Biomonitoring: Current Tools and Approaches for Assessing Human Exposures to Non-persistent Chemicals

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Contributing Organizations: ORD/NERL; Battelle

LTG 2 Poster 08

Science Questions

How do we properly interpret and use urinary biomarkers to estimate human exposures to non-persistent chemicals?

How can we use exposure and dose models to design future exposure and epidemiological studies that include biomonitoring?

Research Goals

-To evaluate the usefulness of currently available tools and approaches for understanding the quantitative relationships between human exposures to non-persistent chemicals and urinary biomarkers

-To estimate children's aggregate and cumulative exposures to non-persistent chemicals using urinary biomarkers of exposure

-To identify the important sources, pathways, and routes of human exposures to non-persistent chemicals

-To develop innovative tools and approaches to help design future exposure and epidemiological studies

Findings and Conclusions

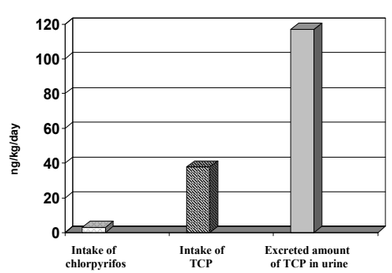
- Refined, linked, and evaluated state-of-the-science exposure and dose models for interpreting exposure biomarker data
- Developed and evaluated approaches for estimating aggregate and cumulative exposures for key pesticides and other pollutants using urinary biomarker data
- Identified key exposure data needed for designing future studies supporting the collection and interpretation of exposure biomarker measurements
- Identified important sources, pathways, and routes of children's aggregate and cumulative exposures to non-persistent pesticides
- Identified important PBPK model parameters required for exposure biomarker interpretation and quantified the uncertainty associated with PBPK-based dose estimates using exposure biomarker data

Conceptual Framework

NERL is developing a conceptual framework that is being used to evaluate the currently available tools (i.e., PBPK models) and approaches (i.e., forward and reverse dosimetry) for assessing the quantitative relationships between urinary biomarkers and human exposures to non-persistent chemicals. Future research is being designed to use the best available tools and approaches for assessing the aggregate and cumulative exposures of humans to non-persistent chemicals using biomonitoring.

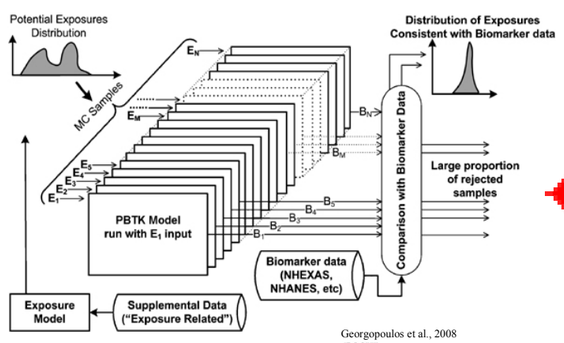
Forward Dosimetry Approach

The forward dosimetry approach is most often used to predict exposure biomarker levels when planning future studies or to interpret the results of an exposure field study. In this approach, estimated or measured chemical concentrations for each environmental matrix are used as inputs into probabilistic exposure and dose models to estimate internal dose and urinary biomarker concentrations. To understand the exposure field study results, researchers compare the modeled estimates with the measured exposure biomarker results. The forward dosimetry approach provides valuable information on the important sources, pathways, and routes of human exposures to non-persistent chemicals in their environments. It also provides a quantitative measure of an integrated internal dose from several sources and routes of exposure over a specified period of time.



TCP is likely not a reliable urinary biomarker of exposure for children exposed to chlorpyrifos due to concurrent exposure to TCP in environmental media.

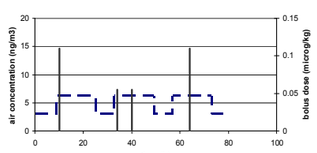
Morgan et al., 2005 (ORD/NERL)



Georgopoulos et al., 2008 (EOSHI)

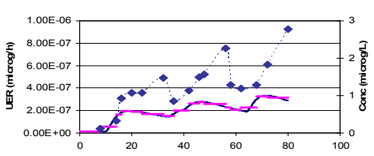
PBPK or PK Models

Physiologically-based pharmacokinetic (PBPK) models or simple PK (pharmacokinetic) models are used as a tool for linking exposure and dose intakes with excreted amounts of urinary biomarker.



Simulated scenario for human exposures to chlorpyrifos in residential settings

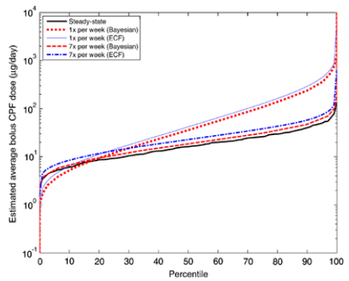
Okino et al., 2008 (ORD/NERL)



A PBPK model showed that collecting one spot urine sample from a study participant is insufficient for proper interpretation of urinary TCP concentrations over time.

Reverse Dosimetry Approach

In the reverse dosimetry approach, also known as exposure reconstruction, this technique is often applied where the exposure scenarios resulting in observed biomarker levels are uncertain. Similar information as for the forward approach is required (chemical toxicokinetics, activity patterns, and exposure factor data), and the magnitude of the exposure events consistent with the biomarker levels are estimated. The most common reverse approaches have been to apply steady-state analyses or to apply reverse dosimetry after a known event, such as in occupational monitoring.



Similar results were obtained when using the steady-state assumption, the Exposure Conversion Factor (ECF) method or the discretized Bayesian method for reconstructing the exposures of participants to chlorpyrifos (CPF) in the NHEXAS-MD study. This research indicated that none of these methods were superior in estimating the participants exposures to chlorpyrifos due to the uncertainties (i.e., amount in environmental media) and short half-life of the urinary biomarker TCP.

Georgopoulos et al., 2008 (EOSHI)

Impact and Outcomes

- Providing EPA's Office of Pesticide Programs (OPP) and Office of Children's Health Protection scientific study results documenting important sources, pathways, and routes of children's exposures to chemicals in their everyday environments mandated under the Food Quality Protection Act (FQPA) of 1996.
- Providing OPP with new exposure and exposure factor data to refine aggregate exposure assessments of young children mandated under the FQPA of 1996.
- Providing ORD's National Center for Environmental Assessment with new exposure and exposure factor data to update the Children's Exposure Factor Handbook.
- Providing ORD and OPP scientists and risk assessors with refined methods, models and approaches for interpreting urinary biomarkers and using these results for FQPA mandated exposure and risk assessments.
- Applying the tools in collaboration with CDC, STAR grantees, and other collaborating organizations for interpreting the exposure biomarker results from these large-scale studies and for designing future exposure and epidemiological studies.

Future Directions

- The results are being used to identify remaining uncertainties, develop hypotheses, and plan future research to develop the next generation of exposure tools for relating chemical exposures with exposure biomarker data.
- These tools and approaches will be used to design future exposure and epidemiological studies to assess the aggregate and cumulative exposures of human to non-persistent chemicals using urinary biomarkers

Researchers Involved

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Cumulative Risk

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