BUILDING A FRAMEWORK FOR HEALTHY HOUSING

2008 National Healthy Homes Conference

Cost and Effectiveness of IPM in Reducing Cockroaches, Cockroach Allergens, and Pesticide Use in Low Income Housing

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Pest Infestations in Low Income Housing

- Cockroaches are the number one indoor pest
  - 66% of surveyed pregnant women in New York city reported cockroach infestations (Whyatt et al. 2002)
  - 50% of the surveyed apartments in Gary, Indiana (Wang et al. 2008)
  - As many as 3,657 cockroaches were captured with sticky traps overnight in an apartment!


Honeywell

Medial and Economical Importance of Cockroach Infestations

- Medical
  - Allergy and Asthma
  - Disease transmission
- Economical
  - Cost to control cockroaches
  - Loss of food due to contamination

Cockroach Control Techniques

- Cultural practices
  - Sanitation
  - Reducing clutter
- Nonchemical methods
  - Sticky traps
  - Cold
  - Heat
  - Vacuuming
- Chemical methods
  - Spray
  - Gel bait or containerized bait
  - Boric acid dust

Common Insecticides Used in Low-income Housing

Gel bait

Boric acid

Aerosol spray

Misuse of pesticides by residents

Why Cockroaches Are Still Thriving?

- Individual control techniques rarely succeed
  - Poor sanitation provides food to cockroaches
  - Clutter provides cockroach hiding places
  - House disrepair provides cockroaches pathways to neighboring apartments

Integrated Pest Management (IPM)

- The use of cultural, physical, and chemical methods to minimize the pest populations and pesticide use

Objective of the HUD Sponsored Cockroach IPM Study

- Evaluate the cost and effectiveness of a cockroach IPM program
  - Reduce dependence on insecticides
  - Increase effectiveness
  - Provide basis for adoption of IPM programs in low income housing

Study sites:

- Gary, Indiana
  - Dorie Miller Homes
  - Delaney Community

Treatment plan

- Entomologists-delivered IPM
  - 191 apartments in Dorie Miller Homes
- Contractor-delivered IPM
  - 251 apartments in Delaney Community

IPM components

1) Educating residents and staff
   - House keeping classes and demonstrations
   - Brochures
2) Periodic monitoring
   - Lay sticky traps monthly to every 3 months
3) Use non-chemical and chemical methods to reduce and eliminate existing cockroach populations
   - Gel bait and boric acid dust applications

GARY HOUSING AUTHORITY
COMMUNITY AND PROGRAM SERVICES DEPARTMENT
DORIE MILLER HOMES

Housekeeping Forum

Overview

The Gary Housing Authority's Community and Program Services Department conducts housekeeping classes for residents. The objective of this project is to provide training for those residents who need enhancement in their domestic skills. The Property Manager, maintenance department, exterminator, or community services specialist refers the resident to this department for domestic training. These sessions will be held on a regular basis as a follow-up to the identified individuals with housekeeping problem(s). Each resident referred for domestic training must attend 3 housekeeping workshop within one year period. After each housekeeping workshop a home inspection will be scheduled as a follow-up on the progress of the resident by the manager.

Applying bait and dust

Results

Initial Pest Infestations in Apartments Based on Interviews and Inspections (n = 306)

German cockroaches	Oriental cockroaches	Mice	Ants	Other pests	No pests
51%	22%	33%	19%	7%	20%

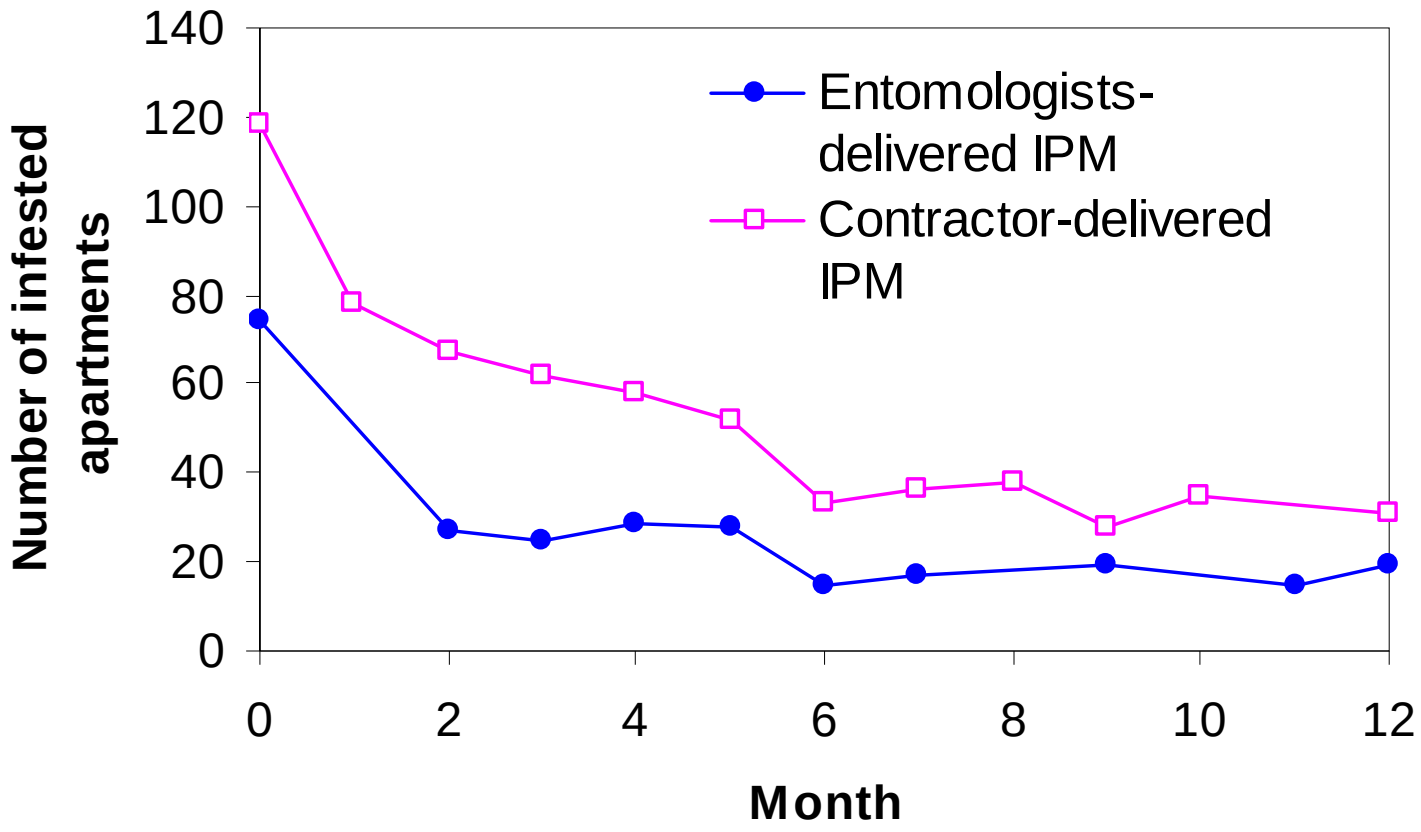
Results (continued)

- Residents: 13% had doctor-diagnosed asthma, 9% had doctor-diagnosed allergy (n = 1,026).
- Households: 36% had asthma patients, 24% had allergy patients (n = 305).

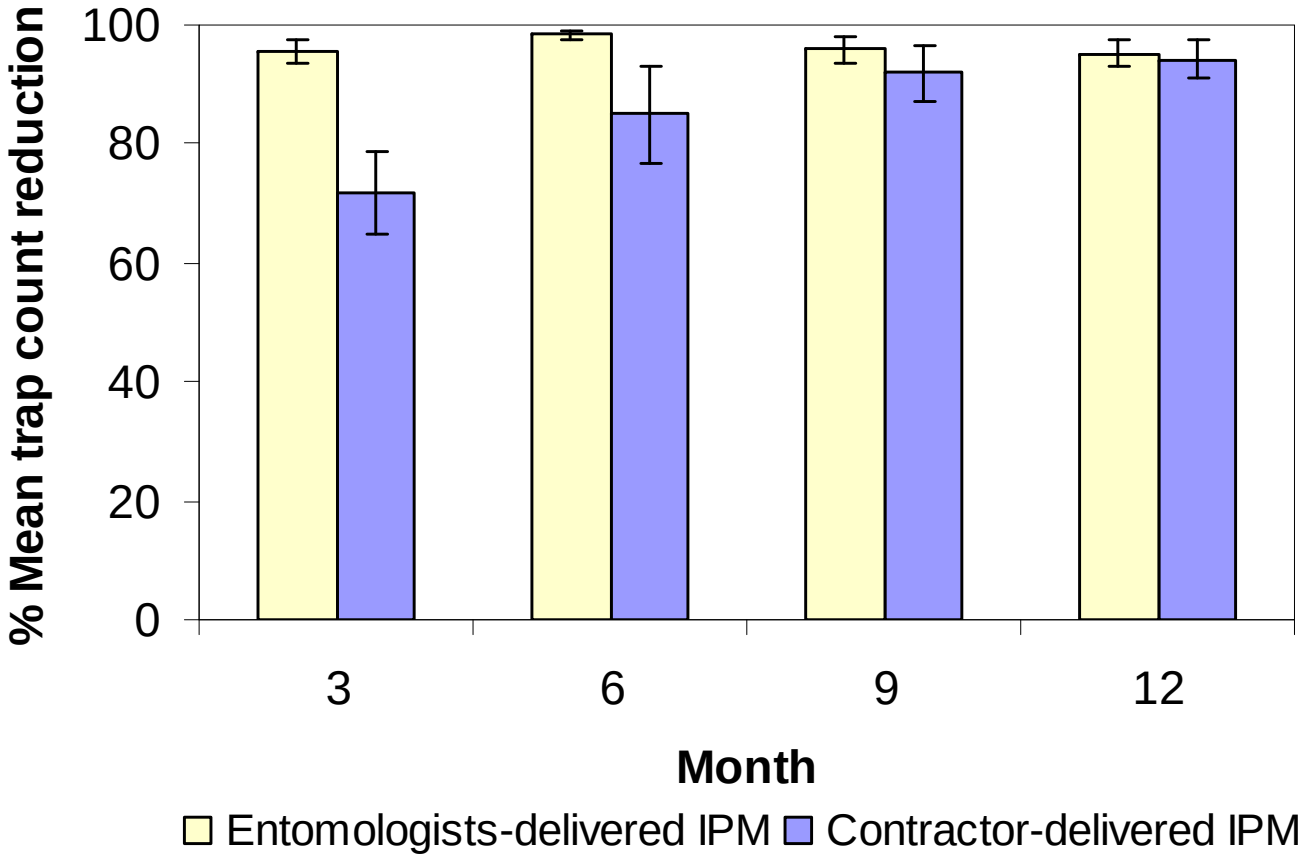
Cockroach Allergens

- Dust samples were collected from 72 randomly selected apartments.
- Bla g 1, a common allergen produced by cockroaches, was detected in 98% of the apartments.

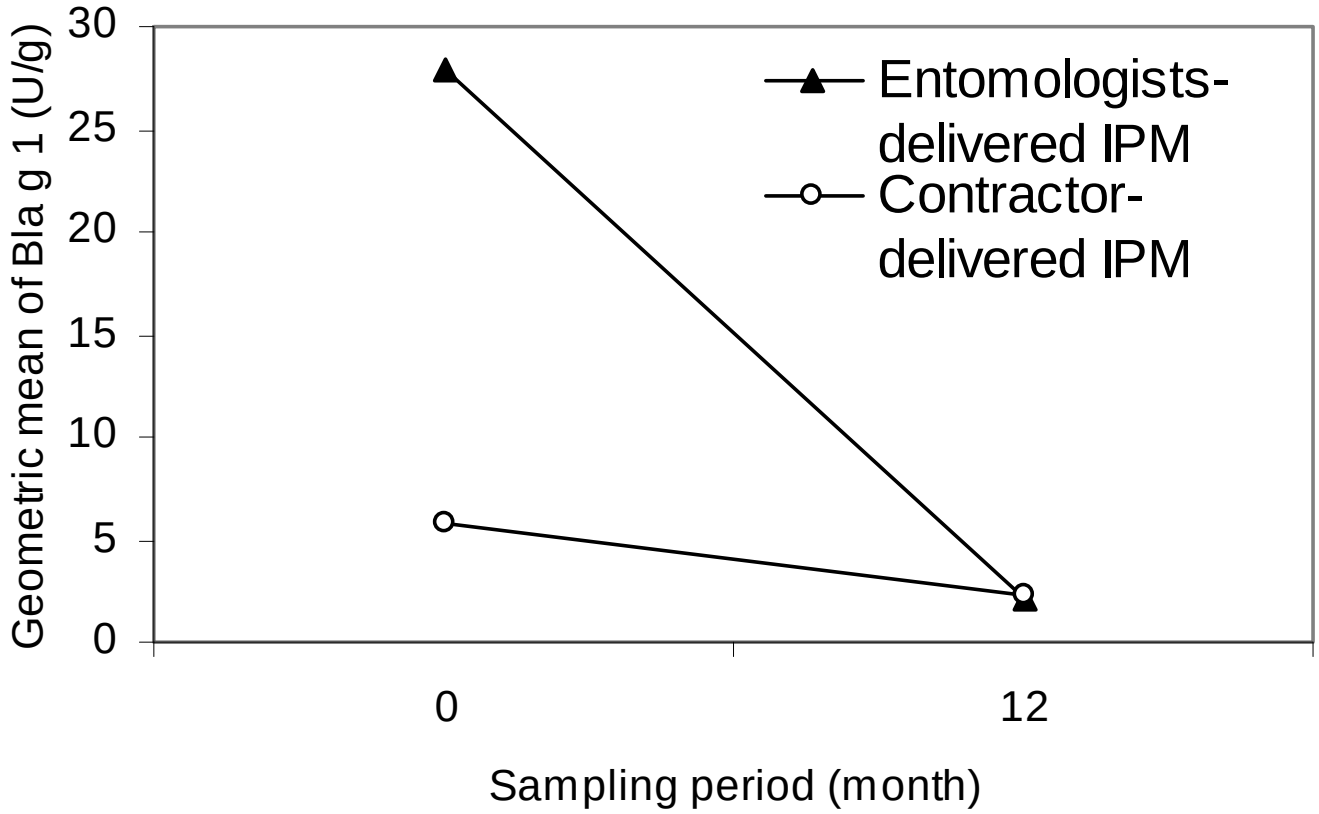
Effect of IPM on Numbers of Cockroach Infestations



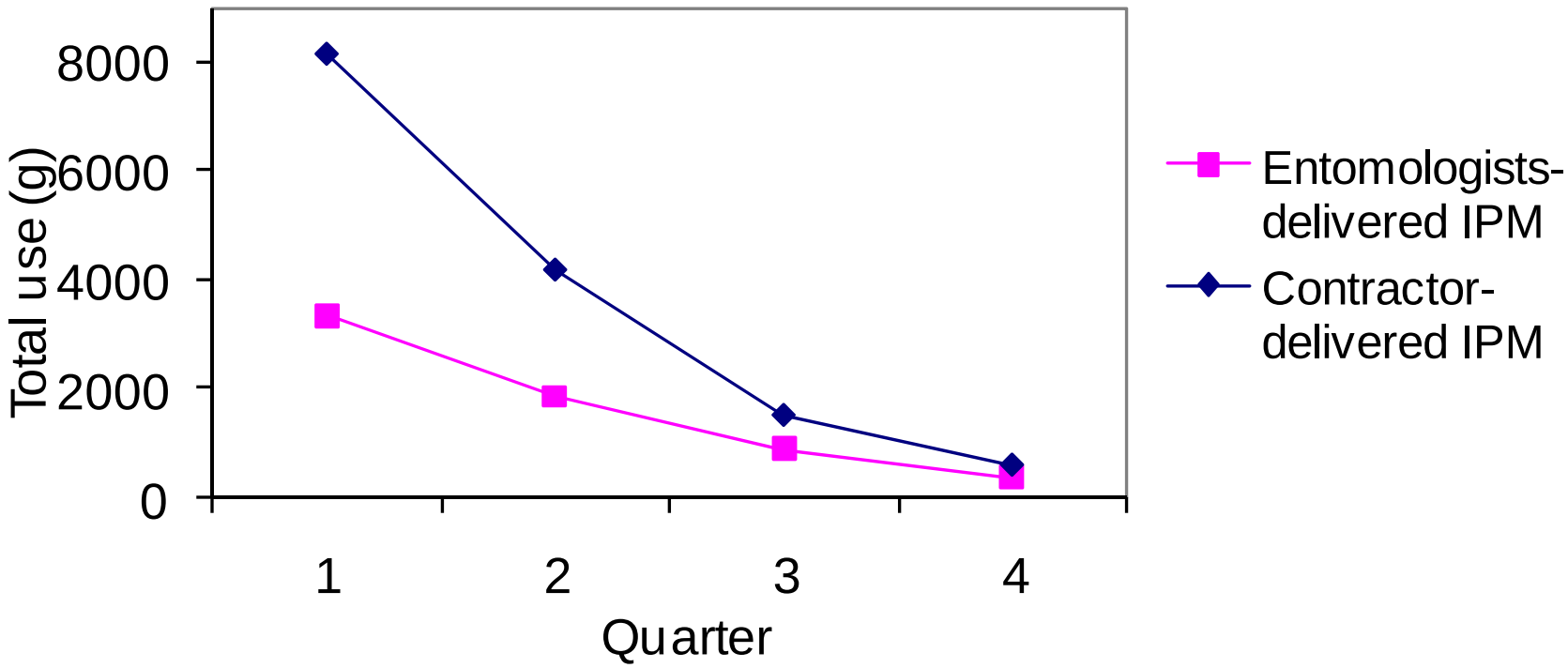
Effect of IPM on Cockroach Population Reduction



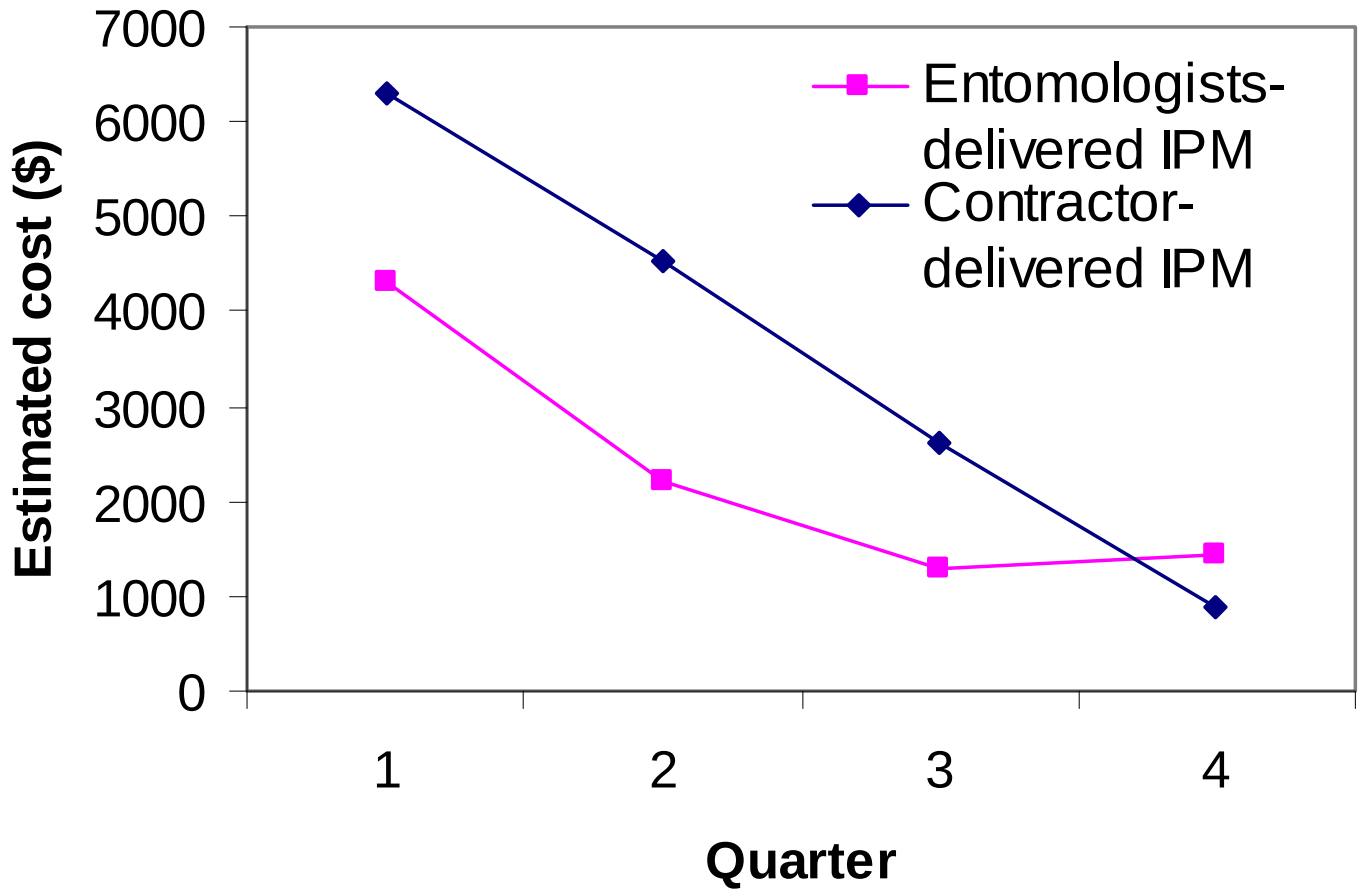
Effect of IPM on Cockroach Allergen Reduction



Effect of IPM on Gel bait Use Reduction



Quarterly IPM Cost



Comparison of Pest Management Practices

	Existing contractor		IPM contractor
	Gary Housing Authority	Indianapolis Housing Agency	
Monthly cost per apartment	$2	$6.3	$4.8 (for cockroaches)

Conclusions

1) Adoption of IPM significantly reduced cockroach infestations, cockroach allergen levels, and pesticide use.
2) The first year IPM program cost is higher than existing service contract but not prohibitive.
3) Subsequent annual IPM cost will be significantly lower than the 1st year cost.

Challenges

- Lack of resident collaboration
- Lack of proper maintenance of the properties
- Motivation from housing management staff

Key Components of a Successful IPM Program

1) Set up a proactive monitoring program
2) Set up an IPM contract that focuses on quality of the service
   - Monitor the results!
3) Educate residents
   - Maintain a clean and clutter-free living environment
4) Repair water leaks and other structural defects promptly

Acknowledgements

- HUD HHLTS program
- Gary Housing Authority
- Bayer Environmental Science
- Purdue University technicians and students

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2008 National Healthy Homes Conference

Household Pesticide Residues in Urban and Rural Low-Income African-American Communities

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Residential Pesticide Exposures

Pesticide and other Chemical Exposures

- Widespread use, especially among poor
- Few studies of residential exposure

Wide range of potential health effects

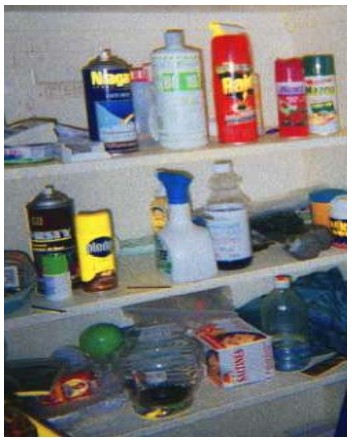
- Cancer
- Respiratory (e.g., asthma)
- Fetal development
- Etc.

Few or no studies addressing disparities:

- Race/Socioeconomic status
- Urban/rural
- Housing conditions

Residential Pesticide Exposures

- **Pesticide exposures in the home**
  - Household products
    - Current (pyrethroids)
    - Discontinued (OPs: chlorpyrifos)
    - Illegal ("street" pesticides: Tempo, Chinese chalk)
  - Occupational exposures
    - "Take home" exposures
  - Outdoor exposures
    - Agricultural communities
    - Outdoor uses



Recent Studies – Exposures and Health

Pesticide loadings of select organophosphate and pyrethroid pesticides in urban public housing

RHONA JULIEN[a], GARY ADAMKIEWICZ[a], JONATHAN I. LEVY[a], DEBORAH BENNETT[a,b], MARCIA NISHIOKA[c] AND JOHN D. SPENGLER[a]

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Prenatal Insecticide Exposures and Birth Weight and Length among an Urban Minority Cohort

Robin M. Whyatt,[1] Virginia Rauh,[1] Dana B. Barr,[2] David E. Camann,[3] Howard F. Andrews,[1] Robin Garfinkel,[1] Lori A. Hoepner,[1] Diurka Diaz,[1] Jessica Dietrich,[1] Andria Reyes,[1] Deliang Tang,[1] Patrick L. Kinney,[1] and Frederica P. Perera[1]

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Impact of Prenatal Chlorpyrifos Exposure on Neurodevelopment in the First 3 Years of Life Among Inner-City Children

Virginia A. Rauh, ScD[a], Robin Garfinkel, PhD[a], Frederica P. Perera, DrPH[a], Howard F. Andrews, PhD[a], Lori Hoepner, MPH[a], Dana B. Barr, PhD, DLS[b], Ralph Whitehead, MPH[b], Deliang Tang, DrPH[a], Robin W. Whyatt, DrPH[a]

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A Changing Landscape

Organochlorines

DDT (1972)
chlordane (1998)

Organophosphates

diazinon (2001)
chlorpyrifos (2000)

Pyrethroids

permethrin
cypermethrin
etc.

???

Indoor Exposures from Pest Control

- High exposure formulations

  Foggers, aerosols, ‘street’ pesticides

- Low exposure formulations

  Baits, gels, traps

CURRENT STUDY

Goals

- Our project aims to advance current state of knowledge by:
  - Quantifying the magnitude of pesticide and chemical exposures for low-income populations
  - Establishing the relative contribution of occupational and residential sources and associations with household characteristics

- This knowledge will inform practical solutions, including:
  - In-home remediation
  - Pest management strategies
  - Public educational campaigns
  - Targeted resident education programs

Population

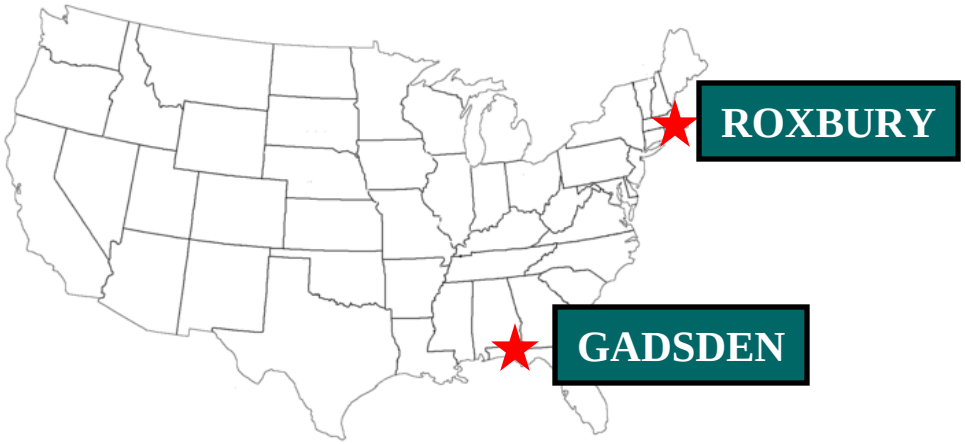
Center for Healthy Options and Innovative Community Empowerment

Collaboration between Harvard and FAMU:

- Center for Healthy Options and Innovative Community Empowerment (CHOICE)

Two predominantly African-American communities:

- Roxbury, MA (urban)
- Gadsden County, FL (rural)



Study Design

- **Recruitment in 2 communities**
  - Roxbury, MA
  - Gadsden County, FL
- **Conducted approximately 200 home visits**
  - Survey/Visual inspection/House dust sampling
- **Lab analysis (dust samples)**
  - Pesticides (approx. 100 in each community)
  - Other chemicals (50 in each community)
- **Data analysis**
  - Reporting of exposures/distributions
  - Associations with household factors
- **Education and community outreach**

Overview – Home Visits

- Each home visit consisted of:
  - Informed consent
  - Survey
  - Visual Inspection
    - Home Walkthrough
    - Product Inventory
  - Vacuum sample collection

Visual Inspection

- Housing type/conditions
- Building sanitation
- Physical conditions (wet walls, peeling paint, etc.)
- Type/condition of flooring
- Signs of condensation/water damage by room and location
- Signs of pest infestation (cockroach residue, mouse droppings)
- Presence of mold
- Bathroom ventilation
- Pest access (pipe penetration)
- Dust on surfaces
- Housekeeping/food sources

Vacuum Sample Collection

- Collection
  - Entire home vacuumed for 40 minutes
  - Teflon crevice tool fitted with cellulose thimble
  - Thimbles placed in pre-cleaned glass jars and frozen
- Analysis
  - Aliquots of sieved fine dust (< 150 µm) from the vacuum thimbles were soxhlet-extracted with 6% diethyl ether in hexane, florisil-cleaned
  - Analyzed by GC/MS selected-ion monitoring for 49 pesticides and associated compounds.

Analytes

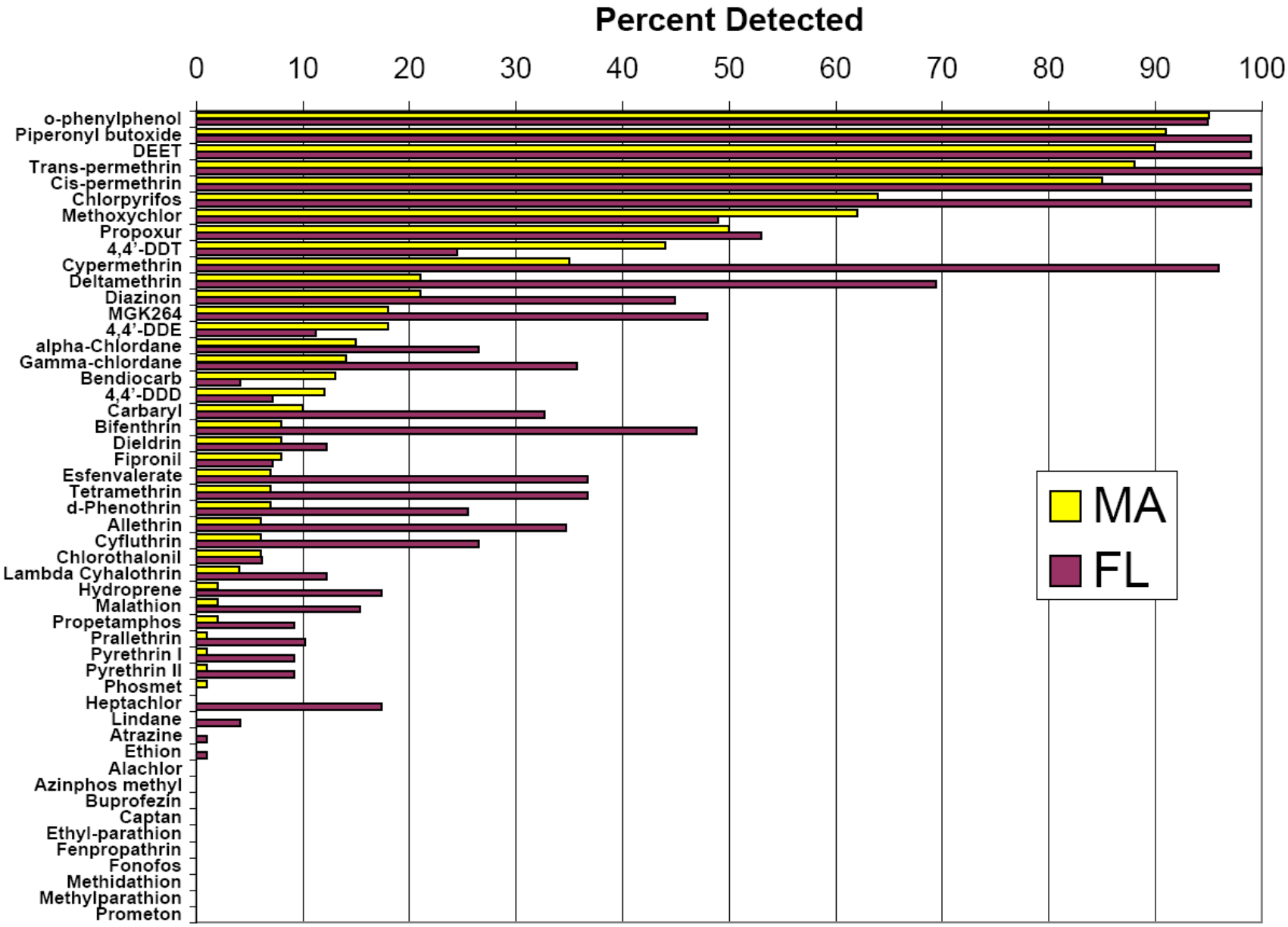
- Alachlor
- Allethrin
- alpha-Chlordane
- Atrazine
- Azinphos methyl
- Bendiocarb
- Bifenthrin
- Buprofezin
- Captan
- Carbaryl
- Chlorothalonil
- Chlorpyrifos
- Cis-permethrin
- Cyfluthrin
- Cypermethrin
- 4,4’-DDD
- 4,4’-DDE
- 4,4’-DDT
- DEET
- Deltamethrin
- Diazinon
- Dieldrin
- d-Phenothrin
- Esfenvalerate
- Ethion
- Ethyl-parathion
- Fenpropathrin
- Fipronil
- Fonofos
- Gamma-chlordane
- Heptachlor
- Hydroprene
- lambda-Cyhalothrin
- Lindane
- Malathion
- Methidathion
- Ethyl-parathion
- Fipronil
- Fonofos
- Gamma-chlordane
- Heptachlor
- Hydroprene
- lambda-Cyhalothrin
- Lindane
- Malathion
- Methidathion
- Methoxychlor
- Methylparathion
- o-phenylphenol
- Phosmet
- Piperonyl butoxide
- Prallethrin
- Prometon
- Propetamphos
- Propoxur
- Pyrethrin I/II
- Tetramethrin
- cis/trans-permethrin

RESULTS

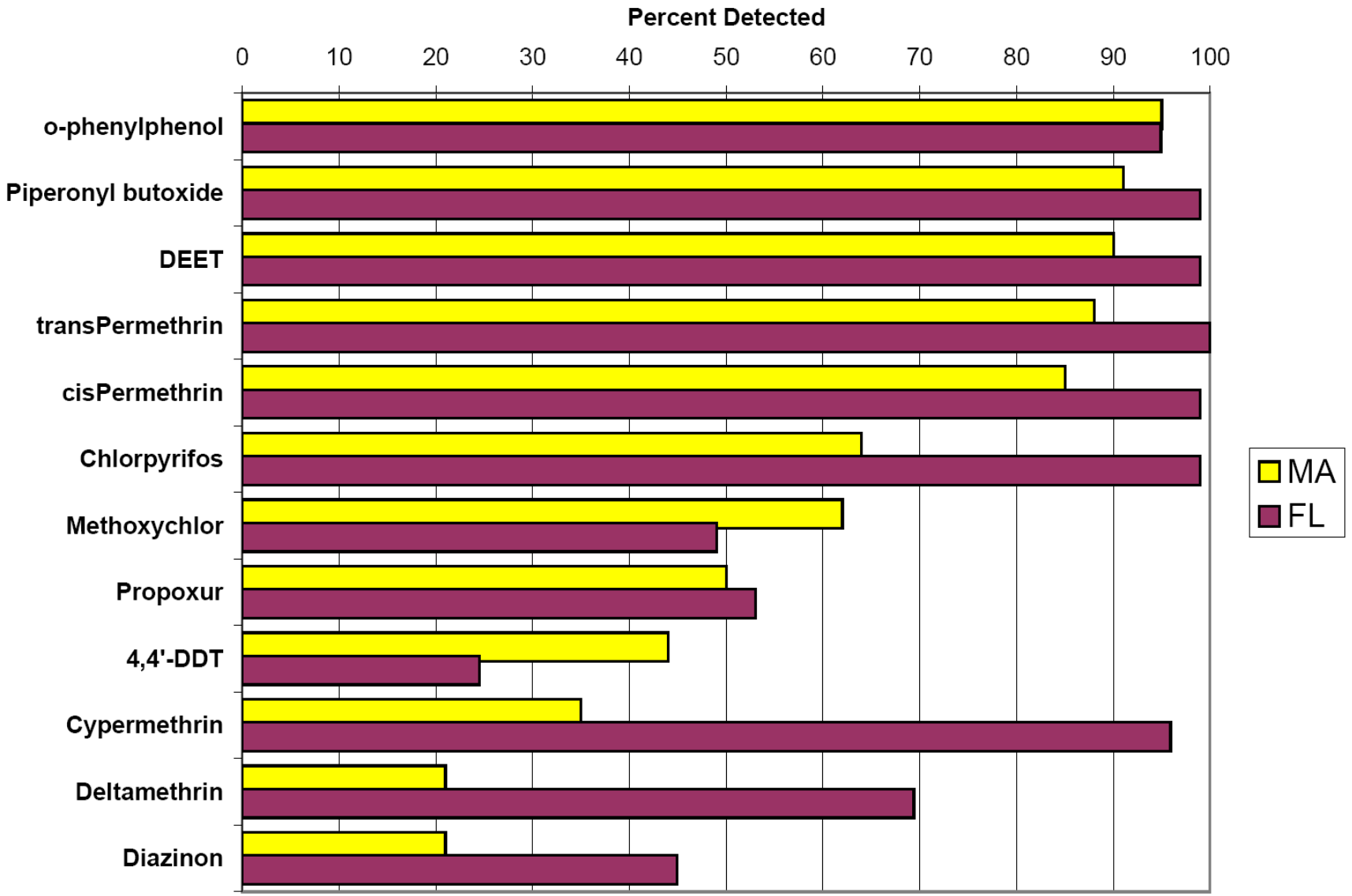
Study Population

		ROXBURY	GADSDEN
Number of participants		100	98
Age: Median (min, max)		51 (18 , 80)	44 (20 , 89)
Race	African American White Other	79 % 6 % 15 %	83 % 5 % 8 %
Ethnicity	Hispanic – Y Hispanic – N	16 % 84 %	15% 83%
Own or rent?	Own Rent	20 % 80 %	61 % 36 %
Dwelling size: Med (min, max) (sq. ft.)		588 (168,1920)	1000 (286,3264)

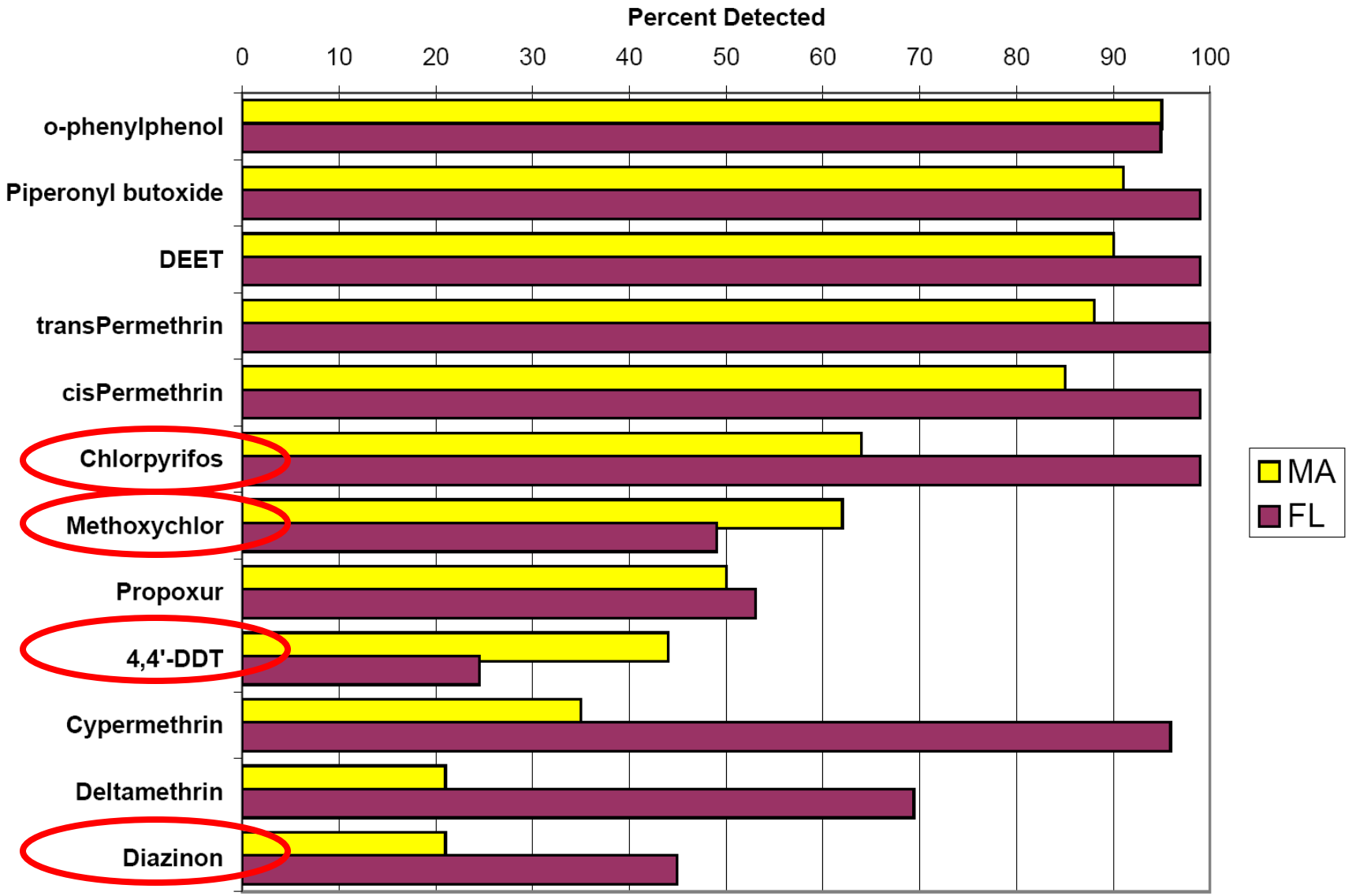
Prevalence – all analytes



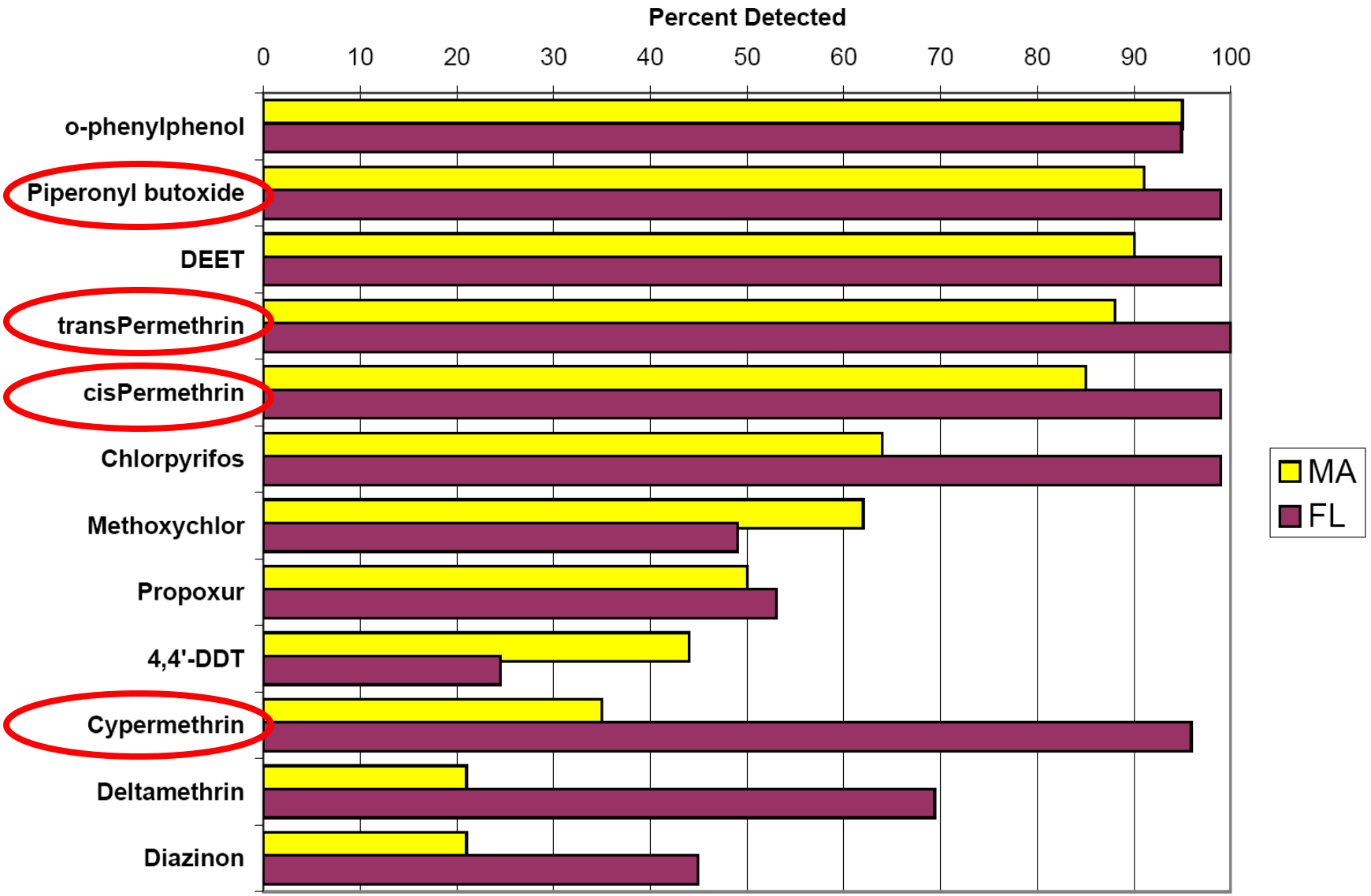
Most prevalent compounds



Most prevalent compounds



Most prevalent compounds



Comparisons between cohorts

Analyte	GADSDEN		ROXBURY		p value
	Median (ng/g)	GM (ng/g)	Median (ng/g)	GM (ng/g)	
α-Chlordane	< LOD	34	< LOD	27	0.76
Chlorpyrifos	**471**	**471**	**38**	**44**	**<.0001**
Cyfluthrin	< LOD	283	< LOD	164	0.19
Cypermethrin	**17400**	**14600**	**< LOD**	**313**	**<.0001**
DEET	**629**	**634**	**315**	**391**	**0.0024**
Diazinon	< LOD	34	< LOD	17	0.21
Dieldrin	< LOD	61	< LOD	64	0.82
Lindane	< LOD	46	< LOD	47	0.25
Methoxychlor	**< LOD**	**85**	**145**	**186**	**0.001**
o-phenylphenol	**63**	**63**	**85**	**98**	**0.0003**
cis-permethrin	**3540**	**3796**	**330**	**383**	**<.0001**
trans-permethrin	**6305**	**6486**	**799**	**1005**	**<.0001**
Piperonyl butoxide	**2045**	**1901**	**189**	**344**	**<.0001**

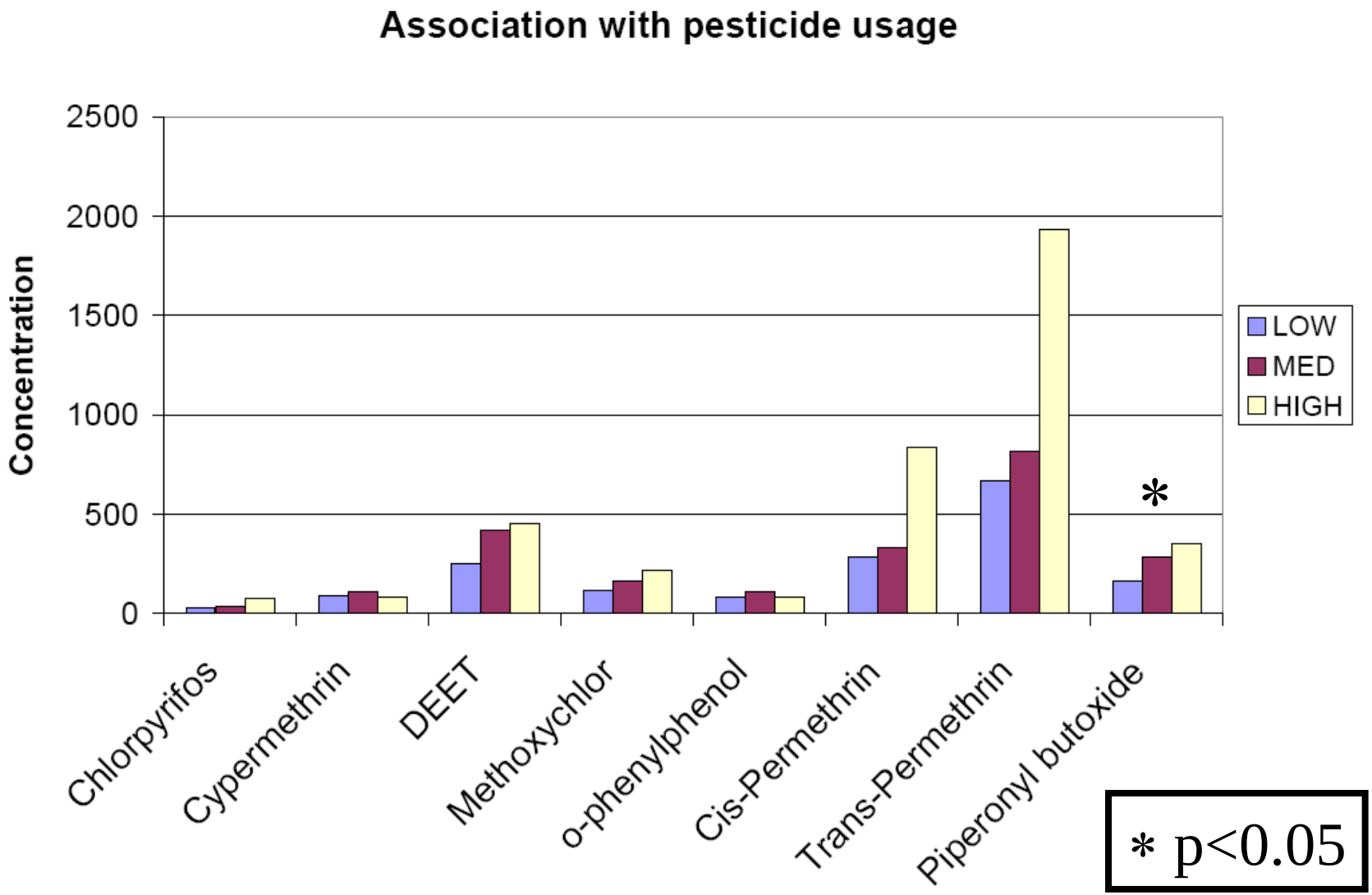
Comparison with other studies

- Prevalence has changed; sub-populations have very different exposures

Analyte	MASSACHUSETTS			FLORIDA	
	ROXBURY	HPHI (Boston)	Silent Spring	GADSDEN	Jacksonville (FL)*
YEAR	**2006-7**	**2002**	**1999-01**	**2006-7**	**1986**
Chlorpyrifos	64	89	18	99	100
Diazinon	21	94	14	44.9	83
Cyfluthrin	6	43	N/A	26.5	N/A
Cypermethrin	35	60	5	95.9	N/A
cis-permethrin	85	100	45	99	N/A
trans-permethrin	88	100	53	100	N/A

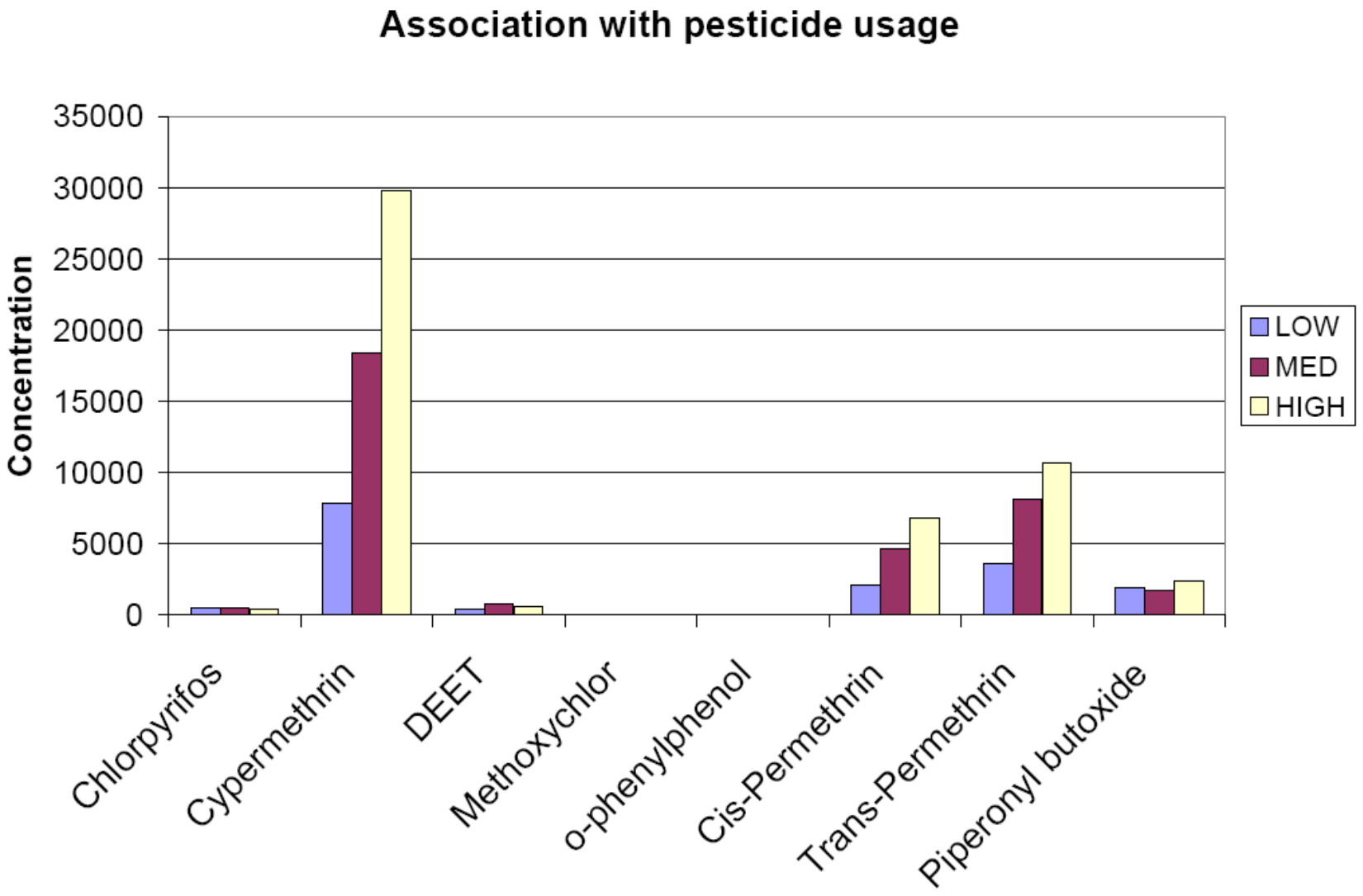
*Air samples

Pesticide usage frequency - Roxbury

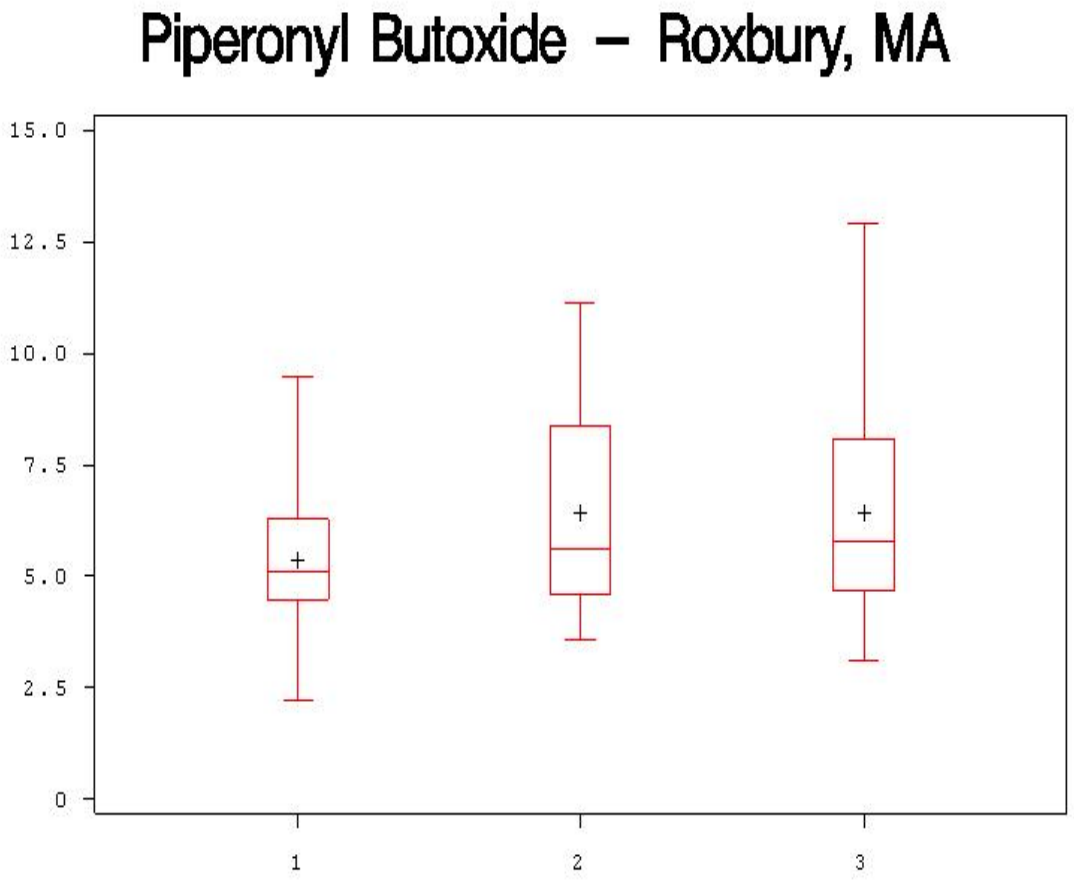


* $p<0.05$

Pesticide usage frequency - Gadsden

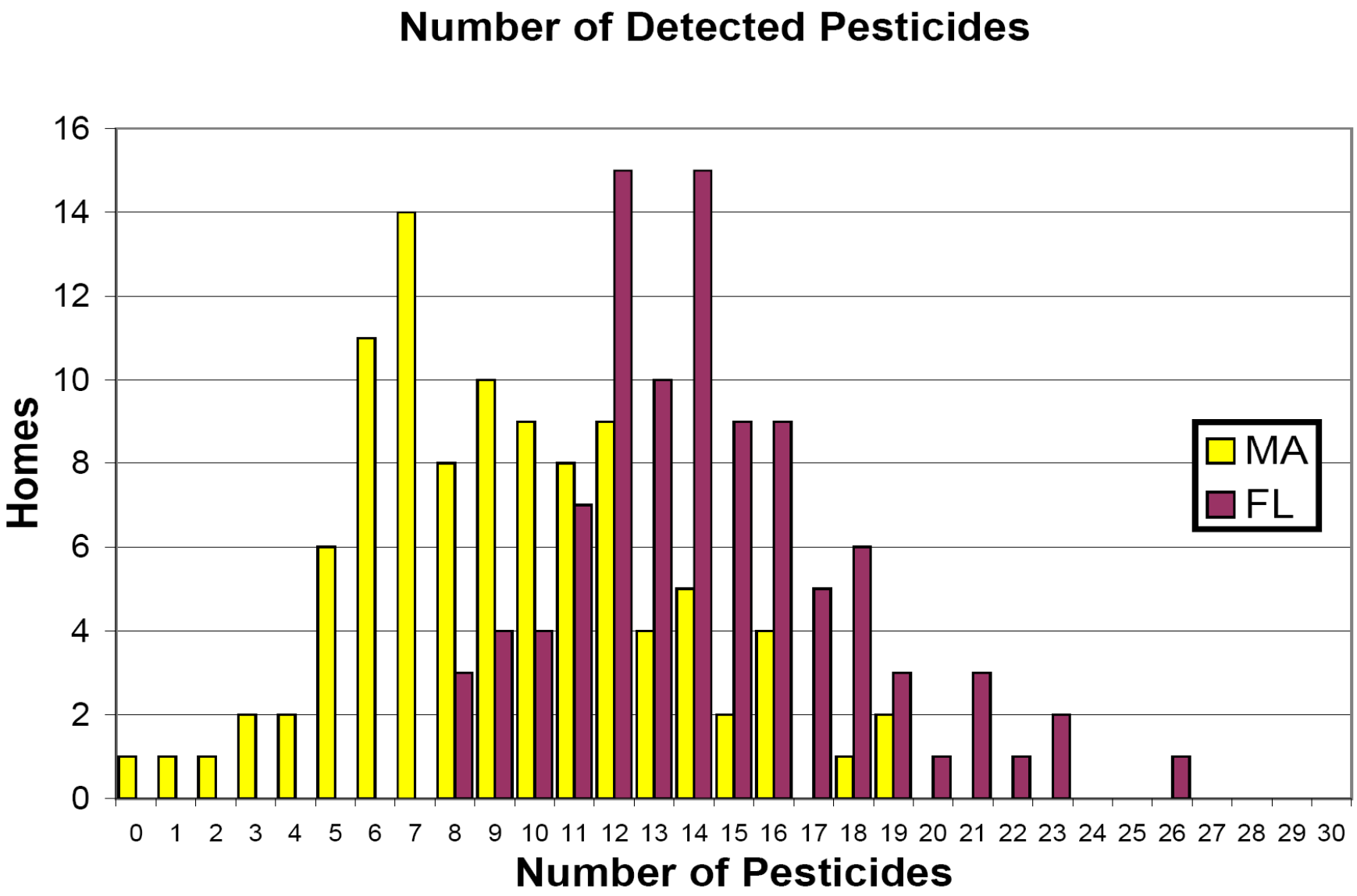


Significant Sources of Variability Remain



- Significant overlap
- Homes with no reported usage can have significant residues

Pesticide “burden”



Conclusions

- Pesticides were present in virtually all homes
- Several banned or restricted use pesticides were detected in both cohorts
- Homes in Gadsden County had higher pesticide burdens than those in Roxbury, based on:
  - the number of analytes detected
  - measured concentrations
- Product usage by residents is associated with concentrations of pesticides in products currently on the market

Next Steps

- Explore associations with:
  - Visual assessment
  - Farmworker surveys
  - Product inventory
- Examine correlation structure
- Compare with chemical analyses (50 homes in each cohort)
  - Phthalates
  - PBDEs
  - Etc.

Acknowledgements

- Study Participants
- Rhona Julien
- Funding
  - U.S. Department of Housing and Urban Development

Residential pesticide use during pregnancy among an inner-city cohort in New York City: resultant health effects and an intervention to reduce exposures

Dana B. Barr, Robin M Whyatt, Frederica P Perera, Megan K Williams, David E Camann, Virginia A Rauh

OUTLINE

CCCEH Study Design

↓

Housing conditions

↓

Residential pesticide exposure

↓

Adverse health effects

↓

Intervention

Residential pesticide use is a problem

- Residential pesticide use is widespread in the US
  - 80-90% of US homes report using pesticides
- Residential pesticide use is concentrated in urban areas
  - Heaviest application of pesticides in New York State occurs in New York City (2002)
  - 93% of NYC public housing residents report using pesticides compared to 41% of residents in Syracuse, a less populated city (2000)
- Infants and children are more susceptible to adverse effects resulting from pesticide exposure
  - Experimental studies with laboratory rodents
  - Longitudinal birth cohort studies

CCCEH Research Goals

Longitudinal birth cohort study designed to understand the nexus between the environment and child health in order to take preventive action to reduce risks to children, one focus is residential pesticide exposure:

1. Determine risk factors associated with pesticide exposure
2. Measure extent of pesticide exposure
3. Examine health effects associated with exposure
4. Develop strategies to reduce exposure

CCCEH Cohort

Enrollment:

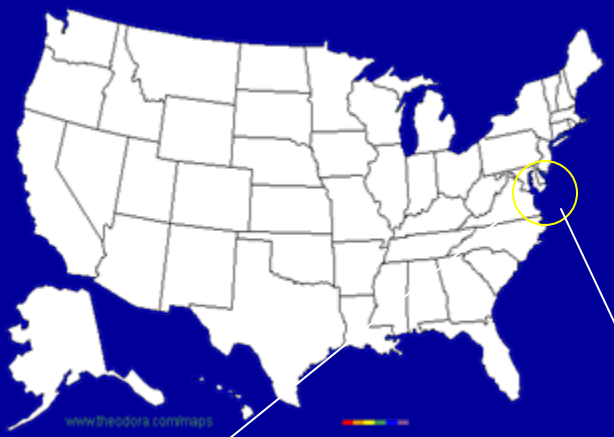
- Prenatal clinics at NY Presbyterian and Harlem Hospitals
- Pregnant African American or Dominican women age 18-35
- Excluded for smoking, illicit drug, HIV, hypertension, diabetes

Sample collection:

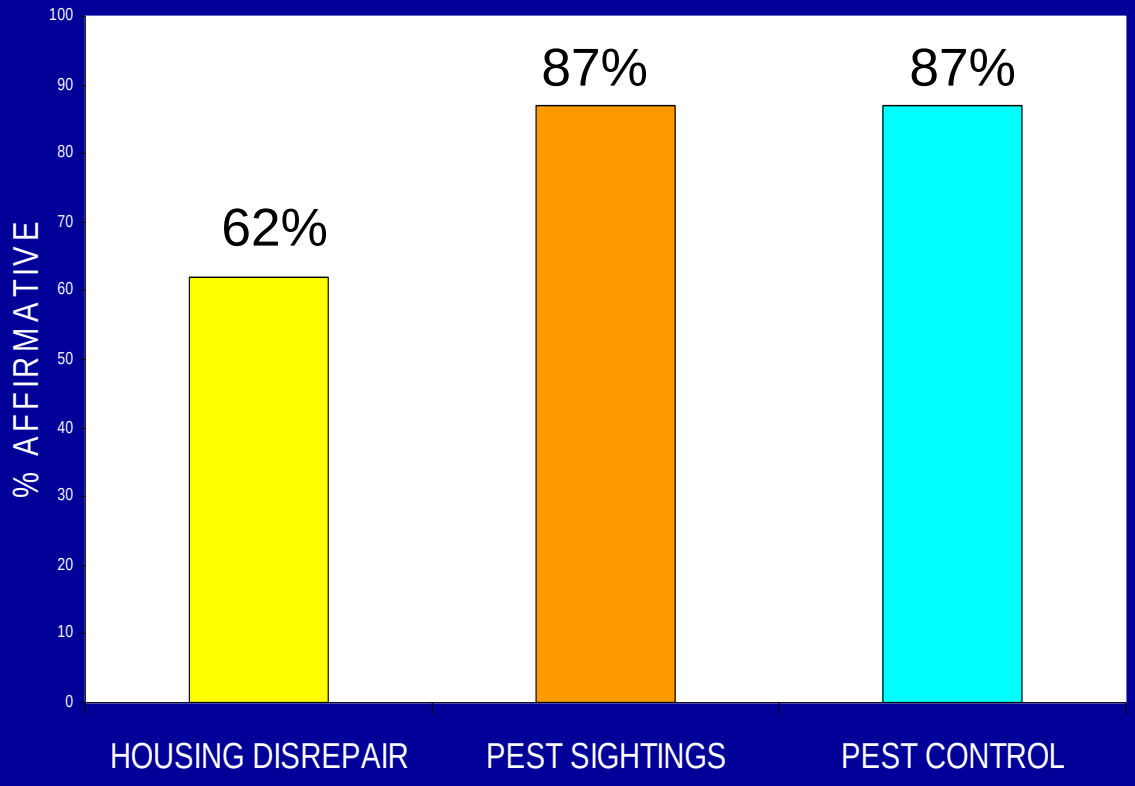
- Prenatal questionnaire
- 48-hr personal air during 32nd week of pregnancy
- Maternal and cord plasma, meconium, urine and birth outcomes at delivery
- Developmental and cognitive testing of infant through childhood
- Follow-up environmental and biological sampling

Demographics of M & N Cohort (n = 720)

Maternal Age	25 (15-38)
Ethnicity	
Hispanic	64.8%
African American	35.2%
Medicaid recipient	90.8%
Marital Status	
Never married	65.6%
Education	
< High School	35.7%
Annual Household Income	
< $10,000	45.3%
Lacked basic necessities shelter, food, clothing, heat, medicine	43.5%



Housing conditions, pest sightings and pesticide use



Housing disrepair: holes in walls and/or ceilings, unrepaired water damage, peeling paint, and/or lack of heating

Pest sightings: cockroaches, rats, mice and/or other

Pest control: low and high toxicity applications by self, member of the household and/or pesticide applicator

Association[1] between housing disrepair, pests sightings and pest control (n = 634)

	Odds ratio (C.I)[2]	p-value
Pest sighted	1.9 (1.5-2.5)	< 0.001
Pest control used	1.4 (1.1-1.8)	< 0.01

[1]Logistic regression analyses controlling for ethnicity

[2]For each unit increase in the degree of housing disrepair reported (0-5)

Levels of insecticides measured in personal air, maternal and newborn plasma samples

	Personal air (ng/m³) (n = 549)		Maternal plasma (pg/g) (n = 446)		Cord plasma (pg/g) (n = 429)	
	% > LOD	Mean ± SD	% > LOD	Range	% > LOD	Range
Chlorpyrifos	99.8%	11.44 ± 26.6	43%	ND-35.0	42%	ND-63.0
Diazinon	100%	75.38 ± 383.4	23%	ND-25.0	22%	ND-13.0
Propoxur[1]	100%	46.4 ± 109.3	8.5%	ND-32.79	9.6%	ND-26.0

[1]2-isopropoxyphenol measured in blood samples

- Maternal personal air and blood levels weakly correlated ($r < 0.2$)
- Maternal and newborn blood levels highly correlated ($r = 0.4$-0.8)

Insecticide exposure and birth weight and length

Change in birth weight/length for each log unit increase in insecticide levels
in umbilical cord plasma (n=314)

	Birth weight(gm)	Birth length (cm)
Chlorpyrifos	B= -42.6, p=0.03	B= -0.24, p=0.04
Sum OP[1]	B= -49.1, p=0.02	B= -0.27, p=0.03

[1]Sum of diazinon and chlorpyrifos adjusted by U.S.EPA relative potency factors.

By multiple linear regression. Independent variable: (ln)pesticide controlling for active and passive smoking, ethnicity, parity, maternal pre-pregnancy weight and net weight gain during pregnancy, gender and gestational age of the newborn, and season of delivery

Chlorpyrifos exposure and mental and motor development

Multiple linear regression of associations between umbilical cord blood chlorpyrifos (high versus low) and mental and motor development at 12, 24 and 36 months using the Bayley Scales of Infant Development

	12 months (n=228)	**24 months (n=227)**	**36 months (n=228)**
Mental	-0.34±1.7 (p=0.8)	-1.5±2.0 (p=0.5)	**-3.3±1.8 (p=0.06)**
Motor	-3.3±2.1 (p=0.12)	1.2±2.0 (p=0.5)	**-6.5±2.2 (p=0.003)**

Controlling for race/ethnicity, gender, gestational age, maternal education, maternal IQ, ETS, and Home Environment (Home Scale)

Rauh et al, in press

Chlorpyrifos exposure and mental and motor development

Odds of mental and motor delay at age 36 months among infants with high versus low umbilical cord blood chlorpyrifos levels[1] (n=228)

	Odds Ratio	95% CI
Mental Delay	**2.37**	**1.08, 5.19**
Motor Delay	**4.52**	**1.61, 12.70**

Logistic regression controlling for race, gender, gestational age, maternal education, maternal IQ, ETS, and Home Environment (Home Scale)

Rauh et al, in press

Chlorpyrifos exposure and risk of behavioral problems at 36 months

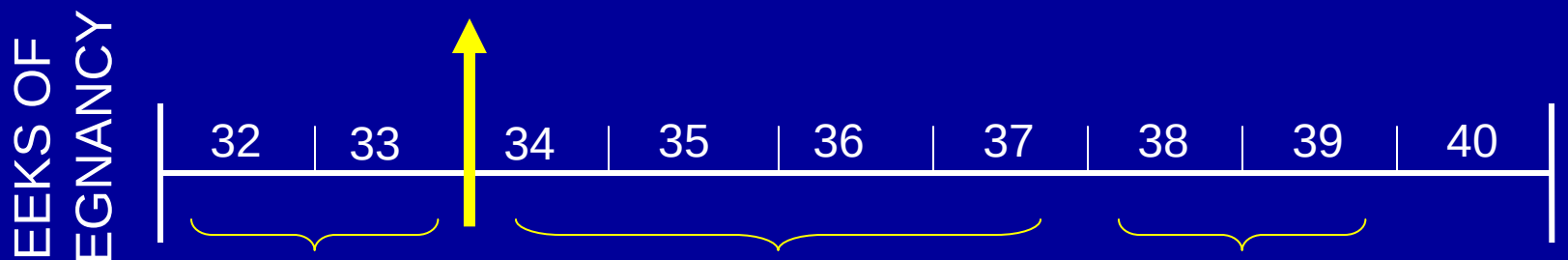
	Attention Problems		ADHD Problems		Pervasive Developmental Disorder Problems	
Prenatal exposures	**OR**	**95% C.I.**	**OR**	**95% C.I.**	**OR**	**95% C.I.**
ETS	**2.50**	**0.41, 6.52**	**7.88**	**1.17, 53.19**	**0.72**	**0.16, 3.29**
CPF	**11.63**	**1.82, 74.22**	**6.30**	**1.03, 38.42**	**5.64**	**1.23, 25.72**

Logistic regression models testing effects of chlorpyrifos and ETS on the odds of behavior problems based on maternal self report at 36 months, adjusted for race, sex, gestational age, maternal education and IQ, ETS, and home environment (N=228)

Rauh et al, in press

Intervention to reduce residential insecticide exposure during pregnancy

STUDY DESIGN: **Twenty-five African American or Dominican women who reported using high toxicity pesticides and 42 controls matched on pesticide use were enrolled into the study during the third trimester of pregnancy and followed until delivery.**



PRE IPM SET-UP
- Questionnaire
- Indoor air
- Pest infestation levels
- Maternal urine

STUDY PERIOD
(4 weeks)

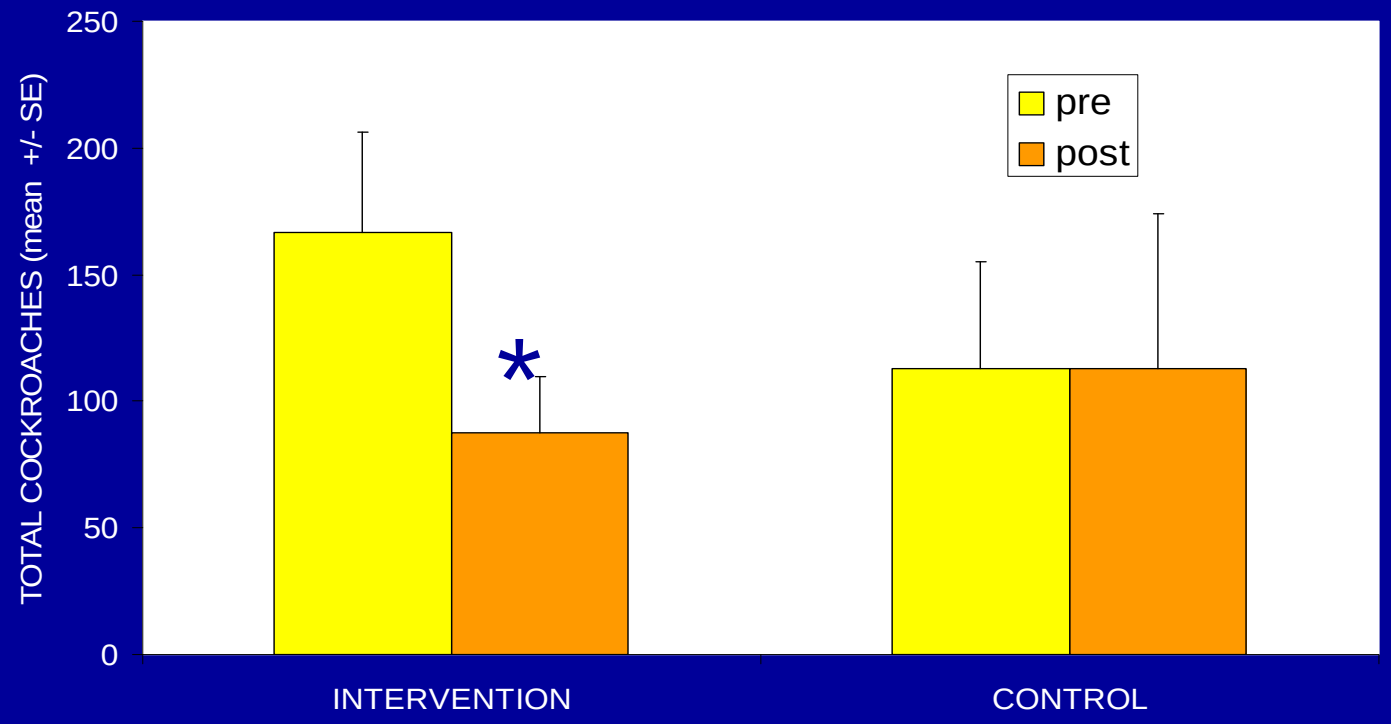
POST-IPM SET-UP
- Questionnaire
- Indoor air
- Pest infestation levels
- Maternal urine
- Maternal and cord blood

Williams et al, EHP, 2006

Integrated pest management (IPM)

- Seal cracks and crevices
- Repair water damage
- Repair holes in walls and ceilings
- Extensive professional cleaning
- Targeted application of pest gels
- Education to address high risk behaviors and distribution of educational materials
- Supply plastic containers for food storage
- 2-week ambient air monitoring

Reduction in cockroach infestation levels following IPM intervention



Mean (+/- SE) cockroaches (adults + nymphs) in traps collected over a two-week period pre- and post-intervention. *Wilcoxon Signed Rank, p = 0.016.

Reduced exposure to insecticides in ambient air following IPM intervention

	LOD (ng/m3)	PRE Mean ± SE	POST Mean ± SE	Wilcoxon Signed Rank Neg.	Pos.	Ties	p-value
Piperonyl butoxide	0.2	1.66 ± 0.71	0.80 ± 0.22	17	6	0	0.016
***cis*-Permethrin**	0.4	1.53 ± 0.85	1.25 ± 0.60	14	11	1	0.510
***trans*-Permethrin**	0.7	2.60 ± 1.45	1.95 ± 0.96	13	11	0	0.475

Levels of PBO decreased by 50% among homes before and after the intervention (no significant change in controls).

Reduced internal dose of insecticides following IPM intervention

		Intervention	Control	Chi-Squared p-value
	LOD (pg/g)	% > LOD	% > LOD	
2-Isopropoxyphenol	1.5	0	12	0.106
***cis*-Permethrin**	0.5	0	12	0.106
***trans*-Permethrin**	0.5	0	29	0.008

Pesticide levels (mean ± SE, median) (pg/g) in maternal plasma samples collected at delivery in intervention group (n = 21) and in control group (n = 17).

CONCLUSION

- Residential pesticide use is widespread
- Use is highly associated with levels of housing disrepair
- Use is highly associated with ambient indoor air levels of pesticides
- Prenatal exposure to pesticides is associated with altered birth outcomes and the risk of developing behavioral problems
- Interventions using IPM may reduce pest infestation and pesticide exposure

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Study participants

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