DOES AIR POLLUTION CAUSE CHILDHOOD OBESITY?

Rob McConnell
Southern California Children’s Environmental Health Center
Keck School of Medicine
University of Southern California
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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
  – Built environment through its role in exercise and food consumption
  – Gut microbiome
  – In utero and childhood chemical exposures

Environmental Risk Factors for Childhood Obesity

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

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 $\text{NO}_x$

• Extending back to birth as part of Children’s Center
Near-Roadway Obesity Associations

- Near-roadway air pollution (NRAP) associated with obesity or increased body mass index trajectory
  - McConnell R, Shen E, et. al. Environ Health Perspectives 2015;123: 360-6
Trajectory of BMI Growth over Adolescence

Boys
BMI Averages:
18.4 at age 10
24.2 at age 18

Girls
BMI Averages:
18.4 at age 10
23.4 at age 18

BMI Association with Traffic Density

Air Quality is Worse Near a Freeway

BMI Association with Dispersion-modeled Near-roadway Air Pollution

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

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

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
BMI Association with Prenatal Polyaromatic Hydrocarbon (PAH) Exposure

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
What Characteristics of Fat Predict the Development of Diabetes?

• Lots of obese people, a relatively small proportion get diabetes…
  – Visceral fat (hence waist circumference better predictor than BMI)
  – “Ectopic” fat (eg in liver, pancreas…)
  – Inflammation
  – Insulin resistance

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

- PM$_{2.5}$ also induced:
  - Larger adipocytes
  - Macrophage infiltration
  - Insulin resistance

Mechanisms for Development of Metabolic Outcomes

CHILDREN’S CENTER RESEARCH QUESTIONS

• Does *in utero* and childhood near-roadway air pollution (NRAP) exposure cause childhood obesity? If so, what are the mechanisms?

• Does NRAP affect fat distribution, ectopic fat and adipose tissue inflammation?

• Does NRAP affect glucose homeostasis, lipid profile, systemic inflammation and the metabolic syndrome?

• Are effects of NRAP on metabolic and inflammatory outcomes the result of changes in fat distribution and/or adipose tissue inflammation?
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Interrelationships of Projects and Cores

Community Engagement

Community Outreach and Translational Core

SC-CEHC Theme:
Air Pollution, Childhood Obesity & Metabolic Consequences

- Project 1: Effects of Air Pollution on the Development of Obesity in Children
- Project 2: Near roadway air pollutant, adipose inflammation and metabolic consequences
- Project 3: Longitudinal Effects of Air Pollution on Obesity in Mice

Career Development

Pediatric Health Specialist

Administrative Coordination
Potential for Harm Reduction?

- Good public policy to reduce ambient levels
- Park siting, zoning restrictions near freeways
- 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?
- ?Filters
- ?Chemoprevention, eg antioxidants
Average Levels of Particles (PM$_{2.5}$) declined 13% to 54%
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Questions?

rmcconne@usc.edu