Analyses of Observational Studies to Identify Exposure Factors Relevant to Children

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LTG 3 Poster 03

Science Questions

•What are the critical exposure pathways in children's homes and other surroundings?
•What are the most influential factors along each pathway?
•How can the knowledge of critical pathways and influential factors be used to reduce exposure and risk? To reduce uncertainties in exposure and risk assessments?

Research Goals

Assessing childhood risks from pesticides and other environmental contaminants is a significant challenge because exposure occurs across multiple routes and pathways, including ingestion from dietary (food, beverage, and drinking water consumption) and non-dietary (hand- or object-to-mouth transfer) routes, inhalation, and dermal absorption. ORD-sponsored observational exposure studies are designed to collect multimedia measurement data, improve our understanding of the critical exposure pathways, and identify the most influential factors related to an individual's surroundings and behaviors. These ORD-funded and conducted studies complement each other in evaluating the research strategy developed to identify pesticide use patterns, measure concentrations and describe their spatial and temporal distributions in residential environments, characterize activity patterns of young children, and evaluate methods and approaches for estimating dietary, indirect, and dermal exposures.

Highlights of Findings and Conclusions

•Pesticide residues are detected in all environments that children occupy.
•Diet is an important route of children's exposures for both organophosphate and pyrethroid pesticides.
•In those homes with frequent pesticide applications, the non-dietary and dermal routes take on an increased importance.
•.Replacing a conventional diet with an organic diet significantly reduced the amount of OP metabolites measured in the urine, underscoring the role of diet in OP pesticide exposure.
•Changing from a conventional to an organic diet does not appreciably reduce the amount of pyrethroid metabolites in urine, suggesting that for pyrethroids, residential exposures have an increased importance relative to diet.
•The importance of inhalation as an exposure pathway has diminished for the current-use pesticides.
•Floor dust appears to be a major source of exposure to OP pesticides for young children.
•Pesticide residues on children's hands are associated with pesticide residues on surfaces and metabolite levels in their urine.
•Large differences often exist between estimated intake and estimated excretion of pesticides.
•Hand-to-mouth contacts are important in estimating non-dietary ingestion exposures.
•With surface residues, considerable variability is observed both among rooms and in different locations within a room. Extensive migration of residues is found to occur.
•Household cleaning activities and increased ventilation reduce both air and surface residue levels.
•Physical activity level appears to affect dermal transfer.

Methods/Approach

ORD's Human Health Research Program supports diverse efforts aimed at reducing uncertainty in risk assessments. The Program develops tools to exhaustively measure total exposure aggregated across all relevant pathways, particularly among susceptible populations, with due consideration of the cumulative deleterious effects of compounds with a common mechanism of toxicity. Research activities inform the human health risk assessments performed by EPA Program Offices by:

•Identifying critical pathways and influential factors affecting exposure;

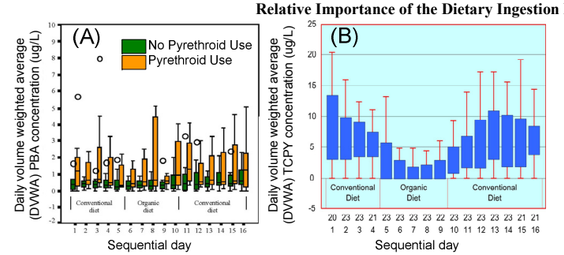
• Identifying the potential for cumulative effects by concomitant stressors; and

• Generating and interpreting data critical, reliable, real-world data to replace default assumptions concerning exposure levels and exposure-determining factors.

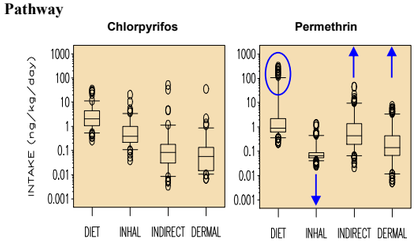
ORD's Human Health Research Program supports collaborative, in-house, and grant-based measurement studies, ranging from small, directed studies to large-scale, probability-based surveys.

While the research encompasses several different classes of compounds, particular attention has been directed towards pesticides. Areas of exceptionally intensive research include pesticide use patterns, translocation of residues into and within residential dwellings, dietary ingestion, dermal transfer and indirect (incidental) ingestion, and birth outcomes.

Relative Importance of the Dietary Ingestion Pathway

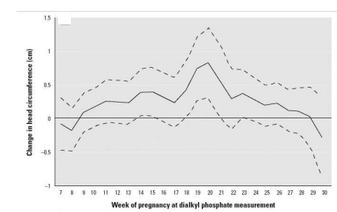


Box Plots of daily volume weighted average pesticide metabolite concentrations among 23 children ages 3-11 years over 15 consecutive days in which conventional and organic diets were sequentially consumed: (A) Pyrethroid metabolite 3-phenoxy benzoic acid (PBA); (B) Organophosphate metabolite 3,5,6-trichloro-2-pyridinol (TCPY). These interventions point to diet being a much greater contributor to total intake for organophosphate pesticides than for pyrethroid pesticides. Source: Lu et al., 2006a and b. (Poster 3-05)



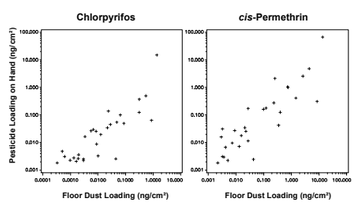
Algorithm-based estimates of daily intakes of chlorpyrifos and permethrin by route reveal that relative to the dietary route, the importance of the dermal and indirect ingestion routes increases for pyrethroid compounds. A likely reason is that pyrethroid transport mechanisms preferentially involve dust as a function of properties that favor the particulate phase. Source: EPA, 2007.

Birth Outcomes

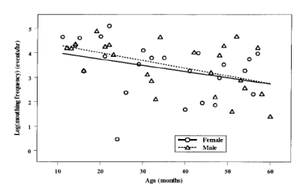


Adjusted regression coefficients (solid lines) and 95% CIs (dashed lines) suggest that the timing of exposure during pregnancy affects the association between urinary dialkyl phosphate metabolites (log10 scale) and head circumference. Source Eskenazi et al., 2004.

Understanding Dermal Transfer and Indirect Ingestion



Loadings of pesticides on children's hands were associated with pesticide levels on surfaces and toys in the home and the number of locations in the home where the children exhibited object-to-mouth activity. Source: EPA, 2007.



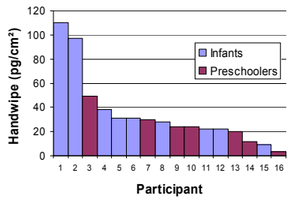
The frequency of mouthing behavior can be described as a function of age and sex. Source: Tulve et al., 2002.

Parameter	Initial Experiments	Refined Experiments
Tracer	--	●○
Skin Condition	●○	●○
Surface Type	○○	●○
Surface Loading	●○	●●
Contact Motion	●○	●○
Contact Duration	○○	--
Contact Pressure	○○	--
Contact Number	●●	●●

Symbols: -- not tested; ○○ not significant; ●○ mixed results or marginally significant at p<0.10; ●● significant at p<0.05 in all tests

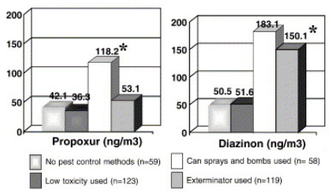
Surface-to-skin transfer experiments found tracer properties, surface type, contact motion, and skin condition to be significant factors affecting dermal transfer. Source: Cohen Hubal et al., 2008.

Effect of Activity on Exposure



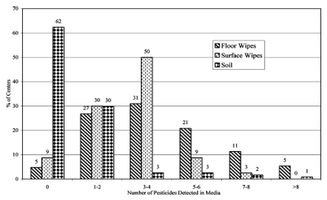
Hand-wipe loadings measured at a daycare, in descending order, illustrate that the highest loadings were typically from infants and the lowest typically from preschoolers. A qualitative review of videotapes found that activity level appeared to be a strong indicator of bodysuit loading (pg/cm²/min) in a daycare setting. Source: Cohen Hubal et al., 2006. (Poster 3-05)

Effect of Application on Air Concentrations

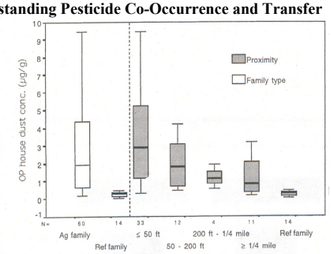


Mean pesticide concentrations (ng/m³) in maternal personal air samples collected during the 3rd trimester show significant differences (p<0.05) based on application event and application method. Source: Whyatt et al., 2005.

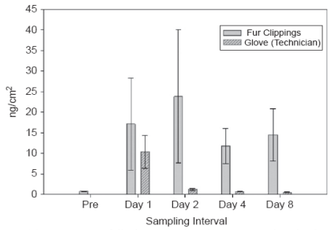
Understanding Pesticide Co-Occurrence and Transfer



Residues of at least three different pesticides were detectable in wipe samples from the majority of locations in the EPA/HUD Child Care Center study. Pesticides no longer registered for residential use were often detected. Source: Tulve et al., 2006. (Posters 2-07 and 2-08)

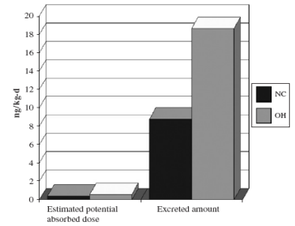


OP house dust concentrations for agricultural and reference families, grouped by proximity to pesticide-treated orchards. When the distance between homes and orchards were considered, proximate homes had the highest concentrations. Source: Lu et al., 2000



Mean amounts of diazinon transferred to a cotton glove by day suggest diazinon residues may be less transferable from dog fur to humans beyond the first post-application day. Pet dogs appear to be good vehicles for the transport and translocation of diazinon residues and may expose occupants to residues through personal contacts Source: Morgan et al., 2008b.

Completeness of Intake Estimates



Median estimates of absorbed dose and of urinary excretion of pentachlorophenol for participating NC and OH children suggest that current exposure algorithms may be insufficient for capturing all intake. Source: Wilson et al., 2007.

Impact and Outcomes

•Results will be incorporated into future updates of the Exposure Factors Handbooks.
•Exposure concentration data are used by OPP to inform the data provided by the registrants.
•Exposure factor data are being used by OPP to inform the revisions of the Residential Standard Operating Procedures (SOPs).
•Research on take home exposures among farmworker children are being used by OPP to develop improved standards for farmworker protection.
•This research program has improved our understanding of environmental risks and their potential health implications.
•Results of these studies are being used in the development of effective educational strategies applicable to children and their caregivers.
•The methods, measurements, and results of the program have wider application to characterization of exposures and risks to chemicals in a wide range of consumer products. (Poster 2-05)

Future Directions

Assessment of cumulative risks from exposure to environmental contaminants depends upon accurate quantification of aggregate exposure. While identifying the most critical pathways is essential, our effectiveness at reducing exposures rests on a better understanding of the factors that lessen or intensify exposures along those identified pathways. Future observational studies must be based on careful consideration of current needs, including a more sophisticated appreciation of the interaction between exposure factors and environmental concentrations. The algorithms currently used to combine pathway-specific environmental monitoring data with exposure factors to estimate an aggregate exposure and subsequent dose require further refinement. Moreover, a clearer understanding of the mechanisms by which identified factors modulate exposure is needed to properly assess risk across and within populations, and to predict how the effects of the exposure factors may change when applied towards newly emerging compounds. By addressing these issues, future research efforts can provide the knowledge base needed to improve the assessment of cumulative risks and develop effective risk reduction, intervention, and education strategies.

Contributors

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Susceptible Populations

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