



# Estimation of Children's Exposure to 2,4-D Using CTEPP Data

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## Abstract

The U.S. EPA contracted/commissioned the Children's Total Exposure to Persistent Pesticides and Other Persistent Organic Pollutants (CTEPP) study to increase knowledge about children's exposure to chemicals. Small children are at an increased risk of exposure because of their behavior and types of activities they participate in. An herbicide named 2,4-Dichlorophenoxyacetic acid (2,4-D) was one of the chemicals that was evaluated in the CTEPP study. There is an increased risk of human exposure to 2,4-D because it is used as a pesticide and for agricultural purposes. The CTEPP study provided both environmental and urinary data for 2,4-D. The data were sorted using a Microsoft® Excel macro and then placed into a 3-pathway model. The primary methods of exposure (dietary, soil ingestion and inhalation) were chosen as the pathways in the model. The 3-pathway model was run with two different assumptions in relationship to the method detection limit (MDL). Both times the model was run it fell short of the biomarker data provided by CTEPP. The shortfall of the model suggests that other exposure pathways need to be added to the model in order to correctly predict total exposure.

## Introduction

The U.S. EPA's Children's Total Exposure to Persistent Pesticides and Other Persistent Organic Pollutants (CTEPP) study was done to improve understanding about the routes and amounts of chemical exposure for young children. A number of papers have been published about the study itself and the different chemicals exposures evaluated in this study [1],[2],[3],[4],[5]. Since children between the ages of 18 months and five years spend a large amount of their time crawling and playing on the ground and are also more likely to put foreign objects in their mouths, the study hypothesized that they would be exposed to more pesticides and pollutants than older children and adults [6]. The CTEPP study collected data from 257 children who were living in six counties in North Carolina and six counties in Ohio; samples were also taken from their adult caregivers. The children were divided into two groups, children who attended daycare (daycare children) and children who did not attend daycare (home children). Data was collected in homes and daycare centers and the study examined exposure to over 50 chemicals using multimedia.



One of the chemicals CTEPP study investigated was a herbicide named 2,4-Dichlorophenoxyacetic acid (2,4-D). 2,4-D is the active ingredient in over 1500 pesticide products [7] and over half of the 2,4-D sold is used on agricultural crops [8]. Because 2,4-D is used for agricultural purposes and as a weed killer there is an increased chance of human exposure to the chemical. Since children are smaller the amount of 2,4-D they absorb compared to their body weight is higher than an

## Rationale

Exposure models can be used to estimate the amount of 2,4-D that children are exposed to by predicting a child's urinary 2,4-D concentration. The exposure pathways selected for the current model were dietary (which included liquid and solid food), soil ingestion, and inhalation for which indoor and outdoor data was provided. Since CTEPP provided data for multiple pathway exposures and actual urine concentrations, the data were used to see how well the 3-pathway model predicts a child's total exposure. Trends from previous runs of the 3-pathway model using other chemical data have indicated that the model yields a shortfall in predicted urine concentrations. Based on this, it can be hypothesized that the shortfall is due to the fact that more than three pathways likely contribute to the total exposure.

## Objectives:

- To compare predicted 2,4-D urine concentrations with biomarker data collected in the CTEPP study
- To investigate how much observed exposure can be explained by diet, soil ingestion, and inhalation
- To provide framework for future modeling exercises based on results found here.

## Methods

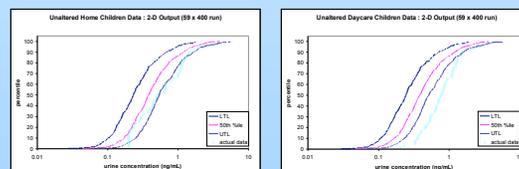
Data extracted from the CTEPP database were sorted by media. This was done for both North Carolina and Ohio datasets, but further analysis presented here only covers the North Carolina child population because additional information is needed for the Ohio children. Using a Microsoft® Excel macro the data was sorted and broken into two groups home children and daycare children. Additional sorting was done to correctly interpret the at home and at daycare exposure of daycare children. Once the data were appropriately organized, dietary ingestion, non-dietary ingestion and inhalation data were used in the 3-pathway exposure model. The 3-pathway model was a stochastic model that was run in Decisioneering's Crystal Ball® using a simulation that involved 59 trials for uncertainty and 400 trials for variability. After the model had been run the results were then extracted and sorted using another Microsoft® Excel macro that presented the data in tables and produced graphs. Between 33% and 100% of environmental data were listed as below the method detection limit (MDL), depending on the media. Uniform distribution were used to generate values below the MDL (between 0 and the MDL). The 3-pathway exposure model was then rerun with these new values.

**Table 1.** Summary of Stochastic Model Parameters (after MDL values were replaced)

Parameter	units	Home Child	Daycare Child at home	Daycare Child at daycare
		median (sd)	median (sd)	median (sd)
Indoor Air	ng/m <sup>3</sup>	.15 (.69)	47 (1.3)	35 (2.0)
Outdoor Air	ng/m <sup>3</sup>	.11 (.34)	13 (.30)	13 (.21)
Soil	ng/g	.24 (3.8)	.27 (2.2)	.21 (.11)
Solid Food (SF)	ng/g	.11 (.06)	10 (.08)	11 (.06)
Liquid Food (LF)	ng/g	.23 (.78)	43 (.69)	21 (.54)
Time indoors (Ti)	hrs/48hrs	46 (2.1)	32 (2.8)	12 (3.1)
Time outdoors (To)	hrs/48hrs	2.0 (2.1)	1.1 (1.7)	1.5 (1.0)
Body weight (W)	kg	16 (4.7)	17 (3.8)	17 (3.8)
Daily intake for SF	kg/day	657 (311)	433 (262)	513 (300)
Daily intake for LF	kg/day	1205 (494)	685 (408)	840 (434)

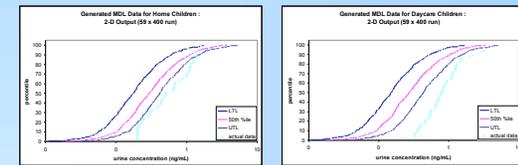
## Results

The CTEPP database assigned MDL values for all data under the MDL. When the 3-pathway exposure model used this data, the resulting prediction curves – the lower tolerance limit (LTL), 50<sup>th</sup> percentile (or median), and upper tolerance limit (UTL) – were fairly close together (Figs 1a and 1b). Both median curves were generally below the observed urine concentration values, particularly for the daycare children.



**Figure 1(a)** predicted vs observed urine concentration for home children, **(b)** predicted vs observed urine concentration for daycare children

When the generated <MDL values were inserted into the 3-pathway model, results showed a shift downwards which would be expected (Figs 2a and 2b). This result is supported by the data summarized in Table 2. This downward shift reinforces the idea that there is a shortfall in the predicted urine concentrations compared to the observed values.



**Figure 2(a)** predicted with generated MDL values vs observed urine concentration for home children, **(b)** predicted with generated MDL vs observed urine concentration for daycare children

**Table 2.** Summary of urinary concentration median values generated by 3-pathway model runs

	Child 2,4-D urinary concentrations [ng/ml]		
	LTL curve	Median curve	UTL curve
<i>MDL values used</i>			
Home children	0.23	0.38	0.54
Daycare children	0.24	0.38	0.52
<i>Generated &lt;MDL values used</i>			
Home children	0.18	0.30	0.42
Daycare children	0.15	0.27	0.43

\*Median values for actual biomarker data: .51ng/mL (home children) and .78ng/mL (daycare children)

## Discussion

Whether the MDL or generated <MDL values were used in the 3-pathway model, the predicted 2,4-D urinary concentrations were below the observed biomarker data. This result suggests that additional exposure pathways other than dietary ingestion, soil, ingestion, and inhalation need to be considered. These could include household dust ingestion, surface- or object-to-mouth contact or dermal absorption. Previous work done in this lab using other chemical data from the CTEPP study (e.g., chlorpyrifos/TCPY and pentachlorophenol) suggests that dermal exposure to low-level residues on surfaces within the home is a likely candidate to help explain the difference seen between predicted and observed urinary concentrations.

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