Prenatal Residential Proximity to Agricultural Pesticide Applications and IQ in Children

Robert Gunier

Center for Environmental Research and Children’s Health
School of Public Health, UC Berkeley

Children’s Environmental Health Centers Webinar
August 12, 2015
A birth cohort study investigating the health effects of environmental exposures in low income Mexican-American children living in an agricultural community.
Salinas Valley - the “Salad Bowl” of the Nation

• Ranked #1 in the country for lettuce and all vegetables
• Almost $3 billion in agricultural revenues in 2012
• Over 4.2 million kg of agricultural pesticide use in 2012
Previous Study in CHAMACOS Cohort: Prenatal Biomarker of Pesticide Exposure

- Urine samples from pregnant mother’s at ~ 13 and 26 weeks gestation
- Measured dialkylphosphate metabolites (DAPs) as a biomarker of exposure to organophosphate pesticides
Adjusted for sex, child’s age, language of assessment, maternal education, household income per person and HOME score.

Bouchard et al. EHP, 2011
Limitations of DAPs as a Measure of Exposure

- Short-term (daily) and long-term (seasonal) variability
- Not pesticide specific
- Not toxicity weighted
- Does not identify source of exposure
Pesticide Use Report (PUR) Data

• Unique database
  • Mandatory since 1990
  • Comprehensive reporting of all pesticides
  • Largest agricultural state in the country
  • Other states are implementing

• Provides the following information:
  • Pesticide active ingredients
  • Pounds applied
  • Application date
  • Location to a square-mile section
  • Crop treated
Agricultural Use of Organophosphates in California
Agricultural Use of Organophosphates in the Salinas Valley
Is nearby agricultural pesticide use related to neurodevelopment of children?
In 1999-2000, we enrolled 601 pregnant women from clinics

- 92% Spanish-speaking
- 85% born in Mexico
- 54% < 5 years in U.S.
- 96% living within 200% of poverty
- 44% 6th grade education or less
- 44% worked in agriculture during pregnancy
- 84% other agricultural workers in home
Methods – Pesticide Use Residential Proximity

<table>
<thead>
<tr>
<th>PLSS Sections</th>
<th>100kg</th>
<th>300kg</th>
<th>500kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticide Use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within 1km of</td>
<td>200kg</td>
<td>200kg</td>
<td>100kg</td>
</tr>
<tr>
<td>Residence</td>
<td>×8%</td>
<td>×85%</td>
<td>×8%</td>
</tr>
<tr>
<td>16kg</td>
<td>= 16kg</td>
<td>= 170kg</td>
<td>= 8kg</td>
</tr>
<tr>
<td>170kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= 252kg</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2% of Section

25% of Section

85% of Section

8% of Section

1 Mile (1.6 km)

16kg + 170kg + 8kg + 2kg + 50kg + 6kg = 252kg

2% of Section

Pesticide Use Reporting (PUR)
Methods – Pesticide Use Wind Weighting

Pesticide Use Within 1km of Residence

16kg +
170kg +
8kg +
2kg +
50kg +
6kg
= 252kg

Wind Adjusted Pesticide Use Within 1km of Residence

(16kg x 12%) +
(170kg x 20%) +
(8kg x 10%) +
(2kg x 4%) +
(50kg x 13%) +
(6kg x 14%)
= 44.14kg
Cognitive Assessment at 7-years of Age

• Wechsler Intelligence Scale for Children, 4th Edition

• Four domains:
  • verbal comprehension
  • perceptual reasoning
  • working memory
  • processing speed

• All assessments by a single bilingual psychometrician

• Conducted in Spanish (67%) and English (33%)
Agricultural OP pesticide use (PUR) is independently associated with IQ at 7 years.

Adjusted for child’s age, sex, language of assessment, maternal education, maternal intelligence, household poverty level, maternal depression, maternal country of birth and HOME score. Adjusted for prenatal DAPs

Bouchard et al., EHP, 2011

Unpublished data
## Organophosphate Pesticide Use in the Salinas Valley, 2000

<table>
<thead>
<tr>
<th>OP Pesticide</th>
<th>Kg Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diazinon</td>
<td>56,434</td>
</tr>
<tr>
<td>Malathion</td>
<td>37,161</td>
</tr>
<tr>
<td>Acephate</td>
<td>34,792</td>
</tr>
<tr>
<td>Oxydemeton</td>
<td>28,767</td>
</tr>
<tr>
<td>Chlorpyrifos</td>
<td>25,357</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>~250,000</td>
</tr>
</tbody>
</table>

Source: California Department of Pesticide Regulation
Prenatal agricultural use of individual OPs and Full-scale IQ at 7-years (Single pesticide models)

Adj usted for sex, child’s age, language of assessment, maternal education, maternal IQ, household poverty level, maternal depression, maternal country of birth, HOME score and prenatal DAPs.
Toxicity Weighted OP Pesticide Use in the Salinas Valley, 2000

<table>
<thead>
<tr>
<th>OP Pesticide</th>
<th>Kg Applied</th>
<th>Relative Potency*</th>
<th>Toxicity Weighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxydemeton</td>
<td>28,767</td>
<td>0.86</td>
<td>24,739</td>
</tr>
<tr>
<td>Acephate</td>
<td>34,792</td>
<td>0.08</td>
<td>2,783</td>
</tr>
<tr>
<td>Chlorpyrifos</td>
<td>25,357</td>
<td>0.06</td>
<td>1,521</td>
</tr>
<tr>
<td>Diazinon</td>
<td>56,434</td>
<td>0.01</td>
<td>564</td>
</tr>
<tr>
<td>Malathion</td>
<td>37,161</td>
<td>0.0003</td>
<td>11</td>
</tr>
</tbody>
</table>

*Relative potency based on AChE inhibition, methamidiphos is reference. Sources: California Department of Pesticide Regulation and US EPA
Prenatal agricultural use of total OPs and FSIQ at 7-years

Adjusted for sex, child’s age, language of assessment, maternal education, maternal IQ, household poverty level, maternal depression, maternal country of birth, HOME score and prenatal DAPs.
Agricultural use of neurotoxic pesticides in the Salinas Valley, 2000

<table>
<thead>
<tr>
<th>Pesticide Group</th>
<th>Kg Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organophosphates</td>
<td>245,105</td>
</tr>
<tr>
<td>Carbamates</td>
<td>66,717</td>
</tr>
<tr>
<td>Mn-fungicides</td>
<td>154,783</td>
</tr>
<tr>
<td>Pyrethroids</td>
<td>16,386</td>
</tr>
<tr>
<td>Neonicotinoids</td>
<td>7,111</td>
</tr>
</tbody>
</table>

Source: California Department of Pesticide Regulation
Prenatal agricultural use of neurotoxic pesticides and Full-scale IQ at 7-years (Single group models)

Adjusted for sex, child’s age, language of assessment, maternal education, maternal IQ, household poverty level, maternal depression, maternal country of birth, HOME score and prenatal DAPs.
Can we combine agricultural use of neurotoxic pesticides?
Prenatal agricultural use of neurotoxic pesticides and Full-scale IQ at 7-years (PCA)

![Graph showing the effect of different pesticides on Full-Scale IQ (FSIQ) with adjusted factors.](graph.png)

Adjusted for sex, child’s age, language of assessment, maternal education, maternal IQ, household poverty level, maternal depression, maternal country of birth, HOME score and prenatal DAPs.
Not just CHAMACOS: PUR and neurodevelopment/degeneration

• Neural Tube Defects
  • Rull et al. 2006 – methomyl and benomyl
  • Yang et al. 2014 – 2,4 D, methomyl and imidaclorpid

• Autism
  • Roberts et al. 2007 – dicofol and endosulfan
  • Shelton et al. 2014 – organophosphates and pyrethroids

• Parkinson’s Disease
  • Costello et al. 2009 – maneb and paraquat
  • Wang et al. 2014 – organophosphates

• Previous studies have not incorporated wind or toxicity
Future Directions:
Improved Exposure Estimates

- Optimize PUR exposure estimates using measured pesticide concentrations in air and house dust
  - Refine use of wind data
  - Buffer distance from residence
  - Time period of applications
  - Physical properties of pesticides
  - Precipitation and temperature
- Collaboration with Department of Pesticide Regulation
Summary

- Prenatal residential proximity to agricultural pesticide use associated with decreased IQ in children at 7-years of age
  - Organophosphates – acephate and oxydemeton-methyl
  - Manganese containing fungicides – mane
  - Pyrethroids
  - Neonicotinoids

- Agricultural pesticide use is highly correlated
  - Both individual pesticides and pesticide groups
  - Statistical and toxicological methods to evaluate cumulative effects
  - Statistical methods to evaluate components of correlated mixtures

- Need to improve PUR estimates of exposure based on measured levels in environmental samples
Thank you to collaborators
Thank you to our funders
And a very special thanks to the families who have participated all these years!