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CREVICE APPLICATION**

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Chlorpyrifos Accumulation Patterns

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Abbreviations:

ng	nanogram	mg	milligram	%	percent
°C	degree Celcius	mL	milliliter	“	inch
CV	coefficient of variation	mm	millimeter		
dL	deciliter	mm Hg	millimeters of mercury		
g	gram	NOEL	No-observed-effect-level		
h	hour	r²	correlation coefficient		
kg	kilogram	µg	microgram		
L	liter	µL	microliter		
m	meter	µm	micrometer		

Outline:

Abstract, Introduction, Methods, Results, Discussion, Conclusions, References

Abstract:

The Children's-Post-Pesticide-Application-Exposure-Study (CPPAES) was conducted to look at the distribution of chlorpyrifos within a home environment for a 2-week period following a routine professional crack-and-crevice application, and to determine the amount of the chlorpyrifos that is absorbed by a child living within the home. Ten residential homes with a 2-5 year old child in each were selected for study, and the homes were treated with chlorpyrifos. Pesticide measurements were made of the indoor air, indoor surfaces and plush toys. In addition, periodic morning urine samples were collected from each of the children throughout the two-week period. The urine samples were analyzed for 3,5,6-trichloropyridinol, the primary urinary metabolite of chlorpyrifos, and the results were used to estimate the children's absorbed dose. Average chlorpyrifos levels in the indoor air and surfaces ranged from 26 (pre)/120 (post) ng/m³ and 0.48 (pre)/2.8 (post) ng/cm², respectively, reaching peak levels between days 0-2; subsequently, concentrations decreased throughout the 2-week period. Chlorpyrifos in/on the plush toys ranged from 7.3-1949 ng/toy post-application, concentrations increasing throughout the 2-week period demonstrating a cumulative adsorption/absorption process indoors. The daily amount of chlorpyrifos estimated to be absorbed by the CPPAES children post-application ranged from 0.04-4.8 µg/kg/day. During the 2-week period following the crack and crevice application, there was no significant increase in the amount of chlorpyrifos absorbed by the CPPAES children.

Introduction

Eighty percent of U.S. households use pesticides more than once a year in and around their homes (Davis et al. 1992; Whitmore et al. 1994). Many of the pesticides applied indoors are semi-volatile with vapor pressures ranging from 10^{-2} to 10^{-8} mm Hg (Dalaker et al. 1997). Once applied indoors, semi-volatile pesticides can vaporize from treated surfaces and can distribute in and on targeted and non-targeted surfaces and objects (Gurunathan et al. 1998; Byrne et al. 1998; Lewis et al. 2001; Wright et al. 1984). This raises concern about exposures as U.S. householders, including children, can spend up to 90% of their time indoors within or around treated areas (Savage et al. 1981). Children in pesticide treated homes may be exposed to pesticides via multiple routes and from multiple media. Given their inherent biological vulnerabilities and characteristic behaviors that are different from adults, children can be particularly susceptible to the effects of pesticides (Guzelian et al. 1992; Aprea et al. 2000; Bearer 1995; Freeman et al. 1997; Reed et al. 1999).

In 1996, the Food Quality Protection Act (FQPA) mandated that contributions from all routes of exposure and from all possible sources be considered when setting food tolerance levels for pesticides, paying particular attention to address the potential risks to infants and small children (FQPA 1996). Several studies have used direct and indirect measures to try to estimate the total pesticide uptake by children via the inhalation, dermal and non-dietary ingestion routes following an indoor pesticide application (Gurunathan et al. 1998; Byrne et al.

1998; Lewis et al. 2001). Pesticide body burden levels estimated from environmental concentrations have been reported following either broadcast (Gurunathan et al. 1998) or home-owner/professional crack-and-crevice applications (Lewis et al. 2001; Byrne et al. 1998). No studies thus far have serially collected biomarker samples from children residing within treated homes to allow a comparison between body burden estimated from environmental data and body burden estimated from biomarker levels. Given that information regarding pesticide uptake by children in treated homes is needed to assess the health risks for exposed children, the lack of information on the time course of body burden levels following in professional indoor application is a gap in the currently available research.

A detailed multi-media/multi-pathway 10 home residential study, referred to as the Children's Post-Pesticide Application Exposure Study (CPPAES) was conducted to provide information on the release and movement of chlorpyrifos, a semi-volatile pesticide (vapor pressure 1.87×10^{-5} mmHg at 20°C), within a residential environment and within children living in this environment over time post an application. The scientific approach involved collecting environmental samples from a treated home coupled with biomarker samples from a child living in the treated home, for a two-week period following a routine crack-and-crevice application of chlorpyrifos. CPPAES was designed to evaluate the extent of aggregate chlorpyrifos exposure for children living within treated homes. The general concept for this study was outlined during a workshop held by ILSI and

published in 2000. The study was carried out between 1999 and 2001, before the USEPA phased out indoor residential use of organophosphate pesticide.

Methods

Study design. Ten residential homes (ID: H1-H10) were selected for CPPAES based on the criteria that they applied pesticides on a routine basis, and had a child between the ages of 2 and 5 that spent the majority of his/her time indoors at home. Each of the CPPAES homes was located in urban areas within New Jersey. The homes varied in size (34 – 96 m²) and style. For the protection of human subjects, the study design was thoroughly evaluated and approved by the Institutional Review Board committee of UMDNJ and the USEPA.

Pesticide Application. The commercial product Dursban 2.E.® or Dursban L.O.® containing the insecticide chlorpyrifos [O,O-diethyl-O-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate, CAS No. 2921-88-2] was applied to each of the CPPAES homes reportedly as a 0.25-0.5% water emulsion. Up until recently and throughout the study period, chlorpyrifos was one of the most commonly used household insecticide within the U.S. used by homeowners, renters, and professional applicators to control cockroaches, fleas and termites (EPA, 2000). A licensed pesticide applicator applied the pesticide solution to each of the homes via a crack-and-crevice mode of application. The applications were made using a hand-pump compressed air sprayer (tank capacity 1 gallon) with a pin stream nozzle, spraying with a downward-directed nozzle tip 12” – 16” from the

floor. Crack-and-crevice applications were made to the cracks and crevices of the homes and in some cases along the perimeters of the walls behind appliances or furniture. The applications lasted approximately 15 minutes per home as the applicator scoped each home for cracks and crevices and evidence of roach trails. Approximately 60 to 700 mL of the chlorpyrifos solution was reportedly sprayed in each CPPAES home. A sample of the pesticide solution applied within each home (except H1) was collected from the pesticide applicator and the samples were analyzed in the laboratory. The amount of pesticide applied in each home was then based on the estimated volume of the pesticide solution applied. Although the study was designed to make uniform applications in each home, the analytical results indicated that the amount of chlorpyrifos applied within homes H8-H10 (4.1×10^{-7} to 4.3×10^{-6} g) was considerably lower than what was applied in homes H2-H7 (0.07 to 0.6 g). A sample of the pesticide application solution was not available for H1; however, based on the chlorpyrifos levels measured in the indoor air post-application, the applied amount in H1 was probably similar to amounts applied in homes H2-H7.

In homes H3, H5, and H8 the pesticide was applied in all rooms. For homes H1, H2 and H4 the pesticide was applied in all of the rooms except the bathrooms. For homes H6, H7 and H9, it was not applied in the parent's bedrooms; for H10, pesticide was not applied in two of the bedrooms. During the crack-and-crevice application, the study participants left the treated homes and no sampling was conducted. Following the application, re-entry did not occur for 3 hours. An

exception was H10, where during this time the participants restricted their movements to the untreated portions of the house rather than vacating the home. The windows in all of the homes were “cracked” open during this 3-hour period.

Sampling Scheme. A two-week multimedia sampling effort was carried out prior to and following an indoor crack-and-crevice application. Environmental samples were collected over time for measuring chlorpyrifos in the indoor environment. Simultaneously, biomarker samples were obtained from the participating children living within the treated homes. Pre-application measurements were made from the CPPAES homes on the day prior to the day of pesticide application. A crack-and-crevice pesticide application was then made to each of the CPPAES homes on what is designated to be day 0. Post application measurements were made on days 1, 2, 3, 5, 7, 9 and 11 following the day of application. The sampling scheme is presented in Table 1.

Samples Collected. In each CPPAES home, measurements were taken in two rooms that had been treated with the pesticide; either in the child’s main play area: “A”, and/or in/near the child’s bedroom area: “B”.

Time weighted average measurements for chlorpyrifos vapor and aerosol were obtained in chlorpyrifos treated rooms (H1-H9 samples collected in “A”; H10 samples collected in “B”). The indoor air samples were collected using a Harvard sampler with a PM-10 inlet and a carbon impregnated filter. Collection and

extraction methods for the air samples were developed by Gurunathan et al. (1998). The sampling time per sample spanned the time interval between each visit (i.e. days -1 to 0, 0 to 1, 1 to 2, 2 to 3, 3 to 5, 5 to 7, 7 to 9 and 9 to 11). Post-sampling, the filters were extracted in 10 mL toluene via sonication and concentrated down to a sample volume of 5 mL. Mean recoveries for chlorpyrifos from laboratory controls were 101% (CV 7.8%).

Surface wipe samples were collected within treated rooms on days -1, 1, 2, 3, 5, 7, 9 and/or 11 from non-targeted surfaces (i.e. areas not directly sprayed with the pesticide). The Lioy-Weisel-Wainman (LWW) sampling method as described by Gurunathan et al. (1998) and Lioy et al. (2000) was used to collect the pesticide wipe samples by the movement of a C18 impregnated Teflon filter media (moistened with iso-propanol) within a 100 cm² template.

The LWW sampler was used to collect wipe samples from smooth surfaces in both areas "A" and "B". The wipe samples obtained from "A" were collected from floor surfaces. All of the wipe samples obtained from "B", except for H1, H2 and H8 (day -1) were also collected from floor surfaces. Two-week "B" samples collected from homes H1 and H2 were obtained from a dresser, 0.1-0.8 m above the floor. The H8 day -1 "B" sample was collected from a windowsill, 0.6 m above the floor. Due to limited resources, except for in homes H2, H9 and H10, samples from "B" were not collected on days 5 and 9. No LWW samples were collected from area B in H8 as the floor was carpeted. Each LWW wipe sample

was collected from a different location within each home to prevent the surface activation previously noted by Gurunathan et al. (1998). However, whenever possible the sampled areas were adjacent to the previous samples. Post-sampling, the LWW filters were extracted in 5 mL iso-propanol via sonication. Mean recoveries for chlorpyrifos from laboratory controls were 106% (CV 4.9%). The data were used to estimate the amount of chlorpyrifos distributed on open surfaces in the treated home environment.

Chlorpyrifos measurements were also made on samples collected from indicator toys placed within CPPAES treated rooms (H1-H3, H5-H9 samples collected in “A”; H4 and H10 samples collected in “B”). This occurred immediately after the 3-hour re-entry time period, and each was sequentially removed for chlorpyrifos analysis on days 1, 2, 3, 5, 7, 9 and 11 post-application. A duplicate toy was collected on days 2, 5 and 9 post-application from homes H3-H10. For H2, a duplicate sample was available only for day 2. For H5, a duplicate toy was collected on days 2, 5, 9, and 11 post-application. “Sweet Stuffs” from the “The First Years Collection” purchased at Toys R’ US (Surface areas ~125-150 cm²), were used as the indicator toys. They were placed in a birdcage to minimize the children from interacting with the toys, but in the same time not sheltering the toys from the movement of pesticide in the air. Plush toys were used as they are a potential sink for pesticides accessible to children within residential homes. Moreover, plush toys can serve as a surrogate for any sorbant medium present indoors with polyfoam filler, such as furniture upholstery and bedding.

A combination of toy surface wipes and toy extractions were analyzed from the duplicate toys to evaluate both dislodgeable and total components of the pesticide in/on the duplicate toys. A surface wipe of the duplicate toys was collected prior to the full extraction of the toys. The surface of each plush toy was wiped using iso-propanol impregnated swabs. The swab wipes were subsequently extracted in 10 mL of iso-propanol via sonication and concentrated down to a sample volume of 5 mL. Mean recoveries for chlorpyrifos from laboratory controls were 102% (CV 3.2%). The plush toys were then extracted in 200 ml hexane via sonication and concentrated down to a sample volume of 5 mL (Gurunathan et al. 1998). Mean recoveries for chlorpyrifos from laboratory controls were 96% (CV 6.2%).

To estimate chlorpyrifos bioaccumulation in the CPPAES children, urine samples were collected and analyzed for 3,5,6-trichloropyridinol (TCPy), the primary urinary metabolite for chlorpyrifos (Nolan et al. 1984). First morning void urine samples were collected from the CPPAES children on each of the sampling days - 0 pre-application, 1, 2, 3, 5, 7, 9 and 11. These urine samples were designed to represent the contact of the children with chlorpyrifos on days -1, 0, 1, 2, 4, 6, 8 and 10, respectively, and estimate body burden; although there would be higher uncertainty in these values since it was a first void and not a 24 hour average (Wessels et al. 2003). The pre-application urine sample was collected as a baseline urine measure for TCPy concentration. Only 10% of the urine samples collected were not the first morning voids, and only two children missed

more than one morning void (H5 and H9). The urine samples were analyzed by the Centers for Disease Control (CDC). The samples were analyzed for TCPy using a slightly modified version of the method described by Hill et al. (1995) following a 3-hour derivatization process. The analytical limit of detection (LOD) for TCPy concentration using this method was 1.0 $\mu\text{g/L}$ for a 4 mL sample. Results for both CR (creatinine) adjusted ($\mu\text{g TCPy/g CR}$) and non-CR adjusted ($\mu\text{g TCPy/L urine}$) TCPy concentrations are reported in this study. The TCPy levels for 5 of the 80 urine samples were reported as less than the analytical LOD. The authors assumed a value of 0.5 x LOD for these samples, which is a generally accepted method of reporting data below the LOD (EPA 1999).

Translating the non-CR adjusted morning void TCPy concentrations ($\mu\text{g TCPy/L urine}$) to estimated daily TCPy excretion ($\mu\text{g/kg/day}$), required an assumption of 0.5 L/day daily urinary excretion rate for children between the ages of 0 and 4 (Lentner 1981). The CR adjusted morning void TCPy concentrations ($\mu\text{g TCPy/g CR}$) required an assumption of 25 mg CR/kg/day daily CR excretion rate (Pediatric Journal 1997) to estimate daily excretion of TCPy ($\mu\text{g/kg/day}$). However, there are uncertainties associated with both estimates. Based on the daily TCPy excreted amounts, the daily estimated amounts of chlorpyrifos absorbed by each of the CPPAES children via all routes were calculated, using the approach of Byrne et al. (1998).

$$\left(\begin{array}{c} \text{Chlorpyrifos} \\ \text{Absorbed Dose} \\ (\mu\text{g}/\text{kg}/\text{day}) \end{array} \right) = \left(\begin{array}{c} \text{TCPy Excreted} \\ \text{on Day n} \\ (\mu\text{g}/\text{kg}/\text{day}) \\ \text{n=1, 0-10} \end{array} \right) \div \left(\begin{array}{c} \text{Fraction of Oral} \\ \text{Dose Eliminated} \\ \text{in Urine (0.7151)} \end{array} \right) \times \left(\begin{array}{c} \text{Molecular Weight} \\ \text{Ratio} \\ \text{(Chlorpyrifos:TCPy)} \\ (350.6:198) \end{array} \right)$$

Chemical analysis. A capillary gas chromatograph (Hewlett-Packard Gas Chromatograph 5860 Series II, Hewlett-Packard, Wilmington, DE) equipped with a HP Nickel 63 Electron Capture Detector (ECD) and an Autosampler Injector 7673 was used for chlorpyrifos analysis of the air, surface wipe and toy samples. HP Chem Station chromatography software (Hewlett-Packard) was used to quantify the concentration of chlorpyrifos in all of the samples. A split/splitless injector was maintained at 250°C. The detector temperature was held at 325° C. A 60-m (0.25 mm inner diameter DB-1) fused silica capillary column with 0.25 μm film thickness (J & W Scientific, Folsom, C.A.) was used. Under splitless conditions, the column was temperature programmed from 50°C to 190°C at 30°C/min (held for 28 minutes), from 190°C to 270 °C at 70°C/min and held at 270°C for 16 minutes, altogether resulting in a run time of approximately 50 minutes per sample run. Helium was used as the carrier gas (flow rate 1.0 mL/min). Nitrogen was used as the make-up gas (flow rate 65 mL/min). An injection volume of 1 μl was maintained for all of the samples.

Instrument quality assurance and quality control. Standard solutions for chlorpyrifos ranged from 0.0012 to 2.4 μg/mL. These were analyzed with every

GC run, and calibration curves were generated for the concentration range of interest. The results were used to generate a linear regression equation ($r^2=0.99$). Replicates of independent standard solutions (prepared by Chem Service) were included with each sample run to evaluate the performance of the gas chromatograph. Pesticide recoveries from the independent standards ($n=10$) were within 2% of the reported values with CV <2.1%. All solvent blanks remained free of chlorpyrifos. Where no peaks were detected, the sample results were reported as non-detects (“ND”). The instrument LOD for chlorpyrifos was 0.0011 $\mu\text{g/mL}$.

Statistical Analyses. CPPAES was designed specifically to study the mechanisms of release and exposure to “semi-volatile pesticide over a two week period post-application. Thus, the emphasis of the study was on the time course of accumulation and elimination of a pesticide in a variety of media in the same home. Thus it was not a population based study. Since three of the homes received approximately five orders of magnitude lower amounts of chlorpyrifos, the CPPAES homes were divided into two groups based on application rate (‘High’ [H1-H7] and ‘Low’ [H8-H10]). The Wilcoxon Signed Ranks Test was used to compare between the pre-treatment and the 2-week post-treatment chlorpyrifos levels as measured from the indoor environment (air, dust, plush toys) and from the children (chlorpyrifos absorbed dose) within these groups. Given the mechanistic design of the study, there was a small sample size, and a non-parametric analysis method was employed to examine between group data.

Using the non-parametric Mann-Whitney U Test, the extent of daily average post-application chlorpyrifos levels were compared between the 'high' and the 'low' homes. This type of study was previously recommended as part of a modeling workshop (ILSI, 2000).

RESULTS

Indoor air samples. Based on estimated chlorpyrifos application rates for homes H1-H7 ($> 4.3 \times 10^{-6}$ g) and homes H8-H10 (4.1×10^{-7} to 4.3×10^{-6} g) (Table 2), air concentrations of chlorpyrifos were categorized into two groups designated to be the 'high' and the 'low' homes, respectively. Boxplots of the indoor air chlorpyrifos concentrations measured throughout the 2-week period are presented in Figure 1.

Post-application air concentrations measured in homes H1-H7 were significantly greater than levels measured in homes H8-H10 ($p=0.000$). The highest levels were measured in H5 and the lowest chlorpyrifos concentrations were found in homes H8-H10 (low application rate homes). Homes H6 and H7 had the highest air exchange rates (Air Changes per Hour - ACH) of 4.9 ± 2.6 and 6.7 ± 3.1 h^{-1} , respectively, which probably lowered the concentrations in homes H6 and H7. ACH of 0.7 - 1.5 h^{-1} were found in the other homes. A recent pesticide application within the apartment complex that housed H6 probably contributed to high levels of chlorpyrifos in H6 between days 0 and 1. This was consistent with the H6 day -1 indoor chlorpyrifos level being 115 ng/m^3 , which was greater than the day 2

post-application level of 44 ng/m³. The highest measured chlorpyrifos indoor air concentrations in homes H1 through H5 were between days 0 and 2 post-application (Mean: 315 ng/m³), which were significantly greater than pre-application levels (Mean: 18 ng/m³) (p=0.002). Indoor air concentrations in homes H1-H5 then decreased throughout the 2-week sampling period (Mean: 172 ng/m³), but were still greater than the pre-application levels. The indoor air concentrations for homes H7-H10 did not follow the same decay patterns as H1-H5. In fact, the H7-H10 post-application indoor air levels (Mean: 16 ng/m³) were not much different from the pre-application levels (Mean: 14 ng/m³) (p=0.67). Infiltration of chlorpyrifos from the building application most likely affected the indoor air levels in H6. All of the measured values were at least 10x lower than the National Academy of Sciences (NAS) 24-hr continuous exposure guideline of 10 µg/m³ (NAS 1982).

Surface wipes. The LWW wipe sample results obtained from the samples collected in the main play areas (A) and bedroom areas (B) are found in Tables 3 and 4, respectively. Boxplots of the chlorpyrifos surface loadings for the 2-week period are presented in Figures 2 and 3, respectively.

Chlorpyrifos levels in the main play areas of the higher application rate homes (H3-H6) were considerably greater than the levels measured in homes H8-H10. For days 0-10 the average ranged from 3.1-6.9 ng/cm² (H3-H6) and 0.17-1.7 ng/cm² (H8-H10). Despite the lower chlorpyrifos application rates in H8-H10,

chlorpyrifos levels were detected; in fact, H10 chlorpyrifos levels (Days 0-10 Mean: 1.7 ng/cm²) were higher than levels measured in homes H1, H2 and H7 (Days 0-10 Mean Range: 0.4-1.0 ng/cm²). The pre-application level in H10 (1.0 ng/cm²), suggested another source to have contributed to H10 chlorpyrifos levels. A potential source could be previous pesticide applications made within the home. LWWA chlorpyrifos surface loadings in H3-H6 peaked between days 1 and 2 post-application (Mean: 13 ng/cm²), and the values were significantly greater than the pre-application levels (<0.9 ng/cm²) (p=0.006). Following the peak day, the loading gradually declined approaching pre-treatment levels by day 11 (Mean: 0.9 ng/cm²). Surface loadings in homes H8 and H10 did not follow the same decay pattern. The highest loading post-application for H8 (1.6 ng/cm²) was observed on day 7 and for H10 (2.1 ng/cm²) on day 3. Post-application surface loadings in homes H8-H10 (Mean: 0.93 ng/cm²) were only slightly greater than pre-application levels (Mean: 0.44 ng/cm²). Levels reached or approached pre-treatment levels on day 11 (Mean: 0.55 ng/cm²).

Chlorpyrifos levels measured in the bedroom areas were generally lower than levels measured in the main play areas for H1-H7, excluding H5. In fact, except for H3 and H5, the highest post-application surface loadings measured in the bedroom areas were only slightly greater than the pre-application levels (Range: 0.18-0.82 ng/cm²; Pre-Treatment = 0.28-0.70 ng/cm²). The highest LWWA and LWVB surface loadings were measured in H5, loadings peaking on day 1 post-application (Range: 21.2-23.8 ng/cm²) (Pre-Treatment levels were Non Detects).

Following the peak day, loadings in H5 gradually declined approaching pre-treatment levels on day 11.

Plush toys. Chlorpyrifos levels found in/on the plush toys are presented in Table 5 and illustrated in Figure 4. Chlorpyrifos concentrations in/on the plush toys increased throughout the 2-week sampling period for all homes. A similar trend was observed by Gurunathan et al. (1998), following a broadcast application of chlorpyrifos. On day 1, the plush toy chlorpyrifos concentrations for CPPAES homes H1-H10 averaged 197 ng/toy, reaching 634 ng/toy on day 11. Overall, levels measured within homes H1-H7 were significantly higher than levels in homes H8-H10 ($p=0.000$). Measured chlorpyrifos levels were the highest in H5 throughout the 2-week period. Less than 5% (Mean 1.6 ± 2.0 %; $n=26$) of the chlorpyrifos was wiped off the plush toys (Mean 3.4 ± 2.6 ng). These amounts were significantly less than the amounts of chlorpyrifos obtained from the toys after full extraction (Mean: 519 ± 606 ng) ($p=0.000$).

Biomonitoring. Chlorpyrifos levels absorbed by the CPPAES children were estimated by quantifying the amount of chlorpyrifos metabolite TCPy that was excreted by the children on the sampled days. The amount of TCPy excreted by the CPPAES children and the corresponding absorbed doses derived from both the non-CR adjusted and the CR adjusted TCPy results are presented in Table 6 and illustrated in Figures 5 and 6, respectively. However, please note that CR is at lower levels in children, and there is probably a higher level of variability due to

the lack of a 24 hour sample. The CPPAES children excreted on average approximately 0.25 μg TCPy/kg/day (non-CR adjusted; n=10) or 0.34 μg TCPy/kg/day (CR adjusted; n=10) pre-application. The estimated average chlorpyrifos absorbed doses were 0.55 μg chlorpyrifos/kg/day (non-CR adjusted) and 0.85 μg chlorpyrifos/kg/day (CR adjusted). The amount of TCPy excreted by the children post-application on average per day ranged from 0.21-0.28 μg TCPy/kg/day (non-CR adjusted) or 0.31-0.51 μg TCPy/kg/day (CR adjusted). The corresponding daily average post-application chlorpyrifos absorbed doses ranged from 0.53-0.7 μg chlorpyrifos/kg/day (non-CR adjusted) and 0.77-1.3 μg chlorpyrifos/kg/day (CR adjusted). A significant increase was not observed in the amount of chlorpyrifos absorbed by the CPPAES children during the 2-week period following the crack-and-crevice application.

Discussion

CPPAES combined extensive multimedia monitoring efforts within residential homes for a 2-week period following a crack-and-crevice application of chlorpyrifos with simultaneous biomonitoring of the children residing within the treated homes. Biomonitoring of the chlorpyrifos metabolite enabled us to quantify the extent of aggregate exposure to the pesticide for a child living within a treated residence and estimate the body burden levels. Although previous studies have examined the time-series distribution of chlorpyrifos within an indoor environment, no studies thus far have concurrently measured the time-series urine levels from children that lived within the pesticide treated homes and spent

the majority of their time indoors. Moreover, since three of the homes (H8-H10) received approximately five orders of magnitude lower amounts of the chlorpyrifos, the reduced level of application gave us an opportunity to investigate the distribution of the pesticide within the home and the children following different application rates.

Some of the findings from CPPAES were in agreement with other studies that have demonstrated that semi-volatile pesticides applied indoors within a home can contaminate the indoor air (Gurunathan et al. 1998; Wright et al. 1978, 1980, 1981; Byrne et al. 1998; Lewis et al. 2001) and non-targeted indoor surfaces (Gurunathan et al. 1998; Wright et al. 1975, 1976) following an indoor pesticide application.

Chlorpyrifos applied inside the 10 CPPAES homes was detected within the treated room indoor air throughout the 2-week post-application period. Mostly, higher pesticide levels were detected from the CPPAES homes that received a greater application rate (Except H7). For homes H1-H6, 2-week post-application indoor air levels ranged from 22-816 ng/m³; H8-H10 levels ranged from 2.2-31 ng/m³. Comparatively, overall CPPAES concentrations in the indoor air were either similar or considerably lower than some of the reported studies. For instance, a study conducted by Wright and Leidy (1978) measured chlorpyrifos concentrations in the air within vacant rooms following a crack-and-crevice application of 0.5% or 1% chlorpyrifos solution. Pesticide measurements were

made from the indoor air throughout a 3-day period following a crack-and-crevice application. Chlorpyrifos levels in the indoor air as measured immediately following the indoor application ranged from 600 to 2700 ng/m³. A more recent study was conducted by Byrne et al. (1998) to estimate chlorpyrifos levels within pesticide treated homes for a 10-day period following a crack-and-crevice application made with a 0.5% pesticide solution. The study was conducted in three residential homes. An estimated 3.3 to 3.9 g of chlorpyrifos was applied to each of the homes. Pre-application indoor air levels from the CPPAES homes were more or less comparable to measurements collected by Byrne et al. (1998) from two of the three treated homes (< 20 ng/m³). The highest indoor air chlorpyrifos level measured post-application in the CPPAES study (816 ng/m³), however, was lower than the maximum concentration (2300 ng/m³) observed by Byrne et al. (1998).

As a measure of the extent of non-target deposition of the chlorpyrifos within the CPPAES homes following the crack-and-crevice application, post-application surface loading measurements were made from non-treated surfaces within the treated homes. The highest post-application chlorpyrifos loadings, as measured via wipe sampling from non-targeted surfaces within the CPPAES children's main play areas and main living areas, were observed within homes H1-H7 (Range: 0.03 to 24.6 ng/cm²). However, not all of the measured post-application loadings from homes H1-H7 were higher than the corresponding levels from homes H8-H10 (Range: 0.08 to 3 ng/cm²). Higher measured loadings in the children's

main play areas were not always accompanied with higher loadings in the children's main living areas (Except H5). Factors such as cleaning of the homes, track-in, or out of home soil/dust most-likely contributed towards the 2-week distribution of the indoor measured surface loadings. The levels observed on the indoor surfaces in the CPPAES were similar, but somewhat higher than levels observed in the Minnesota Children's Pesticide/NHEXAS Study (median 0.34 and 0.42 ng/cm² for two different rooms in each home, and maximum of 3.64 and 14.4 ng/cm² for the same rooms) (Lioy et al. 2000). The latter were obtained in homes that used pesticides like chlorpyrifos but were not necessarily measured immediately post applications.

A number of studies have reported similar or lower indoor levels of chlorpyrifos following crack-and-crevice treatments. In a study conducted by Wright and Jackson (1975), chlorpyrifos measurements were made from non-targeted surfaces (aluminum pie plates) placed within vacant dormitory rooms for an 8-day period following indoor crack-and-crevice pesticide applications with either 0.5% or 1% chlorpyrifos solutions. Chlorpyrifos deposition levels measured from the 0.5% or 1% treated areas ranged from 0.4 to 3.5 ng/cm² and 0.4 to 11.3 ng/cm², respectively, overall pesticide levels decreasing throughout the 8-day period. The higher measured non-targeted surface loadings as measured in the current study compared to levels measured in the reported studies with a greater application rate may have resulted due to a number of reasons. For instance, although the intention of this study was to sample from non-targeted surfaces,

some of the non-targeted surfaces may have accidentally been applied with chlorpyrifos. Some of the variability observed in the surface concentrations may have resulted from the different sampling techniques that were used between the studies. Moreover, less activity within the treated rooms, such as walking or children playing, particularly in the dormitory study conducted by Wright and Jackson (1975), may have contributed towards lower pesticide loadings on the non-targeted surfaces due to less redistribution and resuspension of the indoor dust.

Pesticide levels on non-treated surfaces such as plush toys were also examined in this study since children living within pesticide treated homes may come into contact with contaminated objects, such as toys, within a home environment (Gurunathan et al. 1998). Moreover, similar sorbent surfaces such as furniture upholstery can also contain pesticides that children residing within treated homes can be exposed to. Chlorpyrifos concentrations measured from the plush toys that were placed within homes H1-H7 were significantly greater than levels measured from toys placed within homes H8-H10. H1-H7 chlorpyrifos levels ranged from 87-1949 ng/toy, H8-H10 levels ranged from 7-221 ng/toy. Chlorpyrifos concentrations in/on the CPPAES plush toys increased throughout the 2-week sampling period, demonstrating a cumulative trend.

An increase in chlorpyrifos levels within the CPPAES homes provided an opportunity for increased exposure post-application. However, though an

increase was observed in the amount of chlorpyrifos measured from the CPPAES homes following the crack-and-crevice application, a significant increase was not observed in the amount of chlorpyrifos absorbed by the CPPAES children during the 2-week period following the crack-and-crevice application (Figures 5 and 6). Moreover, even though chlorpyrifos levels as measured from the various media within the indoor environment were considerably greater in the 'high' homes compared to the 'low' homes (Indoor Air: ~10 fold; Indoor Surfaces: ~4 fold; Plush Toys: ~8 fold), post-application daily absorbed chlorpyrifos doses measured from the 'high' home children were only slightly greater (~2 fold) than levels measured from the 'low' home children, essentially indicating that the children in fact were not coming into contact with all of the chlorpyrifos within the indoor environment, and the body burden levels could have been due to multiple sources, a point previously described by Krieger et al. (2003). The children's activities may in fact have played an important role in determining how much pesticide each child actually absorbed. Total absorbed doses of chlorpyrifos as estimated for the children residing within the CPPAES treated homes ($< 4.8 \mu\text{g}/\text{kg}/\text{day}$) were within a factor of 2.5 of the chlorpyrifos doses estimated by Byrne et al. (1998) ($< 2.1 \mu\text{g}/\text{kg}/\text{day}$). The potential absorbed doses for children residing within three chlorpyrifos treated homes were calculated by Byrne et al. (1998) using environmental data gathered following a crack-and-crevice application. The estimated body burden levels, however, could not be compared to the environmental results since body burden levels were not measured for children in the Byrne study (Byrne et al. 1998)

Most (~97%) of the post-application CPPAES children's estimated absorbed doses (Range: 0.02-4.8 $\mu\text{g}/\text{kg}/\text{day}$) were lower than the USEPA oral reference dose (RfD) value of 3 $\mu\text{g}/\text{kg}/\text{day}$ [Based upon a NOEL of 30 $\mu\text{g}/\text{kg}/\text{day}$; Calculated without the additional 10x safety factor added by FQPA (FQPA 1996) to protect young children]. It should however be noted that the majority (88%) of the 10 CPPAES children's estimated absorbed doses exceeded the revised RfD value of 0.3 $\mu\text{g}/\text{kg}/\text{day}$ (Calculated including the additional 10x safety factor) by up to 1600%. EPA in their final risk assessment for chlorpyrifos had considered a safety factor of 3 as opposed to a more conservative FQPA safety factor of 10, which reduced the number of estimated exceedances. Only 29% of the CPPAES children's estimated absorbed doses exceeded the RfD of 1 $\mu\text{g}/\text{kg}/\text{day}$ (Calculated using the safety factor of 3).

Comparison of results from CPPAES and Gurunathan et al. (1998) suggest that selection of the application method will greatly influence the children's exposures and dose received from pesticides applied indoors. In particular, comparison of the results of these two studies have indicated that estimated pesticide body burden levels for children living within homes following a broadcast application of a semi-volatile pesticide were considerably greater than the measured body burden levels for the children living within crack-and-crevice treated homes. For instance, the total absorbed doses of chlorpyrifos for children residing within the crack-and-crevice treated homes were considerably lower than even the non-dietary estimated doses from Gurunathan et al. (1998) (208-356 $\mu\text{g}/\text{kg}/\text{day}$). One

of the possible reasons may have been the fact that the pesticide levels in the indoor environment on child-accessible objects following the broadcast application of Gurunathan et al. (1998) were considerably greater than the levels measured in the crack-and-crevice studies. This was not unexpected, since compared to the Gurunathan et al. (1998) broadcast application, the CPPAES crack-and-crevice application method required a smaller volume of the pesticide applied. For instance, whereas approximately 296 to 473 mL of chlorpyrifos formulation containing ~ 0.07 to 1.8 g of chlorpyrifos were applied to the CPPAES homes, approximately 2000 mL of a chlorpyrifos formulation yielding 12 g of chlorpyrifos was applied to surfaces in each Gurunathan et al. (1998) apartment. The highest indoor air chlorpyrifos level measured post-application in the Gurunathan study was 7000 ng/m³. Whereas cumulative pesticide concentrations measured from the CPPAES toys were < 1,949 ng/toy, plush toy cumulative pesticide concentrations measured by Gurunathan et al. (1998) reached levels > 30,000 ng/toy. Consequently, residents of a crack-and-crevice treated home would be potentially exposed to lower amounts of the pesticide.

A number of data gaps introduce some uncertainties during interpretation of CPPAES post-application urinary TCPy results. For instance, there is limited information available on the natural variability in background urinary TCPy levels, a point that needs to be kept in mind since the values are relatively low. Moreover, both CR adjusted and non-CR adjusted TCPy data have inherent limitations. Even though the amount of CR generated by healthy, working, aged

adults, on a day-to-day and interindividual basis has been shown to vary little, no studies have systematically evaluated the validity of using CR adjustment for children. Moreover, the accuracy of TCPy values derived from samples with CR levels ≤ 30 mg/dL urine is questioned by Lauwerys and Hoet (1993) to be too dilute to provide valid results.

Conclusions

CPPAES results indicate that when chlorpyrifos is applied properly via a crack-and-crevice mode of application, the application does not lead to a significant increase in the children's chlorpyrifos body burden levels. Though an increase was observed in the amount of chlorpyrifos measured from the CPPAES homes following the pesticide application, CPPAES findings indicated that the children living within the crack-and-crevice treated homes were in actuality not coming into contact with the majority of the chlorpyrifos that was present in the indoor environment. Thus, pesticide body burden levels estimated for children living within crack-and-crevice treated homes, which are considerably lower than levels estimated for children living within homes treated via broadcast application (Gurunathan et al. 1998) had other sources. Essentially, by adjusting the mode of application so as to spray the pesticide around pest infested targeted areas rather than an entire surface area of a house, greatly reduced the amount of pesticide that children living within treated homes would potentially be exposed to and uptake following an application.

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Table 1. Sample Collection Scheme for the CPPAES Homes.

	Pre-Application	Day of Application	n th day Post Application							
Day #	-1	0	1	2	3	4	5	7	9	11

Table 2. Indoor Air Measurements for Chlorpyrifos Within Treated Rooms (ng/m³).

HID/Days	(-1 to 0)	(0 to 1)	(1 to 2)	(2 to 3)	(3 to 5)	(5 to 7)	(7 to 9)	(9 to 11)	Average (Days 0-10)
High Homes									
H1	3.4	179	195	178	132	123	87	73	138
H2	10	121	130	71	29	31	39	22	63
H3	7.2	338	207	153	155	107	73	69	157
H4	58	312	203	164	145	158	102	122	172
H5	14	816	648	709	587	386	294	299	534
H6	115	196	44	55	41	45	46	50	68
H7	18	32	14	45	5.5	4.0	4.4	6.3	16
Average	32	285	206	196	156	122	92	92	-
Median	14	196	195	153	132	107	73	69	-
Std. Dev.	41	257	210	233	199	129	95	99	-
Low Homes									
H8	3.8	4.5	2.8	4.0	4.8	3.6	3.7	2.2	3.7
H9	12	18	21	18	20	21	19	19	19
H10	24	24	25	23	29	28	28	31	27
Average	13	15	16	15	18	17	17	17	-
Median	12	18	21	18	20	21	19	19	-
Std. Dev.	10	9.9	12	9.9	12	13	12	14	-

Abbreviations: ng: nanogram; m: meter; HID: Home Identification; Std.Dev.: standard deviation.

Table 3. Surface Loading Measurements for Chlorpyrifos from Non-Targeted Surfaces Within Treated Rooms (Main Play Areas - LWWA) (ng/cm²).

HID/Day	-1	1	2	3	5	7	9	11	Average (Days 0-10)
High Homes									
H1	ND	1.89	1.03	1.02	NA	0.71	NA	0.49	1.03
H2	0.10	0.49	0.60	0.59	0.24	0.18	0.29	0.33	0.39
H3	ND	2.55	6.04	4.39	1.96	2.81	2.69	1.36	3.11
H4	ND	24.6	10.9	4.48	3.40	1.46	0.75	0.61	6.60
H5	ND	21.2	10.1	7.93	5.26	1.71	1.33	0.83	6.90
H6	0.85	16.5	9.6	7.7	6.6	2.2	0.82	0.83	6.32
H7	0.57	0.46	0.42	0.45	0.46	0.25	0.67	0.67	0.48
Average	0.51	9.7	5.5	3.8	3.0	1.3	1.1	0.73	-
Median	0.57	2.6	6.0	4.4	2.7	1.5	0.79	0.67	-
Std. Dev.	0.38	10.7	4.8	3.2	2.6	1.0	0.85	0.33	-
Low Homes									
H8	0.21	0.24	0.41	0.91	1.3	1.6	1.2	0.81	0.91
H9	0.12	0.25	0.23	0.19	0.24	0.10	0.09	0.08	0.17
H10	1.0	1.8	2.1	2.1	1.6	1.5	2.0	0.8	1.70
Average	0.44	0.75	0.91	1.08	1.05	1.04	1.09	0.55	-
Median	0.21	0.25	0.41	0.91	1.26	1.46	1.18	0.78	-
Std. Dev.	0.49	0.88	1.00	0.99	0.72	0.82	0.96	0.41	-

Abbreviations: LWW: Liroy-Weisel-Wainman; ng: nanogram; cm: centimeter;
 HID: Home Identification; ND: Non Detect; NA: Not Available; Std. Dev.: standard deviation.

Table 4. Surface Loading Measurements for Chlorpyrifos from Non-Targeted Surfaces Within Treated Rooms (Bedroom Areas - LWWB) (ng/cm²).

HID/Day	-1	1	2	3	5	7	9	11	Average (Days 0-10)
High Homes									
H1	ND	0.18	0.10	0.12	NA	0.18	NA	0.16	0.15
H2	0.63	NA	0.27	0.18	0.10	0.05	0.07	0.16	0.14
H3	ND	2.7	4.7	3.1	NA	1.1	NA	0.03	2.3
H4	0.28	0.29	0.47	0.26	NA	0.20	NA	0.30	0.30
H5	ND	23.8	21.8	23.0	NA	6.6	NA	3.1	15.7
H6	0.49	0.82	0.41	0.40	NA	0.34	NA	0.23	0.44
H7	0.70	0.49	0.41	0.38	NA	0.15	NA	0.27	0.34
Average	0.53	4.7	4.0	3.9	0.10	1.20	0.07	0.61	-
Median	0.56	0.66	0.41	0.38	0.10	0.20	0.07	0.23	-
Std. Dev.	0.19	9.4	8.0	8.5	-	2.4	-	1.1	-
Low Homes									
H8	0.21	NA	-						
H9	0.23	0.27	0.17	0.26	0.11	0.10	0.26	0.28	0.21
H10	1.6	1.3	2.3	1.5	3.0	1.9	2.8	1.8	2.1
Average	0.67	0.76	1.24	0.86	1.54	1.02	1.50	1.03	-
Median	0.23	0.76	1.24	0.86	1.54	1.02	1.50	1.03	-
Std. Dev.	0.78	0.70	1.5	0.84	2.0	1.3	1.76	1.1	-

Abbreviations: LWW: Liroy-Weisel-Wainman; ng: nanogram; cm: centimeter;

HID: Home Identification; ND: Non Detect; NA: Not Available; Std. Dev.: standard deviation.

Table 5. Chlorpyrifos Levels in/on Reference Plush Toys Placed Within Treated Rooms (ng/toy).

HID/Days	1	2	3	5	7	9	11
High Homes							
H1	329	761	911	957	578	665	721
H2	189	278	342	343	362	427	442
H3	344	445	672	625	824	746	753
H4	150	247	300	420	374	374	962
H5	481	926	1615	1495	1275	1480	1949
H6	302	328	457	384	434	566	588
H7	87	145	221	284	293	437	552
Average	269	447	646	644	592	671	852
Median	302	328	457	420	434	566	721
Std. Dev.	135	289	490	440	350	382	512
Low Homes							
HID/Days	1	2	3	5	7	9	11
H8	7.3	10	11	13	13	18	22
H9	45	62	81	96	130	139	134
H10	35	76	87	144	156	157	221
Average	29	50	60	84	100	105	126
Median	35	62	81	96	130	139	134
Std. Dev.	19	35	42	66	76	75	100

Abbreviations: ng: nanogram; HID: Home Identification; Std.Dev.: standard deviation.

Table 6. Amount of TCPy excreted in urine calculated for the CPPAES children.

Chlorpyrifos Absorbed Doses within ().

Day/HID	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10
Non-Creatinine Adjusted ($\mu\text{g}/\text{kg}\text{-day}$)										
PRE	0.22 (0.53)	NA ^b (NA) ^b	0.11 (0.28)	0.02 ^b (0.04) ^b	0.34 ^a (0.83) ^a	0.64 (1.6)	0.28 (0.68)	0.14 (0.35)	0.11 (0.27)	0.14 ^b (0.35) ^b
1	0.14 (0.35)	0.29 (0.71)	0.05 (0.14)	0.07 (0.18)	0.24 ^{ab} (0.60) ^{ab}	0.46 (1.1)	0.66 (1.6)	0.21 (0.53)	0.20 ^b (0.49) ^b	0.33 (0.81)
2	0.22 (0.53)	0.44 (1.1)	0.08 (0.21)	0.02 ^{bc} (0.05) ^{bc}	0.26 (0.64)	0.39 (0.97)	0.25 (0.63)	0.15 (0.37)	0.30 (0.73)	0.15 (0.37)
3	0.22 (0.53)	0.37 (0.91)	0.09 (0.22)	0.19 (0.48)	0.29 ^a (0.71) ^a	0.71 (1.8)	0.32 ^b (0.78) ^b	0.14 (0.35)	0.28 (0.69)	0.24 (0.58)
5	0.24 (0.58)	0.34 (0.84)	0.05 (0.12)	0.27 (0.67)	0.27 (0.68)	0.64 (1.6)	0.086 ^b (0.21) ^b	0.12 (0.30)	0.35 (0.86)	0.02 ^c (0.04) ^c
7	0.39 (0.97)	0.28 (0.70)	0.04 ^b (0.10) ^b	0.06 ^b (0.15) ^b	0.21 (0.52)	0.39 (0.97)	0.22 (0.56)	0.17 (0.42)	0.29 (0.71)	0.08 (0.21)
9	0.20 (0.49)	0.25 (0.62)	0.01 ^c (0.02) ^c	0.24 (0.58)	0.43 (1.1)	0.50 (1.2)	0.28 (0.69)	0.33 (0.82)	0.13 ^a (0.33) ^a	0.10 (0.25)
11	0.15 ^a (0.38) ^a	0.48 (1.2)	0.14 (0.34)	0.24 (0.58)	0.34 (0.83)	0.46 (1.1)	0.086 ^b (0.21) ^b	0.18 ^b (0.44) ^b	0.08 ^a (0.19) ^a	0.02 ^c (0.04) ^c
Creatinine Adjusted ($\mu\text{g}/\text{kg}\text{-day}$)										
PRE	0.30 (0.74)	NA ^b (NA) ^b	0.09 (0.22)	NA ^b (NA) ^b	0.68 ^a (1.7) ^a	0.70 (1.7)	0.18 (0.44)	0.21 (0.51)	0.16 (0.40)	0.43 ^b (1.1) ^b
1	0.38 (0.93)	0.35 (0.87)	0.08 (0.19)	0.10 (0.25)	1.9 ^{ab} (4.8) ^{ab}	0.73 (1.8)	0.26 (0.64)	0.23 (0.56)	0.70 ^b (1.7) ^b	0.39 (0.96)
2	0.30 (0.74)	0.20 (0.50)	0.09 (0.22)	NA ^b (NA) ^b	0.50 (1.2)	0.83 (2.0)	0.21 (0.52)	0.18 (0.45)	0.53 (1.3)	0.12 (0.30)
3	0.23 (0.56)	0.38 (0.93)	0.10 (0.25)	0.30 (0.74)	0.40 ^a (1.0) ^a	0.90 (2.2)	1.9 ^b (4.6) ^b	0.16 (0.40)	0.27 (0.67)	0.42 (1.0)
5	0.45 (1.1)	0.40 (0.99)	0.12 (0.29)	0.38 (0.93)	0.43 (1.1)	0.68 (1.7)	0.35 ^b (0.86) ^b	0.11 (0.27)	0.48 (1.2)	NA (NA)
7	0.38 (0.93)	0.21 (0.51)	NA (NA)	0.21 ^b (0.51) ^b	0.50 (1.2)	0.53 (1.3)	0.33 (0.82)	0.32 (0.79)	0.22 (0.54)	0.12 (0.29)
9	0.63 (1.5)	0.35 (0.87)	NA (NA)	0.22 (0.53)	0.30 (0.74)	0.50 (1.2)	0.33 (0.82)	0.37 (0.91)	0.13 ^a (0.31) ^a	0.17 (0.42)
11	0.60 ^a (1.5) ^a	0.35 (0.87)	0.17 (0.43)	0.38 (0.93)	0.28 (0.68)	0.75 (1.9)	0.32 ^b (0.79) ^b	0.82 ^b (2.0) ^b	0.17 ^a (0.42) ^a	NA (NA)

Abbreviations: μg : microgram; kg: kilogram; NA: Not Available; HID: Home Identification; mg: milligram; dl: deciliter; Cr: Creatinine; bw: Body Weight.

^a Not Morning Void Urine Sample.

^b Sample Dilute. Urine samples with creatinine levels < 30 mg/dl urine (Lauwerys and Hoet 1993).

^c Analyte (TCPy) concentrations were <1 $\mu\text{g}/\text{L}$ (Limit of Detection for a 4 ml sample). For these a value of 0.5 x Limit of Detection (i.e. 0.5 $\mu\text{g}/\text{L}$) was assumed.

Daily Total Urine Volume Excretion assumed to be 0.5 L (Lentner 1981); CPPAES Children's Body Weights H1-10 (kg) = 25,14,25,14,16,14,14,18,15,14, respectively.

Daily Cr Excretion Rate assumed to be 25 mg Cr/kg-day; (Average of the 20-30 mg Cr/day excretion rate for children suggested by the Pediatric Journal).

Absorbed Chlorpyrifos ($\mu\text{g}/\text{kg}\text{-day}$) = {(TCPy Excreted on Day n $\mu\text{g}/\text{kg}$ bw) x (Molecular Weight Ratio of Chlorpyrifos_350.6 to TCPy_198)} / (Fraction of oral dose eliminated in urine_0.7151); (Byrne et al. 1998).

Figure 1. Boxplots for Chlorpyrifos Concentrations in Indoor Air (ng/m^3). Note: The y-axis on each plot is not the same.

Figure 2. Boxplots for Chlorpyrifos Surface Loadings (Main Play Areas – LWWA) (ng/cm^2). Note: The y-axis on each plot is not the same.

Figure 3. Boxplots for Chlorpyrifos Surface Loadings (Bedroom Areas - LWWB) (ng/cm^2). Note: The y-axis on each plot is not the same.

Figure 4. Boxplots for Chlorpyrifos Concentrations Within Reference Plush Toys (ng/toy). Note: The y-axis on each plot is not the same.

Figure 5. Boxplots for Daily TCPy Excreted Amounts Measured From The CPPAES Children Post-Application (H1-H7 vs. H8-H10) ($\mu\text{g TCPy}/\text{kg}/\text{day}$).

Figure 6. Boxplots for Daily Chlorpyrifos Absorbed Doses Calculated For The CPPAES Children Post-Application (H1-H7 vs. H8-H10) ($\mu\text{g chlorpyrifos}/\text{kg}/\text{day}$).

Figure 1.

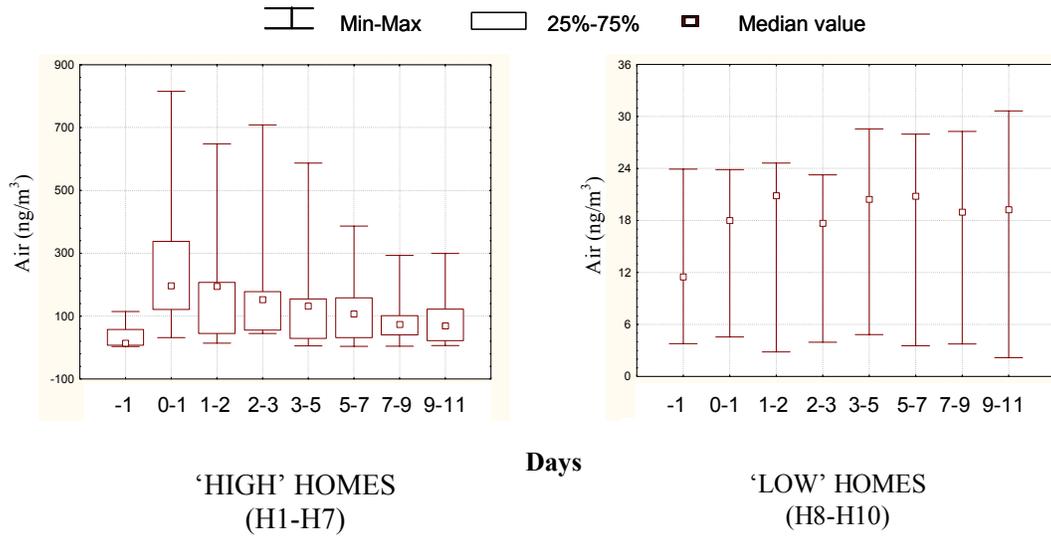


Figure 2.

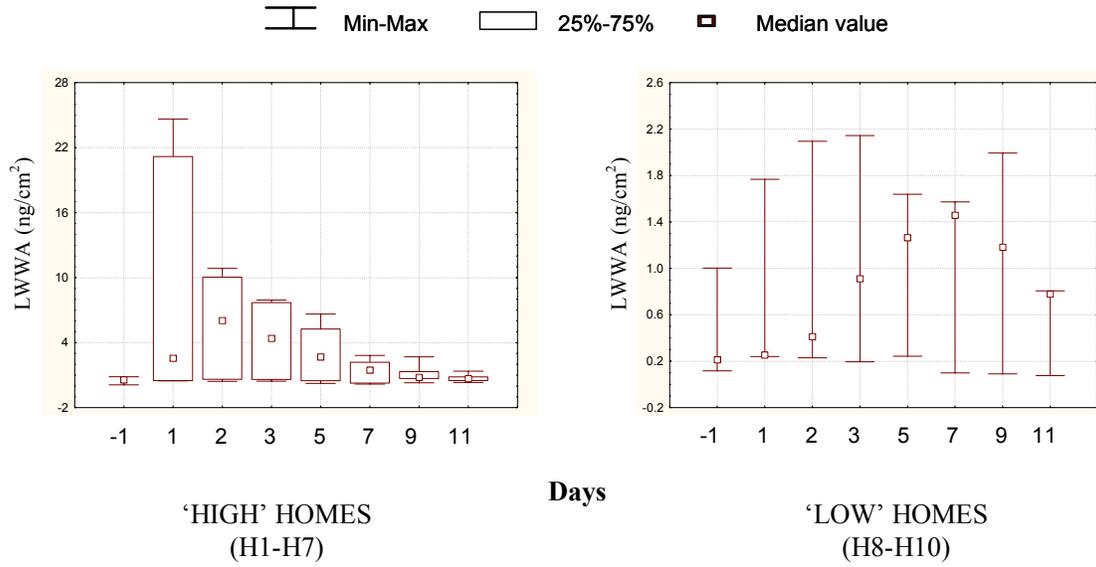


Figure 3.

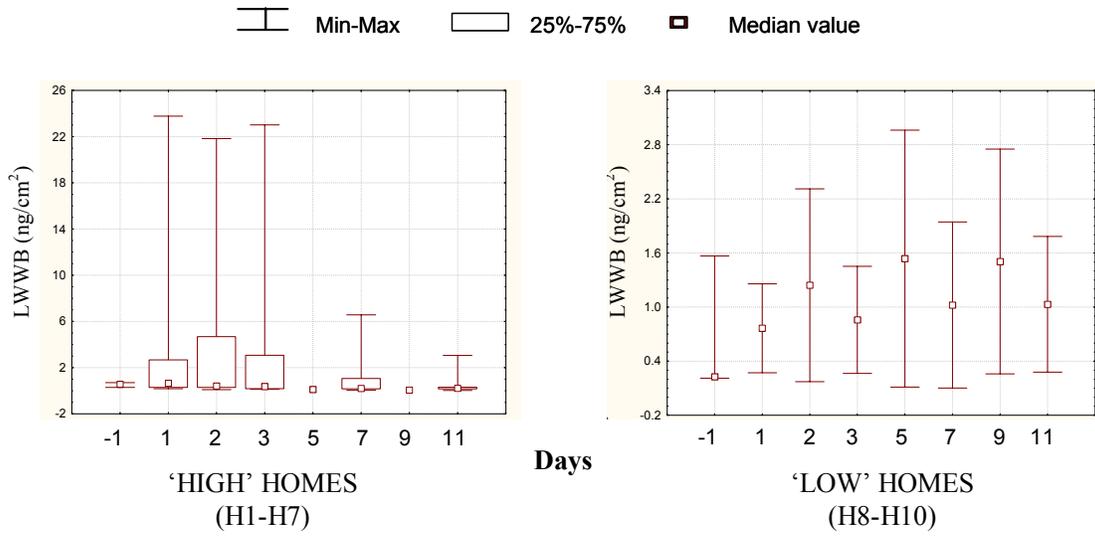


Figure 4.

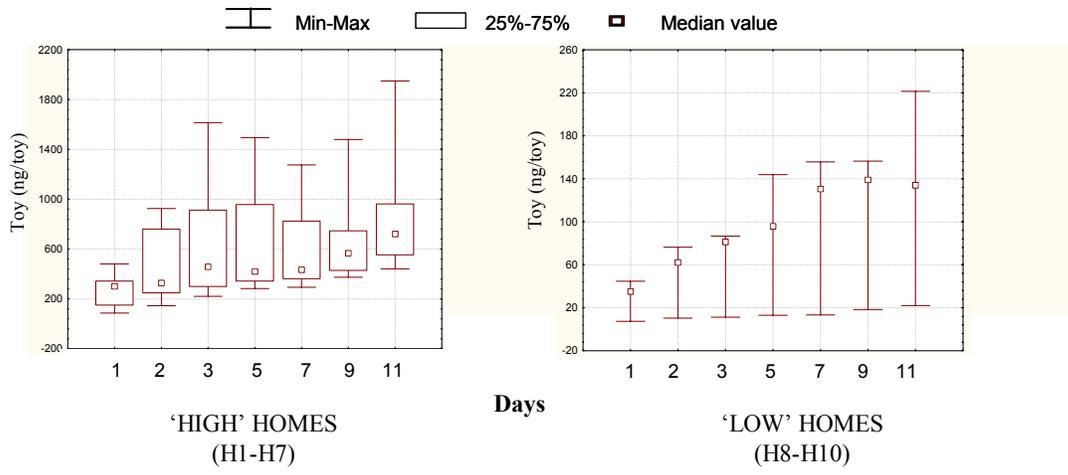


Figure 5.

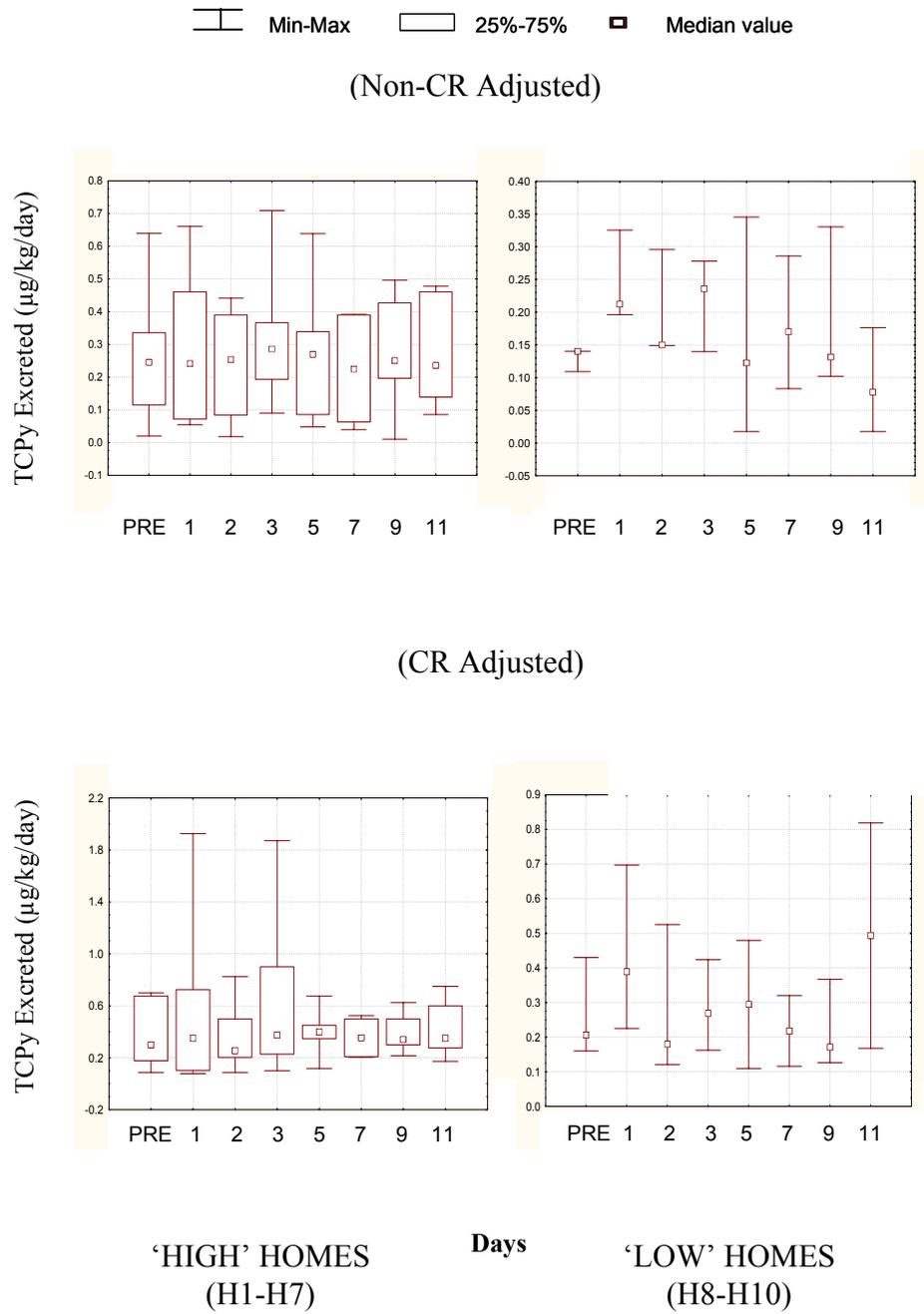
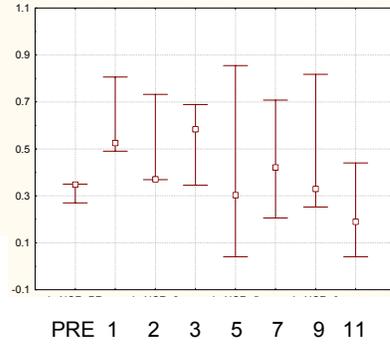
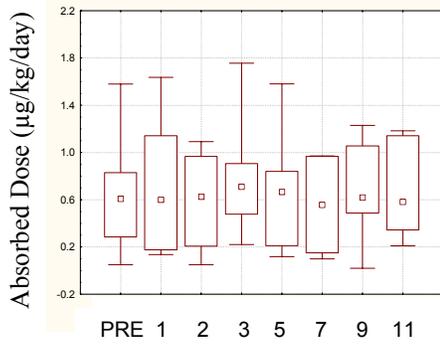


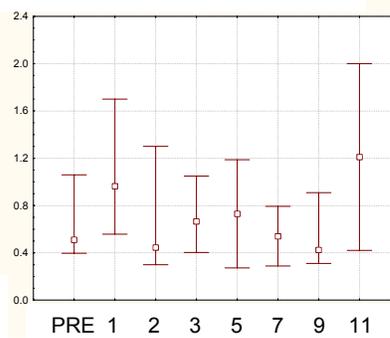
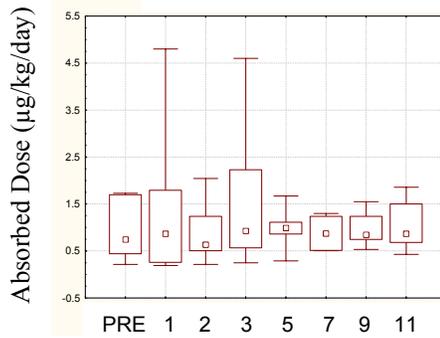
Figure 6.

Min-Max 25%-75% Median value

(Non-CR Adjusted)



(CR Adjusted)



'HIGH' HOMES
(H1-H7)

Days

'LOW' HOMES
(H8-H10)