Organophosphate Pesticide Exposure and Work in Pome Fruit: Evidence for the Take-Home Pesticide Pathway

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Organophosphate (OP) pesticides are commonly used in the United States, and farmworkers are at risk for chronic exposure. Using a sample of 218 farmworkers in 24 communities and labor camps in eastern Washington State, we examined the association between agricultural crop and OP pesticide metabolite concentrations in urine samples of adult farmworkers and their children and OP pesticide residues in house and vehicle dust samples. Commonly reported crops were apples (71.6%), cherries (59.6%), pears (37.2%), grapes (27.1%), hops (22.9%), and peaches (12.4%). Crops were grouped into two main categories: pome fruits (apples and pears) and non-pome fruits. Farmworkers who worked in the pome fruits had significantly higher concentrations of dimethyl pesticide metabolites in their urine and elevated azinphos-methyl concentrations in their homes and vehicles than workers who did not work in these crops. Among pome-fruit workers, those who worked in both apples and pears had higher urinary metabolites concentrations and pesticide residue concentrations in dust than did those who worked in a single pome fruit. Children living in households with pome-fruit workers were found to have higher concentrations of urinary dimethyl metabolites than did children of non-pome-fruit workers. Adult urinary concentrations showed significant correlations with both the vehicle and house-dust azinphos-methyl concentrations, and child urinary concentrations were correlated significantly with adult urinary concentrations and with the house-dust azinphos-methyl concentration. The results provide support for the take-home pathway of pesticide exposure and show an association between measures of pesticide exposure and the number of pome-fruit crops worked by farmworkers. *Key words:* children of farmworkers, contamination, crops, farmworkers, house dust, occupational exposure, pesticides, take-home pathway, urinary metabolites, vehicle dust, WinBUGS. *Environ Health Perspect* 114:999–1006 (2006). doi:10.1289/ehp.8620 available via *http://dx.doi.org/* [Online 13 March 2006]

DEPT MEETING
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Organophosphate (OP) pesticides

Acute Exposure, Acute Health Effect: Well characterized

Acute Exposure, long-term health effect ??
Chronic Exposure, long-term health effect ??

? → Deficits in verbal and visual attention
Motor dexterity
Confusion, Lapses in memory, Leukemia,
Lung cancer

Intro-2

Transfer coefficients: the estimated amount of pesticide exposure

By Crops

Thinner > whose who harvest, prune, weed ..

Transfer coefficients
Total amount of pesticide
Time of application
Number of crops

Pesticide exposure among children of farmworkers?

(National Research Council, 1993)

Pesticide exposure among children

-Direct

-Take-home pathway

↑

Children usually wear minimal clothing

Children often play on the floor

Fensk et al. (2000)

Children of agricultural workers: urinary metabolites ↑

Lambert et al. (2000)

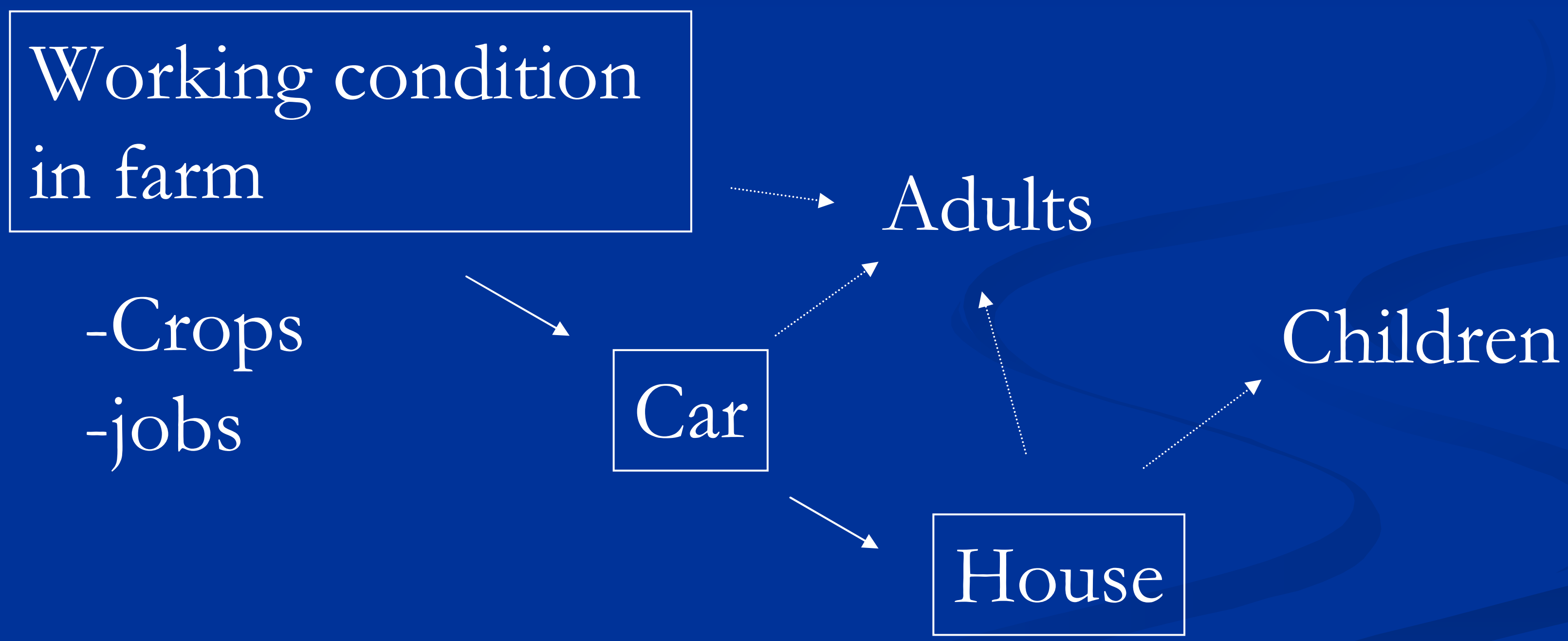
Children of agricultural workers who work in pear : urinary metabolites ↑

Curl et al. (2000)

Urinary metabolites of Children and that of adults in the same household: Correlated

Few investigation of house dust

Using a large sample in Washington State,



Materials and methods-8

Setting

- Yakima valley of Washington State
- 50000 agricultural workers
- Apples, pears, cherries, hops, peaches
- 50%=Hispanic

Materials and methods-9

In Yakima county, Washington State in 1999,

-75,264 acres: apples

-10,190 acres: pears

-6,129 acres: cherries

-1,438 acres: peaches

-20,061 acres: hops

-15,529 acres: grape

Materials and methods-10, 11

OP pesticides: Table 1

Table 1. Limits of detection of pesticide residues in dust (μg/g) and percentages of analyzed vehicle (*n* = 190) and house-dust samples (*n* = 156) containing detectable levels of pesticide residue.

	Azinphos-methyl	Phosmet	Malathion	Methyl-parathion	Chlorpyrifos	Diazinon
Limit of detection (μg/g)	0.08	0.08	0.13	0.11	0.11	0.11
Vehicle dust (%)	87	16	12	22	18	2
House dust (%)	85	15	13	14	26	4

Minimum interval=14 days

Max application amount: 8 pounds/a/y apple, 6 pounds/a/y pears, less for other crops

Materials and methods-12

Questionnaire

73 item

-Crops that the workers worked in for the last 3 months
-Jobs for the last 3 months
- in Spanish

Survey procedures

N=571 HH (recruit from the previous survey, recruit in farm camps)

218 HH with 2-6 years children

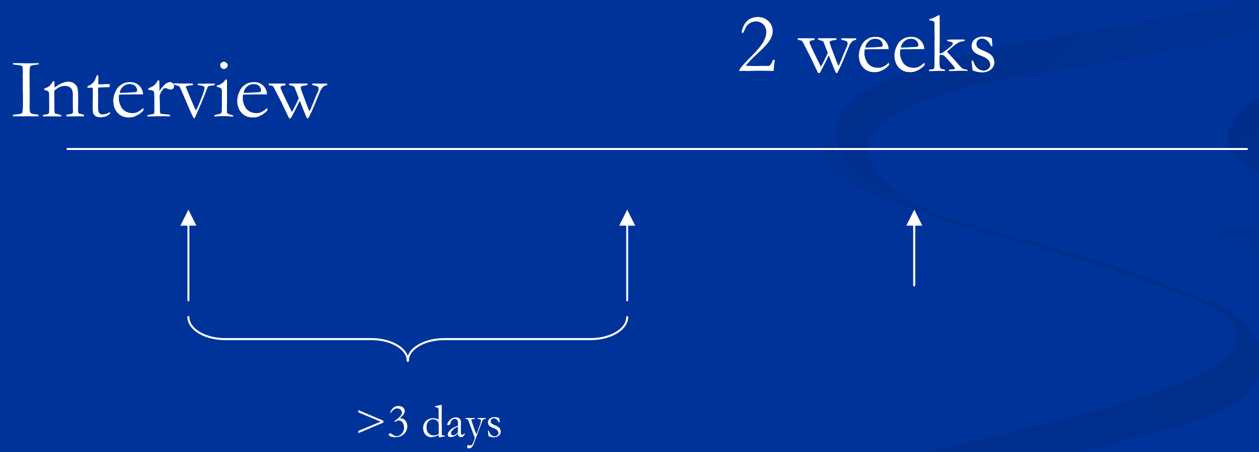
Materials and methods-14

Urine for a worker and his/her child
Dust on the floor of the house
Dust in the vehicle

June-October 1999

Materials and methods-15

2-3 spot urine samples: combined



Materials and methods-16

Gas chromatography was used for the detection of 5 pesticide metabolites:

Dimethylphosphate (DMP): 7.2 μ g/L -DL
Dimethylthiophosphate (DMPT): 1.1 μ g/L
Dimethyldithiophosphate (DMDTP): 0.65 μ g/L
Diethylphophate: 2.9 μ g/L
Diethylthiophosphate: 1.2 μ g/L

Materials and methods-17

Dust samples

Home

- 1m × 1m plush carpets

-2m × 2m hard/smooth floor

Car

- footwells

6 of OP pesticides: Table 1

Materials and methods-18

Pome fruits: apple, pears

Non-Pome fruits: others

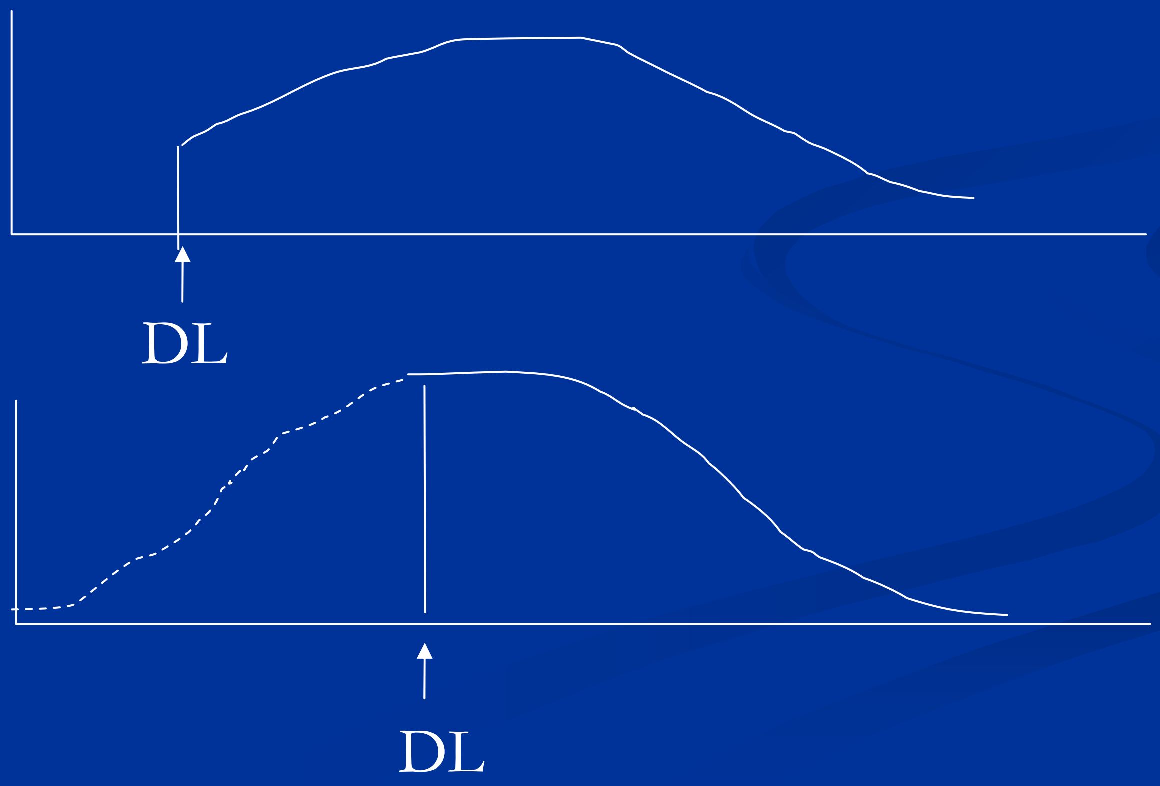
Pome fruits workers: Pome + the others

Non-Pome fruits workers: Non-Pone fruits

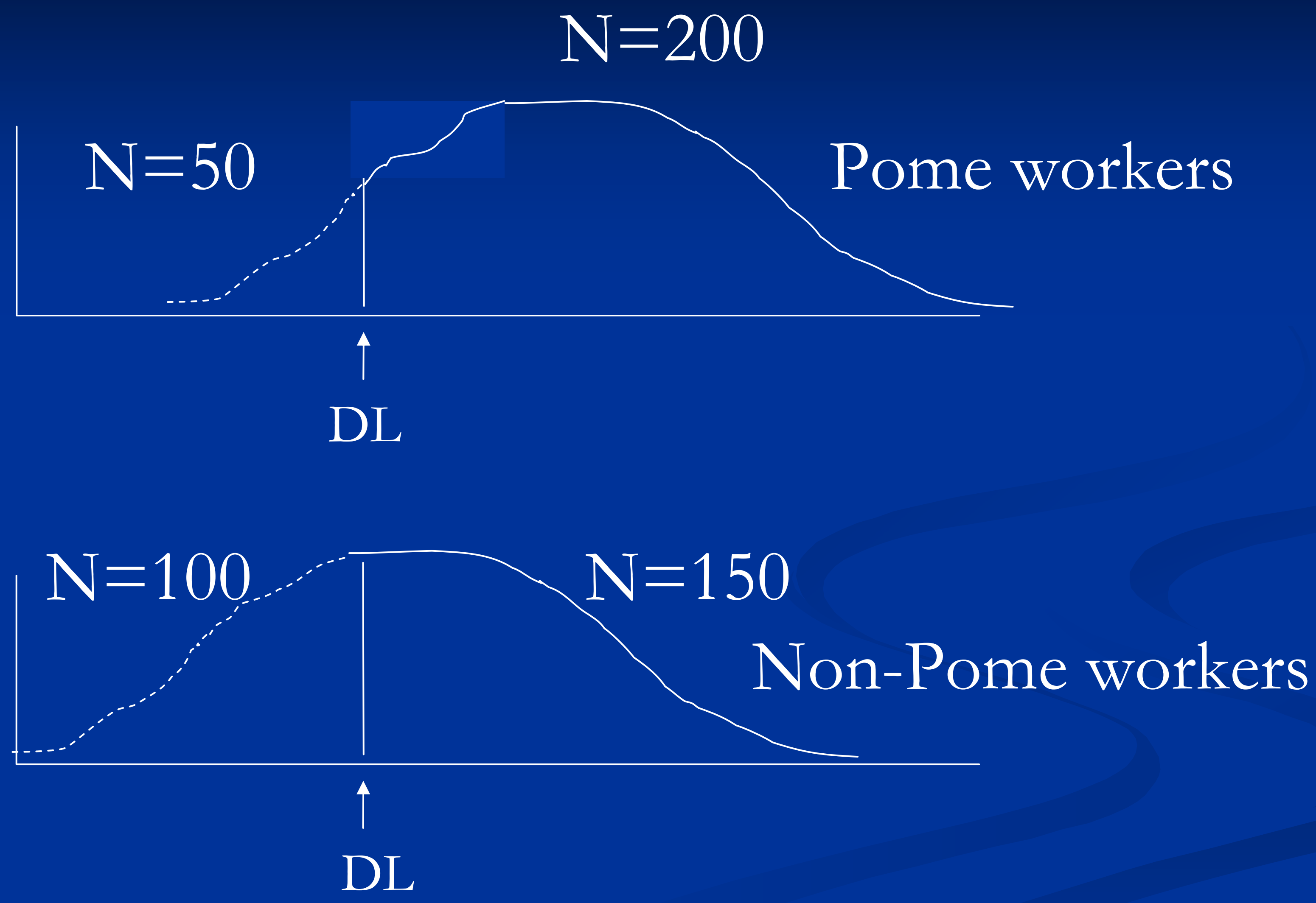
Geometric Means and SDs
No creatinine adjustment

<Detection limit (DL)

- replace with figure of DL, or
- replace with 0



Materials and methods-20



25000 simulations

Results-21

213 urine samples of adults
211 urine samples of children
156 samples of house dust
190 samples of vehicle dust

Results-22, 23

Table 2. Crops in which study participants (n = 218) reported performing agricultural job tasks within the previous 3 months.

	Apples	Pears	Peaches	Cherries	Grapes	Hops	Other
Apples	156[a]						
Pears	79	81					
Peaches	27	24	27				
Cherries	105	62	17	130[a]			
Grapes	41	18	6	32[a]	59		
Hops	31[a]	16	7	24	20	50	
Other	39	21	11	36	12	13	63[a]

[a]No answer was recorded for three different farmworkers as to whether or not they worked in apples, cherries, or other crops, respectively. For these cross-tabulations, n = 217.

>1/3 : apple
1/3 : pears
2/3 : cherries
1/10 : grapes, hops

Apple greatly overlapped with pears and peaches

Results-24

Table 3. Demographic characteristics of study participants (%): selected adult farmworkers with a child 2–6 years of age in the household by pome/non-pome crop classification ($n = 217^a$).

Characteristic	Non-pome ($n = 59$)	Pome ($n = 158$)	One pome ($n = 79$)	Two pome ($n = 79$)
Age (years)				
18–24	15.3	8.9	7.6	10.1
25–34	47.5	41.1	46.8	35.4
35–49	23.7	28.5	24.1	32.9
≥ 50	5.1	5.1	6.3	3.8
Not reported	8.5	16.5	15.2	17.7
Education				
< 4th grade	25.4	32.3	27.8	36.7
5th through 8th	35.6	41.1	41.8	40.5
9th through 12th	32.2	21.5	22.8	20.3
≥ High school graduate	6.8	5.1	7.6	2.5
Annual household income (US$)				
< 10,000	18.6	21.5	19.0	24.1
10,000 < 15,000	22.0	29.1	29.1	29.1
15,000 < 25,000	49.2	37.3	38.0	36.7
≥ 25,000	10.2	10.1	11.4	8.9
Not reported	0.0	1.9	2.5	1.3
Marital status				
Married or living as married	86.4	88.6	91.1	86.1
Separated or divorced	3.4	2.6	2.5	2.5
Never married	10.2	8.2	6.3	10.1
Other	0.0	0.6	0.0	1.3
Birthplace				
Mexico	83.1	94.9	93.7	96.2
United States	15.3	3.8	5.1	2.5
No. of years working in agriculture				
< 10	45.8	48.1	53.2	43.0
10– < 20	28.8	31.0	22.8	39.2
≥ 20	25.4	20.9	24.1	17.7
Male sex	57.6	67.7	64.6	70.9
Interview in Spanish	86.4	94.3	92.4	96.2

[a]Total $n = 217$ because of one pome classification missing value.

Results-25

<u>8 adults</u> had higher DMP by orders:

3780-12000 μg/ml

Cf. the others: DL～100 μg/ml

→ Work in apples, 4 work in pears

7 were thinner

A. Analysis for all the subjects (incl above 8)

B. Analysis for all but above 8 subjects

→ Similar results　　Table 4 ～B

Results-26, 27

%detection
μ g/L

Pome > Non-Pome
2 Pomes > 1 Pomes

Adult = Child

Table 4. Frequency of detection and estimated GM concentrations of dimethyl urinary metabolites among adult farmworkers and their children, by agricultural crop ($n = 210$).

Metabolite and crop	Detection[a] (%)	Estimated[b] GM (μg/L)	Estimated[b] GSD	$p(\text{pome}_{GM} \le \text{non-pome}_{GM})$
Adult DMP			5.96 (4.02–10.74)	
Non-pome fruit	8.8	0.71 (0.20–1.68)		0.017
Pome fruit	20.4	1.72 (0.80–2.89)		
Apples or pears	14.7	1.19 (0.42–2.45)		
Apples and pears	26.4	2.22 (0.97–4.00)		
Adult DMTP			4.48 (3.90–5.29)	
Non-pome fruit	86.0	4.35 (2.92–6.47)		0.000
Pome fruit	96.6	15.34 (12.02–19.54)		
Apples or pears	94.7	13.42 (9.55–18.93)		
Apples and pears	98.6	17.52 (12.41–24.83)		
Adult DMDTP			6.72 (5.34–8.91)	
Non-pome fruit	36.8	0.47 (0.26–0.81)		0.001
Pome fruit	61.2	1.37 (0.97–1.90)		
Apples or pears	60.0	1.19 (0.74–1.88)		
Apples and pears	62.5	1.58 (0.98–2.49)		
Child DMP			2.84 (2.28–3.91)	
Non-pome fruit	7.1	1.34 (0.59–2.39)		< 0.001
Pome fruit	22.5	3.53 (2.40–4.65)		
Apples or pears	18.9	3.06 (1.87–4.38)		
Apples and pears	26.0	3.96 (2.54–5.49)		
Child DMTP			3.61 (3.19–4.20)	
Non-pome fruit	78.6	3.54 (2.50–4.98)		0.003
Pome fruit	91.2	6.18 (5.00–7.61)		
Apples or pears	93.2	5.76 (4.29–7.76)		
Apples and pears	89.0	6.61 (4.89–8.90)		
Child DMDTP			4.83 (3.90–6.30)	
Non-pome fruit	41.1	0.65 (0.39–1.03)		0.061
Pome fruit	46.3	0.98 (0.71–1.30)		
Apples or pears	40.5	0.88 (0.58–1.32)		
Apples and pears	52.1	1.08 (0.71–1.59)		

GSD, geometric SD. Ranges are posterior predictive probability intervals.
[a]Based on the number of samples analyzed: non-pome, adult $n = 57$, child $n = 56$; apples or pears, adult $n = 75$, child $n = 74$; apples and pears, adult $n = 72$, child $n = 73$. [b]Based on the total number of samples: non-pome, $n = 59$; apples or pears, $n = 75$; apples and pears, $n = 75$; missing fruit classification, $n = 1$.

Results-28

Table 5. Frequency of detection and estimated GM concentrations and geometric standard deviations (GSDs) of azinphos-methyl residues in vehicle and house dust ($n = 210$).

Pesticide and crop	Detection[a] (%)	Estimated[b] GM (µg/g)	Estimated[b] GSD	$p(\text{pome}_{GM} \leq \text{non-pome}_{GM})$
Vehicle azinphos-methyl			4.65 (3.97–5.61)	
Non-pome fruit	63.5	0.17 (0.11–0.26)		< 0.001
Pome fruit	95.4	1.16 (0.89–1.51)		
Apples or pears	94.1	0.78 (0.54–1.11)		
Apples and pears	96.8	1.79 (1.24–2.58)		
House azinphos-methyl			3.55 (3.07–4.25)	
Non-pome fruit	62.5	0.17 (0.11–0.25)		< 0.001
Pome fruit	92.7	0.79 (0.63–1.00)		
Apples or pears	90.7	0.59 (0.43–0.82)		
Apples and pears	94.6	1.05 (0.76–1.45)		

Ranges are posterior predictive probability intervals.
[a]Based on the number of samples analyzed: non-pome, vehicle $n = 52$, house $n = 40$; apples or pears, vehicle $n = 68$, house $n = 54$; apples and pears, vehicle $n = 62$, house $n = 55$. [b]Based on the total number of samples: non-pome, $n = 59$; apples or pears, $n = 75$; apples and pears, $n = 75$; plus one sample with missing fruit classification.

Pome > Non-Pome

2 Pomes > 1 Pomes

Results-29

Table 6. Correlation matrix of dimethyl phosphate urinary metabolite concentrations and azinphos-methyl residue concentrations in vehicle and house dust (n = 210).

Metabolite or pesticide	Adult			Child			Azinphos-methyl	
	DMP	DMTP	DMDTP	DMP	DMTP	DMDTP	Vehicle	House
Adult DMP	1.00							
Adult DMTP	0.51*	1.00						
Adult DMDTP	0.35*	0.73*	1.00					
Child DMP	0.20	0.12	0.12	1.00				
Child DMTP	0.21*	0.34*	0.22*	0.53*	1.00			
Child DMDTP	0.13	0.34*	0.37*	0.39*	0.81*	1.00		
Vehicle azinphos-methyl	0.28*	0.22*	0.13	0.10	0.15	0.09	1.00	
House azinphos-methyl	0.32*	0.25*	0.09	0.25*	0.24*	0.16	0.52*	1.00

*Statistically significant: 95% posterior predictive probability interval does not include 0.0.

Among metabolites
Between adult and child
Between urine and dust

Results-30

No effect of thinning

Table 7. Frequency of detection and estimated GM concentrations of dimethyl urinary metabolites among adult farmworkers and their children, by agricultural crop ($n = 210$).

Metabolite and pome versus thin	Detection[a] (%)	Estimated[b] GM (μg/L)	$p(\text{thin}_{GM} \le \text{non-thin}_{GM})$
Adult DMP			
Non-pome/non-thin	8.9	0.70 (0.17–1.82)	0.641
Non-pome/thin	8.3	0.49 (0.05–2.56)	
Pome/non-thin	20.7	1.93 (0.59–4.63)	0.669
Pome/thin	20.3	1.55 (0.67–2.76)	
Adult DMTP			
Non-pome/non-thin	84.4	3.84 (2.45–5.99)	0.111
Non-pome/thin	91.7	7.01 (2.96–16.50)	
Pome/non-thin	96.6	15.07 (8.74–26.03)	0.470
Pome/thin	96.6	15.43 (11.76–20.22)	
Adult DMDTP			
Non-pome/non-thin	37.8	0.46 (0.23–0.85)	0.443
Non-pome/thin	33.3	0.50 (0.14–1.68)	
Pome/non-thin	65.5	1.71 (0.81–3.53)	0.752
Pome/thin	60.2	1.30 (0.88–1.87)	
Child DMP			
Non-pome/non-thin	6.7	1.15 (0.44–2.26)	0.335
Non-pome/thin	9.1	1.53 (0.37–4.13)	
Pome/non-thin	21.4	3.37 (1.73–5.65)	0.477
Pome/thin	22.7	3.42 (2.25–4.62)	
Child DMTP			
Non-pome/non-thin	77.8	3.62 (2.45–5.30)	0.602
Non-pome/thin	81.8	3.24 (1.49–6.95)	
Pome/non-thin	85.7	7.52 (4.63–12.18)	0.813
Pome/thin	92.4	5.90 (4.67–7.45)	
Child DMDTP			
Non-pome/non-thin	40.0	0.60 (0.34–1.02)	0.336
Non-pome/thin	45.5	0.77 (0.26–2.11)	
Pome/non-thin	53.6	1.18 (0.62–2.20)	0.751
Pome/thin	44.5	0.93 (0.66–1.28)	

Ranges are posterior predictive probability intervals.
[a]Based on the number of samples analyzed: non-pome/non-thin, adult $n = 45$, child $n = 45$; non-pome/thin, adult $n = 12$, child $n = 11$; pome/non-thin, adult $n = 29$, child $n = 28$; pome/thin, adult $n = 118$, child $n = 119$. [b]Based on the total number of samples: non-pome/non-thin, $n = 47$; non-pome/thin, $n = 12$; pome/non-thin, $n = 29$; pome/thin, $n = 121$; plus one sample with missing fruit classification.

Results-30

No effect of thinning

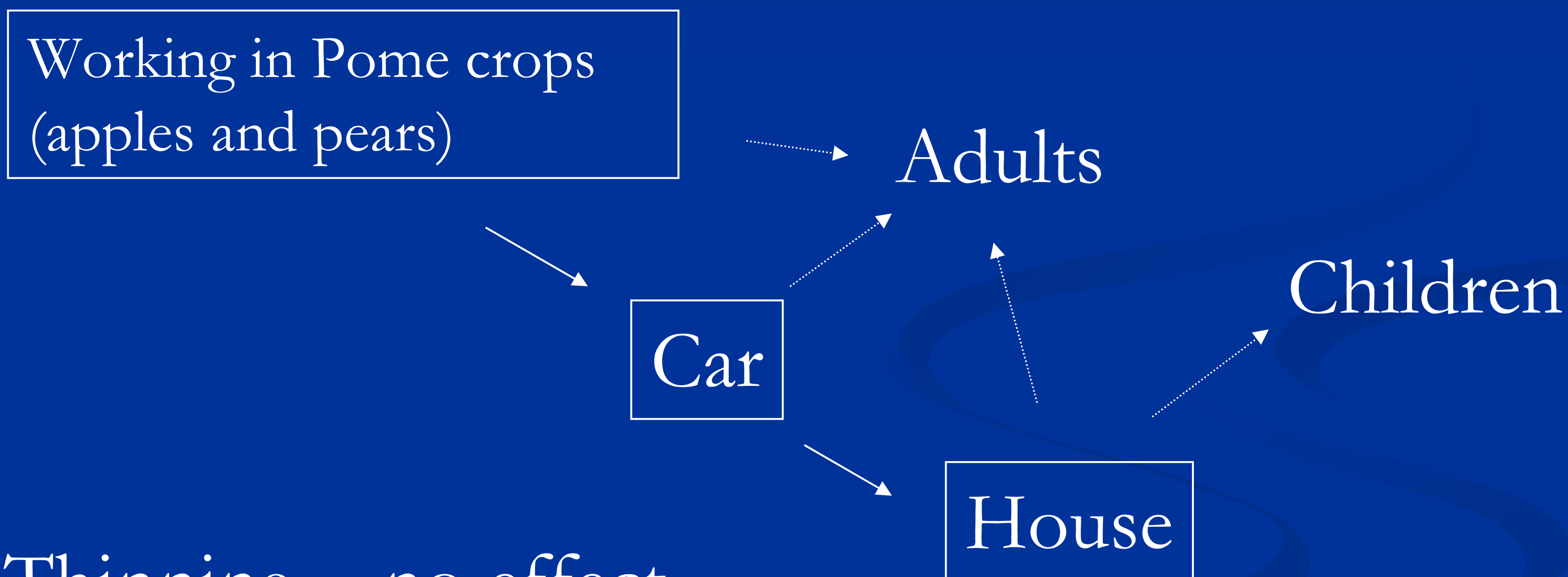
Table 8. Frequency of detection and estimated GM concentrations of azinphos-methyl residues in vehicle and house dust (n = 210).

Pesticide and crop	Detection[a] (%)	Estimated[b] GM (µg/g)	$p(\text{thin}_{GM} \leq \text{non-thin}_{GM})$
Vehicle azinphos-methyl			
Non-pome/non-thin	63.4	0.18 (0.11–0.29)	0.677
Non-pome/thin	63.6	0.14 (0.05–0.36)	
Pome/non-thin	96.0	0.96 (0.53–1.75)	0.242
Pome/thin	95.2	1.22 (0.91–1.63)	
House azinphos-methyl			
Non-pome/non-thin	58.1	0.14 (0.09–0.22)	0.087
Non-pome/thin	77.8	0.27 (0.12–0.61)	
Pome/non-thin	91.3	0.65 (0.39–1.09)	0.201
Pome/thin	93.0	0.83 (0.64–1.08)	

Ranges are posterior predictive probability intervals.
[a]Based on the number of samples analyzed: non-pome/non-thin, vehicle n = 41, house n = 31; non-pome/thin, vehicle n = 11, house n = 9; pome/non-thin, vehicle n = 25, house n = 23; pome/thin, vehicle n = 105, house n = 86. [b]Based on the total number of samples: non-pome/non-thin, n = 47; non-pome/thin, n = 12; pome/non-thin, n = 29; pome/thin, n = 121; plus one sample with missing fruit classification.

Discussion-31

Summary of findings



Thinning – no effect

Discussion-32

The authors' previsou study (Coronado et al., 2004):

-Children of thinner had higher DMTP than others
-House dust of thinner was high in OP pesticides concentration

↕

The present study

True factor was "Crops"
Cf. 91% of thinners worked in Pome fruits

Discussion-33, 34

Pome fruits require more pesticides than others:

Washington Agricultural Statistics survey (1999)

Azinphosmethyl application:

1.8 lb/acre/y – apple	Pome fruits
1.4 lb/acre/y – pears	Pome fruits
1.0 lb/acre/y – cherries	
0.8 lb/acre/y – peaches	

Discussion-35

Recent exposure (evaluated by questionnaire) did not explain the variation in urinary metabolites

↓

Work place exposure < take-home pesticide exposure

Discussion-36

CDC report: general people

Urinary DMTP (20-59 years) = 1.47 μ g/L

--- Non-Pome = 4.4 μ g/L (present study)

--- Pome = 15.3 μ g/L (present study)

CDC report: general children

Urunary DMTP (6-11 yeas)=2.95 μ g/L

--- Non-Pome = 3.5 μ g/L (2-6 years)

--- Pome = 6.2 μ g/L (2-6 years)

Age effect

Discussion-37

House dust azinphosmethyl for Pome workers:

- 0.79 μ g/L

Lu et al (2000): 1.0 μ g/L in Washington State

Shalat et al (2003) 0.51 μ g/L in US-Mexico border

Discussion-38, 39

Children of Pome fruits workers had higher urinary metabolites,
House of Pome fruits workers had higher residues of pesticides.

×

Pesticide use in the house
Dietary intake

Take-home pathways

Lu et al. (2000)
Koch et al (2002)
Fenske et al (2000)

Discussion-40

Limitation

- Timing of sample collection

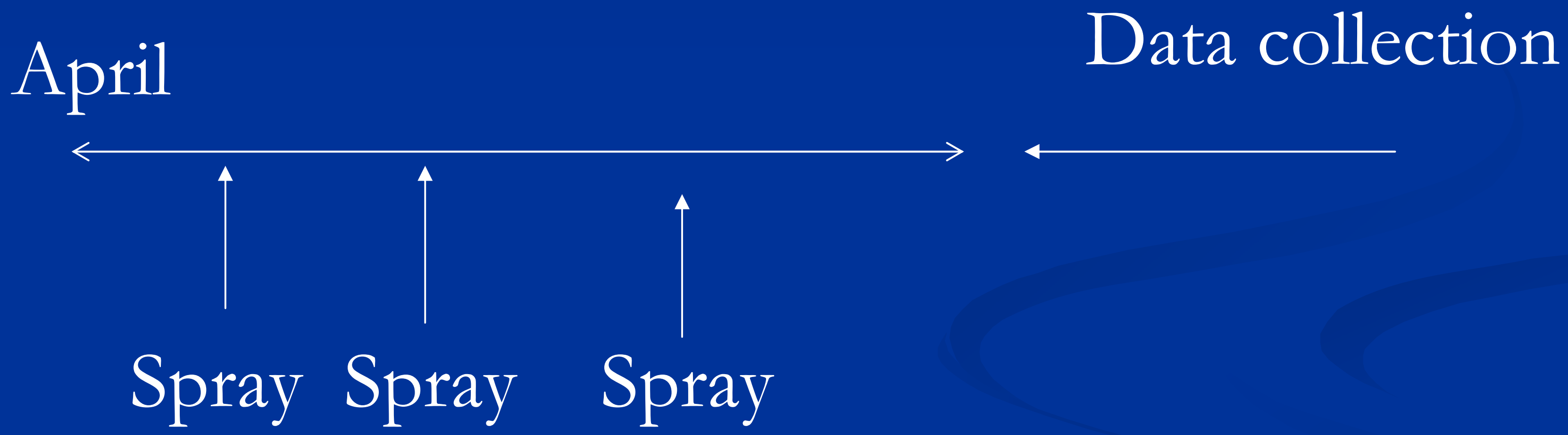
Data collection

Spray season

?

Discussion-41

In 1999, frequency of spray ↓



Urunary metabolites peak after 24-48 hours from exposure

Judgement of Two Pome fruits workers

Asked the number of crops worked for the last 3 months
→most people were categorized as multi-crops workers

No information about hours/week

Strength

Large sample size
Variation in crops
Adult, child, house, vehicle
Baysian estimation of values lower than DL
Bias ↓

Conclusions-44

Children of farmworkers who worked in two Pome crops were exposed to OP pesticides probably through "take-home pathway"