DOES AIR POLLUTION CAUSE CHILDHOOD OBESITY?

Rob McConnell
Southern California Children’s Environmental Health Center
Keck School of Medicine
University of Southern California
January 13, 2016

Overview of Presentation

• Findings from the Southern California Children’s Health Study (CHS)
• Other influential epidemiological studies
• Biological plausibility
• Air pollution, diabetes and metabolic outcomes
Risk Factors for Childhood Obesity

- Major risk factors: family history, increased caloric density and decreased physical activity
- Other factors may promote development of obesity
  - Absorption
  - Basal metabolism
  - Adipose deposition
- Environmental obesogens
  - Dietary composition
  - Gut microbiome
  - Built environment through its role in exercise and food consumption
  - In utero exposures


Environmental Risk Factors for Childhood Obesity

- Chemical exposures are implicated
  - Organochlorines (PCBs, DDT, HCB)
  - Bisphenol A
  - Cigarette smoke (nicotine?)
  - Air pollution?

Children’s Health Study Communities

MAIN OUTCOMES

• Currently
  – Asthma
  – Respiratory symptoms (eg. bronchitis)
  – Lung function (spirometry)
  – Exhaled nitric oxide
  – Respiratory school absences
  – Carotid intima medial thickness, arterial stiffness, blood pressure
  – Obesity/BMI trajectory
  – Epigenetic marks

• With Southern California Children’s Environmental Health Center (SC-CEHC) support
  – Metabolic outcomes
  – Fat distribution
  – Fat tissue phenotype
Exposure

• Age 5+
  – Regional pollutants
  – Near-roadway Air Pollution (NRAP)
    • Traffic proximity
    • Traffic density
    • Estimated from land use regression and dispersion modeled NO\textsubscript{x}

• Extending back to birth as part of ia Children’s Center

Near-Roadway Obesity Associations

• Near-roadway air pollution (NRAP) associated with obesity or increased body mass index trajectory
  • Rundle A, Hoepner L. et. al. American J Epidemiol 2012; 175:1163-72
  • McConnell R, Shen E, et. al. Environ Health Perspectives 2015;123: 360-6
BMI Association with Traffic Density


BMI Association with Prenatal Polyaromatic Hydrocarbon (PAH) Exposure

BMI Association with Dispersion-modeled Near-roadway Air Pollution

![Graph showing BMI association with dispersion-modeled near-roadway air pollution.](image)

Figure 3 Predicted BMI. Plot of predicted BMI comparing children in the 10th and the 90th percentiles with the 10-90th percentile exposure contrasts shown for reference.


Main and Synergistic Effects of SHS and Pollution Attained BMI by Age Among Long-term Residents

![Graph showing main and synergistic effects of SHS and pollution on attained BMI by age.](image)

Difference in mean BMI (95% confidence intervals) at each age was compared with reference exposure category of children with neither exposure (X-axis).

McConnell, et. al. Environ Health Perspect 2015;123:360-366
Implications

• These are big effects, if causal
  – Potentially large public health implications
• No nicotine in near-roadway air pollution
  – Are there complementary or overlapping pathways that account for SHS effects?

What Might Cause These Effects?

• Near-roadway pollution composition is a complex mixture…
  – Fresh particle and gaseous combustion products
  – Debris from tires and brake wear
  – Metals from engine wear
Tox Studies

• Prenatal diesel exhaust exposure resulted in increased weight in males in early life and primed female adults for weight gain on high fat diet
• Possible mechanism through damage diesel exhaust did to feeding centers in the hypothalamus or to anxiety-associated eating?


Potential Mechanisms

• Changes in basal metabolism
  – Polyaromatic hydrocarbons inhibit catecholamine-induced lipolysis
  – Mitochondrial damage from early life urban particle exposure
  – Reduced methylation and increased expression of PPARγ induced by early life particle exposure
  – Estrogenic effects of urban particles
  – Increased visceral adipose tissue (AT) and AT inflammation resulting from in utero PM exposure

Air Pollution and Diabetes

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Population</th>
<th>NO₂ OR (95% CI)</th>
<th>Heterogeneity measures (I², p-value, Tau²)</th>
<th>PM₂.₅ OR (95% CI)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Main model (random effects)</td>
<td>Males: 0.99 (0.93, 1.07)</td>
<td>0; 0.744; 0</td>
<td>1.04 (0.93, 1.17)</td>
<td>0; 0.486; 0</td>
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<td>Females: 1.15 (1.05, 1.27)</td>
<td>46.1; 0.135; 0.0042</td>
<td>1.14 (1.03, 1.26)</td>
<td>0; 0.405; 0</td>
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<td>Overall: 1.08 (1.00, 1.17)</td>
<td>58.4; 0.025; 0.0063</td>
<td>1.10 (1.02, 1.18)</td>
<td>0; 0.473; 0</td>
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<td>Studies assessing air pollution before DM diagnosis</td>
<td>Males: 1.02 (0.92, 1.13)</td>
<td>NA; NA; 0</td>
<td>1.04 (0.93, 1.17)</td>
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<td>Females: 1.20 (1.10, 1.30)</td>
<td>12.5; 0.265; 0.0006</td>
<td>1.13 (1.02, 1.25)</td>
<td>0; 0.344; 0</td>
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<td>Overall: 1.12 (1.05, 1.19)</td>
<td>69.8; 0.036; 0.008</td>
<td>1.09 (1.01, 1.18)</td>
<td>0; 0.495; 0</td>
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<td>Studies including both men and women</td>
<td>Males: 0.99 (0.93, 1.07)</td>
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<td>1.04 (0.93, 1.17)</td>
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<td>Females: 1.11 (1.01, 1.23)</td>
<td>30.2; 0.238; 0.0023</td>
<td>1.13 (1.02, 1.25)</td>
<td>0; 0.344; 0</td>
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<td>Overall: 1.05 (0.98, 1.12)</td>
<td>34.3; 0.175; 0.0024</td>
<td>1.09 (1.01, 1.18)</td>
<td>0; 0.498; 0</td>
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<td>Only longitudinal studies</td>
<td>Males: 1.02 (0.92, 1.13)</td>
<td>NA; NA; 0</td>
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<td>Meta-analysis using fixed-effects model</td>
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NA, not applicable. I² is the proportion of total variability explained by heterogeneity. Tau² is a measure of among-study variance.

Eze IC, et. al. Environ Health Perspect. 2015;123:381-389

Ambient Air Pollution Exaggerates Adipose Inflammation and Insulin Resistance in a Mouse Model of Diet-Induced Obesity

Sun Q. Circulation 2009

Increased systemic adipokines and inflammatory biomarkers

- PM₂.₅ also induced:
  - Larger adipocytes
  - Macrophage infiltration
  - Insulin resistance

Open Questions

• Does air pollution cause obesity?
• Are there different effects of near-roadway and regional pollutant mixtures?
• What is the mechanism(s) for these effects?
• How do environmental obesogens interact with diet and physical activity?
Potential for Harm Reduction?

- Good public policy to reduce ambient levels

- Outdoor activity not coincident with pollution
  - Exercise! ...but not next to a freeway or busy road, or during high pollution times (eg. ozone in mid-day, PM in early morning)
  - Unintended negative consequences from reduced physical activity?

- Park siting, zoning restrictions near freeways

- Filters

- Chemoprevention, eg antioxidants

Average Levels of Particles (PM$_{2.5}$) declined 13% to 54%

**CEHC/CHS Acknowledgments**

- Omid Akbari
- Hooman Allayee
- Ed Avol
- Britni Belcher
- Kiros Berhane
- Carrie Breton
- Tuck Finch
- Scott Fruin
- Jim Gauderman
- Frank Gilliland
- Michael Goran
- Rima Habre
- Nino Kunzli
- Fred Lurmann
- Todd Morgan
- Fred Sattler
- Duncan Thomas

- National Institute for Environmental Health Sciences
- US Environmental Protection Agency
- South Coast Air Quality Management District
- Hastings Foundation

**Questions?**

rmcconne@usc.edu