Pesticides & Child Health

Catherine J. Karr MD PhD MS FAAP
Dept. Peds/Env Occ Health Sciences
University of Washington
Director, UW Ped. Env. Health Specialty Unit
November 02, 2011
IPM Workshop – Seattle, WA
Outline

Pesticides and Child Health: What do we know?
What do we wish we knew?
- Sources and pathways of exposure for children
- Vulnerability of children
- An abbreviated review of the evidence base: Health endpoints
- Strengths/Limitations of available data

Reduce risk of pesticide use
- Policy/practice approaches
Sources – Child/Pesticide Encounters

**Residential Use – indoor/outdoor**

**School/Daycare – indoor/outdoor**

**Agricultural Use**

Variability based on geography, cultural/social factors, policies

How much/what types from each source?

**Dietary**

**Drinking water**

**Rx – lice/scabies**

**Parks/neighborhood**
Parental Take-Home Pathway
Importance of diet as exposure source: Urinary pesticides concentrations of 22 Children Before, During, and After Organic Diet Intervention

Lu et al. 2005
Child vulnerability to pesticide toxicity

“Kids are not small adults”

- Enhanced exposure opportunities
  Differences in behavior and metabolism

Perturbations of developmental processes
  Form & function of organs and organ systems: birth defects, low birth weight, susceptibility to infections, learning disabilities
Indoor pesticide application: Kid vs. Adult

![Graph showing ventilation and pesticide exposure over time and age](image)

- **Child zone (25 cm)**
- **Adult zone (100 cm)**

- **Pesticide Exposure (liters/kg/day)**

- **Age in years**: <1, 4, 12, 24

*Guzelian, ILSI, 1992*
Dietary intake: Kids vs. Adults

Maintenance requirements

<table>
<thead>
<tr>
<th>Age in Years</th>
<th>Calories</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>100</td>
<td>60</td>
</tr>
<tr>
<td>1.0-3.0</td>
<td>160</td>
<td>90</td>
</tr>
<tr>
<td>4.0-6.0</td>
<td>120</td>
<td>80</td>
</tr>
<tr>
<td>7.0-10.0</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>11.0-14</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>15-18</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>19-24</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>25-50</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>50+</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
## Dietary differences

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Apple (g/kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>5.0</td>
</tr>
<tr>
<td>3-5</td>
<td>3.8</td>
</tr>
<tr>
<td>Adolescent/Adult</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Adapted from Selevan 2000, US EPA 2011
Incidental soil ingestion: Kids Vs Adults

![Bar chart showing comparison between children and adults in mg/day ingestion of soil. The chart includes:
- "Child (mean)"
- "Child (upper percentile)"
- "Adult"
Body Burden of Organophosphate Metabolite

Figure 32. Dimethylphosphate (creatinine corrected)
Selected percentiles with 95% confidence intervals of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6-59 years, National Health and Nutrition Examination Survey, 1999-2002.

Child vulnerability to pesticide toxicity

“Kids are not small adults”

Enhanced exposure opportunities
Differences in behavior and metabolism

✓ Perturbations of developmental processes
Form & function of organs and organ systems: birth defects, low birth weight, susceptibility to infection, learning disabilities
Fetal period: Major organ development

Organ and organ system development: birth to adolescence

- Vital organ growth
  - Brain
  - Lungs
  - Kidneys
  - Reproductive organs

- Physiological function
  - Central nervous system
  - Immune system
  - Endocrine system

Altman eds, FASEB, 1962
Pesticides & Child Health Impacts

Acute Toxicity (poisoning)
- Toxicological/Experimental data
- Case reports

Chronic (long lasting) effects after acute poisoning
- Animal models
- Observation epidemiology
Pesticides and child health impacts

Influence on disease or disability from low level, chronic exposure

Do pesticide exposures contribute to increases in the major chronic diseases of childhood?

- Asthma
- Cancer
- Birth outcomes (Birth defects, Low birthweight/prematurity)
- Neurodevelopment (e.g. learning disabilities, ADHD, Autism)
Acute poisoning

Overall – acute poisoning in U.S. children is rare

Mild, reversible short term symptoms to fatalities

- Improper application*
- Drift*
- Improper storage
- Unintentional ingestion

*UW PEHSU cases
Local Case

- Family (11 & 12 yo sons) commercial residential application early in morning
  - Casoron 4G (Chemtura, 4% dichlorbenil)
  - Ronstar G (2% oxadiazon) (Bayer)

- Dust entered townhouse via open below ground window & two fresh air intakes
- Kids enter home after school, one went to basement and immediately felt dizzy and started coughing. Dust & granules noted on desk and other surfaces.
- Mom arrives after work noted strong chemical odor
- All occupants described feeling dizzy, developing sore and burning throats, cough, and a chemical taste in the mouth on arrival and continued for few days
- Moved out – symptoms resolved
- Complaint filed with WSDA
  - Investigation and environmental sampling
  - Citations issued: improper application method, lack of appropriate posting, used in manner that harmed humans
- 3 months later, 1 child recurrent hives and nasal/eye allergy symptoms
Prevention

☐ IPM approach?

☐ In this case:
  - Proper application techniques
  - Label external furnace/air intakes and prohibit application near intakes
Acute poisoning

No national surveillance/no rates available
Poison center data summaries:

Approximately 45% of all pesticide incident reports occurred in children
8th most common substance encountered in children < 5 years (43,526 = 3.4% of young child NPDS reports)

Bronstein 2008
## Poison Control Center Data 2007

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>&lt;6 Years</th>
<th>6–19 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticoagulant rodenticides</td>
<td>11,592</td>
<td>360</td>
</tr>
<tr>
<td><strong>Pyrethroids</strong></td>
<td>5468</td>
<td>1801</td>
</tr>
<tr>
<td>Insect repellents</td>
<td>6,738</td>
<td>1,625</td>
</tr>
<tr>
<td>Organophosphates</td>
<td>1,096</td>
<td>429</td>
</tr>
<tr>
<td>Borates/boric acid</td>
<td>3,447</td>
<td>131</td>
</tr>
<tr>
<td><strong>Glyphosate</strong></td>
<td>1,133</td>
<td>321</td>
</tr>
<tr>
<td>Carbamates</td>
<td>1,062</td>
<td>235</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>1,042</td>
<td>106</td>
</tr>
</tbody>
</table>

Bronstein 2008
Poison Center data

- Rates of reported pesticide poisonings described as moderate/ major / and fatal have declined from 1995-2004 by approximately 42%.

- Sharpest declines in poisonings were from organophosphate and carbamate insecticides (reflective of policy change)

Blondell 2008
Chronic Health Implications

Most focus in recent years, most robust evidence:

- **neurodevelopmental effects**
- **childhood cancer**

Fewer informative data but concern for:

- **birth outcomes** including growth and gestational deficits
- **birth defects**, **immunological function effects**, **respiratory disease including asthma**, and **endocrine/reproductive effects**
Neurodevelopment & Pesticides

- Organochlorines, organophosphates – accumulating and consistent support for adverse impacts

  Biological plausibility and toxicological mechanisms

  Multiple epidemiological studies

- Functional deficits (mental, motor) -- symptoms and behaviors (inattention, hyperactivity, autism-related) -- diagnosed conditions (ADHD)

Rosas 2008
OP Pesticides and ADHD

- Cross section study using U.S. NHANES – Are children with higher concentrations of OP metabolites in urine more likely to meet diagnosis of ADHD based on structured interview?

- Kids with 10 x’s higher metabolites – (1 ½ - double likelihood of ADHD diagnosis) 

- Strengths – Large sample size, valid case definition, biomarker of exposure, representative sample of US kids 8-15 y, some covariates (ses, lead, prem/lbw)

- Limitations – Cross-sectional, potential confounders not addressed (parental neurobehavioral status, stress, etc)

Bouchard 2010
Pediatric cancer and pesticides

- Some pesticides have undergone cancer classification by EPA
  Malathion (possible), Dichlorvos (probable), permethrin (likely human)

- Substantial observational epidemiological data demonstrating a link between pesticide exposure and childhood cancers

- Challenges/limitations: Exposure assessment is generally crude, recall bias, specificity of cancer type
Pediatric leukemia and pesticides

- Most consistently associated tumor type = Acute Lymphocytic Leukemia (ALL)

- Associations with household insecticide use (lawn/garden herbicides, insecticides)

- Maternal pre-conceptional and prenatal exposures

Infante-Rivard 2007
Pediatric brain tumors and pesticides

- 2nd most commonly associated cancer - Brain tumors

- Prenatal exposure to insecticides, particularly in the household, as well as both maternal and paternal occupational exposure before conception though birth

Fetal growth/pre-term birth

- Several studies associate maternal DDT/DDE preterm birth, IUGR, LBW
- OPs - NYC follow up cohorts
- Ecological studies link triazine herbicide exposure and fetal growth

Birth defects and pesticides

Available studies are heterogeneous in design, conflicting in results, and they often have an insufficient exposure assessment/ecological designs. Recognizing these limitations they do suggest role of:

- paternal or maternal occupational exposures
- OC and OP insecticides, phenoxy and triazine herbicides
- cryptorchidism, orofacial clefts, limb reduction defects, and heart defects

Bottom line, a small risk is noted but the findings are not robust and data specific to pesticide subtypes are not adequate

Asthma & pesticides: emerging hypothesis

- Iowa rural kids - any pesticide use indoors or any outdoor use in the previous year ≠ asthma symptoms and prevalence (Merchant 2005)

+ California Children’s Health Study (So.CA) – herbicides and pesticides/insecticides strong association with asthma diagnosis before age 5 years (5 x’s more likely, 2.4 times more likely, respectively) (Salam 2004)
Pesticide Child Health Studies: Key Points Summary

- Most evidence for adverse effects associated with insecticides (organochlorines/organophosphates)
  Or simply & often non-specific “pesticide exposure”

- Animal models + well designed human studies demonstrate OP exposures that are being experienced by U.S. children/pregnant women may have adverse neurodevelopmental consequences

- Prenatal and very early life exposure are of high concern

- Animal and human investigations of other chronic health endpoints raise concern but are less robust and better characterization is needed (cancer, birth outcomes, asthma, endocrine disruption)
Known Effects

WHAT WE KNOW

Impact of mixtures

WHAT WE DON’T KNOW

Cumulative effects: AI, “inerts”

THE “UNKNOWN UNKNOWN”

Other toxicants

Long latency effects

Gene-environment interactions

Windows of vulnerability
Reducing exposure and impact

Use pesticides ONLY when the benefits outweigh the risks

- Avoid cosmetic or scheduled use of pesticides in/around the home
- Use integrated pest management (IPM), non-chemical pest controls

If pesticides are used:

- Store in original containers with child-proof seals, out of reach, in a locked cabinet
- Know safe use guidelines
  - Label, PPE, re-entry,
- Use least hazardous chemicals, least dangerous mode of application
Thank you

Acknowledgement:

- Dr. James Roberts (MUSC) - AAP Council on Environmental Health
- WHO (CEH Modules)
Disclaimer

- This presentation was prepared by Dr. Catherine Karr, Region 10 PEHSU. The PEHSU receives funding from the Association of Occupational and Environmental Clinics (AOEC) (in part) by the cooperative agreement award number 1U61TS000118-02 from the Agency for Toxic Substances and Disease Registry (ATSDR) at the US Centers for Disease Control & Prevention.

- Acknowledgement: The U.S. Environmental Protection Agency (EPA) supports the PEHSU by providing funds to ATSDR under Inter-Agency Agreement number DW-75-92301301-0. Neither EPA nor ATSDR endorse the purchase of any commercial products or services mentioned in PEHSU publications.