Children's Exposure to Chlorpyrifos and Parathion in an Agricultural Community in Central Washington State

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We measured two diethyl organophosphorus (OP) pesticides—chlorpyrifos and parathion—in residences, and their metabolic by-products, in the urine of children 6 years old or younger in a central Washington State agricultural community. Exposures to two dimethyl OP pesticides (azinphos-methyl and phosmet) in this same population have been reported previously. We categorized children by parental occupation and by household proximity to pesticide-treated farmland. Median chlorpyrifos house dust concentrations were highest for the 49 applicator homes (0.4 µg/g), followed by the 12 farm-worker homes (0.3 µg/g) and the 14 nonagricultural reference homes (0.1 µg/g), and were statistically different ($p < 0.001$); we observed a similar pattern for parathion in house dust. Chlorpyrifos was measurable in the house dust of all homes, whereas we found parathion in only 41% of the homes. Twenty-four percent of the urine samples from study children had measurable 3,5,6-trichloro-2-pyridinol (TCPy) concentrations [limits of quantitation (LOQ) = 8 µg/L], and 7% had measurable 4-nitrophenol concentrations (LOQ = 9 µg/L). Child urinary metabolite concentrations did not differ across parental occupational classifications. Homes in close proximity (200 ft/60 m) to pesticide-treated farmland had higher chlorpyrifos ($p = 0.01$) and parathion ($p = 0.014$) house dust concentrations than did homes farther away, but this effect was not reflected in the urinary metabolite data. Use of OP pesticides in the garden was associated with an increase in TCPy concentrations in children's urine. Parathion concentrations in house dust decreased 10-fold from 1992 to 1995, consistent with the discontinued use of this product in the region in the early 1990s. *Key words*: **agriculture, children, chlorpyrifos, exposure, house dust, organophosphorus, parathion, pesticides, urinary metabolites.** *Environ Health Perspect* **110:549–553 (2002). [Online 5 April 2002]**
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Children can be exposed to pesticides and other hazardous chemicals through multiple pathways and by multiple routes. Diet is considered the primary exposure pathway for most pesticides, with drinking water and residential contact contributing to aggregate exposure in some cases (*1,2*). A 1992 study in central Washington State found that children of agricultural families had higher potential exposures to organophosphate (OP) pesticides in soil and house dust than did those living in nonagricultural families, suggesting that both proximity to farmland and parental occupation can contribute to increased environmental concentrations (*3*). In 1995, a further evaluation of children's exposure was conducted in the same region and included biological monitoring. A preliminary report of this study (*4*) focused on concentrations of a single urinary metabolite of the OP pesticides (dimethylthiophosphate) for a subset of the study population (children of workers who applied pesticide). A subsequent report presented findings of the full study, including house dust, hand wipe, and surface wipe values for two dimethyl OP pesticides, as well as total dimethyl dialkylphosphate excretion levels in children (*5*). In this article we present findings for two diethyl OP pesticides—chlorpyrifos and parathion—in the same study population.

Methods

Study design and population. The study design and population have been described previously (*5*). The study took place in central Washington State in a major tree fruit production region. Agricultural families had at least one family member employed as an orchard applicator or farm worker. Nonagricultural or reference families were those in which no family member's work involved contact with agricultural pesticides, and whose residences were located more than one-quarter mile (about 400 m) from any pesticide-treated orchard. In this study, pesticide applicators were individuals responsible for pest management for a specific orchard and who therefore conducted periodic spraying for pest control as well as other farm management tasks. The study population did not include applicators who provided commercial services to growers or whose primary work activity was pesticide spraying. Farm workers in this study were individuals who conducted orchard hand labor tasks such as irrigation, thinning and pruning, and harvesting. The University of Washington Human Subjects Review Committee approved the study procedures, and all subjects provided their informed consent.

We sampled 109 children and 75 homes from May through July of 1995. All children were 6 years old or younger. An initial visit included an interview and collection of the following samples: a spot urine sample and an isopropanol hand wipe from each participating child, a house dust sample from a carpeted area in the house, and wipe samples from a noncarpeted floor surface, the steering wheel of the vehicle, and the workers' boots. We conducted interviews in either Spanish or English, as appropriate, and included questions regarding frequency and extent of occupational and residential pesticide use, hygienic practices, housekeeping practices, proximity to pesticide-treated orchards, and child activity. We visited all homes a second time, 3–7 days after the first visit, and performed a short interview and collected urine and hand wipe samples.

We analyzed samples for the OP pesticides chlorpyrifos [Chemical Abstracts Service (CAS) no. 2921-88-2] and ethyl parathion (CAS no. 56-38-2). Chlorpyrifos is commonly used in the spring in this region to control leaf rollers. Parathion was the most commonly used OP pesticide in the region for many decades, but its use was discontinued in the early 1990s.

Proximity exposure pathway. We considered house dust to be the best medium in which to characterize residential accumulation of pesticides due to nearby agricultural use. We collected house dust samples using a small high-volume surface sampler [HVS3; see Roberts et al. (*6*)], a vacuum system designed specifically for house dust sampling. We conducted vacuuming in the main entrance/living area of the home if it was carpeted, or in the area where children

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played most frequently in the home. We marked an area of 45 cm × 137 cm divided longitudinally into three strips with masking tape for sampling. We placed the HVS3 at the first strip and pushed from the beginning to the end of the strip in 4 sec. We sampled each strip back and forth four times.

Take-home exposure pathway. Investigation of take-home exposure involved wipe sample collection from the steering wheel of the vehicle used for travel to work, work boots, and noncarpeted indoor floors where children play. We considered residues on the steering wheel indicative of worker skin and clothing contamination, residues on work boots as potential for track-in, and residues on noncarpeted floors as recent track-in.

We used two sterile 4 inch × 4 inch all-cotton gauze pads wetted with 1–2 mL of 100% isopropanol to wipe the noncarpeted floor area with a 50 × 50 cm metal template and a sequence of three vertical and three horizontal strokes. We used a similar procedure to wipe the toe area of the work boots of a worker at home at the time of sampling using a 5 cm × 5 cm template. Aftep wiping the boots with three vertical strokes, we folded the same gauze pad so that we used a fresh surface for the second wipe of three horizontal strokes. We used the same procedure for the steering wheel, except that instead of using a template, we collected samples from the top half of the steering wheel using one continuous stroke.

Personal and biological exposure sampling. We performed hand wipe sampling to measure pesticides on the skin. We used one gauze pad for the palm and the back of each hand and a second pad for the fingers, so that we wiped the entire surface of the hand. We wiped both hands, using a total of four gauze pads, which we placed in a prelabeled jar and treated as one sample. We collected a single urine void at each visit from each child. We obtained samples using either a urine collection bag (Lil'Katch; General Medical Corp., Richmond, VA, USA), for the non-toilet-trained child, or a commode insert (Specipan; Baxter Scientific, McGaw Park, IL, USA) for the toilet-trained child. If the field staff could not collect samples at the time of the visit, we gave a parent a collection apparatus and instructions, and picked up samples within 24 hr of the void. Timing of the sample in these cases was at the convenience of the family.

Analytical methods for house dust and wipe samples. Samples were brought to the field laboratory in Wenatchee in an ice chest, where we processed them and stored them at –10°C; we later transported them to the analytical laboratory in Seattle with dry ice and stored them at –20°C until analysis. We sieved house dust samples in a 100-mesh (150 µm) stainless-steel sieve for 6 min; we then sonified the sieved samples in 50 mL of acetone for 1 min, centrifuged them at 2,500 rpm for 8 min, concentrated them under purified nitrogen stream, and solvent exchanged the concentrate into 1 mL of cyclohexane. We subjected the samples to further cleanup in a series of filtration, gel permeation chromatography, concentration, and evaporation steps before gas chromatography analysis with a mass selective detector in selected ion monitoring mode for the targeted pesticides: chlorpyrifos and parathion (*3*).

We extracted all gauze pad samples with 50 mL of ethyl acetate on a shaker table for 30 min. Extraction of chlorpyrifos and parathion in gauze pads was complete: 106 ± 15% for chlorpyrifos and 100 ± 12% for parathion (mean ± SD). Extraction was less efficient for house dust: 46 ± 5% for chlorpyrifos and 92 ± 7% for parathion. We adjusted house dust samples by these extraction efficiencies. We made no adjustment for wipe samples.

The limits of quantitation (LOQs) for chlorpyrifos and parathion varied among analytical batches for the house dust and wipe samples (see Table 1–3 notes for details). Samples below the respective LOQs we assigned one-half the value of LOQ. Samples that produced no recognizable signal (signal:noise ratio < 3:1) we assigned values of zero for statistical analysis.

Analytical methods for urine samples. We analyzed urine samples for the chlorpyrifos metabolite 3,5,6-trichloro-2-pyridinol (TCPy) and the parathion metabolite 4-nitrophenol at the National Center for Environmental Health Laboratory at the Centers for Disease Control and Prevention (CDC; Atlanta, GA, USA). We quantified the samples, collected for the Third National Health and Nutrition Examination Survey (NHANES III), using a modification of the method of Hill et al. (*7*). Briefly, we spiked the urine samples with ^{13}C- and ^{15}N-labeled analogues of the metabolites, subjected it to an enzyme hydrolysis to liberate the glucuronide- or sulfate-bound metabolites, and then extracted the metabolites with organic solvent. We extracted the free metabolites back into a basic solution and derivatized to their respective chloropropyl ethers using a phase transfer catalysis reaction. We then cleaned the reaction mixture using a silica solid-phase extraction column. We analyzed the final extract using isotope dilution gas chromatography–tandem mass spectrometry in which we monitored the $[M+H]^+$ ions containing ^{35}Cl and ^{37}Cl as the

Table 1. Chlorpyrifos and ethyl parathion concentrations in household dust,[a] and 3,5,6-trichloropyridinol and 4-nitrophenol[b] in focus children of pesticide applicator, farm-worker, agricultural[c] and reference families.

Sample medium	Applicator (n = 49)	Farm-worker (n = 12)	Agricultural (n = 61)	Reference (n = 14)
Housedust (µg/g)				
Chlorpyrifos				
Median	0.37[f]	0.25[f]	0.34[g]	0.07[f,g]
Mean	0.55	0.27	0.50	0.09
SD	0.58	0.18	0.54	0.09
Range	0.01–2.6	0.07–0.56	0.01–2.6	0.01–0.29
Frequency (%)[d]	49 (100)	12 (100)	61 (100)	14 (100)
Ethyl parathion				
Median	0.01[h,i]	0[h,i]	0[j]	0[h,j]
Mean	0.07	0.02	0.06	0.003
SD	0.16	0.08	0.14	0.01
Range	0–0.95	0–0.28	0–0.95	0–0.02
Frequency (%)	27 (55)	2 (17)	29 (48)	2 (14)
Urine (µg/L)				
3,5,6-TCP[e]				
Median	0	0	0	0
Mean	4.5	6.4	4.9	4.6
SD	15	15	15	9.2
Range	0–100	0–53	0–100	0–27
Frequency (%)	10 (20)	4 (33)	14 (23)	4 (29)
4-Nitrophenol[e]				
Median	0	0	0	0
Mean	1.1	121	25	0.46
SD	5.1	419	190	1.7
Range	0–32	0–1,500	0–1,500	0–6.5
Frequency (%)	3 (6)	1 (8)	4 (7)	1 (7)

[a]LOQ in house dust samples (µg/g) varied from batch to batch; chlorpyrifos, 0.013–0.027; ethyl parathion, 0.013–0.052. Data were adjusted by the extraction efficiencies. [b]Limits of detection (LD) for 3,5,6-trichloropyrinol (3,5,6-TCP) and 4-nitrophenol in urine sample were 8 and 9 µg/L, respectively; samples < LD were assigned values of zero. [c]The combination of applicator and farm-worker families. [d]Frequency = proportion of families or children with quantifiable values; percentages in parentheses. [e]Average values of visit 1 and visit 2 of focus child for each family. [f]Significantly different (Kruskal-Wallis one-way ANOVA, $p < 0.001$). [g]Significantly different (Whitney U–Wilcoxon rank sum W, $p < 0.001$). [h]Significantly different (Kruskal-Wallis one-way ANOVA, $p < 0.01$). [i]Significantly different (Whitney U–Wilcoxon rank sum W, $p = 0.03$). [j]Significantly different (Whitney U–Wilcoxon rank sum W, $p = 0.02$).

precursor ions for both the native and labeled metabolites. We used fragment ions (product ions) specific to the analytes of interest to quantify the metabolites in the urine. Limits of detection for TCPy and 4-nitrophenol were 8 µg/L and 9 µg/L, respectively. Samples below the limit of detection we assigned values of zero for statistical analysis.

We measured creatinine concentrations at the University of Washington by the Jaffe method (*8*) using a Sigma 555-A colorimetric kit (Sigma, St. Louis, MO, USA) and a Milton Roy Spectronic 301 spectrophotometer (Milton Roy, San Leandro, CA, USA). We used these measurements to identify abnormal samples.

Data analysis. Median values were lower than mean values in most cases, suggesting a skewed distribution of OP pesticide concentrations in house dust and other environmental samples. We therefore performed statistical analyses using nonparametric tests in SPSS, version 6.1.1 (SPSS, Inc., Chicago, IL, USA).

We averaged the two urine values for each child to produce a single urinary metabolite concentration value for statistical analysis. If we collected only one urine sample, we used this value as the best estimate of the child's urinary metabolite level. To remove the within-household dependence for families with more than one child participating in the study, we selected a focus child from each family based on the criteria of collection of two spot urine samples and acceptable creatinine measurements for both samples. In families with more than one child meeting the above criteria, we randomly selected one as the focus child.

Results

Agricultural and reference family comparisons. Participating families consisted of 49 applicator, 12 farm-worker, and 14 reference families. Thirty-one families had more than one participating child; 72, 19, and 18 children lived in pesticide applicator, farm-worker, and reference families, respectively. Pesticide applicator and farm-worker families have been combined as agricultural families for some analyses because of the small sample size of the farm-worker group.

Table 1 presents chlorpyrifos and parathion concentrations in house dust for applicator, farm-worker, agricultural, and reference homes. Chlorpyrifos was measurable in all house dust samples, whereas parathion was measurable in 31 of 75 samples (41%). Pesticide applicator families had the highest median chlorpyrifos house dust concentration (0.4 µg/g), followed by farm-worker (0.3 µg/g) and reference families (0.1 µg/g), and concentrations across these three groups were statistically different [Kruskal-Wallis one-way analysis of variance (ANOVA), $p < 0.001$]. We observed a similar pattern for parathion ($p < 0.01$). Chlorpyrifos house dust concentrations were not significantly different between pesticide applicator and farm-worker families. In the case of parathion, however, concentrations were higher for the applicator families (Mann-Whitney *U*–Wilcoxon rank sum *W*, $p = 0.03$). When we compared all agricultural families against reference families, median values were significantly different for chlorpyrifos (Mann-Whitney *U*–Wilcoxon rank sum *W*, $p < 0.001$), and for parathion ($p = 0.02$). Median house dust concentrations of chlorpyrifos were four times higher in agricultural than in reference families; the box plot in Figure 1 illustrates that most agricultural families showed higher chlorpyrifos levels in house dust than did reference families.

Twenty-three families sampled in this study also participated in our 1992 study (*3*). We collected house dust samples from 22 of these 23 homes in 1995. Table 2 compares the 1992 chlorpyrifos and parathion house dust concentrations with those in samples collected in this study in 1995. A paired nonparametric analysis of these data found that chlorpyrifos concentrations did not change across this period but that parathion levels decreased by about an order of magnitude ($p < 0.001$).

The frequency of detection of TCPy—the major metabolite of chlorpyrifos—was 24% among the focus children (18 of 75). We found the highest TCPy concentrations in agricultural children, but levels between the agricultural and reference groups were not statistically different (Table 1). The highest value measured was 100 µg/L. The frequency of detection of 4-nitrophenol, the major metabolite of parathion, was 7% (5 of 75). We observed no differences across occupational groups.

Proximity. We categorized the agricultural families by distance from a nearby orchard that had been treated with pesticides (Table 3). Initial categories were less than or more than 200 ft (60 m), because this distance is considered the spray drift range for air-blast applications in orchards (*9*). Chlorpyrifos concentrations in house dust were significantly higher in homes near treated farmland (Mann-Whitney *U*–Wilcoxon rank sum *W*, $p < 0.01$); this trend was not significant for parathion. We observed no differences for the urinary metabolite data.

We then refined proximity to include four categories (Figure 1): 33 agricultural families lived within 50 feet (15 m), 13 lived 50–200 feet away (15–60 m), 4 lived between 200 feet and 0.25 mile (400 m) away, and 11 lived more than 0.25 mile away from a pesticide-treated orchard. By definition, all of the 14 reference families lived more than 0.25 mile away from a pesticide-treated orchard. Using the four proximity categories for agricultural families presented in Figure 1, a test of slope for the linear regression line indicated a decreasing trend in chlorpyrifos house dust concentrations with increasing distance ($y = -0.16x + 0.8$; $p < 0.001$).

Take-home exposure pathway. Table 4 presents summary statistics for chlorpyrifos and parathion on children's hands, parents' work boots, vehicle steering wheels, and noncarpeted floors from agricultural families. Neither hand nor environmental wipes collected from reference families had detectable levels of either of the target OP pesticides. We found measurable chlorpyrifos levels on the hands of 11% of the agricultural children and on 34% of parents' work boots. Very little chlorpyrifos was measured in steering wheel and noncarpeted floor wipe samples. We measured parathion on only one child's hands, on one set of work boots, and on two steering wheels.

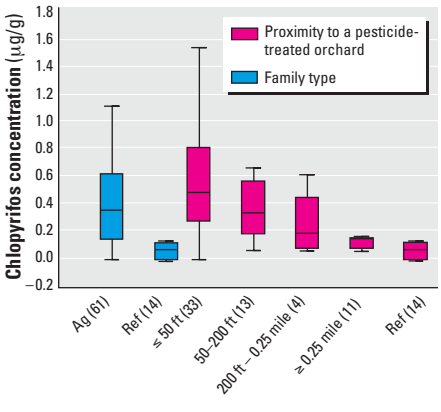

Figure 1. Box plots of chlorpyrifos concentrations in house dust of agricultural (Ag) and reference (Ref) families, and grouped by proximity to pesticide-treated farmland; *n* is shown in parentheses. From bottom to top, the lines represent, respectively, 10th, 25th, 50th, 75th, and 90th percentiles.

Table 2. Chlorpyrifos and ethyl parathion concentrations (µg/g) in the house dust of 22 homes sampled in 1992 and again in 1995.

	Chlorpyrifos		Ethyl parathion	
	1992	1995	1992	1995
Median	0.20	0.19	0.17[a]	< LOQ[a]
Mean	0.54	0.38	0.56	0.04
SD	0.82	0.45	0.84	0.09
Range	0.040–3.6	0.01–1.9	0.01–2.9	< LOQ–0.28

[a]Significantly different (Wilcoxon matched-pairs signed-ranks test, $p < 0.001$).

We evaluated differences in chlorpyrifos house dust concentrations between agricultural families living more than one-quarter mile from treated farmland and reference families, using a Mann-Whitney *U*-test (see the two box plots on the far right in Figure 1). We performed the test to remove the effect of proximity from the analysis of the take-home exposure pathway. We found chlorpyrifos residues, but not parathion residues, to be significantly higher in the house dust of agricultural family homes when compared with reference family homes ($p < 0.01$).

Residential activities. We gathered data through parental interviews regarding children's behavior, family hygienic practices, or residential pesticide use. Parental responses regarding children's time spent outdoors, hand washing before each meal, hand-to-mouth activity, and frequent thumb-sucking were not associated with differences in urinary metabolite concentrations. Questions regarding parental hygienic practices focused on the presence of doormats, the wearing of work shoes and work clothes in the house, laundering practices, and vacuuming frequency, but none of these activities was associated with differences in house dust or urinary metabolite concentrations. In terms of residential pesticide use, children in 20 homes with reported OP pesticide use in the garden had higher TCPy concentrations than did children in 54 homes with no such use (8.3 vs. 2.4 μg/L; $p = 0.02$).

Discussion

This study suggests that children of agricultural families can be exposed to pesticides through pathways other than diet, drinking water, and residential pesticide use. We found a clear effect of proximity to treated farmland through measurement of both chlorpyrifos and parathion residues in house dust. We also found evidence for the take-home exposure pathway, because chlorpyrifos house dust concentrations were elevated in those agricultural family homes more than a quarter mile from farmland, and we detected chlorpyrifos residues on work boots and children's hands for many of the agricultural families but for none of the reference families.

Several findings of this study parallel those of our recent analysis of azinphos-methyl and phosmet exposure in this same population (*5*), in which we found significant differences across agricultural and reference homes for pesticide concentrations in house dust as well as for children's urinary metabolite levels. In the present study, we also identified proximity to treated farmland and parental transfer of pesticides from the workplace to the home as relevant pathways for children's exposures. In a study of children's OP pesticide exposure in the Seattle metropolitan area (*10*), we found that both dimethyl and diethyl OP metabolites were elevated in children whose parents reported use of pesticides in the garden. In the present study we also found a positive association between garden use of OP pesticides and TCPy metabolites in children's urine.

Perhaps the most striking finding of the present study was the dramatic reduction in parathion house dust levels from 1992 to 1995: we observed a more than 10-fold reduction in house dust levels during this period. Parathion was also virtually absent from children's hands, parents' work boots, vehicle steering wheels, and noncarpeted floors. Parathion was the most commonly used OP pesticide in this region for several decades, and continued to be used widely through 1991, when its registration was discontinued. Farmers were allowed to use existing stocks (i.e., products already purchased), so some spraying may have continued in the 1992, 1993, and 1994 seasons.

These findings suggest that if a nonpersistent pesticide such as parathion is removed from use in the agricultural environment, it will dissipate from the residential environment relatively quickly. We speculate that normal home cleaning procedures, in the absence of replenishment from an agricultural spraying source, led to this reduction. This reasoning is supported by the parallel finding that chlorpyrifos, a compound with continued agricultural use, did not decrease significantly in house dust over this same 3-year period. It is possible that changes in residential use of chlorpyrifos across this time period could have affected our measurements, but in light of the findings of a strong association between chlorpyrifos concentrations in house dust and home proximity to treated farmland, it seems more plausible to assume that agricultural spraying was a major source of the residues found in these homes. In our previous report (*5*) we noted a significant decrease in azinphos-methyl and phosmet concentrations in house dust from 1992 to 1995 and speculated that this change may have been due to public health educational materials distributed to study

Table 3. Chlorpyrifos and ethyl parathion concentrations in house dust, and 3,5,6-trichloropyridinol and 4-nitrophenol levels in agricultural children, categorized by proximity to pesticide-treated farmland.

	Proximity	
Sample medium	≤ 200 ft ($n = 46$)	> 200 ft ($n = 15$)
House dust (μg/g)		
Chlorpyrifos		
Median	0.40[a]	0.15[a]
Mean	0.59	0.22
SD	0.59	0.18
Range	0.01–2.6	0.06–0.60
Ethyl parathion		
Median	0.01	0[b]
Mean	0.05	0.08
SD	0.10	0.24
Range	0–0.40	0–0.95
Urine (μg/L)		
3,5,6-TCP		
Median	0[c]	0
Mean	6.0	1.3
SD	17	4.9
Range	0–100	0–19
4-Nitrophenol		
Median	0	0
Mean	33	0
SD	210	0
Range	0–1,500	0

[a]Significantly different (Whitney *U*–Wilcoxon rank sum *W*, $p < 0.01$). [b]Samples < LOQ were assigned values of one-half the LOQ; samples that were not detectable (signal:noise ratio < 3:1) were assigned values of zero. [c]Limits of detection (LD) for 3,5,6-trichloropyridinol (3,5,6-TCP) and 4-nitrophenol in urine sample were 8 and 9 μg/L, respectively; samples < LD were assigned values of zero.

Table 4. Chlorpyrifos and ethyl parathion concentrations[a] on agricultural children's hands (μg/pair of hands),[b] parent's work boots (μg/cm^2),[c] steering wheel (μg/cm^2),[d] and floor (μg/cm^2).[e]

	Chlorpyrifos	Ethyl parathion
Children's hands		
Median	0	0
Mean	0.52	0.01
SD	3.8	0.06
Range	0–29	0–0.48
No.	62	62
Frequency (%)[f]	7 (11)	1 (2)
Parent's work boots		
Median	0	0
Mean	0.11	0.0004
SD	0.36	0.003
Range	0–2.2	0–0.03
No.	61	61
Frequency (%)	21 (34)	1 (2)
Steering wheel		
Median	0	0
Mean	0.001	0.00004
SD	0.004	0.0002
Range	0–0.02	0–0.001
No.	56	56
Frequency (%)	19 (34)	2 (4)
Noncarpeted floor		
Median	0	0
Mean	0.0006	0
SD	0.002	0
Range	0–0.008	0
No.	56	56
Frequency (%)	9 (16)	0 (0)

[a]LOQ in wipe samples (μg/g) varied from batch to batch; chlorpyrifos, 0.006–0.027, ethyl parathion, 0.003–0.009. Data were adjusted by the extraction efficiencies. Samples < LOQ were assigned values of one half the LOQ; samples that were not detectable (signal:noise ratio < 3:1) were assigned values of zero. [b]Samples represent the average values of visit 1 and 2 for focus children only. [c]A 5 cm × 5 cm template was used to wipe toe area of work boot. [d]Wipe samples were taken from the top half of the steering wheel, an estimated area of 550 cm^2. [e]A 50 cm × 50cm template was used to wipe the floor near the entryway, if it is not carpeted, or a noncarpeted area where the child often played. [f]Frequency = number of families (or focus children) with quantifiable chlorpyrifos or ethyl parathion; percentages in parentheses.

participants. However, the chlorpyrifos results are not consistent with this explanation.

Most children in this study did not have measurable levels of chlorpyrifos or parathion metabolites in their urine. This finding may be due in part to the relatively high LOQs for TCPy (8 µg/L) and 4-nitrophenol (9 µg/L). The CDC laboratory that conducted these analyses can achieve much lower detection limits (approximately 1 µg/L for both metabolites), but this study had insufficient urine sample volumes for its normal analytical procedures. In the case of TCPy, we found only 24% of the samples at or above 8 µg/L. Thus, the LOQ was roughly equivalent to the 75th percentile in this population. For comparison purposes, the 75th percentile TCPy concentration from the NHANES III study was 6 µg/L (*7*). The highest TCPy concentration measured in this study (53 µg/L) was within the range of values reported for NHANES III.

Hygienic practices such as use of doormats, removal of work shoes and work clothes before entering the home, separation of work clothes for laundering, and frequent vacuuming are often included as common sense recommendations in farm-worker education programs. Our analysis failed to demonstrate that these self-reported practices reduce either pesticide house dust concentrations or children's biological levels. These results suggest that such questions may not be useful as predictors of residential contamination levels or body burdens.

Conclusions

Residences that include household members who work with agricultural pesticides or that are in proximity to pesticide-treated farmland have higher diethyl OP pesticide concentrations in house dust than do homes without these characteristics. However, children living in these homes did not appear to have increased exposures, as measured through biological monitoring. Once an OP pesticide is removed from general agricultural use, residue levels in agricultural community homes appear to decrease significantly within several years.

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