Title

Home-based community health worker intervention to reduce pesticide exposures to farmworkers’ children: A randomized-controlled trial

Permalink

https://escholarship.org/uc/item/2h59m07m

Journal

Journal of Exposure Science & Environmental Epidemiology, 25(6)

ISSN

1559-0631

Authors

Salvatore, Alicia L
Castorina, Rosemary
Camacho, José
et al.

Publication Date

2015-11-01

DOI

10.1038/jes.2015.39

Peer reviewed

Published in final edited form as:
J Expo Sci Environ Epidemiol. 2015 ; 25(6): 608–615. doi:10.1038/jes.2015.39.

Home-based Community Health Worker Intervention to Reduce Pesticide Exposures to Farmworkers' Children: A Randomized Controlled Trial

Alicia L. Salvatore, DrPH[1,2], **Rosemary Castorina, PhD**[2], **José Camacho**[3], **Norma Morga**[3], **Jesús López**[4], **Marcia Nishioka, PhD**[5], **Dana Boyd Barr, PhD**[6], **Brenda Eskenazi, PhD**[2], and **Asa Bradman, PhD**[2]

[1]University of Oklahoma Health Sciences Center College of Public Health, Oklahoma City, OK, USA

[2]Center for Environmental Research and Children's Health (CERCH), School of Public Health, University of California, Berkeley, CA, USA

[3]Center for the Health Assessment of Mothers and Children of Salinas (CHAMACOS), Clínica de Salud del Valle de Salinas, Salinas, CA, USA

[4]California Rural Legal Assistance, Salinas, CA, USA

[5]Battelle Memorial Institute, Columbus, OH, USA

[6]Emory University, School of Public Health, Atlanta Georgia, USA

Abstract

We conducted a randomized-controlled trial of a home-based intervention to reduce pesticide exposures to farmworkers' children in Monterey County, California (n=116 families). The intervention consisted of three home-based educational sessions delivered by community health workers in Spanish. Measurements of organophosphate (OP) insecticide metabolites in child urine (n=106) and pesticides in home floor wipes (n=103) were collected before and after the intervention. Median child urinary dialkylphosphate (DAP) metabolite levels were slightly lower among the intervention group children at follow-up compared to baseline, albeit nonsignificantly. DAP metabolite levels in the control group children were markedly higher at follow-up compared to baseline. In adjusted models, intervention participation was associated with a 51% decrease in total DAP metabolite levels. Carbaryl, chlorpyrifos, cypermethrin, dacthal, diazinon, malathion and trans-permethrin were commonly detected in the floor wipes. In adjusted models, intervention participation was significantly associated with a 37% decrease in trans-permethrin floor wipe levels in homes, but not organophosphate (OP) or other agricultural pesticides. In summary, intervention group children had slightly reduced pesticide exposures, whereas child exposures were higher among the control group. Additional intervention studies evaluating methods to reduce pesticide exposures to farmworker families and children are needed.

Corresponding author: Asa Bradman, PhD, Center for Environmental Research and Children's Health (CERCH), School of Public Health, University of California, Berkeley, 1995 University Avenue, Suite 265, Berkeley, CA 94704, Phone: (510) 643-3023, Fax: (510) 642-9083, abradman@berkeley.edu.

Keywords

farmworker; pesticides; intervention; children; exposure; community-based participatory research

INTRODUCTION

Several studies show that children are widely exposed to pesticides at home (1–4). Pesticides in house dust or on surfaces can be ingested and absorbed by children because they crawl and play on the floor and frequently put their hands and other objects into their mouths; they also eat more food, drink more fluids, and breathe more air per unit of body weight compared to adults, potentially increasing their exposures (5). Children are also less developed physiologically and neurologically and thus may be at greater risk of health effects from pesticide exposure (5, 6).

In addition to sources common to other children (e.g., food, home pesticide use), farmworkers' children can be exposed to agricultural pesticide residues carried home on the clothing and skin of their farmworker parents and other household members (1, 7, 8). Several studies have reported the presence of agricultural pesticides in farmworker homes (1, 9, 10), and measurements of pesticide exposure biomarkers have shown associations with parent or household member occupations (9, 11).

Growing public health concern about the health effects of pesticide exposures on children's health coupled with research indicating that farmworkers' children experience significantly higher pesticide exposures than other children have resulted in the development of community-based interventions to reduce pesticide exposures to farmworkers' children. A number of studies have examined the efficacy of interventions to reduce pesticide exposures to farmworkers' children (8, 12–15). Results suggest that worksite and community-based interventions conducted with farmworkers and their families may be effective in promoting behaviors that could reduce children's pesticide exposure (8, 12, 14–17). There is limited evidence, however, about whether these interventions will actually reduce pesticides in the home environment or decrease children's pesticide exposures. To our knowledge, only one intervention study conducted to date, a randomized-controlled trial of *Para Niňos Saludables*, a community-based intervention conducted in the Yakima Valley of Washington State, used environmental and biological measurements of pesticide exposure to evaluate the intervention's impact on decreasing pesticides in the home environment, and children's pesticide exposures (14).

We report here results from a randomized-controlled trial of a home-based educational intervention to reduce pesticide exposures to farmworkers' children. This study was conducted in Monterey County, California among farmworker families with young children (N=116). Using pre- and post-intervention measurements of home floor wipe pesticide levels and child urinary dialkyl phosphate (DAP) metabolite levels, we examined the intervention's efficacy in reducing pesticide residues in participants' homes and decreasing organophosphate (OP) pesticide metabolite levels in children's urine. This study differs from the Yakima Valley study (14) in a couple of ways. First, our study investigates the unique impact of a home-based educational intervention, whereas the Yakima Valley study evaluated a multi-component community-based educational intervention in which home-based educational activities were included. Second, our study was conducted with a cohort of farmworker families over a four-month period, whereas the Yakima Valley study conducted two cross-sectional measurements in intervention and control communities over a three-year period.

MATERIALS AND METHODS

Study Orientation

A community-based participatory research (CBPR) orientation guided the development of the study. This approach involves “systematic inquiry, with the collaboration of those affected by the issue, for the purposes of education and action or effecting social change” (18). The partnership included university researchers from the Center for Environmental Research and Children’s Health (CERCH) at the University of California, Berkeley, and community partners in Monterey County, including farmworkers, health care providers, farmworker advocates, and agricultural organizations (19). Partners’ participation in the development of the intervention study was facilitated through meetings of CERCH’s Community Advisory Board and Farmworker Council, which met monthly. More information about the CERCH’s community-university partnerships is published elsewhere (19, 20).

Setting

The study was conducted from May to October 2004 in Salinas, California, an agricultural area located approximately 100 miles south of San Francisco. In 2004, Monterey County, where Salinas is located, was ranked fifth highest of all California counties for total kilograms (kgs) of pesticide active ingredient applied (>4.1 million kgs) (21). OP pesticide active ingredient applied that year in the region exceeded 240,000 kgs. Pyrethroid pesticides, including permethrin, are also frequently used in the region, primarily for home pesticide use, landscape maintenance, structural pest control purposes, and some agricultural use (21, 22).

Participants and Recruitment

Potential participants were recruited from local churches and Spanish language classes at the Women, Infants, and Children Program (WIC) and screened for eligibility using an interviewer-administered questionnaire. Eligible participants were at least 18 years old, Spanish-speaking, currently employed as a farmworker or living with a partner/spouse who was employed in farmwork, and had at least one child who was younger than four years old and walking. The primary adult participant in all households was the mother. Of the 263 mothers who were screened, 193 (73%) were eligible. A total of 116 participants enrolled in the study. After the completion of pre-intervention data collection 61 (53%) were randomly assigned to an intervention group that received the home-based intervention and 55 (47%) to a control group that received a one-day training covering the same topics as the intervention after follow-up data collection was completed. All procedures were reviewed and approved by the University of California, Berkeley Committee for the Protection of Human Subjects and written informed consent was obtained from participants prior to data collection. At each data collection visit the adult participant (mother) received a $40 grocery store gift card and the child participant was given an age-appropriate book in Spanish.

Intervention

Our home-based intervention aimed to educate farmworker families about children’s potential vulnerability to pesticide exposures and encourage them to adopt strategies to reduce “take home” and home pesticide exposures. The intervention, which drew from the health belief model (23) and social cognitive theory (24), consisted of three educational home visits conducted by trained community health workers (CHWs). All sessions were in Spanish and consisted, on average, of approximately one hour of education and discussion. Six CHWs, all of whom were hired from the community, bilingual (Spanish and English) and either former farmworkers or members of farmworker families, conducted home visits in teams of two and worked with the same families for the duration of the intervention. Educational flip charts, similar to the Environmental Protection Agency’s Worker Protection Standard training flip chart and easels, and handouts were developed specifically for the intervention.

During the first home visit, CHWs educated participants about potential sources and risks of pesticide exposures to children and about strategies to reduce the “take home” of pesticide exposures to their home (e.g., washing hands before leaving work; removing work clothing and shoes outside; changing out of work clothes and bathing within 15 minutes of getting home; storing and washing work clothes separately from other clothes) and information about additional strategies to decontaminate the home environment (e.g., mopping, dusting, vacuuming and washing children’s toys regularly; washing and vacuuming of car regularly). CHWs introduced the concept of a household action plan, presented the family with an action plan poster and assisted them in selecting pesticide exposure reduction strategies that they would like to implement. The family discussed the steps needed to carry-out selected strategies and affixed relevant action step stickers on their poster.

During the second and third educational visits, CHWs facilitated discussions about the successes and challenges experienced by the family when carrying out their action plans. They also reviewed information from past visits and educated participants about other potential sources of pesticide exposure (e.g., home pesticide use) and strategies for reducing these exposures (e.g., integrated pest management techniques). Participants selected additional strategies for their action plan at each of these visits.

Data Collection

Data collection took place in participants’ homes one month prior to initiation of intervention activities (baseline) and after three months of intervention (follow-up). At both time points, trained study workers completed an interviewer-administered questionnaire in Spanish and collected floor surface wipes and child urine samples. A pamphlet containing information about community resources such as health care, women’s services, and Head Start was given to participants at the pre-intervention visit.

Interviews—A standardized questionnaire, based on instruments used in prior studies of farmworker behaviors (8, 15, 25), was administered to the mother by female, bilingual study interviewers at baseline and follow-up. Information collected included demographics, household composition, income, occupational status of household members, and child fruit and vegetable consumption based on child food intake diaries (number of time food eaten in last 24 hours). Parents recorded all of the food items consumed by the child each day based on validated guidelines (26, 27). Standardized home observations were made during data collection visits to assess the characteristics of the home environment, inventory pesticides present, and measure the home's location and distance from the nearest cultivated fields.

Floor Wipe Sampling Procedure—Surface wipe samples were collected from the living room and the kitchen floors of participants' homes to assess levels of transferable pesticides. This method was used in order to avoid measuring deep pesticide residues in carpets that would not necessarily lead to child exposure. On hard surface floors (e.g., linoleum), samples were obtained from a central location. A 30×30 cm area on the floor was thoroughly wiped using Excilon dressing sponges dampened with reagent-grade isopropanol alcohol (28). On carpeted floors, samples were collected using a custom built device based on the Edwards and Lioy (EL) press sampler (29). C_{18}-impregnated Teflon extraction disks (3M Empore disks) were mounted on the EL press and moved across an area on the floor. All sampling materials were cleaned with isopropanol alcohol between each use. Samples collected from each room were placed in separate sealed jars and transported in a cooler to the field office laboratory where they were frozen to –80°C and later shipped on dry ice to Batelle Laboratories for pesticide analysis.

Child Urine Sampling Procedure—Urine samples were collected from one child in each household. The same child was sampled at baseline and at follow-up. Sampling procedures utilized those outlined by the Centers for Disease Control and Prevention (CDC) for use in the National Health and Nutrition Examination Survey 1999–2000 (NHANES) (30). Toilet-trained children were asked to void in a cleaned specimen container (Specipan; Baxter Scientific, McGaw Park, IL). For children who were not toilet-trained, a standard infant urine collection bag (Hollister) was used. Urine samples were packed on ice, brought to a field processing facility, and stored at −80°C until shipment on dry ice to CDC. For quality control purposes, frozen field blanks and spikes, prepared earlier by CDC, were defrosted, re-packaged in the field according to collection procedures for actual samples, and then shipped blind with the unknown samples to CDC.

Sample Analysis

Floor Wipes—Living room and kitchen wipe samples were combined and analyzed for 19 pesticides including eight pyrethroids (allethrin, bifenthrin, cyfluthrin, cypermethrin, deltamethrin, esfenvalerate, sumithrin, and trans-permethrin), two carbamates (carbaryl and carbofuran), six organophosphates (chlorpyrifos, diazinon, diazinon-oxon, malathion, methidathion, and phosmet), one chlorinated terephthalate (dacthal), one dicarboximide (iprodione), and a synergist (piperonyl butoxide). Isomers of cypermethrin and cyfluthrin were summed. [See Supplementary Information (SI) for a summary of 2004 agricultural usage in Monterey County of pesticides frequently detected in floor wipe samples (Table

S1)]. The wipes were spiked with a mixture of surrogate recovery standards (SRSs) prior to extraction. SRSs, chosen to represent the major compound classes, included fenchlorphos, $^{13}C_6$-carbaryl, $^{13}C_6$ trans-permethrin, and $^{13}C_6$ cypermethrin. Wipes were extracted using a Dionex accelerated solvent extraction (Thermo Scientific, Sunnyvale, CA) with dichloromethane, cleaned-up using solid phase extraction, and analyzed using gas chromatography/mass spectrometry (GC/MS) in the multiple ion detection mode (Agilent 5973, Santa Clara, CA). GC conditions included: a DB-1701 column (30 m, 0.25 mm id, 0.25 um film thickness); temperature program of 70°C for 2 min, then 70–130°C @25 C/min, 130–220°C @2 C/min, and 220–280°C @10 C/min. Extract concentrations were determined using the internal standard method of quantification, based on a 7-point calibration curve.

Overall, quality assurance and quality control (QA/QC) results were acceptable. Excluding $^{13}C_6$-carbaryl (206%), SRS recoveries ranged from 73–95%. Reported floor wipe pesticide levels are SRS-adjusted. Except for malathion (interference computed as average malathion of 127 ng) and carbaryl (average of 10 ng), field blanks were mostly non-detectable or below 5 ng/sample. Field spike recoveries averaged 103%, and the majority of recoveries were between 70% and 125%. The limits of detection (LODs) ranged from 3–50 ng. We assigned an imputed value of the LOD/√2 to levels below the LOD (31).

Child Urine—Six non-specific DAP metabolites of OP pesticides were measured, including three dimethyl phosphates: dimethylphosphate (DMP), dimethylthiophosphate (DMTP), and dimethyldithiophosphate (DMDTP); and three diethyl phosphates: diethylphosphate (DEP), diethylthiophosphate (DETP), and diethyldithiophosphate (DEDTP). These metabolites devolve from approximately 28 OP compounds registered in the United States, representing approximately 81% of OP pesticide use in the Salinas Valley of Monterey County (SI, Table S2). Due to their high agricultural use in the study area, urinary metabolites of OP pesticides were measured exclusively. Urine specimens were lyophilized to remove water then the residue was redissolved in acetonitrile: diethyl ether (1:1). The DAPs were derivatized to their chloropropyl phosphate esters. The concentrated extracts were then analyzed by isotope dilution GC-tandem mass spectrometry (GC-MS/MS) (32), which is widely regarded as the definitive technique for trace analysis for DAP metabolites with detection limits of 1 ppb or less (33). Laboratory quality control included repeat analysis of three in-house urine pools enriched with known amounts of pesticide residues whose target values and confidence limits were previously determined. Westgard rules for quality control were used to validate each analytical run (34). LODs ranged from 0.08 mg/l for DMDTP to 0.4 mg/l for DMP. Urinary metabolite levels below the LOD were imputed to LOD/√2 (30, 33, 35).

Field quality control samples included blank, spike, and duplicate urine samples. No metabolites were measured in blank samples indicating that little or no contamination occurred in the field during processing or shipment to the laboratory. For field-spiked samples, laboratory methods yielded an average percent recovery of 96% for total DAPs. As many OP pesticides devolve to more than one metabolite in their class (diethyl or dimethyl phosphates), quantities were converted to molar concentrations (nmol/l) and summed to obtain the total concentrations of the diethyl and dimethyl phosphates (35). We report urinary DAP metabolite levels unadjusted for creatinine (36–38). Due to sample losses during shipment, the total number of urine samples available for analysis at follow-up was reduced from 106 to 61 (42%); sample losses in the control and intervention groups were 49 to 25 (49%) and 57 to 36 (37%), respectively. The sample loss resulted in reduced statistical power to detect differences in DAP metabolite levels in the intervention and control group, described below.

Statistical Analysis

Baseline differences in demographic characteristics between the two treatment groups (control vs. intervention) were tested using chi-square and t-tests. Chi-square tests were used to examine group differences in detection frequencies (DFs) of child urinary DAP metabolites and floor wipe pesticide levels. We limited further statistical analysis of the floor wipe data to the compounds that had detection levels of 50% or greater (carbaryl, chlorpyrifos, cypermethrin, dacthal, diazinon, malathion, and trans-permethrin). We computed summary statistics for pesticide levels in floor wipes and child urinary total dimethyl, diethyl and DAP metabolite levels. Urinary metabolite and floor wipe levels were log(10)-transformed to approximate a normal distribution. Pearson correlation coefficients were computed for total child urinary dimethyl metabolite levels and malathion floor wipe levels, and for total child urinary diethyl metabolite levels and chlorpyrifos and diazinon floor wipe levels. Pre-intervention differences between those who completed the study and those who did not were tested using Fisher’s exact and Wilcoxon rank-sum tests.

To accommodate the correlation of observations taken from the same individual, general Estimating Equation (GEE) models with robust standard errors (Huber-White sandwich estimator) were fitted to assess the effect of the intervention on child pesticide urinary metabolite levels and on pesticide levels in floor wipes. GEE models fit to assess across group effects (i.e., differences of the pre-to-post-intervention changes in the intervention group and the control group) included variables for group (control vs. intervention), time (baseline vs. follow-up), and an interaction term of group and time. Beta coefficients (β) and 95% confidence intervals for the interaction term in these models are interpreted as the difference of the baseline-to-follow-up change in the intervention group and the baseline-to-follow-up change in the control group (i.e., the difference of the differences). P-values of less than 0.10 for the interaction term in the final multivariate regression model indicated a significant interaction or an intervention effect.

We conducted adjusted analyses for across group effects using fitted GEE modeling. Final GEE models of floor wipe levels were adjusted for poverty status (below the poverty threshold vs. above), residential proximity to an agricultural field (≤¼ mile from field vs. >¼ mile from field), and number of farmworkers living in the home. Final GEE models of urinary DAP metabolites were adjusted for child age (in years) at urine collection, and the number of times the child ate fresh fruit in the previous 24 hours. These covariates were selected *a priori* based on previous literature (39, 40) and associations observed in bivariate analyses (p-values<0.1)(see SI, Tables S3 & S4). For ease of interpretation, we converted beta coefficients and 95% confidence intervals into measurements of percent change in child pesticide urinary metabolite levels and pesticide levels in floor wipes associated with a one-unit increase in the predictor variable using the formula: percent change = 100 x (antilog(β)-1) (41). All analyses were conducted in STATA 13 (StataCorp, College Station, TX).

RESULTS

Participants

Table 1 presents an overview of the pre-intervention demographic characteristics of adult (mom) and child participants by treatment group. We found no significant differences in demographic characteristics between groups.

Baseline demographic characteristics were balanced across intervention and control groups. Eighty-nine percent of the 116 families completed the study [n=50 (91%) of the control group and n= 53 (87%) of the intervention group (p=0.43)]. Those who did not complete the study were, on average, significantly younger (mean=24 vs. 28 years, $p<0.01$) and living with significantly fewer family members (mean= 4 vs. 6, $p<0.05$) and more agricultural workers (mean = 4 vs. 3) than those who completed the study.

Pesticide Levels in Floor Wipes

Table 2 presents the baseline and follow-up detection frequencies (DFs), geometric means and percentiles for the most commonly detected pesticide floor wipe levels by treatment group. Trans-permethrin (median = 35.0 pg/cm^2) was detected in all households pre- and post-intervention (DF=100%). Dacthal (median = 4.8 pg/cm^2), carbaryl (median = 6.6 pg/cm^2) and diazinon (median=3.4 pg/cm^2) were detected in almost all households (DF=98%, 93% and 94% respectively), and chlorpyrifos (median =4.5 pg/cm^2) and malathion (median = 9.2 pg/cm^2) were detected in a majority of households (DF=79% and 61%, respectively). Of the seven compounds detected in >50% of floor wipe samples (Table 2), only the pyrethroid compounds trans-permethrin and cypermethrin are commonly applied for agricultural as well as for household use purposes. Piperonyl butoxide (median = 1.1 pg/cm^2), a synergist used to enhance the potency of carbamates and pyrethroids, was detected in about half of the households (DF=46%). Measured compounds with detection frequencies < 50% included, allethrin, bifenthrin, carbofuran, cyfluthrin, deltamethrin, diazinon-oxon, esfenvalerate, iprodione, methidathion, phosmet and sumithrin (data not shown).

In bivariate analyses of floor wipe levels and potential covariates, we found that carbaryl dacthal and diazinon were associated with living ≤¼ mile from an agricultural field; and cypermethrin and malathion were associated with increasing numbers of household members working in agriculture (p-values<0.1). No significant associations were found in floor wipe levels with resident density or poverty status (See SI, Table S3).

Child Urinary Pesticide Metabolite Levels

Table 3 presents the pre-intervention and follow-up child urinary DAP metabolite detection frequencies, geometric means and 95th percentile confidence interval concentrations by treatment group. Pre-intervention detection frequencies of the urinary DAP metabolites were not significantly different between the control and intervention groups. However, total DAP metabolite levels in the control group children were notably higher at follow-up compared to baseline, albeit not significantly [total DAP geometric mean (95th CI) = 91.5 (42.7, 195.9) vs 63.3 (41.3, 97.2) nmol/l, respectively; p=0.2]. Among children in the intervention group, total DAP metabolite levels were slightly lower at follow-up compared to baseline [total DAP GMs (95th CI) = 73.3 (42.4, 126.8) vs 84.6 (56.4, 127.0) nmol/l, respectively; p=0.6].

In bivariate analyses of child urinary DAP metabolite levels and potential covariates, we found that total DAP metabolite levels were positively correlated with child's age at urine collection, and number of times child ate fresh fruit in previous 24 hours (Pearson r's = 0.2; p-values<0.1). No significant associations were found with child's sex, residential proximity to agricultural fields, number of household members working in agriculture, resident density (#people/room) or poverty status and urinary DAP metabolite levels (See SI, Table S4).

Pre-to-Post Intervention Differences

Table 4 presents the results of unadjusted and adjusted GEE modeling of across group effects on pesticide floor wipe levels (ng/cm^2) and child urinary metabolite concentrations (nmol/l) for the control and intervention groups. For ease of interpretation, we present results in terms of percent change (and 95% CI) from baseline in wipe levels for the seven most frequently detected pesticides (DF>50%) (i.e., carbaryl, chlorpyifos, cypermethrin, dacthal, diazinon, malathion and trans-permethrin) and child urinary DAP metabolite concentrations (nmol/l). The unadjusted and adjusted floor wipe levels were lower for all compounds in households receiving the intervention compared to controls except chlorpyrifos, but only differences in trans-permethrin levels reached statistical significance (Table 4). Unadjusted trans-permethrin wipe levels were 35.2% lower in households receiving the intervention compared to control households (p<0.05). Similarly, the trans-permethrin wipe levels adjusted for poverty status, residential proximity to fields and housing density were 36.9% lower in households receiving the intervention compared to control households (p<0.05).

Table 4 also presents the calculated percent change (and 95% CI) in child urinary metabolite levels (nmol/L) for total diethyl, total dimethyl and total DAP metabolites based on GEE model results. The unadjusted and adjusted child urinary metabolite levels were lower for all compounds in households receiving the intervention compared to control households, but none of the differences in child urinary DAP metabolite levels were statistically significant. For example, total DAP metabolite levels adjusted for child age at urine collection and number of times child ate fresh fruit in the previous 24 hours were 51.3% lower in households receiving the intervention compared to control households (p=0.14).

DISCUSSION

In this randomized-controlled trial, we evaluated the efficacy of a home-based educational intervention in reducing pesticide residues in farmworkers' homes and decreasing OP pesticide metabolite levels in the urine of farmworkers' children. We found that the intervention had a significant effect on decreasing trans-permethrin levels in floor wipes collected from participants' homes; however, no other floor wipe levels were significantly reduced. We also found non-significant reductions in urinary OP pesticide metabolite levels among children from the intervention compared to control households.

The child urinary DAP metabolite levels measured in this study were similar to those reported in other studies of young children living in agricultural communities. For example, the median total DAP metabolite levels measured in 24-month old children (n=381) of the CHAMACOS study, also from Monterey County, California (2003–2004), was 76 nmol/L (39) compared to 78 nmol/L in this study (2004). Further, Curl et al. (45) reported median total dimethyl metabolite levels of ~80 nmol/L in a study of 221 children of agricultural workers living in Yakima Valley, Washington compared to 70.8 nmol/L in this study. The Yakima Valley children were older (24- to 72-months old), however, and metabolite levels from this and other populations of older children (46) may not be directly comparable to the younger children in the current study.

The pyrethroid insecticide trans-permethrin was detected in 100% of home floor wipe samples, and measured levels were higher than any of the other compounds we studied. The compound is commonly applied for home use, and there is some agricultural use. These findings suggest that home pesticide use for insect control may be an important source of exposure in farmworker homes. High detection rates of trans-permethrin have also been reported in floor wipe samples from other homes of farmworkers with children (1, 4). While the mean and median trans-permethrin wipe levels we found were in general lower than other studies, the maximum level we found was similar. In a study of 41 farmworker homes in North Carolina and Virginia, Quandt et al. (4) reported 93% detection of trans-permethrin in floor wipe samples and mean and maximum levels of 33.5 ± 85.7 and 488 $\mu g/m^2$, respectively, compared to 4.0 ± 31.2 and 436 $\mu g/m^2$ in this study.

One limitation of this study is that, although we randomized allocation to the intervention, participants were recruited through convenience sampling at community locations such as WIC. Therefore, results are not necessarily generalizable to other farmworker families. In addition, this study would have been enhanced had we measured the urinary metabolites of the pyrethroid pesticides trans-permethrin and cypermethrin. Given funding constraints and the high-use of OP pesticides in Monterey County agriculture, we measured urinary DAP metabolites only. Another limitation is that the surface wipes collected from hard surface and carpeted floors were combined into one sample for analysis. In doing so, we eliminated the possibility of assessing the effect of the intervention on each respective surface. It is possible that some of the promoted behaviors (e.g., dusting with a damp cloth) might have reduced pesticide residues on hard surfaces, which are easier to clean. Furthermore, since follow-up data collection occurred within a month of the final home visit, we cannot assess the efficacy of this intervention at longer term.

Another limitation is that due to sample losses during shipment, the number of urine samples available for analysis at follow-up was reduced from 106 to 61. This decrease in sample data available for analysis reduced this study’s statistical power. Power calculations showed that, given our sample size of 25 controls post-intervention, the power to detect a one geometric standard deviation change in urinary metabolite concentrations was low at 4% (47). If the sample size is doubled (from 25 to 50 controls) by copying the actual data and rerunning the

GEE models, the p-values for the interaction term (intervention group x time) approach statistical significance (p-value=0.04 for total diethyl and p=0.05 for total dimethyl urinary metabolites), suggesting that our intervention model may have been successful and warrants additional evaluation.

Although we previously reported significant changes in exposure-related behaviors with this intervention (42), it is also possible that the recommended behaviors were not carried out frequently enough to substantively reduce indoor pesticide levels. It is also possible that the behaviors that were promoted in the intervention might not be effective in reducing the "take home" of agricultural pesticide residues or the use of home pesticides or for decontaminating the home environment substantially enough to reduce children's pesticide exposures. While the behaviors we promoted are commonly recommended to prevent and/or reduce pesticide exposures (12, 13, 25), their selection is largely based on "common sense" and they have not necessarily been scientifically validated.

Little information is available about which behaviors, what level of compliance, or what combination of behaviors will most effectively prevent the "take home" of pesticides or decontaminate the homes of pesticide residues. Observational studies that have examined correlates of pesticide levels in house dust offer inconclusive evidence regarding the relationship between recommended behaviors and pesticide levels. For example, studies in Oregon and North Carolina have found delays in changing work clothes and bathing to be associated with higher levels of pesticides in house dust (3) and adult and child urinary pesticide metabolite levels (7). Other studies, however, have not found vacuuming, laundering, or delays in changing work clothing or shoes, to be associated with pesticide loading in house dust (4, 43) or in children's urinary pesticide metabolite levels (43, 44).

To our knowledge, this is the first study that has used environmental and biomarker data to evaluate the unique effect of a home-based educational CHW intervention to reduce pesticide exposures to farmworkers' children. While Thompson et al. (2008) used biomarker and dust data to evaluate *Para Niños Saludables*, a community-based intervention to reduce pesticide exposures to farmworker families in the Yakima Valley of Washington State, their study measured the impact of a package of intervention activities of which home visits were one component (e.g., community health fairs, school-based activities and others) (14). Furthermore, our study assesses intervention efficacy with a single cohort of farmworker families over one growing season (i.e., four months) whereas Thompson et al.'s evaluation included two cross-sectional measurements during a three-year period.

In summary, although this educational CHW intervention moderately decreased the floor wipe levels for most pesticide compounds measured in participants' homes, and child urinary DAP metabolite levels, in general the changes were not statistically significant. It is possible that a more intensive or longer home-based educational intervention would be more effective. Nevertheless, the results of this study suggest that interventions that rely on participant behavior change alone to bring about reductions in pesticide exposure might not be adequate in preventing pesticide exposures to farmworkers' families and children. Instead "upstream" approaches such as interventions that effectively prevent farmworkers' occupational exposures (e.g., using alternative pest control methods, providing adequate protective clothing to workers, or other engineering interventions to limit exposures) or reduce take-home of pesticide residues before farmworkers leave work (e.g., work clothing that is provided and laundered by the employer, showering facilities at work) may be more effective at reducing these home exposures. Additionally, the use of less toxic or alternative methods of pest control and increases in the waiting periods between spraying and worker entry to the fields could reduce take-home pesticide exposures and potential risks to families and children and should be considered in addition to other worksite interventions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ACKNOWLEDGEMENTS

This publication was made possible by U.S. Environmental Protection Agency (US EPA) grant RD 83171001 and National Institute for Environmental Health Sciences (NIEHS) grants RO1 ES11352 and PO1 ES009605. Its contents are solely the responsibility of the grantee and do not necessarily represent the official views of the US EPA or NIEHS. Further, the US EPA does not endorse the purchase of any commercial products or services mentioned in the publication.

Abbreviations:

DAPs	dialkylphosphates
DMP	dimethylphosphate
DMTP	dimethylthiophosphate
DMDTP	dimethyldithiophosphate
DEP	diethylphosphate
DETP	diethylthiophosphate
DEDTP	diethyldithiophosphate

REFERENCES

1. Bradman A, Whitaker D, Quiros L, Castorina R, Claus Henn B, Nishioka M, et al. Pesticides and their metabolites in the homes and urine of farmworker children living in the Salinas Valley, CA. Journal of exposure science & environmental epidemiology. 2007;17(4):331–49. [PubMed: 16736054]
2. Landrigan PJ, Claudio L, Markowitz SB, Berkowitz GS, Brenner BL, Romero H. Pesticides and inner-city children: exposures, risks, and prevention. Environ Health Perspect. 1999;107((suppl 3),): 431–7.
3. McCauley LA, Michaels S, Rothlein J, Muniz J, Lasarev M, Ebbert C. Pesticide exposure and self-reported home hygiene: practices in agricultural famlies. AAOHN. 2003(51):113–9.
4. Quandt SA, Arcury TA, Rao P, Snively BM, Camann DE, Doran AM, et al. Agricultural and residential pesticides in wipe samples from farmworker family residences in North Carolina and Virginia. Environ Health Perspect. 2004;112(3):382–7. [PubMed: 14998757]
5. NAS (National Academy of Sciences). Pesticides in the diets of infants and children. Washington, D.C.: 1993 Contract No.: NAS. 1993 Washington, DC: National Academy of Sciences.

6. Eskenazi B, Bradman A, Castorina R. Exposures of children to organophosphate pesticides and their potential adverse health effects. Environ Health Perspect. 1999;107 Suppl 3:409–19. [PubMed: 10346990]
7. Arcury TA, Quandt SA, Rao P, Doran A, Snively BM, Davis S, et al. Organophosphate pesticide exposure in farmworker family members in western North Carolina and Virgina: Case comparisons. Hum Organ. 2005;64:40–51.
8. Bradman A, Salvatore AL, Boeniger M, Castorina R, Snyder J, Barr DB, et al. Community-based intervention to reduce pesticide exposure to farmworkers and potential take-home exposure to their families. Journal of exposure science & environmental epidemiology. 2009;19(1):79–89. [PubMed: 18368011]
9. Lu C, Fenske RA, Simcox NJ, Kalman D. Pesticide exposure of children in an agricultural community: evidence of household proximity to farmland and take home exposure pathways. Environ Res. 2000;84(3):290–302. [PubMed: 11097803]
10. McCauley LA, Lasarev MR, Higgins G, Rothlein J, Muniz J, Ebbert C, et al. Work characteristics and pesticide exposures among migrant agricultural families: a community-based research approach. Environ Health Perspect. 2001;109(5):533–8.
11. Coronado GD, Thompson B, Strong L, Griffith WC, Islas I. Agricultural task and exposure to organophosphate pesticides among farmworkers. Environ Health Perspect. 2004;112(2):142–7. [PubMed: 14754567]
12. Arcury TA, Marin A, Snively BM, Hernandez-Pelletier M, Quandt SA. Reducing farmworker residential pesticide exposure: evaluation of a lay health advisor intervention. Health promotion practice. 2009;10(3):447–55. [PubMed: 18287581]
13. Liebman AK, Juárez PM, Leyva C, Corona A. A Pilot Program Using Promotoras de Salud to Educate Farmworker Families About the Risks from Pesticide Exposure. Journal of Agromedicine. 2007;12(2):33–43.
14. Thompson B, Coronado GD, Vigoren EM, Griffith WC, Fenske RA, Kissel JC, et al. Para ninos saludables: a community intervention trial to reduce organophosphate pesticide exposure in children of farmworkers. Environ Health Perspect. 2008;116(5):687–94. [PubMed: 18470300]
15. Salvatore AL, Chevrier J, Bradman A, Camacho J, Lopez J, Kavanagh-Baird G, et al. A community-based participatory worksite intervention to reduce pesticide exposures to farmworkers and their families. Am J Public Health. 2009;99 Suppl 3:S578–81. [PubMed: 19890160]
16. Strong LL, Thompson B, Koepsell TD, Meischke H, Coronado GD. Reducing the take-home pathway of pesticide exposure: behavioral outcomes from the Para Ninos Saludables study. J Occup Environ Med. 2009;51(8):922–33. [PubMed: 19620892]
17. Quandt SA, Grzywacz JG, Talton JW, Trejo G, Tapia J, D'Agostino RB, Jr., et al. Evaluating the effectiveness of a lay health promoter-led, community-based participatory pesticide safety intervention with farmworker families. Health promotion practice. 2013;14(3):425–32. [PubMed: 23075501]
18. Green LW, George MA, Frankish CJ, Herbert CJ, Bowie WR, O'Neil M. Study of Participatory Research in Health Promotion: Review and Recommendations for the Development of Participatory Research in Health Promotion in Canada Ottawa: Royal Society of Canada 1995.
19. Israel BA, Parker EA, Rowe Z, Salvatore A, Minkler M, Lopez J, et al. Community-based participatory research: lessons learned from the Centers for Children's Environmental Health and Disease Prevention Research. Environ Health Perspect. 2005;113(10):1463–71. [PubMed: 16203263]
20. Eskenazi B, Bradman A, Gladstone EA, Jaramillo S, Birch K, Holland NT. CHAMACOS, A longitudinal birth cohort study: Lessons from the Fields. J Child Health. 2003;1:3–27.
21. CDPR (California Department of Pesticide Regulation). "Pesticide Use Report 2004, Indexed by Chemical and by Crop", Department of Pesticide Regulation (ed.). Sacramento: California Environmental Protection Agency, 2004 2004.
22. Bradman A, Chevrier J, Tager I, Lipsett M, Sedgwick J, Macher J, et al. Association of housing disrepair indicators with cockroach and rodent infestations in a cohort of pregnant Latina women and their children. Environ Health Perspect. 2005;113(12):1795–801. [PubMed: 16330367]

23. Champion VL, Skinner CS. The Health Belief Model. Glanz K, Rimer BK, Lewis FM, editors. San Francisco: Jossey-Bass; 2008.
24. McAlister AL, Perry CL, Parcel GS. How individuals, environments, and health behaviors interact: Social Cognitive Theory. In: Glanz K, Rimer BK, Lewis FM, editors. Health Behavior and Health education: Theory, Research and Practice (4th ed). San Francisco: Jossey-Bass; 2008 p. 169–88.
25. Thompson B, Coronado GD, Grossman JE, Puschel K, Solomon CC, Islas I, et al. Pesticide take-home pathway among children of agricultural workers: study design, methods, and baseline findings. J Occup Environ Med. 2003;45(1):42–53. [PubMed: 12553178]
26. Block G, Thompson FE, Hartman AM, Larkin FA, Guire KE. Comparison of two dietary questionnaires validated against multiple dietary records collected during a 1-year period. Journal of the American Dietetic Association. 1992;92(6):686–93. [PubMed: 1607564]
27. Block G, Woods M, Potosky A, Clifford C. Validation of a self-administered diet history questionnaire using multiple diet records. Journal of clinical epidemiology. 1990;43(12):1327–35. [PubMed: 2254769]
28. Geno P, Camann D, Harding H, Villalobos K, Lewis R. Handwipe sampling and analysis procedure for the measurement of dermal contact with pesticides. Arch Environ Contam Toxicol. 1996(30): 132–8. [PubMed: 8579382]
29. Edwards RD, Lioy PJ. The EL sampler: a press sampler for the quantitative estimation of dermal exposure to pesticides in household dust. Journal of Exposure Analysis and Environmental Epidemiology. 1999(9):521–9. [PubMed: 10554154]
30. Centers for Disease Control and Prevention (CDC). Third National Report on Human Exposure to Environmental Chemicals. NCEH Pub. No. 05–0570. Atlanta:National Center for Environmental Health, Centers for Disease Control and Prevention 2005.
31. Hornung R, Reed L. Estimation of average concentration in the presence of nondetectable values. Appl Occup Env Hyg. 1990;5(1):46–51.
32. Bravo R, Caltabiano LM, Weerasekera G, Whitehead RD, Fernandez C, Needham LL, et al. Measurement of dialkyl phosphate metabolites of organophosphorus pesticides in human urine using lyophilization with gas chromatography-tandem mass spectrometry and isotope dilution quantification. J Expo Anal Environ Epidemiol. 2004;14(3):249–59. [PubMed: 15141154]
33. Barr DB, Barr JR, Driskell WJ, Hill RH, Jr., Ashley DL, Needham LL, et al. Strategies for biological monitoring of exposure for contemporary-use pesticides. Toxicology and industrial health. 1999;15(1–2):168–7s9. [PubMed: 10188199]
34. Caudill SP, Schleicher RL, Pirkle JL. Multi-rule quality control for the age-related eye disease study. Statistics in medicine. 2008;27(20):4094–106. [PubMed: 18344178]
35. Barr DB, Bravo R, Weerasekera G, Caltabiano LM, Whitehead RD, Jr., Olsson AO, et al. Concentrations of dialkyl phosphate metabolites of organophosphorus pesticides in the U.S. population. Environ Health Perspect. 2004;112(2):186–200. [PubMed: 14754573]
36. Barr DB, Wilder LC, Caudill SP, Gonzalez AJ, Needham LL, Pirkle JL. Urinary creatinine concentrations in the U.S. population: implications for urinary biologic monitoring measurements. Environ Health Perspect. 2005;113(2):192–200. [PubMed: 15687057]
37. Boeniger MF, Lowry LK, Rosenberg J. Interpretation of urine results used to assess chemical exposure with emphasis on creatinine adjustments: a review. American Industrial Hygiene Association journal. 1993;54(10):615–27. [PubMed: 8237794]
38. Lu C, Toepel K, Irish R, Fenske RA, Barr DB, Bravo R. Organic diets significantly lower children’s dietary exposure to organophosphorus pesticides. Environ Health Perspect. 2006;114(2): 260–3. [PubMed: 16451864]
39. Bradman A, Castorina R, Barr DB, Chevrier J, Harnly ME, Eisen EA, et al. Determinants of organophosphorus pesticide urinary metabolite levels in young children living in an agricultural community. International journal of environmental research and public health. 2011;8(4):1061–83. [PubMed: 21695029]
40. Morgan MK. Children’s exposures to pyrethroid insecticides at home: a review of data collected in published exposure measurement studies conducted in the United States. International journal of environmental research and public health. 2012;9(8):2964–85. [PubMed: 23066409]

41. Wooldridge J Introductory Econometrics: A Modern Approach. Cincinnati, OH: South-Western College; 2000.
42. Salvatore AL, Camacho J, Vargas A, Cabrera E, Kavanagh-Baird G, Lopez J, et al., editors. A Home-based Intervention to Reduce Pesticide Exposure to Farmworkers' Children (Abstract). Proceedings of the 132nd Annual Meeting of the American Public Health Association; 2004; Washington, DC.
43. Fenske RA, Lu C, Barr D, Needham L. Children's exposure to chlorpyrifos and parathion in an agricultural community in central Washington State. Environ Health Perspect. 2002;110(5):549–53. [PubMed: 12003762]
44. Arcury TA, Grzywacz JG, Davis SW, Barr DB, Quandt SA. Organophosphorus Pesticide Urinary Metabolite Levels of Children in Farmworker Households in Eastern North Carolina. Am J Ind Med. 2006(49):751–60 [PubMed: 16804908]
45. Curl CL, Fenske RA, Kissel JC, Shirai JH, Moate TF, Griffith W, et al. Evaluation of take-home organophosphorus pesticide exposure among agricultural workers and their children. Environ Health Perspect. 2002;110(12):A787–92. [PubMed: 12460819]
46. Quiros-Alcala L, Bradman A, Smith K, Weerasekera G, Odetokun M, Barr DB, et al. Organophosphorous pesticide breakdown products in house dust and children's urine. Journal of exposure science & environmental epidemiology. 2012;22(6):559–68. [PubMed: 22781438]
47. Murray DM, Varnell SP, Blitstein JL. Design and analysis of group-randomized trials: a review of recent methodological developments. Am J Public Health. 2004;94(3):423–32. [PubMed: 14998806]

Table 1.

Baseline sociodemographic characteristics for control and intervention groups.[a]

Characteristic	Control (n=55)		Intervention (n=61)		p-value
Adult participant (mother)					
Age, Mean (M) ± SD	26.4 ± 5.8		26.5 ± 5.3		0.9
Total years living in U.S., M ± SD	6.5 ± 4.9		7.6 ± 6.0		0.3
Married/living as married, n (%)	52	(94.6)	59	(96.7)	0.5
Ethnicity, n (%)					
Mexican / Mexican-American	51	(92.7)	59	(96.7)	
Other Latina	3	(5.5)	2	(3.3)	
Other non-Latina	1	(1.8)	0	(0.0)	0.4
Monthly household income, n (%)					
$750 or less	8	(14.8)	6	(10.5)	
$751–1500	18	(33.3)	28	(49.1)	
$1501–2000	19	(35.2)	13	(22.8)	
> $2000	9	(16.7)	10	(17.5)	0.4
Poverty level, n (%)[b]					
< Poverty	37	(71.2)	45	(79.0)	
> Poverty – 200% Poverty	13	(25.0)	12	(21.1)	
> 200% Poverty	2	(3.9)	0	(0.0)	0.3
Household Density (# people/# rooms), M ± SD	1.9 ± 1.3		1.6 ± 0.6		0.2
Employed in agriculture, n (%)					
Yes	31	(56.4)	30	(49.2)	
No	24	(43.6)	31	(50.8)	0.3
No. household members working in ag, M ± SD	3.5 ± 3.1		3.0 ± 2.0		0.3
Residence proximity to agricultural field, n (%)					
<=200 feet	3	(5.5)	2	(3.3)	
>200 feet – 1/4 mile	2	(3.6)	5	(8.2)	
>1/4 mile	50	(90.9)	54	(88.5)	0.5
Child participant					
Child age, M ± SD	2.2 ± 0.8		2.2 ± 0.6		0.6
Child sex, n (%)					
Male	30	(54.6)	31	(50.8)	
Female	25	(45.5)	30	(49.2)	0.2
# Times ate fresh fruit in last 24 hours, M ± SD	2.2 ± 1.3		2.1 ± 1.8		0.8

Abbreviations: N = number; M = mean; SD = standard deviation.

[a] Chi-squared and t-tests used to test differences in baseline characteristics between intervention and control groups. No significant differences were found.

[b] Poverty levels were calculated using the U.S. Department of Health and Human Services' thresholds for the year 2004. A family of four with an annual income of $18,850 or less was considered to be at or below the poverty level; the same family earning between $18,851 and $37,770 is within 200% of the poverty level.

Table 2.

Pre- and post-intervention pesticide levels (pg/cm^2) in floor wipe samples for control and intervention groups.[a]

	Control (n=50)[f]							Intervention (n=53)[g]						
Pre-intervention	**DF%**	**GM (95%CI)**	**25th**	**50th**	**75th**	**90th**	**Max**	**DF%**	**GM (95%CI)**	**25th**	**50th**	**75th**	**90th**	**Max**
Carbaryl[b]	92.0	8.0 (5.6, 11.4)	3.8	6.6	14.0	27.1	1,510	94.3	7.3 (5.0,10.4)	3.1	5.7	18.1	38.1	162
Chlorpyrifos[c]	82.0	5.9 (4.0, 8.7)	2.0	5.8	14.7	33.2	124	79.3	4.3 (3.0, 6.1)	1.9	3.8	11.9	22.0	61.8
Cypermethrin[d]	80.0	50.7 (28.0, 92.0)	10.2	27.4	251	1,360	7,210	67.9	34.1 (20.0, 58.1)	9.8	28.5	84.4	229	24,000
Dacthal[e]	98.0	5.8 (4.2, 8.0)	2.8	4.7	13.8	29.1	138	100	5.0 (3.8, 6.6)	2.2	4.9	8.4	16.4	154
Diazinon[c]	92.0	3.0 (2.2, 4.3)	1.1	3.2	6.8	11.4	83.4	92.5	2.7 (1.9, 3.70)	1.0	2.8	6.2	9.1	67.9
Malathion[c]	54.0	7.7 (5.7, 10.6)	<LOD	7.4	13.0	32.8	91.0	62.3	8.1 (5.5, 12.0)	<LOD	8.1	15.2	44.0	220
trans-Permethrin[d]	100	46.8 (35.4, 86.6)	14.7	50.3	166	373	1,360	100	39.3 (23.4, 66.2)	10.7	29.2	147	392	43,600
	Control (n=50)[h]							**Intervention (n=53)[i]**						
Post-intervention	**DF%**	**GM (95%CI)**	**25th**	**50th**	**75th**	**90th**	**Max**	**DF%**	**GM (95%CI)**	**25th**	**50th**	**75th**	**90th**	**Max**
Carbaryl[b]	90.0	11.6 (8.0, 16.9)	5.2	9.6	23.5	58.3	292.0	94.3	8.4 (6.0, 11.8)	3.2	5.9	22.0	48.5	90.4
Chlorpyrifos[c]	78.0	5.0 (3.2, 7.8)	1.6	4.9	14.0	47.8	136	75.5	3.9 (2.8, 5.5)	1.9	4.0	6.6	27.9	82.7
Cypermethrin[d]	79.0	67.9 (31.8, 14.5)	9.0	37.8	348	4,290	19,000	67.9	29.4 (18.4, 47.0)	11.5	20.6	66.9	183	5,972
Dacthal[e]	98.0	5.9 (4.2, 8.3)	2.34	5.2	13.1	27.2	76.5	98.1	4.5 (3.4, 5.9)	2.9	4.8	7.3	10.9	112
Diazinon[c]	98.0	4.6 (3.3, 6.3)	2.04	4.7	9.7	19.4	60.7	92.5	3.5 (2.6, 4.8)	1.9	3.3	7.2	12.3	92.9
Malathion[c]	70.0	10.8 (7.3, 16.1)	<LOD	10.7	23.5	86.7	149	56.6	8.5 (6.1, 11.8)	<LOD	9.6	15.2	33.4	98.2
trans-Permethrin[d]	100	60.7 (37.0, 99.7)	18.3	52.5	204	603	5,510	100	32.9 (21.6, 50.1)	11.1	26.9	68.9	274	7,660

[a] Floor wipe MDLs: carbaryl: 10 ng; chlorpyrifos: 10 ng; cypermethrin: 20 ng; dacthal: 3 ng; malathion: 50 ng; trans-permethrin: 6 ng.

[b] Carbamate;

[c] Organophosphate;

[d] Pyrethroid;

[e] Alkyl Phthalate.

[f] Sample size n=50 for all except Cypermethrin (n=49);

[g] Sample size n=53 for all except Cypermethrin (n=52).

[h] Sample size n=50 for all except Carbaryl (n=46), Cypermethrin (n=44), Dacthal (n=49).

[i] Sample size n=53 for all except Cypermethrin (n=51).

Table 3.

Pre- and post-intervention child urinary metabolite concentrations (nmol/l) for control and intervention groups.

	Control (n=49)									Intervention (n=57)								
Pre-Intervention	**DF %**	**GM**	**95% CI**		**25th**	**50th**	**75th**	**90th**	**Max**	**DF %**	**GM**	**95% CI**		**25th**	**50th**	**75th**	**90th**	**Max**
Total diethyls	40.8	4.7	3.1	7.1	ND	ND	12.0	81.2	219.3	52.6	7.3	4.5	11.8	ND	2.8	35.5	156.0	409.2
Total dimethyls	83.7	51.9	33.1	81.5	19.3	55.4	172.6	353.3	1423.0	87.7	64.9	42.7	98.7	12.8	73.8	187.1	418.1	2640.7
Total DAPs	83.7	63.3	41.3	97.2	23.2	64.2	174.3	355.0	1528.9	91.2	84.6	56.4	127.0	21.0	106.3	285.6	465.8	2856.5
	Control (n=25)									**Intervention (n=36)**								
Post-Intervention	**DF%**	**GM**	**95% CI**		**25th**	**50th**	**75th**	**90th**	**Max**	**DF%**	**GM**	**95% CI**		**25th**	**50th**	**75th**	**90th**	**Max**
Total diethyls	48.0	6.0	3.1	11.6	ND	ND	18.2	56.0	164.4	33.3	4.7	2.7	8.3	ND	ND	14.6	71.5	360.8
Total dimethyls	80.0	77.8	34.7	174.3	24.1	106.0	251.6	324.3	3626.5	88.9	59.5	33.5	105.5	14.1	76.4	277.6	672.0	827.8
Total DAPs	84.0	91.5	42.7	195.9	25.8	112.1	253.3	488.7	3682.5	88.9	73.3	42.4	126.8	21.5	82.0	310.8	673.7	1188.6

Table 4.

Across group effects on pesticide floor wipe (ng/cm^2) and child urinary metabolite concentrations (nmol/l) for control and intervention groups.

	Unadjusted Across Group		**Adjusted Across Group**	
	% change (95% CI) [a]	**p-value**	**% change (95% CI)**[a]	**p-value**
Floor wipe levels (ng/cm^2) [b]				
Carbaryl	−20.0 (−47.5, 21.6)	0.30	−13.0 (−44.7, 36.9)	0.55
Chlorpyrifos	7.9 (−15.1, 37.1)	0.54	8.1 (−25.6, 57.0)	0.68
Cypermethrin	−34.3 (−62.0, 13.6)	0.13	−30.4 (−61.1, 25.3)	0.23
Dacthal	−10.8 (−31.4, 15.9)	0.39	−9.3 (−30.8, 18.8)	0.48
Diazinon	−9.2 (−31.5, 20.4)	0.50	−8.9 (−32.8, 23.9)	0.55
Malathion	−24.8 (−54.8, 23.3)	0.26	−19.5 (−51.9, 34.9)	0.41
trans-Permethrin	−35.2 (−57.7, −0.6)	<0.05	−36.9 (−59.8, −1.0)	<0.05
Child urinary metabolite levels (nmol/l) [c]				
Total diethyls	−49.8 (−81.8, 38.3)	0.18	−53.0 (−83.4, 33.0)	0.16
Total dimethyls	−38.9 (−75.7, 53.8)	0.30	−50.6 (−81.9, 34.8)	0.17
Total DAPs	−42.7 (−76.3, 38.7)	0.22	−51.3 (−81.3, 26.8)	0.14

Abbreviations. CI=confidence interval.

[a] Percent change calculated from beta coefficient, 95% confidence interval and p-values for the interaction term of time and group in GEE multivariate regression. Effect represents [(baseline-to-follow-up mean change in level in the intervention group) – (baseline-to-follow-up mean change in level in the control group)]. Models included all participants.

[b] Adjusted models were controlled for poverty status (below poverty threshold vs. not), distance from field (≤ ¼ mile from field vs. not), and number of household members working in agriculture.

[c] Adjusted models were controlled for child age at urine collection and number of times child ate fresh fruit in previous 24 hours.