



2,4-D levels in the Homes and Urine of 135 Preschool Children and their Adult Caregivers

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Abstract

Context
The aggregate exposures of 135 preschool children and their primary adult caregivers to chemicals commonly found in their everyday environments were investigated. One objective was to identify sources and pathways of the participants' exposures to the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) at their homes.

Methods
Participants were recruited randomly from selected homes in six North Carolina (NC) and six Ohio (OH) counties. Monitoring was performed over a 48-h period at the participants' homes. Environmental samples collected at the homes included soil, carpet dust, indoor air, and outdoor air (Table 1). Personal samples collected from both children and adults consisted of hand wipes, solid food, liquid food, and urine. All samples were analyzed by gas chromatography/mass spectrometry (GC/MS) for 2,4-D (acid form).

Results
2,4-D was detected in all environmental and personal media, but was most often in dust (>82%) and urine (>86%). The median levels of 2,4-D in dust samples were at least three times lower in the NC homes (47.5 ng/g) than in the OH homes (156 ng/g). In addition, 2,4-D was detected in 8% compared to 49% of the hand wipe samples from NC children and OH children, respectively. Similarly, it was detected in 5% compared to 63% of the hand wipe samples from NC adults and OH adults, respectively. At the 95th percentile, the levels of 2,4-D were at least three times higher for OH children compared to OH adults.

Discussion
This information suggests that 2,4-D may have been more commonly used at the selected homes in OH than in NC. The results overall showed that these participants were potentially exposed to 2,4-D from several sources and pathways at their homes. In addition, the urinary 2,4-D levels confirmed that these preschool children and their adult caregivers were exposed to low levels of 2,4-D in their daily environments.

Results

For the OH participants, the levels of 2,4-D were higher in their dust and hand wipe samples. In addition, the OH children had higher urinary 2,4-D concentrations than the NC children. The distributions of 2,4-D concentrations in the participants' dust, hand wipe, solid food, and urine samples are shown in Figure 1.

Dust (Figure 1a). 2,4-D was detected most often in dust samples (>82%). However, median levels of 2,4-D in the dust samples were three times lower in the sampled NC homes than in OH homes (47.5 vs. 156 ng/g, $p < 0.0002$).

Hand wipes (Figure 1b). 2,4-D was detected in 8% compared to 49% of hand wipe samples for NC and OH children, respectively. Similarly, it was detected in 5% compared to 63% of the hand wipe samples from NC and OH adults, respectively. At the 95th percentile, the levels of 2,4-D were at least three times higher for OH children compared to OH adults.

Solid food (Figure 1c). The levels of 2,4-D in the solid food samples were below 7 ng/g for all participants, except for one OH child with a maximum value of 20.2 ng/g.

Urine (Figure 1d). The median concentrations of 2,4-D in urine were two times lower for NC compared to OH children (0.5 vs. 1.2 ng/mL, $p < 0.0001$). In contrast, the median 2,4-D concentrations were similar for NC compared to OH adults (0.6 vs. 0.7 ng/mL). The maximum levels of 2,4-D were 12.5 ng/mL for one child and 7.3 ng/mL for one adult from different households in OH.

Introduction

2,4-Dichlorophenoxyacetic acid (2,4-D) is an aryloxyalkanoic acid herbicide that is commonly used to control for broadleaf weeds in agricultural and residential settings in the US (Baker et al., 2000; Arbutckle and Ritter, 2005; USEPA, 2005). Over 40 million lbs of 2,4-D are applied annually in this country, mainly in agriculture (~70%) and to a lesser extent at residences (~25%) on lawns and gardens (USEPA, 2005).

A few small studies have recently reported detecting low levels of 2,4-D in media at children's homes in the United States (Nishioka et al., 2001; Wilson et al., 2003). Wilson showed that 2,4-D residues were measurable at low levels in soil, air, carpet dust, and food samples collected at nine preschool children's homes in NC. Nishioka reported measuring low concentrations of 2,4-D in carpet dust and surface wipe (floors, tabletops, and window sills) samples at several children's homes in the Midwest.

Humans can be exposed to 2,4-D through inhalation, ingestion, and dermal routes of exposure. Once 2,4-D is absorbed into the body, it is rapidly eliminated unchanged in the urine (Knopp and Glass, 1991; Garabrant and Philbert, 2002). The biological half-life of 2,4-D through oral ingestion ranges from 10 to 33 hours in humans (Kohli et al., 1974; Sauerhoff et al., 1977; CDC, 2005). A few studies have recently reported measuring low levels of 2,4-D (< 3.5 ng/mL) in urine samples from non-occupationally exposed adults and children in the US (Wilson et al., 2003; CDC, 2005; Curwin et al., 2005).

In this work, we quantified the distributions of 2,4-D in environmental and personal media for 135 preschool children and their adult caregivers at homes in NC and OH. We examined potential sources and pathways of the participants' exposures to this herbicide.

Study Design

The Study
The Children's Total Exposure to Persistent Pesticides and Other Persistent Organic Pollutants (CTEPP) study was an observational study that investigated the aggregate exposures of 257 preschool children and their adult caregivers to chemicals commonly found in their everyday environments. As part of this study, we investigated the exposures of non-daycare participants to 2,4-D at their homes in NC and OH. One important hypothesis of this study was whether children's exposures to targeted pollutants were significantly greater than those of adults living in the same household.

Participants
Preschool children, ages 2 to 5 years, and their adult caregivers were randomly recruited from homes in six NC and six OH counties. The participants were recruited by field staff between February 2000 and February 2001 in NC and January 2001 and November 2001 in OH. We successfully recruited 66 and 69 preschool children and their adult caregivers in NC and OH, respectively. A total of 135 preschool children and their adult caregivers completed the study (Table 2).

The study protocol and procedures to obtain the assent of the children and informed consent of their parents or guardians were reviewed and approved by an independent institutional review board (IRB) and complied with all applicable requirements of the Common Rule regarding additional protections for children.

Sampling

Table 1. Environmental and personal samples collected over a 48-h period at the participants' homes in NC and OH

- Food	- Drinking Water	- Hand Wipes
- Beverages	- Indoor Air	- Play Area Soil
- Urine	- Outdoor Air	- Floor Dust

Table 2. Demographic characteristics of the participants

	Children		Adults	
	NC	OH	NC	OH
N	66	69	66	69
Age (yr)				
Median	3.4	3.9	33	33
Range	1.7-5.4	1.9-5.6	20-44	19-49
Gender				
Female	61%	48%	95%	90%
Male	39%	52%	5%	10%

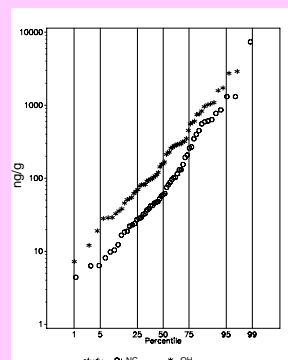


Figure 1a. Distribution of 2,4-D in dust samples at homes in NC and OH.

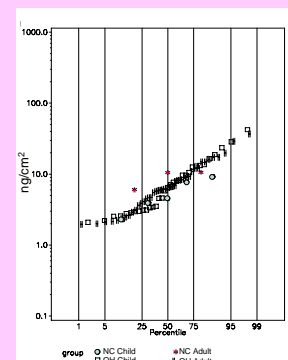


Figure 1b. Distribution of 2,4-D in hand wipe samples for participants at homes in NC and OH.

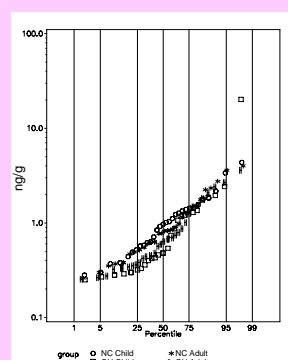


Figure 1c. Distribution of 2,4-D in solid food samples for participants at homes in NC and OH.

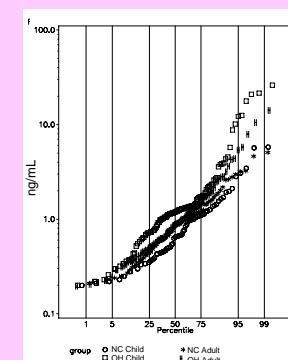


Figure 1d. Distribution of urinary 2,4-D concentrations for participants at homes in NC and OH.

Discussion

- These children and their adult caregivers in NC and OH were likely exposed to low levels of 2,4-D through several pathways and routes of exposure at their homes.
- The results suggest that 2,4-D was likely being tracked in by occupants and/or transported through air intrusion into homes after outdoor applications.
- This information suggests that 2,4-D may have been more commonly used at homes in OH than in NC.
- The urinary biomarker of exposure, 2,4-D itself, confirmed that most of these preschool children and their adult caregivers were exposed to low levels of 2,4-D in their daily environments.

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