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Pyrethroids in house dust from the homes of farm worker families in the MICASA study

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Abstract

Indoor pesticide exposure is a growing concern, particularly for pyrethroids, a commonly used class of pesticides. Pyrethroid concentrations may be especially high in homes of immigrant farm worker families, who often live in close proximity to agricultural fields and are faced with poor housing conditions, potentially causing high pest infestation and pesticide use. We investigate levels of pyrethroids in the house dust of farm worker family homes in a study of mothers and children living in Mendota, CA, within the population-based Mexican Immigration to California: Agricultural Safety and Acculturation (MICASA) Study. We present pesticide use data and levels of pyrethroid pesticides in indoor dust collected in 2009 as measured by questionnaires and a GC/MS analysis of the pyrethroids *cis*- and *trans*-permethrin, cypermethrin, deltamethrin, esfenvalerate and resmethrin in single dust samples collected from 55 households. *Cis*- and *trans*-permethrin had the highest detection frequencies at 67%, with median concentrations of 244 and 172 ng/g dust, respectively. Cypermethrin was detected in 52% of the homes and had a median concentration of 186 ng/g dust. Esfenvalerate, resmethrin and deltamethrin were detected in less than half the samples. We compared the pyrethroid concentrations found in our study to other studies looking at both rural and urban homes and daycares. Lower detection frequencies and/or lower median concentrations of *cis*- and *trans*-permethrin and cypermethrin were observed in our study as compared to those studies. However, deltamethrin, esfenvalerate and resmethrin were detected more frequently in the house dust from our study than in the other studies. Because households whose children had higher urinary pyrethroid metabolite levels were more likely to be analyzed in this study, a positive bias in our estimates of household pyrethroid levels may be expected. A positive association was observed with reported outdoor pesticide use and

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cypermethrin levels found in the indoor dust samples ($r_s = 0.28$, $p = 0.0450$). There was also a positive association seen with summed pyrethroid levels in house dust and the results of a pesticide inventory conducted by field staff ($r_s = 0.32$, $p = 0.018$), a potentially useful predictor of pesticide exposure in farm worker family homes. Further research is warranted to fully investigate the utility of such a measure.

Keywords

Pyrethroids; House dust; Farm worker; Pesticide inventory

1. Introduction

A number of pyrethroids, such as permethrin, cypermethrin, deltamethrin, and esfenvalerate, have been reported to be present in house dust with detection frequency (%D) ranges from various studies of 45–100%, 5–64%, 5–17% and 5–29%, respectively (Bradman et al., 2007; Colt et al., 2004; Hwang et al., 2008; Julien et al., 2008; Morgan et al., 2007; Quirós-Alcalá et al., 2011; Rudel et al., 2003; Starr et al., 2008). Much of this data was collected before or in the same year as the federally mandated phase-out of residential uses of the organophosphate pesticides chlorpyrifos and diazinon in 2001, which subsequently caused household pyrethroid use to increase (Horton et al., 2011; USEPA, 2001, 2012; Williams et al., 2008). This can be seen in the above mentioned studies, with the highest %Ds of pyrethroids occurring in studies whose samples were collected during or after 2001. Although pyrethroids have low toxicity, particularly compared to other insecticides, studies have shown that high levels of exposure to pyrethroids may cause significant toxicity and health effects, including acute neurotoxic effects (Costa et al., 2008; Ray and Fry, 2006), immunotoxic effects (Blaylock et al., 1995; Emara and Draz, 2007) and negative effects on mammalian reproduction (Ji et al., 2011; Zhang et al., 2008). Pyrethroids are also possible human carcinogens (USEPA, 2006).

Families living in close proximity to farms may have higher than average pyrethroid exposure due to household pesticide use, drift from agricultural application and take-home exposure pathways from occupational use by another family member (Curl et al., 2002; Harnly et al., 2005; Lu et al., 2000; You et al., 2004). High levels of pesticides in carpet dust are a particular concern for young children who, due to their continual exploration of their environments, spend a large amount of time on the floor and have increased hand to mouth activity, resulting in increased exposure to pollutants through dermal and non-dietary ingestion routes (Fenske et al., 1990; Gurunathan et al., 1998; Moya et al., 2004; Zartarian et al., 1997). These two factors combined make children living in agricultural communities especially susceptible to pesticide exposure (Arcury et al., 2007; Bradman et al., 2007). Data on pyrethroid concentrations in the house dust of rural farm worker homes is limited.

This study was conducted in order to address participant concerns about pesticide exposure in the community-based Mexican Immigration to California: Agricultural Safety and Acculturation (MICASA) study. Our objectives were to characterize the levels of pyrethroid pesticides in the house dust of farm worker families and characterize their residential pesticide application practices in order to evaluate possible associations between the dust levels and pesticide use practices. We report the pesticide use data and levels of pyrethroid pesticides in indoor dust collected in 2009 as measured by questionnaires and dust concentrations of the pyrethroids *cis*- and *trans*-permethrin, cypermethrin, deltamethrin, esfenvalerate and resmethrin among 55 households of farm worker families living in Mendota, CA.

2. Material and methods

2.1. Sample size

Single dust samples were collected from 105 homes of families participating in the MICASA study. Of the 105 available samples, 70 had sufficient quantities of dust after sieving for instrumental analysis of pyrethroids. Of those, there were 55 samples selected, with relatively higher selection probabilities assigned to those households with elevated levels of the common pyrethroid urinary metabolite 3-phenoxybenzoic acid (3PBA) in urine samples collected from the children in order to increase the probability of having detectable levels of pyrethroids in the dust. Data on the 55 dust samples that were analyzed are presented here. Data on urine concentrations will be reported in a future publication.

2.2. Study population

The MICASA study is a prospective cohort sample of 467 hired farm worker family households from Mendota, CA, designed to evaluate occupational and environmental exposures of significance for a farm worker population. Households were sampled from randomly selected census blocks and, following door-to-door enumeration, those households containing at least one hired farm worker were contacted for recruitment. Eligible participants in the MICASA study were men and women, residing in Mendota, CA, ages 18–55 years, self-identified as Mexican or Central American, and with at least one household member who worked in agriculture 45 days or more in the previous year, with both members of the household completing the interview (Stoecklin-Marois et al., 2011).

MICASA recruitment was conducted between January 2006 and May 2007. Recruitment for the home pyrethroid exposure study began in February of 2009, and sample collection took place between June and December of 2009.

The analysis highlighted in this paper was designed to look at levels of pyrethroid pesticides in the homes of the MICASA study population. Because children typically have higher levels of exposure to pesticides (Moya et al., 2004), we restricted eligibility to those MICASA families with at least one child aged 7 or under at the time of recruitment in order to better understand pyrethroid sources in this potentially highly exposed population. Among the MICASA households completing baseline interviews, 175 (37.5%) were eligible for participation in the homepyrethroid exposure study. Eligible households were listed in random order for contact. One hundred twenty seven households were contacted for recruitment before reaching our goal of 105 (82.7%) households who agreed to participate and were enrolled in the study. The remaining 22 households either could not be contacted or declined to participate. If a family had multiple eligible children, one child was randomly selected and enrolled. At the time of sample collection, children ranged from 2 to 8 years of age.

Written informed consent was obtained from each participant. Each study component was described verbally and in writing to the participant prior to obtaining written informed consent. Spanish was the primary language of the participants, thus the study description and written informed consent were provided in Spanish. All study procedures were approved by the University of California, Davis, Institutional Review Board.

2.3. Sample collection

Dust samples were collected and questionnaires were conducted between June and December of 2009. Dust samples were collected in the main living area of the home, which was defined as the most frequently used room in the house that was not a bedroom or kitchen. Dust samples were collected using a Eureka Mighty-Mite vacuum cleaner and standard crevice tool attachment (Model 3670) modified to collect dust into a 19 × 90 mm cellulose extraction thimble (Whatman Inc.) that was secured to the crevice tool using a rubber O-ring. More detailed information on collection methods using the Eureka Mighty-Mite have been described elsewhere (Allen et al., 2008; Rudel et al., 2003). The square footage of the main living area was measured and recorded as well as the temperature and humidity. Dust was collected over the equivalent of the entire measured floor area. Once sampling was complete, the thimble was removed from the Mighty Mite, wrapped in cleaned foil, weighed, placed in a polyethylene zip-top bag and labeled with the household ID number. Dust samples were then refrigerated at the MICASA field office for generally less than one day and delivered on ice to UC Davis, where they were stored in a −20 °C freezer until sample extraction and analysis. All Mighty-Mite equipment was cleaned using a 1% solution of detergent and hot water and allowed to air-dry between home visits in order to prevent cross-contamination.

At the time of sample collection, a questionnaire was administered to the mothers. We obtained the frequency of pesticide use in both the hot and cold season of the previous year, including sprays, foggers, sticky traps, bait traps, gels, and any application by professional exterminators. Participants were asked if anyone living in the home had seen rodents, rodent feces, live or dead roaches, roach feces or ants inside the home at any time in the last year, with answer options including: large amounts, moderate amounts, none or don't know. On the day of dust collection a staff member conducted a pesticide inventory in which detailed information on all pesticide products in the home was recorded, this included the name of each product, the size of the product container, the EPA registration number and all active ingredients.

2.4. Preparation of dust extracts

All dust and materials contained in each cellulose thimble were removed and weighed. The particulates were then sieved, first to 1500 μm, and then to 150 μm for analysis. The dust samples were extracted using a method similar to that described in Starr et al. (2008). Briefly, dust samples were each weighed to 0.5 g aliquots, spiked with 250 ng of $^{13}C_6$-labeled *trans*-permethrin, the surrogate recovery standard (SRS), and vortexed with 12 mL hexane. Samples were sonicated for 20 min, centrifuged at 3000 rpm for 10 min, decanted and volume reduced to 2 mL hexane. The extracts were subjected to alumina:silica gel (1:1 by weight) column chromatography to remove interferences following methods similar to those described in Hwang et al. (2008). Prior to use, alumina and sodium sulfate were heated (450 °C for 4 h) as well as the silica gel (170 °C for 24 h). All heated products were stored at 130 °C. When needed, alumina was deactivated (4% by weight) with purified water. The columns were conditioned with hexane and eluted with 50 mL of dichloromethane:hexane (1:1) mixture. The eluted solvents were concentrated to 1 mL of hexane, and the internal standard (IS) phenanthrene-d10 was added.

2.5. Instrumental analysis

Dust extracts were analyzed by gas chromatography mass spectrometry (GC/MS) operated in selected ion mode (Hewlett-Packard 6890 GC with a Hewlett-Packard 5873 mass spectral detector). Multiple ions, including one used for quantitation and one to two for qualification and confirmation, were monitored for each compound. Calibration curves for all analytes were generated using the response ratio of each quantitation ion to the quantitation ion of the IS. Individual pyrethroid pesticide stock solutions (100 μg/mL in methanol) for permethrin, cypermethrin, deltamethrin, esfenvalerate, and resmethrin were obtained from AccuStandard (New Haven, CT). Concentrations of the pyrethroid standards ranged from 62.5 to 2000 ng/mL. All samples and standards contained 100 ng of the IS. For each analyte and standard, confirmation of the identity was based upon the retention time and the presence and correct ratio of qualifier ions relative to the ion used for quantitation. The chromatographic column used was a J&W DB-5MS fused silica capillary column (30 m × 0.25 mm ID, 0.25 μm film thickness) with a helium flow rate of 1 mL/min. The injection temperature was 280 °C, with the initial GC oven temperature set to 80 °C and ramped to 100 °C at 20 °C/min, then 300 °C at 10 °C/min, and maintained for 10 min. The total run time for the analysis of each sample was 31 min. In this analysis, *cis*- and *trans*-isomers are only reported for permethrin and its metabolites. All other pesticides and metabolites are reported as summed totals of all isomers.

2.6. Statistical analysis

Summary statistics for the pyrethroid data were calculated. For concentrations below the limit of detection (LOD), an imputed value was assigned equal to the LOD divided by the square root of 2 (Barr et al., 2010; Hornung and Reed, 1990). A Spearman rank-order correlation procedure was used to determine the intra-household correlations between particular pyrethroid concentrations, with significance set at $p < 0.05$.

A Spearman rank-order correlation procedure and 95% confidence intervals (CI) were used to evaluate associations between interview questionnaire variables and the presence of pyrethroid pesticides in the house dust, with significance set at $p < 0.05$.

As part of the main MICASA study questions on pesticide use were asked of the full cohort of 436 households in both an interview conducted from January 2006 to May 2007 and an interview conducted from February 2009 to June 2010. These questions were asked of both the male and female heads of household. Responses to these questions allowed us to look at the consistency of reporting pesticide use among family members as well as the consistency of reporting pesticide use over time. In both interviews the male and female heads of household were asked separately if either they or anyone in the household uses indoor and/or outdoor pesticide sprays. The consistency of responses to these pesticide use questions between the men and women from the same household was assessed using Cohen's kappa, a measure of chance-corrected agreement (Landis and Koch, 1977; Lin et al., 2011). Temporal comparisons from the same participant between the two interviews conducted approximately 3 years apart were also made using Cohen's kappa.

All statistical analyses were performed using SAS version 9.2 (SAS Institute, Cary, NC).

3. Results

3.1. Population demographics & questionnaire

The demographics of the entire MICASA population, as well as the 55 participating households whose dust was analyzed can be seen in Table 1. The participants in the MICASA study ranged in age from 18 to 83 years old, while those participants whose house dust is reported on here ranged in age from21 to 55 years old at the time of the baseline interview. A chi-square test of independence was performed to examine the relation between age and participation in this portion of the study. Participants whose house dust is reported on here were significantly younger than the rest of the MICASA population (χ^2 (3, N = 875) = 82.7, $p < 0.0001$). MICASA participants had very low educational levels, with 68.7% of the male participants and 58.7% of the female participants having only a 6th grade education or lower, while those participating in this portion of the study had significantly higher educational levels than the rest of the MICASA population (χ^2 (2, N = 875) = 7.2, $p = 0.03$). The MICASA population was almost all married, with 100% of those that participated in the portion of the being married, significantly more than those in the main MICASA population (χ^2 (2, N = 875) = 13.6, $p = 0.001$). Most of the MICASA participants were born in either Mexico or El Salvador, with only 3.9 and 5.2% of the male and female participants, respectively, being born in the United States, there was no significant difference in the birth country of those participating in this study.

3.2. Pyrethroid concentrations in house dust

Of the five pyrethroids tested for, at least one pyrethroid, generally permethrin, was detected in 89% of the dust samples. Detection frequencies (%Ds) for the individual pyrethroids were variable among the dust samples, and ranged from 20 to 67% (Table 2). *Cis*- and *trans*-permethrin had the highest %D at 67% with median concentrations of 244 and 172 ng/g dust, respectively, and an average ± standard deviation (SD) *cis*- to *trans*-permethrin ratio of 1.8 ± 1.1. Cypermethrin had the next highest %D at 52% and median concentration of 186 ng/g dust. Deltamethrin, esfenvalerate, and resmethrin were detected in less than half the samples.

Multiple intra-household correlations between particular pyrethroid concentrations were found to be statistically significant (Table 3). The correlation of the *cis*- and *trans*-permethrin isomers was significant with a Spearman rank correlation coefficient (r_s) of 0.81,

$p < .0001$. All other correlations between pyrethroids that were statistically significant ($p < 0.05$) had r_s values below 0.5.

3.3. Correlation of interview data with measured concentrations in dust

In the field staff-collected pesticide inventory, 29.1% of the homes had at least one bottle of residential pesticide present. In the participant interview, 30.2% of the women reported using outdoor spray pesticides and 34.6% reported using indoor pesticide sprays. Many women reported pest problems, with 25.5% reporting rodents, 36.4% reporting roaches and 40.0% reporting ants.

Univariate analysis showed multiple questionnaire variables to significantly correlate with pyrethroid concentrations (Table 4). The number of pesticide products in each home, as determined by the pesticide inventory was found to be a significantly positive correlate of the sum of pyrethroid concentrations found in the house dust. The reported use of outdoor pesticide sprays, based on average annual frequency significantly correlated with increased levels of both the sum of pyrethroids and cypermethrin. When the use of outdoor pesticide sprays was split into three categories: no annual use, 1–2 times/year and more than 3 times/year, significant positive correlations were still seen with levels of summed pyrethroids and cypermethrin. The reported amount of roaches present in the home was negatively correlated with the summed pyrethroid concentrations, as well as the esfenvalerate concentrations in the house dust. Permethrin concentrations in the house dust were positively correlated with the reported amount of rodents in the home.

3.4. Consistency of responses to pesticide use questionnaires

The levels of agreement of responses to pesticide use questions, asked of the main MICASA cohort during two separate interviews conducted in 2006–2007 and 2009–2010, between men and women from the same household were found to be moderately high, with Cohen kappa values ranging from 0.56 to 0.76 (Table 6). In the 63 of 436 households (17%) in which either the man or the woman reported using outdoor pesticide sprays during the first interview, use was reported by both the man and the woman in 28 households (44%), with approximately equal proportions of only the man or only the woman reporting pesticide use (Cohen's kappa = 0.56, 95% CI: 0.43–0.69). There was higher estimated consistency for indoor sprays in the first interview (Cohen's kappa = 0.76, 95% CI: 0.67–0.85).

There was only slight consistency in how a given participant answered both the indoor and outdoor pesticide use questions when asked the same questions at the two interviews conducted approximately 3 years apart (Table 7), with Cohen's kappa estimates ranging from 0.08 to 0.15. A larger fraction of the population reported using pesticides at the second interview than at the first interview, with between 20.0 and 26.9% of individuals reporting use at the second that did not report at the first, in contrast to the 5.4 to 11.3% of individuals reporting use at first but not at the second. Only between 5.6 and 6.7% of individuals reported use for both time periods. When answers from both men and women were combined to show if either one had reported pesticide use, results were slightly higher with 7.3 and 7.7% reporting use of indoor and outdoor sprays at both interviews.

4. Discussion

We assessed the levels of pyrethroid pesticides in 55 homes in a farm worker population by laboratory measurements of permethrin, cypermethrin, resmethrin, esfenvalerate and deltamethrin in house dust samples and by questionnaire data. This population had a relatively low educational level, with less than half of the participants reporting a 6th grade education or higher, in contrast to the 85% of U.S. adults who have a high school diploma (Stoops, 2004).

Detectable levels of the common pyrethroids permethrin, cypermethrin, deltamethrin, esfenvalerate and resmethrin were found in the dust samples collected in this study. Most of these pyrethroids have been detected in house dust from several different studies (Table 5). The majority of these studies were conducted with the general population and two were conducted with farm working communities; however there was little difference between pyrethroid concentrations in the house dust from the two types of populations. We observed lower detection frequencies and/or lower median concentrations of *cis*- and *trans*-permethrin than many of these studies (Bradman et al., 2007; Colt et al., 2004; Hwang et al., 2008; Julien et al., 2008; Morgan et al., 2007; Quirós-Alcalá et al., 2011; Starr et al., 2008). We also observed lower or comparable detection frequencies and median concentrations of cypermethrin in our study as compared to others (Bradman et al., 2007; Hwang et al., 2008; Julien et al., 2008; Quirós-Alcalá et al., 2011; Rudel et al., 2003; Starr et al., 2008). Deltamethrin and esfenvalerate were detected more frequently in the house dust from our study than in any other (Bradman et al., 2007; Julien et al., 2008; Quirós-Alcalá et al., 2011; Starr et al., 2008). Only two other studies looked at resmethrin in house dust, and neither was able to find detectable levels (Bradman et al., 2007; Julien et al., 2008) compared to the 29% detection in our study. The differences in detection frequencies in our study as compared to these other studies may be the result of different LODs. Additionally, our study population was restricted to only those families with young children, potentially causing differences in pesticide use practices when compared to a more diverse population containing people of differing ages, marital statuses, and living arrangements. Also, because we weighted our sample selection to those households whose participants already showed exposure to pyrethroids, a true random sampling from our study population may have exhibited lower detection frequencies than what has been reported here. We also did not observe the seemingly extreme outliers or maximum concentrations several orders of magnitude over the median concentration that some of the other studies reported (Julien et al., 2008; Morgan et al., 2007; Quirós-Alcalá et al., 2011; Rudel et al., 2003; Starr et al., 2008). This may be due to our study population being better trained in pesticide use practices and precautions from work in agriculture than urban dwellers.

We wanted to examine the potential reasons for the lack of correlations with the questionnaire data. We used data from the main MICASA study questions on pesticide use, which were asked of the full cohort of 436 households in two interviews, the first conducted from January 2006 to May 2007 and the second from February 2009 to June 2010. The consistency of responses to these pesticide use questions between the men and women from the same household was assessed and within-household levels of agreement were moderately high. Use was reported by both the man and the woman in 44% of the households in which either the man or the woman reported using outdoor pesticide sprays during the first interview. Assuming pesticides were actually applied if reported by either the man or the woman, asking only the man or the woman would misclassify many of the households that used pesticides as non-users, which may be partially responsible for the lack of correlation. Temporal comparisons from the same participant between the two interviews conducted approximately 3 years apart were also made. A larger fraction of the population reported using pesticides at the second interview than at the first interview, with only between 5.6 and 6.7% of individuals reporting use for both time periods. The low levels of agreement could be due either to actual changes in use patterns or due to differences in reporting and may also be partially responsible for the lack of correlation between questionnaire responses and house dust concentrations.

Many previous studies have reported that residential pesticide use questions were ineffective at identifying exposure levels (Sexton et al., 2003). We also saw a lack of consistency in the relationships between questionnaire data and measured levels of pyrethroids in the house dust (Table 4). There was a positive correlation with reported outdoor pesticide use and pyrethroid levels in the house dust. However there was no relationship with indoor pesticide use. We found a slightly negative correlation with outdoor traps and levels of indoor pyrethroids, suggesting that families that use traps to reduce their pest problems use less pesticide in their homes. A possible reason for the lack of correlations between reported pesticide use (especially indoor pesticide use) and pyrethroid levels found in the home is that the questionnaire asked about any pesticide products used for insect control, while we only measured five specific pyrethroid compounds. It is very likely that products used contained other pyrethroids' active ingredients as well. There are also likely to be large discrepancies in the amount of pesticide applied, as well as cleaning practices between participants. This information was not accounted for in our questionnaire.

The most promising predictor of exposure was the pesticide inventory. There was a significant correlation between the pesticide inventory and the sum of pyrethroid concentrations found in the house dust. With traditional questionnaires, it is often difficult for participants to accurately recall pesticide use. The pesticide inventory on the other hand is relatively easy data to collect, requiring only a few minutes time for the interviewer to note the pesticide products present in the participant's homes. Although neither method gives information on what, or the concentrations of, specific pesticides that may be found in the physical samples from the home, the pesticide inventory may be a more useful tool to predict possible pesticide exposure than the traditional participant recall.

This study has many limitations. Data from households with higher levels of dust or whose children had higher pyrethroid metabolite levels in the urine were more likely to be analyzed, which can be expected to lead to a positive bias in our estimates of household pyrethroid levels. Our small sample size limited the statistical power and may have prevented us from observing statistically significant correlations in our data. Additionally, as mentioned above, there was a lack of consistent reporting of pesticide applications between husband and wife.

Despite these limitations, this study contributes to existing research by providing further evidence that farm working families face exposures to pyrethroid pesticides. These results can be used to develop interventions to reduce pesticide exposure in vulnerable populations. Additionally, this study provides evidence that a pesticide inventory may be a more useful tool in estimating possible pesticide exposure than traditional pesticide use questionnaires have been in the past. Further research is warranted to fully investigate the usefulness of such a measure.

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Abbreviations

MICASA	, Mexican Immigration to California: Agricultural Safety and Acculturation
3PBA	3-phenoxybenzoic acid
SRS	surrogate recovery standard
IS	internal standard
GC/MS	gas chromatographymass spectrometry
LOD	limit of detection
CI	confidence intervals
%D	detection frequencies
SD	standard deviation
$\mathbf{r_s}$	Spearman rank correlation coefficient

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Table 1

Socio-demographic characteristics of all participants in the MICASA study and those who also participated in the Home Pesticide Study assessed on the MICASA baseline interview, 2006–2007.

	All baseline participants		Home pesticide participants	
N (%)	**Male**	**Female**	**Male**	**Female**
Age range				
18–30	111 (25.5)	130 (29.6)	23 (44.2)	27 (49.1)
31–40	145 (33.3)	168 (38.2)	21 (40.4)	25 (45.5)
41–45	64 (14.7)	63 (14.3)	6 (11.5)	3 (5.4)
46+	115 (26.5)	79 (17.9)	2 (3.9)	0 (0.0)
Education				
No school	18 (4.6)	16 (4.1)	0 (0.0)	3 (6.4)
≤6th grade education	252 (64.1)	212 (54.6)	31 (67.4)	17 (36.2)
>6th grade education	123 (31.3)	160 (41.3)	15 (32.6)	27 (57.4)
Marital status				
Married	413 (95.2)	411 (93.4)	55 (100)	55 (100)
Divorced/separated/widow	4 (0.9)	15 (3.4)	0 (0.0)	0 (0.0)
Single	17 (3.9)	14 (3.2)	0 (0.0)	0 (0.0)
Country of birth				
United States	17 (3.9)	23 (5.2)	1 (1.9)	1 (1.8)
Mexico	279 (64.1)	296 (67.3)	34 (65.4)	37 (67.3)
El Salvador	126 (29.0)	107 (24.3)	16 (30.8)	17 (30.9)
Honduras/Nicaragua/Guatemala	13 (3.0)	14 (3.2)	1 (1.9)	0 (0.0)

Table 2

Detection frequencies, select percentiles and maximum pyrethroid concentrations reported permass dust (ng/g) and per surface area (ng/m^2) from the MICASA Home Pesticide Study, 2009 (n = 55).

	Pyrethroid	%D	50th	75th	90th	95th	Max
ng/g dust	Cis-permethrin	67	244	568	670	755	1410
	Trans-permethrin	67	172	207	274	421	1737
	Cypermethrin	52	186	590	3223	7036	15,059
	Esfenvalerate	44	<LOD	246	426	454	585
	Resmethrin	29	<LOD	161	208	261	964
	Deltamethrin	20	<LOD	<LOD	250	385	701
ng/m^2	Cis-permethrin	67	16	22	36	56	80
	Trans-permethrin	67	5.7	6.7	9.3	14	98
	Cypermethrin	52	18	63	175	334	516
	Esfenvalerate	44	<LOD	12	15	16	19
	Resmethrin	29	<LOD	5.2	6.1	6.6	54
	Deltamethrin	20	<LOD	<LOD	13	15	16

Table 3

Relationship between individual pyrethroid concentrations found in house dust (N = 55 households) using the Spearman rank correlation coefficient (*p*-value).

	***cis*-Permethrin**	***trans*-Permethrin**	**Total permethrin**	**Cypermethrin**
trans-Permethrin	0.81 (<.0001)			
Total permethrin	0.98 (<.0001)	0.88 (<.0001)		
Cypermethrin	0.26 (0.054)	0.32 (0.019)	0.27 (0.049)	
Esfenvalerate	0.43 (0.0012)	0.37 (0.0055)	0.45 (0.00050)	0.30 (0.025)

Table 4

Spearman rank correlation analysis results showing the relationship between pyrethroid concentrations and various pesticide use and questionnaire items.

Variable	Sum pyrethroids		Permethrin		Cypermethrin		Esfenvalerate	
	r_s (95% CI)	$p > \lvert r \rvert$	r_s (95% CI)	$p > \lvert r \rvert$	r_s (95% CI)	$p > \lvert r \rvert$	r_s (95% CI)	$p > \lvert r \rvert$
Pesticide Inventory	0.32 (0.05–0.53)	0.018	0.21 (−0.06–0.45)	0.12	0.20 (−0.07–0.44)	0.13	0.21 (−0.07–0.44)	0.13
Outdoor sprays[a]	0.23 (−0.04–0.47)	0.096	0.18 (−0.10–0.42)	0.21	0.28 (0.00–0.51)	0.0450	0.06 (−0.21–0.32)	0.67
Roaches[b]	−0.23 (−0.47–0.04)	0.090	−0.12 (−0.37–0.15)	0.40	−0.11 (−0.36–0.16)	0.43	−0.23 (−0.46–0.04)	0.092
Rodents[b]	0.08 (−0.19–0.34)	0.57	0.23 (−0.04–0.47)	0.096	−0.04 (−0.30–0.24)	0.80	0.04 (−0.23–0.31)	0.76
Ants[b]	0.14 (−0.13–0.39)	0.30	0.20 (−0.07–0.44)	0.10	0.02 (−0.25–0.29)	0.90	0.04 (−0.23–0.31)	0.80

Bold text: $p < 0.1$, Gray box: $p < 0.05$.

[a] Based on frequency of use during previous year.

[b] Based on categorical amount: large amount, moderate amount, none.

Table 5

Summary statistics for pyrethroid concentrations (ng/g) in dust from multiple studies.

Pyrethroid (ng/g)			*cis*-Permethrin				*trans*-Permethrin				Cypermethrin				Deltamethrin				Esfenvalerate				Resmethrin			
Study	**Year**	**N**	**%D**	**50th**	**95th**	**Max**	**%**	**50th**	**95th**	**Max**	**%D**	**50th**	**95th**	**Max**	**%D**	**50th**	**95th**	**Max**	**%D**	**50th**	**95th**	**Max**	**%D**	**50th**	**95th**	**Max**
MICASA, Farmworker Families, Mendota, CA	2009	55	67	244	755	1410	67	172	421	1737	52	186	7036	15059	20	<LOD	385	701	44	<LOD	454	585	29	<LOD	261	964
Urban & Rural CA, Quirós-Alcalá et al. (2011)	2006																									
Oakland		13	100	291	21600	26700	100	504	36400	46800	64	587	5990	13100	12	<LOD	13000	16300	ND	–	–	–				
Salinas		15	100	568	5930	6300	100	952	9170	9690	55	230	4540	13500	17	<LOD	3780	5590	3	<LOD	<LOD	67				
Davis, CA Apartments, Hwang et al. (2008)	2004	11	91	52	319[a]	NR	91	126	680[a]	NR	91	177	1033[a]	NR												
Farmworker Families, Salinas, Bradman et al. (2007)	2002	20	100	210	NR	2900	100	570	NR	5800	40	100	NR	1500	5	<LOD	NR	560	5	<LOD	NR	50	ND	–	–	–
Urban Public Housing, Boston, Julien et al. (2008)	2002–2003	35	100[b]	920[b]	NR	13100[b]					60	300	NR	5200	9	<LOD	NR	7000	29	<LOD	NR	1200	ND	–	–	–
Ohio Preschool Children - homes, Morgan et al. (2007)	2001	120	100	470	7630	79600	100	344	9210	78800																
Ohio & N. Carolina Homes & Daycares, Starr et al. (2008)	2000–2001	85	100	666	14122	30553	100	711	11980	30420	34	<LOD	1571	6492	5	<LOD	<LOD	2503	8	<LOD	60	943				
National Cancer Institute, Colt et al. (2004)	1999–2001	513	72	337[c]	NR	NR	74	517[c]	NR	NR																
Cape Cod, MA Homes, Rudel et al. (2003)	1999–2001	119	45	<LOD	NR	61900	53	387	NR	98000	5	<LOD	NR	172000												

[a] 90th percentiles reported.

[b] Total permethrin reported.

[c] Geometric mean reported.

Table 6

Comparison of pesticide use reporting between adult male and female members of the same household for both the baseline and follow-up interviews.

		Total N	Both no Cell N (%)	Users N	Both yes Cell N (% of users)	Women yes, Men no Cell N (% of users)	Men yes, Women no Cell N (% of users)	Cohen's kappa (95% CI)
Baseline	Outdoor spray	373	310 (83)	63	28 (44)	18 (29)	17 (27)	0.56 (0.43–0.69)
	Indoor sprays	364	292 (80)	72	48 (67)	9 (12)	15 (21)	0.76 (0.67–0.85)
Follow-up	Outdoor spray	282	163 (58)	119	67 (56)	25 (21)	27 (23)	0.58 (0.48–0.68)
	Indoor sprays	282	186 (66)	96	51 (53)	23 (24)	22 (23)	0.59 (0.48–0.69)

Table 7

Temporal comparison of pesticide use reporting per individual participant between the baseline vs. follow-up interviews.

		Baseline						
		Yes	No	Yes	No	Yes	No	
	Cell N (% of total)	**Men indoor, N = 275**		**Women indoor, N = 337**		**Man and/or woman indoor, N = 467**		**Indoor**
Follow-up	Yes	16 (6)	55 (20)	22 (6)	71 (21)	34 (7)	86 (18)	
	No	31 (11)	173 (63)	36 (11)	208 (62)	56 (12)	291 (62)	
	Cohen's kappa (95% CI)	0.08 (−0.04–0.20)		0.10 (−0.01–0.21)		0.13 (0.04–0.23)		
	Cell N (% of Total)	Men outdoor, N = 276		Women outdoor, N = 342		Man and/or woman outdoor, N = 467		Outdoor
	Yes	17 (6)	72(26)	23 (7)	92 (27)	36 (8)	108 (23)	
	No	15 (6)	172 (62)	19 (5)	208 (61)	40 (8)	283 (61)	
	Cohen's kappa (95% CI)	0.13 (0.03–0.24)		0.14 (0.04–0.23)		0.15 (0.06–0.24)		