_1 < 80\% \text{ of Normal} \]

R = 0.79
P = 0.002

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?
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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
Living NEAR A FREEWAY reduces lung function.

Example: Santa Maria, Close to Hwy 101
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?
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 1998, 1999, 1997, and 2000. 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...
CHS Cohorts, By School Year & Class Grade

| Cohort | N  | '93 | '94 | '95 | '96 | '98 | '99 | '00 | '01 | School Year '02 | '03 | '04 | '05 | '06 | '07 | '08 | '09 | '10 | '11 | '12 | '13 | '14 |
|--------|----|-----|-----|-----|-----|-----|-----|-----|-----|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 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

Overlap across cohorts: 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

<table>
<thead>
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<th>Pollutant</th>
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<th>Years</th>
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<th>Riverside</th>
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<td>34.4</td>
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<td>D</td>
<td>1997-2000</td>
<td>32.9 (-4.5%)</td>
<td>25.3 (8.5%)</td>
<td>25.7 (4.0%)</td>
<td>32.4 (-11.6%)</td>
<td>36.2 (-8.1%)</td>
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<td>E</td>
<td>2007-2010</td>
<td>20.3 (-41.0%)</td>
<td>16.7 (-28.3%)</td>
<td>21.4 (-13.2%)</td>
<td>21.5 (-41.3%)</td>
<td>23.4 (-40.7%)</td>
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<td>O₃ (10a-6p, ppb)</td>
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<td>D</td>
<td>1997-2000</td>
<td>28.8 (0.7%)</td>
<td>49.3 (-12.3%)</td>
<td>54.1 (-12.5%)</td>
<td>41.4 (-20.5%)</td>
<td>40.9 (-16.1%)</td>
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<td>E</td>
<td>2007-2010</td>
<td>31.4 (10.0%)</td>
<td>48.4 (-13.9%)</td>
<td>54.5 (-11.9%)</td>
<td>46.6 (-10.5%)</td>
<td>47.5 (-2.6%)</td>
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<td>PM₁₀ (µg/m³)</td>
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<td>11.9 (-51.6%)</td>
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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

FeV₁ < 80% of Normal

PM₂.₅ (µg/m³)

R = 0.79
P = 0.002

NEJM, 2004
Better air quality

Fewer children with “low” Lung Function

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

• Reductions in air pollution are associated with measurable improvements in children’s health
Summary

• We **cannot** get complacent!
  
  – More cars, trucks, industry, population, etc. are projected
Summary

• We **cannot** get complacent:

  – More cars, trucks, industry, population, etc. are projected

...but hard work to improve air quality pays off!
Questions?

JimG@usc.edu