Bystander and Indoor Residential Pesticide Exposure

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Children Pesticide Exposure Study (CPES)

Study Hypothesis

Does dietary intake contribute the majority of pesticide exposure in urban/suburban children ?

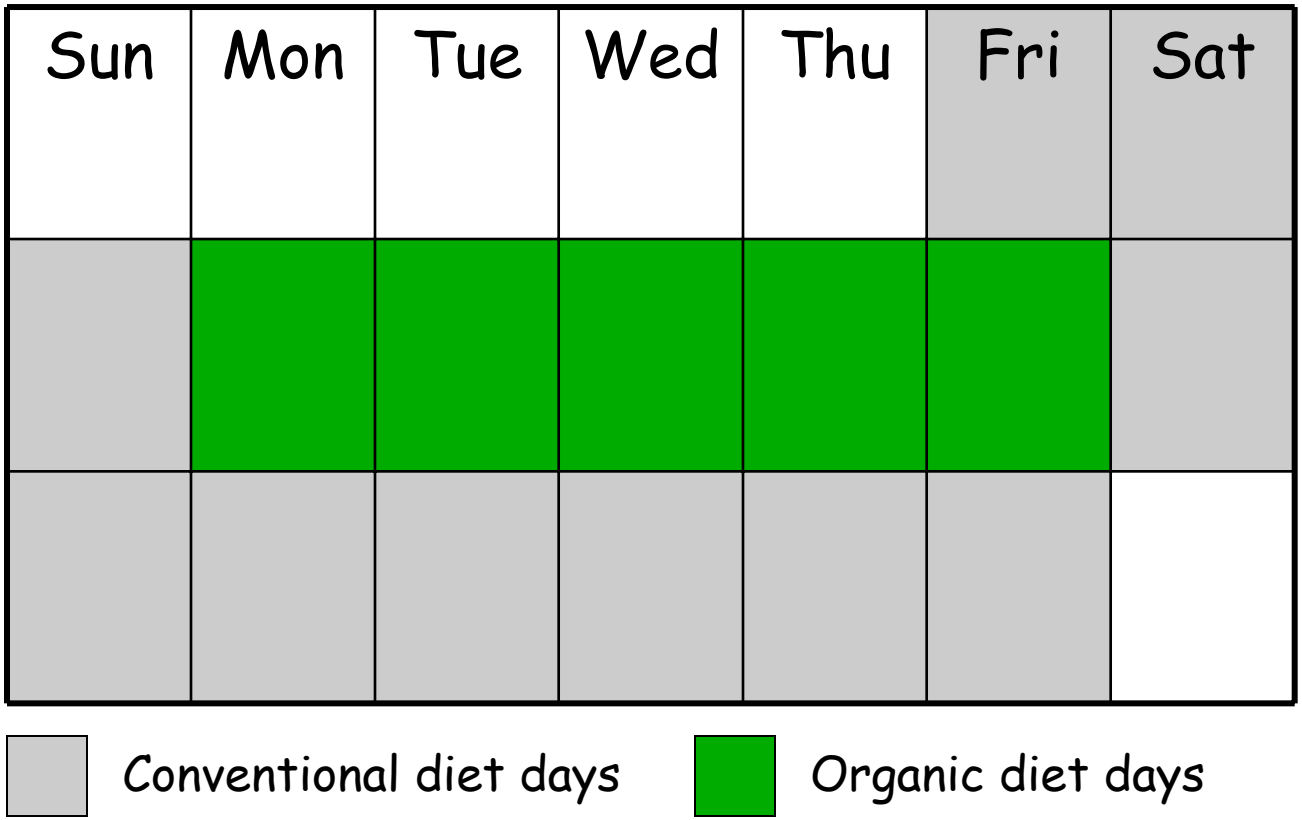
Study Design

- 23 children ages 3-11 *ONLY* consuming conventional diets,
- Children participated in the study for *one year, separated by 4 seasons*,
  - 15 consecutive days in summer;
  - 12 consecutive days in fall;
  - 7 consecutive day in the following winter and spring seasons.

Study Design

- From Day 4 - 8 (a total of 5 days) in summer and fall sampling seasons, children's conventional diets were replaced with *organic food items*,
  - Mostly fresh and processed fruits and vegetables, juices, wheat- or corn-based items,
  - Do not intend to change the consumption pattern,
  - Selected organic food items were analyzed to confirm "free of pesticides",
- No "organic food replacement" was implemented in the winter and spring seasons.

Sampling Calendar



Study Design

- *Two spot urine and salvia samples* collected daily, first morning and before bedtime voids, throughout the study periods (a total of 41 days in the 12-month period),
- *24-hour duplicate food samples* collected twice in the summer and once in the fall seasons during conventional diet days,
- *Daily dietary consumption information* was collected *via* the use of *iDL* (Internet Data Logger) for the entire study period.

Study Design

- Study was first conducted in Seattle WA area from 2003 to 2004 (CPES-WA),
- Study was later replicated in Atlanta GA area from 2005 to 2006 (CPES-GA).

Sample Analysis - Urine

- Specific metabolites for OP pesticides
  - Malathion (MDA), Chlorpyrifos (TCPY), Diazinon (IMPY), Coumaphos (CMHC)
- Metabolites for pyrethroids
  - Permethrin, Cypermethrin, Cyfluthrin, Deltamethrin
- Metabolites for herbicides
  - 2,4-D, Atrazine

Results

- Study protocol did not modify children's dietary consumption patterns
  - Overall, each child consumed 2 more items of fresh fruits and wheat-base food items during the organic diet period than the conventional diet period.

Results

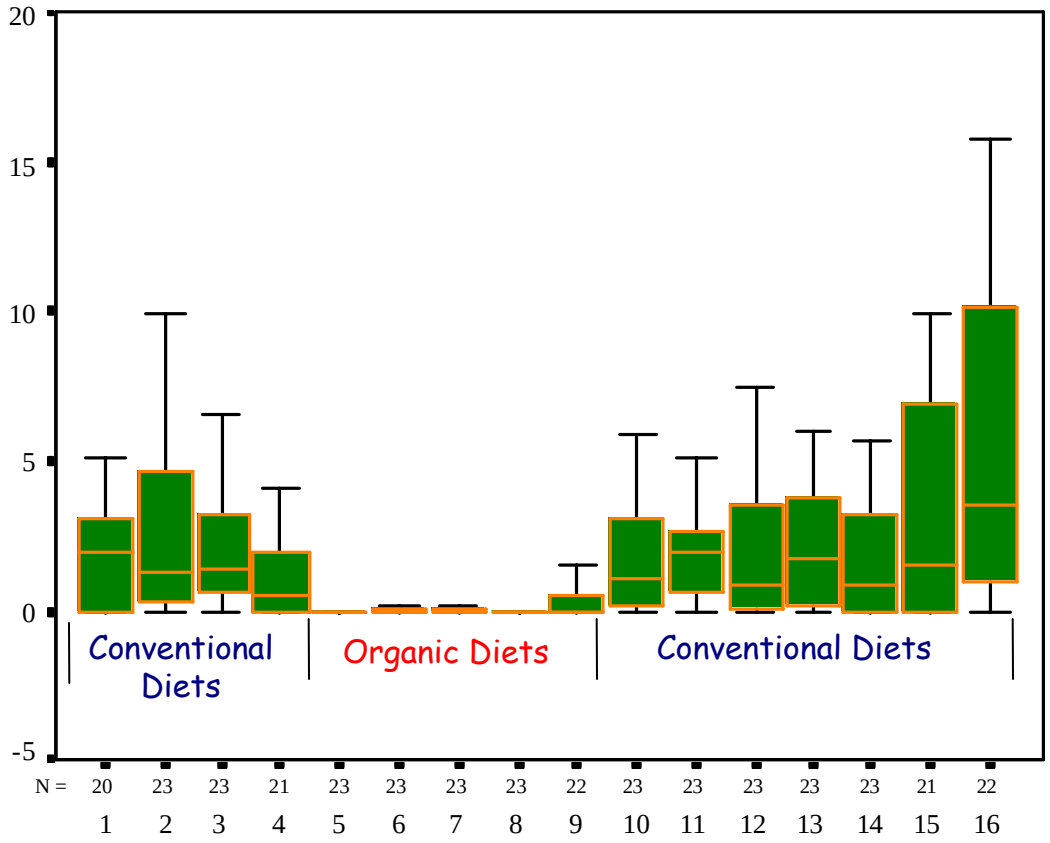
- Study protocol did not bias the findings
  - None of the samples that we selected from the pool of organic food items that are provided to the study children contained detectable OPs or other pesticides.

Descriptive statistics of DVWA concentrations of OP pesticide metabolites measured in CPES-WA children from summer 2003 to spring 2004

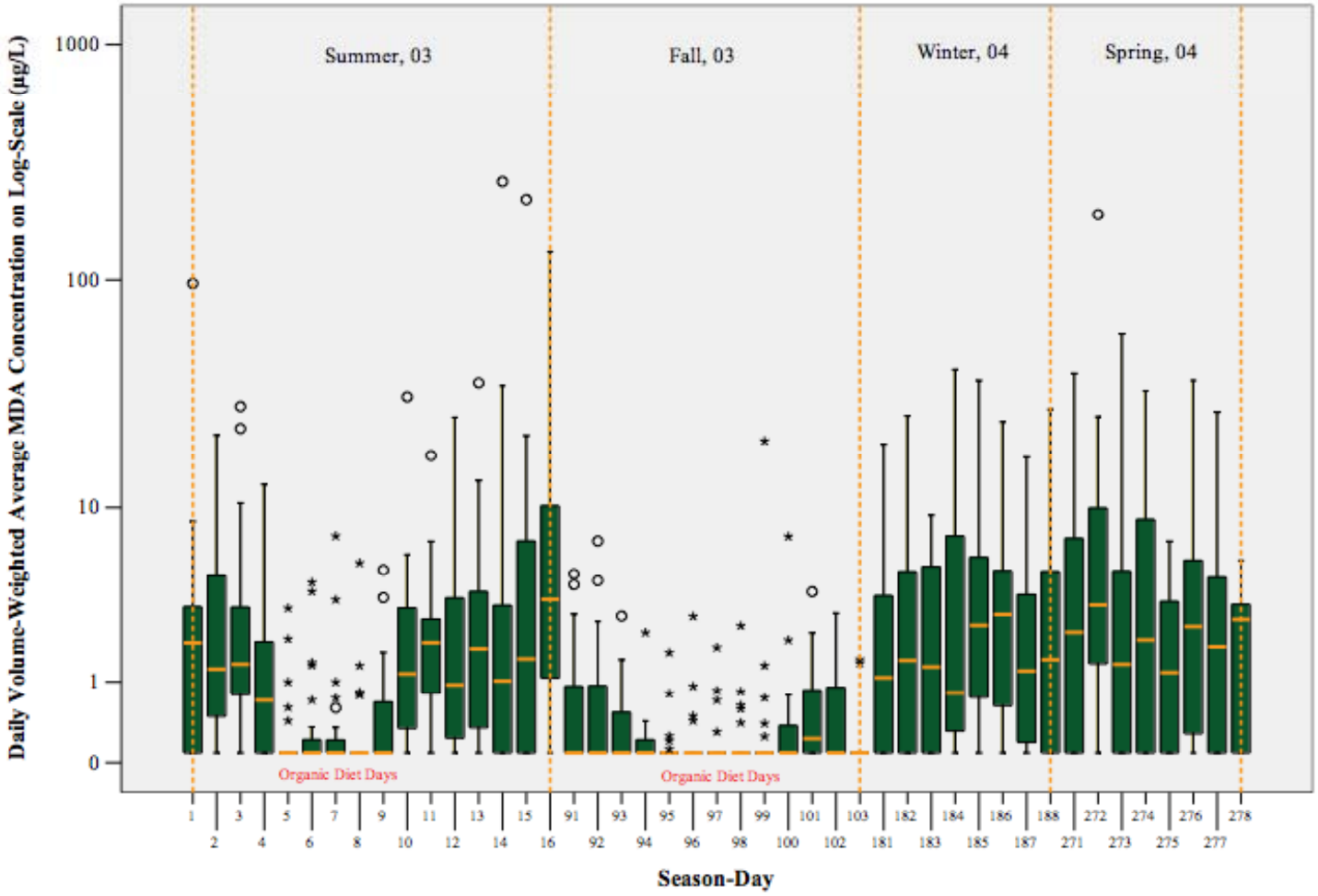
		MDA	TCPY	IMPY	CMHC	DEAMPY
Mean (µg/L)		4.6	5.1	0.2	0.01	0.3
St. Dev.		17.1	5.0	1.2	0.02	1.3
N (DVWA Measurement[a])		702	701	677	702	675
Range (µg/L)		(0, 263)	(0, 32)	(0, 15)	(0, 0.5)	(0, 18)
LOD (µg/L)		0.3	0.2	0.7	0.2	0.2
Frequency of Detection (%)		66	91	9	13	25
Percentile	5th	0	0	0	0	0
	10th	0	0.2	0	0	0
	25th	0	1.5	0	0	0
	50th	1.6	3.7	0	0	0
	75th	3.6	7.5	0	0	0.01
	90th	8.9	11.3	0	0.02	0.5
	95th	17.1	14.7	0.5	0.07	0.9

[a] These numbers do not include the measurements from the days (5 days) when children consumed organic diets.

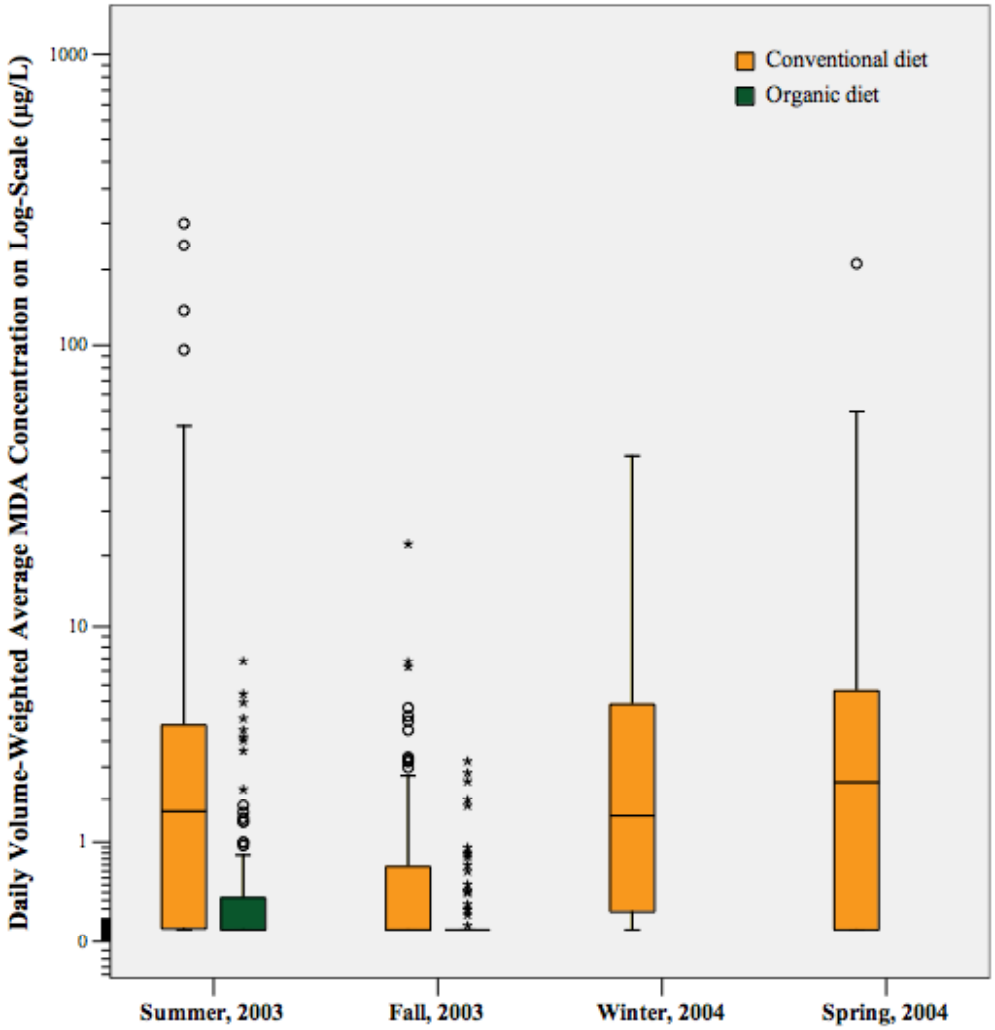
The exposure profile of Malathion for CPES-WA children in the summer '03 season as measured by the DVWA of urinary MDA concentrations (µg/L)



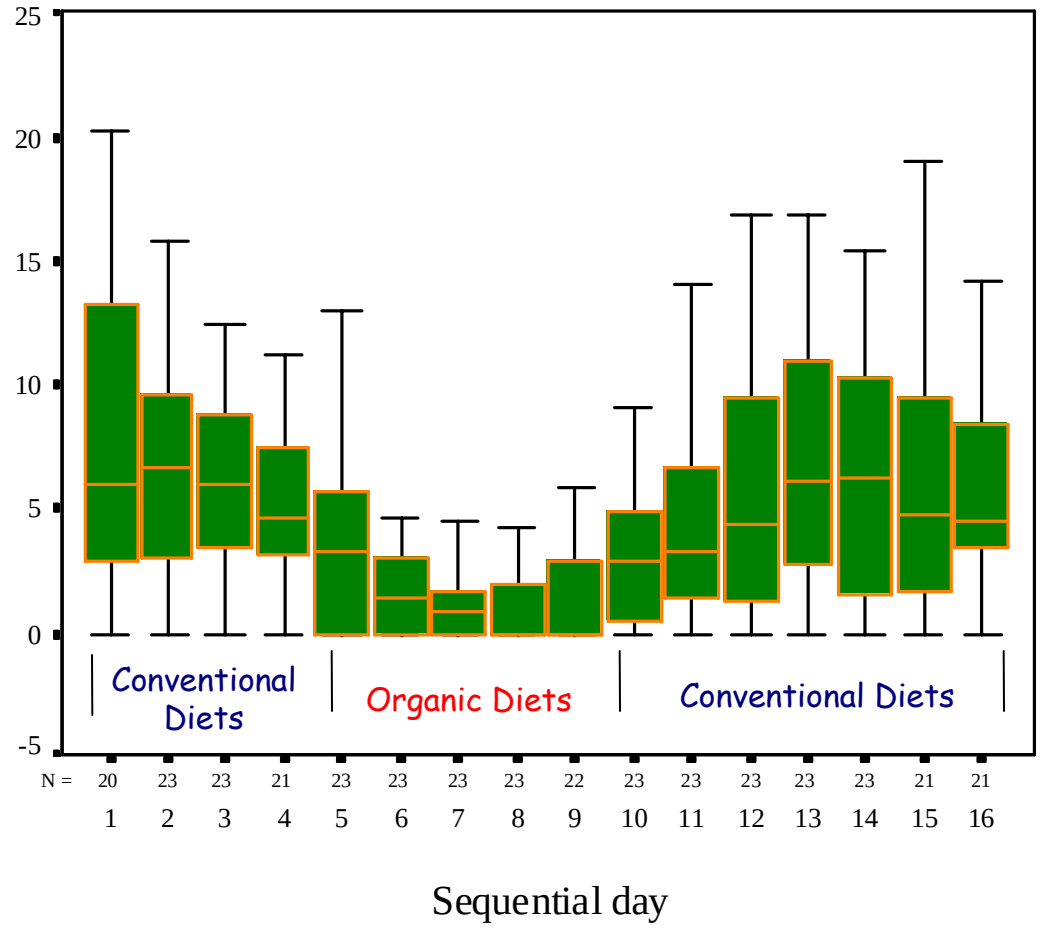
One-year exposure profile of Malathion for CPES-WA children as measured by the DVWA of urinary MDA concentrations (µg/L)



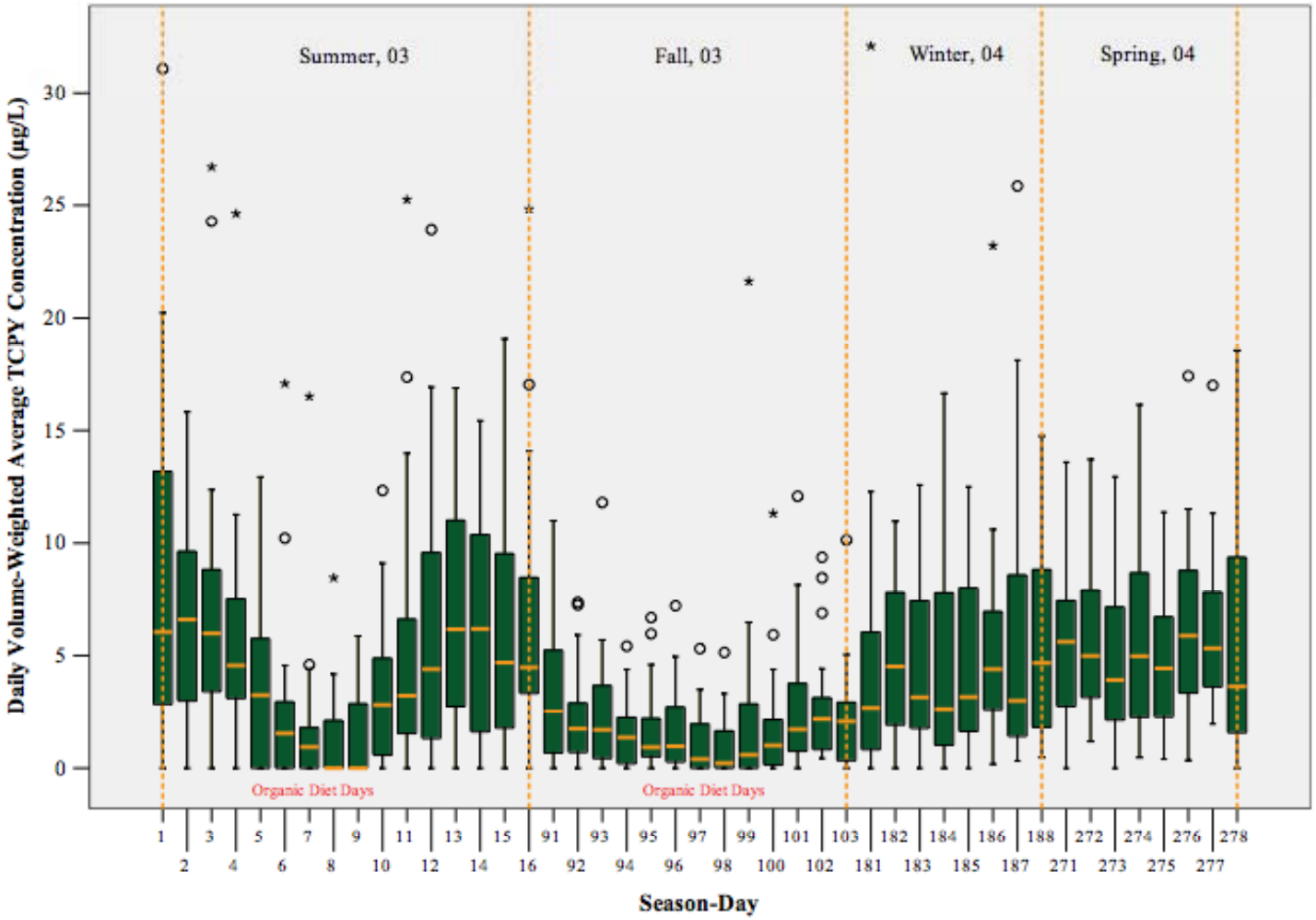
The distribution of the DVWA of urinary MDA concentrations (μg/L) in the CPES-WA children grouped by the consumption of conventional or organic food in four seasons



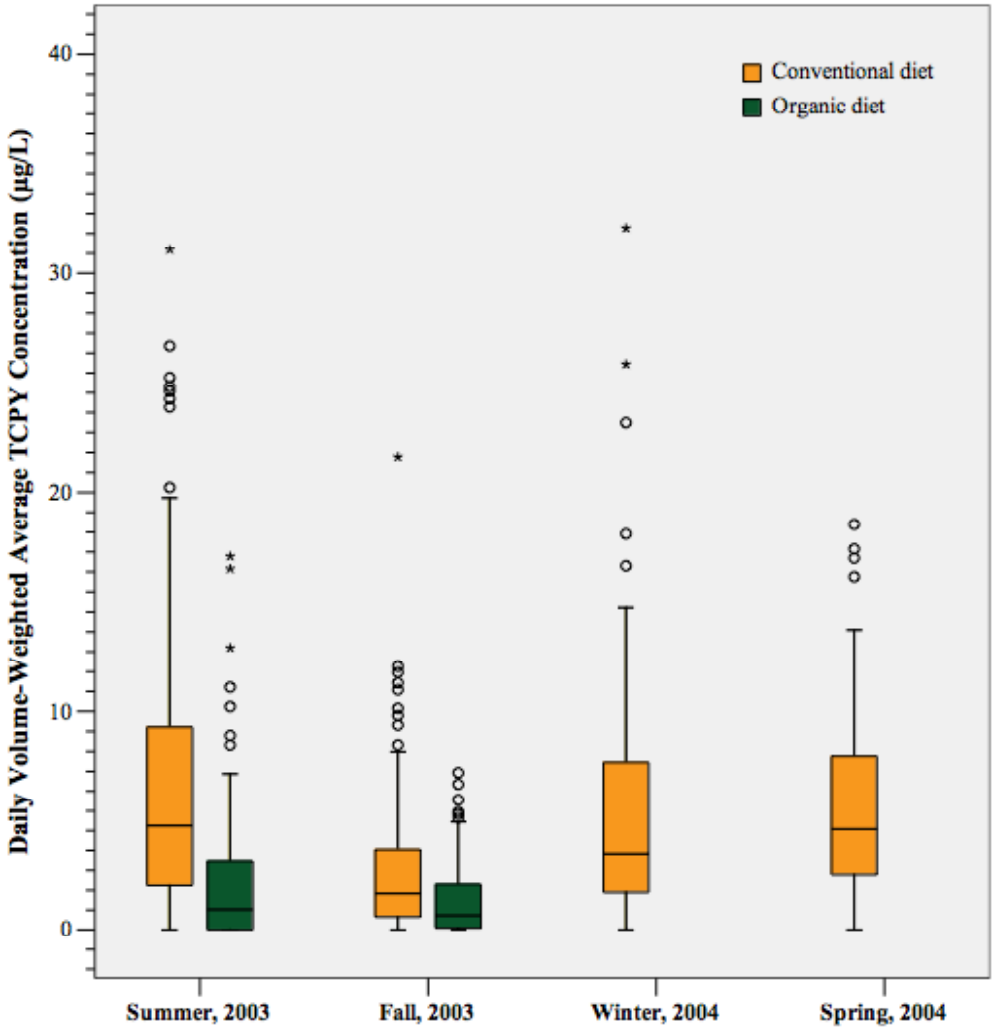
The exposure profile of Chlorpyrifos for CPES-WA children in the summer '03 season as measured by the DVWA of urinary TCPY concentrations (µg/L)



One-year exposure profile of Chlorpyrifos for CPES-WA children as measured by the DVWA of urinary TCPY concentrations (µg/L)



The distribution of the DVWA of urinary TCPY concentrations (μg/L) in the CPES-WA children grouped by the consumption of conventional or organic food in four seasons



The linear mixed-effect models for the repeated measurement of urinary DVWA of MDA and TCPY concentrations (μg/L) for CPES-WA children

		MDA		TCPY	
Source	Numerator df [a]	Denominator df [a]	F-value (Pr [b] > F)	Denominator df [a]	F-value (Pr [b] > F)
Intercept	1	121	0.01 (0.9)	145	5.8 (0.03)
Season	3	685	**4.2 (< 0.01)** [c]	680	**21.9 (< 0.01)** [c]
Age	1	15	0.6 (0.7)	14	0.4 (0.9)
Gender	1	17	0.8 (0.4)	19	0.1 (0.7)

[a] degree of freedom

[b] probability

[c] linear mixed-effect model using repeated measurement

Consumption of major fruit, fruit juice, and vegetable items by CPES-WA children in 2003/2004

	Summer '03	Fall '03	Winter '04	Spring '04
Fruits	**318[a] (1.38[b])**	**155 (1.05)**	**154 (1.10)**	**167 (1.26)**
apples	56 (0.24)	50 (0.34)	46 (0.33)	29 (0.22)
blueberries[c]	28 (0.12)	0 (0)	1 (0.01)	2 (0.02)
cantaloupe	25 (0.11)	9 (0.06)	6 (0.04)	12 (0.09)
grapes	43 (0.19)	20 (0.14)	24 (0.17)	11 (0.08)
organes	11 (0.05)	20 (0.14)	21 (0.15)	16 (0.12)
peaches	13 (0.06)	1 (0.01)	1 (0.01)	4 (0.02)
pears	4 (0.02)	12 (0.08)	5 (0.04)	3 (0.02)
plums[c]	10 (0.04)	2 (0.01)	2 (0.01)	0 (0)
raspberries[c]	14 (0.06)	1 (0.01)	1 (0.01)	2 (0.02)
strawberries	20 (0.09)	2 (0.01)	16 (0.11)	39 (0.29)
watermelon[c]	26 (0.11)	2 (0.01)	2 (0.01)	11 (0.08)
sub-total	*250 (1.09)*	*119 (0.81)*	*125 (0.89)*	*129 (0.97)*
Fruit Juices	**194 (0.84)**	**90 (0.61)**	**114 (0.81)**	**101 (0.76)**
apple juice[c]	24 (0.10)	21 (0.14)	23 (0.16)	22 (0.17)
lemonade[c]	30 (0.13)	2 (0.01)	4 (0.03)	5 (0.04)
orange juice	63 (0.27)	32 (0.22)	40 (0.29)	24 (0.18)
sub-total	*117 (0.5)*	*55 (0.37)*	*67 (0.48)*	*51 (0.39)*
Vegetables	**189 (0.82)**	**146 (0.99)**	**128 (0.91)**	**116 (0.87)**
cucumber	8 (0.03)	4 (0.03)	4 (0.03)	1 (0.01)
lettuce	17 (0.07)	16 (0.11)	19 (0.14)	11 (0.08)
mixed salad[c]	12 (0.05)	7 (0.05)	10 (0.07)	8 (0.06)
peas[c]	14 (0.06)	10 (0.07)	5 (0.04)	12 (0.09)
spinach	5 (0.02)	6 (0.04)	2 (0.01)	2 (0.02)
tomato	9 (0.04)	5 (0.03)	8 (0.06)	4 (0.03)
sub-total	*65 (0.28)*	*48 (0.33)*	*48 (0.34)*	*38 (0.29)*
Total Consumption	***701 (3.05)***	***391 (2.66)***	***396 (2.83)***	***384 (2.89)***

[a] total consumption count.

[b] consumption count per child per day.

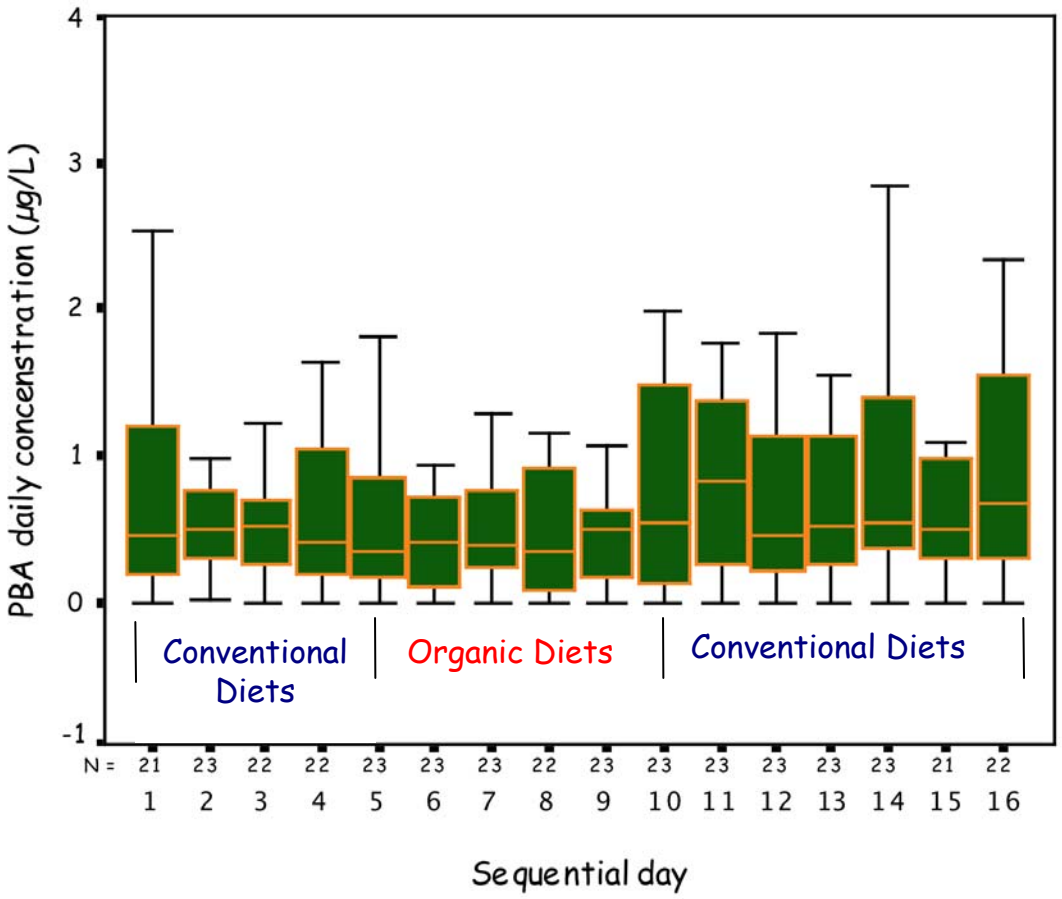
[c] commodity that were not analyzed by USDA PDP for pesticide residues in 2004.

Descriptive statistics of DVWA concentrations of pyrethroid insecticide metabolites measured in CPES-WA children from summer 2003 to spring 2004

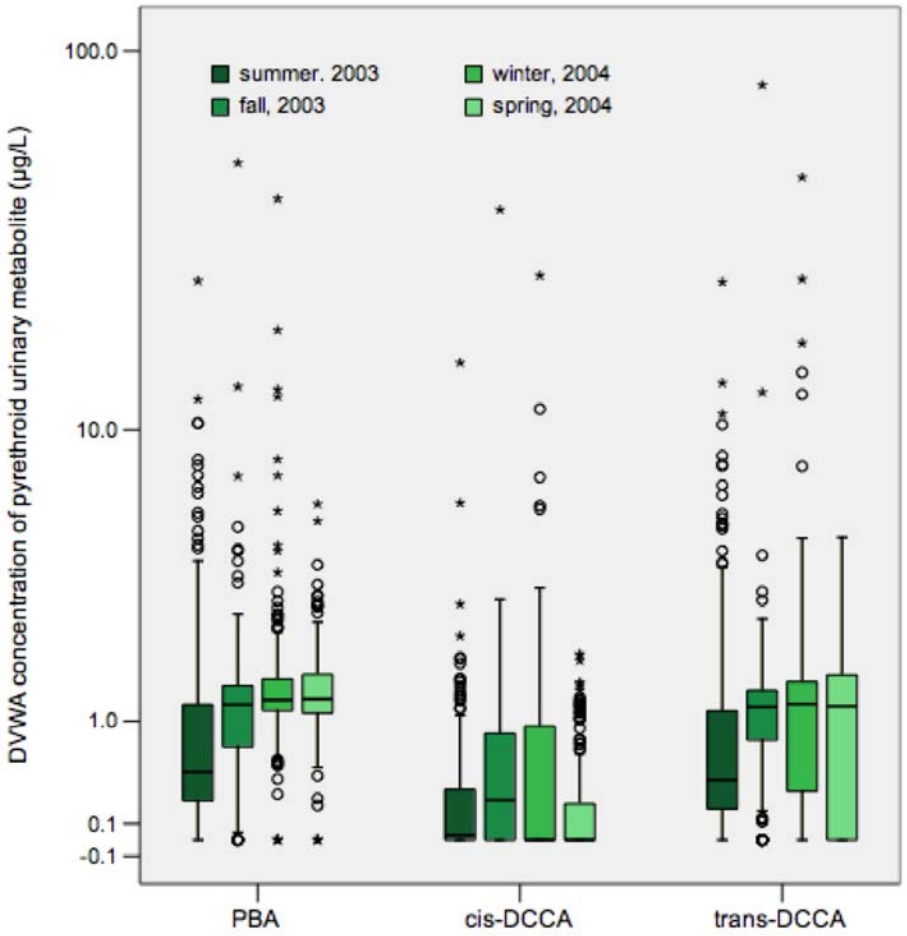
		PBA	*trans*-DCCA	*cis*-DCCA	FPBA	DBCA
Mean (µg/L)		1.5	1.4	0.5	0.2	0.007
St. Dev.		3.1	4.1	2.0	0.4	0.03
N (DVWA Measurement[a])		706	706	706	706	706
Range (µg/L)		(0, 51.4)	(0, 81.6)	(0, 38.8)	(0, 3.5)	(0, 0.2)
LOD (µg/L)		0.1	0.4	0.2	0.2	0.1
Frequency of Detection (%)		94	83	44	19	6
Percentile	5th	0	0	0	0	0
	10th	0.2	0	0	0	0
	25th	0.5	0.3	0	0	0
	50th	1.2	1.0	0	0	0
	75th	1.5	1.5	0.7	0	0
	90th	2.6	2.3	1.1	0.9	0
	95th	4.1	3.7	1.4	1.2	0.04

[a] These numbers do not include the measurements from the days (5 days) when children consumed organic diets.

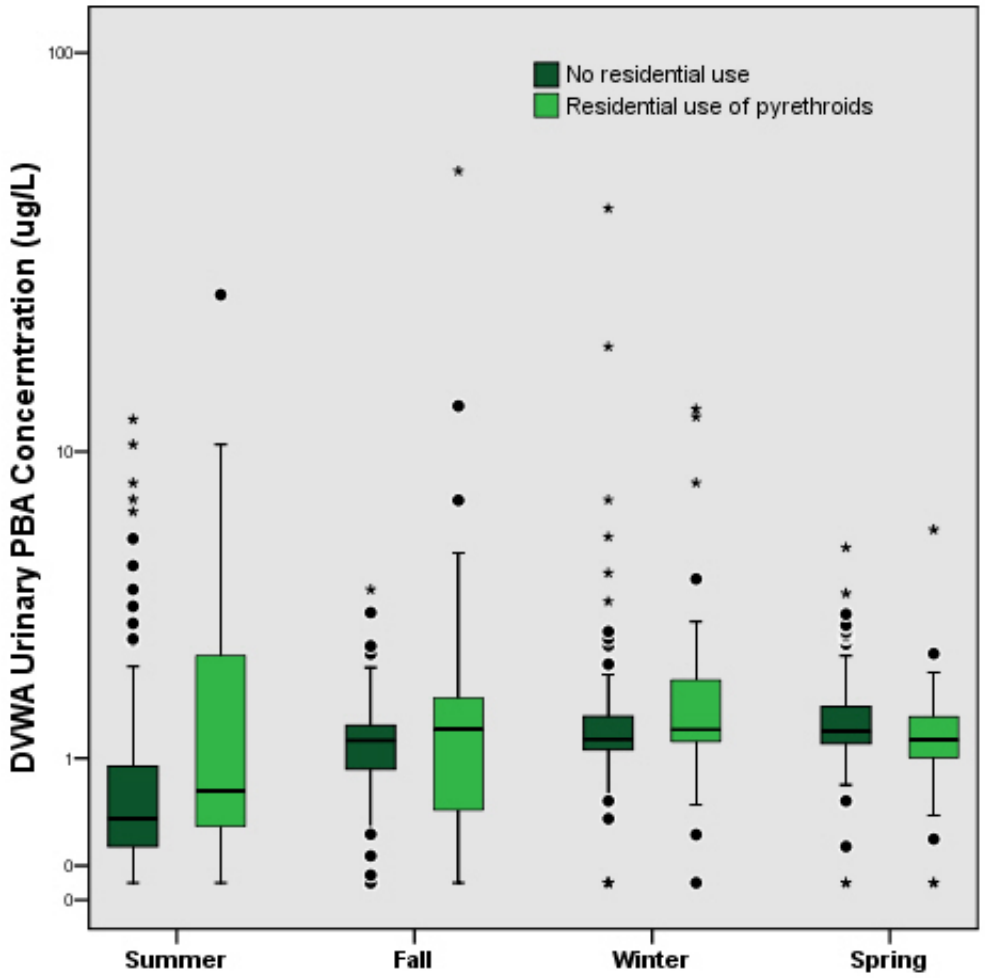
The exposure profile of pyrethroid insecticides for CPES-WA children in the summer '03 season as measured by the DVWA of urinary PBA concentrations (μg/L)



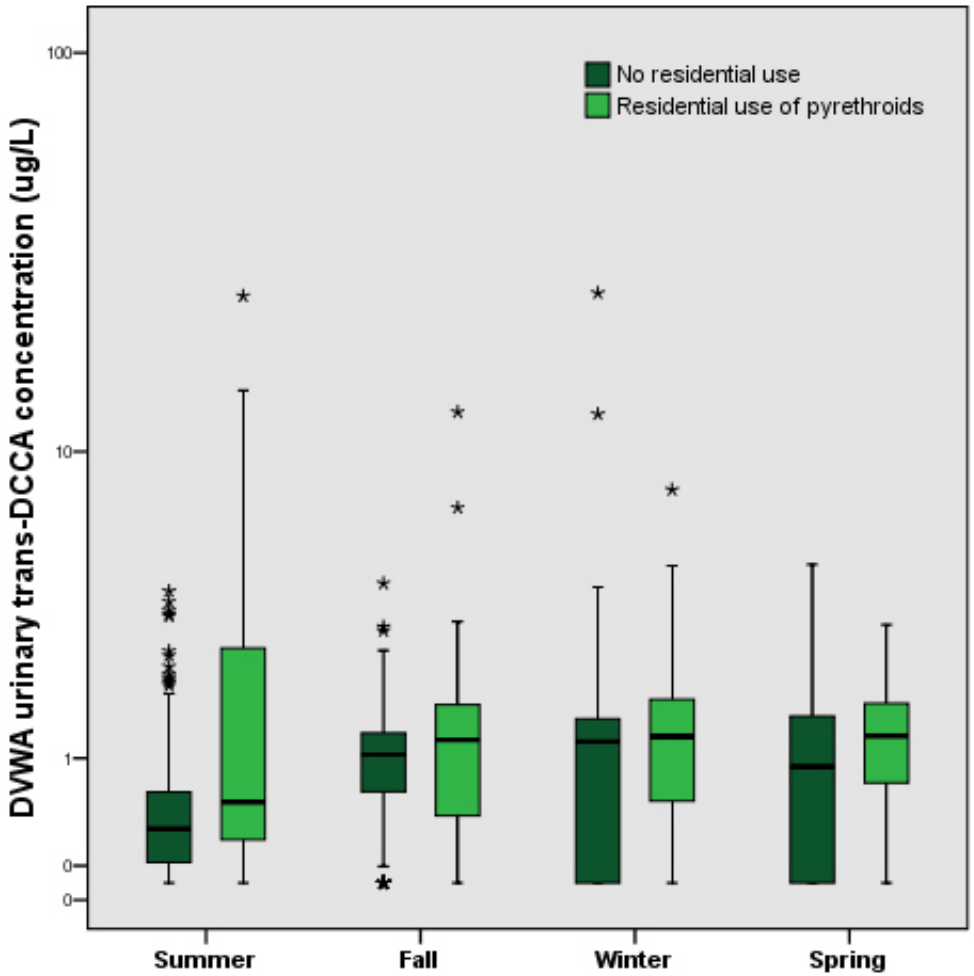
The seasonal distribution of the DVWA of urinary PBA, *trans*-DCCA and *cis*-DCCA concentrations (μg/L) in the CPES-WA children



The distribution of the DVWA of urinary PBA concentrations (μg/L) in the CPES-WA children grouped by the self-reported residential use of pyrethroid insecticides in four seasons



The distribution of the DVWA of urinary *trans*-DCCA concentrations (μg/L) in the CPES-WA children grouped by the self-reported residential use of pyrethroid insecticides in four seasons



The linear mixed-effect models for the repeated measurement of urinary DVWA of PBA and *trans*-DCCA concentrations (μg/L) for CPES-WA children

		PBA		*trans*-DCCA	
Source	Numerator df [a]	Denominator df [a]	F-value (Pr [b] > F)	Denominator df [a]	F-value (Pr [b] > F)
Intercept	1	98	0.05 (0.8)	145	<0.01 (0.95)
Season	3	672	**3.7 (< 0.01)** [c]	654	**2.5 (0.06)** [d]
Age	1	19	0.3 (0.6)	20	0.4 (0.6)
Gender	1	19	0.2 (0.7)	20	0.2 (0.6)
Residential Use (RU)	1	469	2.2 (0.14)	355	**4.5 (0.04)** [c]
Diet	1	673	<0.01 (0.99)	676	<0.01 (0.9)
Age*Gender	1	19	1.4 (0.3)	20	1.5 (0.2)
RU*Season	3	670	**2.3 (0.08)** [d]	652	**2.2 (0.09)** [d]

[a] degree of freedom
[b] probability
[c] linear mixed-effect model using repeated measurement
[d] marginal significant (linear mixed-effect model using repeated measurement)

Self-reported use of pyrethroid pesticides by the parents, and the numbers of days in which children's urinary metabolite concentrations of pyrethroid insecticides exceeded the median DVWA levels.

Child Age	Pyrethroids use	Location of use	Numbers of days of DVWA exceeded the median levels				
			PBA	FPBA	*cis*-DCCA	*trans*-DCCA	DBCA[1]
10	Ortho (permethrin)	Home (inside)	3	8	1	2	0
8	Green Light (permethrin and others)	Garden	15	4	7	15	11[2]
7	Terminix (permethrin)	Crawl space	10	1	3	9	3[2]
6	Pyrethroids E.C.	Deck	5	0	1	5	0
8	Hot Shot fogger (tetramethrin /permethrin)	Home (inside)	16	2	16	16	0
4	RID (permethrin)	Bedding/ Furniture	7[2]	1	6[2]	6[2]	0
11	Hartz (pyrethrin piperony butoxides) RID (permethrin)	Carpet Dog Cat	16	1	16	16	2[2]

[1] All the urine samples with detectable levels were collected from children listed in this table.

[2] One of the urine samples has the highest level of the pyrethroid metabolites among the 724 urine samples collected.

Conclusions

- Most likely that dietary intake of OP pesticides contribute the majority of exposure in urban/suburban children,
  - Due to the lack of residential uses,
    - The registration change made by U.S. EPA in 2001 prohibits the sales and uses of most OPs in the residential environment.
  - Due to the increasing use of OP in agriculture evident by the annual pesticide use survey conducted by US Department of Agriculture Pesticide Data Program (PDP).

Conclusions

- Dietary pesticide exposure correlates with seasonal food consumption patterns,
  - Urinary metabolite levels rose in the summer when consumption of fresh produces increased,
  - The opposite (lower consumption) was seen in the fall season,
  - The elevated urinary OP metabolite levels measured in the following winter and spring seasons require further attention,
    - Domestic vs. Imported foods

Conclusions

- Although dietary intake attribute certain portion of the total pyrethroid insecticide exposure, residential use of pyrethroid insecticide is the most significant risk factor for urban/suburban children.

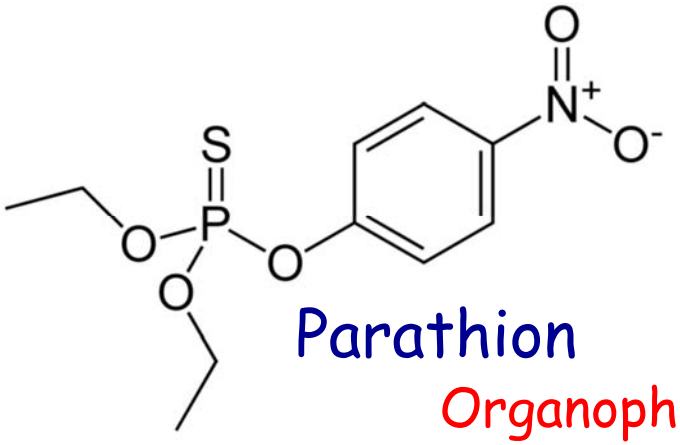
Conclusions

- Significant elevated urinary PBA, *trans*-DCCA, and *cis*-DCCA levels were found in 7 children whose parents reported uses of pyrethroid insecticides in the households,
  - The highest levels of metabolites were measured in those children,
  - Organic diets can only reduce total exposure to as much as 50%,
  - Seasonal dietary intakes did not modify the levels measured in the summer and fall seasons when residential use is common.

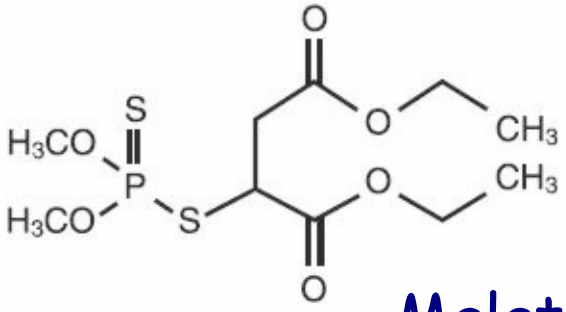
Conclusions

- Longitudinal exposure data using biomarker approach identify risk factors that otherwise would be omitted in the cross-sectional data,
  - Seasonal exposure patterns associated with sources of foods;
- Longitudinal data could strengthen the conclusion made by cross-sectional measurements,
  - The attribution of residential use;
- Longitudinal data would minimize measurement errors that could lead to biased conclusion,
  - The association of children's age and gender to the total pesticide exposures.

Pesticide Exposure and Chronic Health Effects

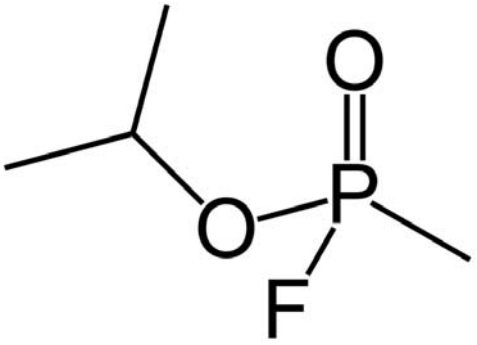


Parathion



Malathion

Organophosphate (OP) Pesticides



Sarin (nerve gas)

Pesticide Exposure and Chronic Health Effects

- Neurodegenerative diseases
  - Commonly used insecticides, such as OPs and pyrethroids, acted on central nerve system in insects,
  - Recent environmental epidemiological studies suggest the association with Parkinson's (OP pesticides) and Autism (pyrethroids)

Pesticide Exposure and Chronic Health Effects

- Neurodegenerative diseases
- Endocrine Disrupting
  - Due to chemical-structural similarity, several herbibcides and pyrethroids have long been suspected as endocrine disrupting chemicals,
  - Atrazine caused deformities in amphibian

Pesticide Exposure and Chronic Health Effects

- Neurodegenerative diseases
- Endocrine Disrupting
- Cancer
  - Most of pesticides are not carcinogenic
  - Many cancers thought to be genetic related, are now focusing on the interaction with environmental factors (exposure)
    - Gene-Environmental Interaction
    - Epigenetics

Pesticide Exposure and Chronic Health Effects

- Neurodegenerative diseases
- Endocrine Disrupting
- Cancer
- Mostly unknown

Pesticide Exposure and Chronic Health Effects

- Mostly unknown, because
  - Acute health effect (self-harm) usually not a concern in developed and developing countries,
  - Chronic health end points rarely incorporated in toxicological studies,
  - Lacking longitudinal exposure assessment at the population levels,
  - Epidemiological studies lack of
    - Sufficient scientific evidence for the causation
    - Statistical power to eliminate confounding factors and background noise

Why Minimizing Pesticide Exposure Critical to Reducing Disease Burden ?

- Its acute lethal toxicity by design,
  - The toxicity at the sub-lethal dose unknown;
- Its common exposure pattern,
  - Dietary exposure constitutes the baseline,
  - Modified by periodic elevated exposure from other pathways;
- Its synergistic interaction with other environmental chemicals in causing adverse health effects?

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- Children and parents who participated in this study.