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# Do workplace and home protective practices protect farm workers? Findings from the For Healthy Kids Study

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## Abstract

**Objective—**To assess associations of protective workplace and home practices to pesticide exposure levels.

**Methods—**Using data from orchard workers in the Yakima Valley, Washington, we examined associations of workplace and home protective practices to (1) urinary metabolite concentrations of dimethylthiophosphate (DMTP) in adults and children aged 2–6; and (2) azinphos-methyl levels in house and vehicle dust.

**Results—**Data were from 95 orchard workers and 94 children. Contrary to expectation, adult farm workers who wore boots or washed hands using hand sanitizer had higher concentrations of DMTP than those who did not. Children who attended daycare had higher DMTP concentrations than children who did not.

**Conclusions—**Few workplace or home practices were associated with pesticide exposure levels; workers who used hand sanitizer had higher concentrations of DMTP, as did children who attended daycare.

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**Contributors**

All authors contributed to the study design, analytic approach, and interpretation of results. S.E. Holte conducted the statistical analysis. G.D. Coronado prepared the article. All authors critically reviewed and revised article drafts and approved the final version.

**Human Participant Protection**

This study was approved by the institutional review board of the Fred Hutchinson Cancer Research Center, and informed consent was obtained from all adult participants.

**Conflicts of Interest**

The authors report no conflicts of interest.

**Keywords**

Pesticides; agriculture; United States Environmental Protection Agency Worker Protection Standard; home practices; workplace practices

## INTRODUCTION

Farm workers are at high risk for chronic exposures to organophosphate (OP) pesticides, routinely used in U.S. agriculture. Such exposures have been studied for a number of health effects influencing both adult farm workers and their children.(1–6)

It is generally believed that farm workers' pesticide exposures can be reduced if they engage in certain workplace and home practices. The Worker Protection Standard (WPS), mandated by the U.S. Environmental Protection Agency (EPA), seeks to protect workers from occupational exposures to agricultural pesticides. The WPS establishes regulation for the notification of pesticide applications, use of personal protective equipment, restricted entry intervals following pesticide application, availability of decontamination supplies, and information about emergency medical assistance.(7)

The WPS also mandates pesticide-safety training, which includes key concepts such as strategies for preventing pesticides from entering the body; washing hands before eating, drinking, using chewing gum or tobacco, or using the toilet; wearing protective work clothes (e.g., long-sleeved shirts, pants, and close-toed shoes); immediately, upon arriving home, removing shoes and boots and washing/showering with soap and water, shampooing hair, and putting on clean clothes after work; washing work clothes separately from other clothes before wearing them again; and never holding children while wearing work clothes.(7)

Few studies have examined whether workplace and home practices, including those recommended by the WPS, actually reduce exposures to agricultural pesticides. A limited number of studies have suggested that some practices, such as wearing protective clothing and gloves, can reduce dermal exposures to pesticides.(8–11) In a study involving dust collection from 24 agricultural households in Hood River, Oregon, McCauley and colleagues reported higher mean azinphos-methyl (AZM) levels in households where workers reported waiting more than two hours before changing out of work clothes, compared to homes in which workers changed within two hours.(12) AZM, a broad-spectrum OP insecticide classified as level I toxicity (13), is used on a wide variety of crops and is highly toxic through inhalation, dermal absorption, ingestion, and eye contact.(14)

We report on the relation of workplace and home behaviors to pesticide exposure levels, using data from a predominantly female sample of farm workers who participated in a cohort study designed to examine pathways of pesticide exposure in Yakima Valley, Washington. Approximately 50,000 people work in agriculture in the Yakima Valley; about half are Hispanic. Most of the country's agricultural AZM application (66%) is in Washington State: for example, in 2007, over 236,000 pounds of AZM were applied to Washington's apple orchards.(15) We hypothesized that workers who engage in workplace or home practices recommended as part of WPS training would have lower urinary pesticide metabolite concentrations along with their children, and lower levels of pesticides would be found in their households, when compared to those who did not.

## METHODS

This report is based on a larger study that examined pesticide exposures among a cohort of farm worker and non-farm worker adults and children living in Eastern Washington State. Agricultural practices as well as setting, study design, study participants, and survey procedures are described elsewhere.(16;17)

The study design, recruitment procedures, and participant eligibility criteria have been described previously.(16) Briefly, we recruited two cohorts (100 farm workers and 100 non-farm workers, aged 18–65) along with a referent child aged 2–6 in the household. The cohorts were contacted three times: first, during the “thinning” season when dimethyl OP pesticides are heavily used among orchard crops; second, during the harvest season, when OP pesticides are used less frequently on orchard crops; and third, in the non-spray season, when crops are dormant. Because we were primarily interested in orchard crops on which OP pesticides were applied, we limited our farm worker cohort to those who worked in pome fruit crops.(18)

For this report, we limited our data to the 2005 thinning season (April–June), when farm workers remove, by hand, small buds and shoots from the limbs of apple and pear trees to allow the remaining buds to produce larger fruit; this is when highest exposures were expected and correlations with behavioral practices would be most apparent.

### Recruitment and data collection procedures

A convenience sample was recruited through flyers distributed by project staff at grocery stores, organizations, churches, worksites, health fairs, and other activities and events throughout the Valley. All farm worker participants were required to be in the Valley for an entire year and work as a thinner and/or harvester in apple or pear crops. We offered a household total of $160 for participation in all phases of data collection. All participants reviewed and signed an informed consent prior to study participation. The study protocol and procedures were reviewed and approved by the FHCRC Institutional Review Board (#5946).

Six bilingual (Spanish and English) project staff were certified as survey interviewers following a 3-day training session, which included specimen collection procedures. Each adult completed an interview on the first day and the fifth day of data collection. Topics included self-reported level of general pesticide exposure, job tasks, worker self-protective practices, employer practices, family protective practices, family pesticide use, proximity to fields, eating behaviors, child behavioral practices, child eating behaviors, contact information, and socio-demographics.

For OP pesticide metabolite measurementss, we collected three urine samples; we also obtained one venous blood sample and one finger-stick blood sample from each adult farm worker and non-farm worker. For AZM levels, we also collected dust samples from the homes and vehicles of farm workers and non-farm workers. For farm workers only, we also collected saliva samples. For all children, we collected three urine samples and a finger-stick blood sample (with the parent’s permission). Each participant (adult and child) provided urine samples on the first, third, and fifth day of data collection. We repeated this sampling during the harvest and no-spray seasons. For dust collection, areas were vacuumed in a standardized and consistent manner. The area vacuumed was where the parent reported "the child played most frequently." Vehicle dust was collected by vacuuming footwells.

### Urine and dust sample analyses

Samples were analyzed using the method of Bravo et al.(19) Briefly, 2-mL urine samples were lyophilized to remove residual water. The residue was reconstituted in solvent and the dialkylphosphate (DAP) metabolites were converted to their respective chloropropyl esters using derivatization. Concentrated derivatized DAPs were analyzed using gas chromatography- tandem mass spectrometry. Two precursor/product ion pairs were analyzed per analyte, one for quantification and one for confirmation. Analyte concentrations were quantified using isotope dilution calibration. Approximately 10% of the samples tested were positive and negative quality control samples. The analyzed OP metabolites included dimethylphosphate (DMP), dimethylthiophospate (DMTP), and dimethyldithiophosphate (DMDTP), which corresponded to the pesticides most commonly used in the Valley. For the purposes of this paper, we limit our analysis to DMTP, the most commonly detected metabolite in our sample (detectionn limit 0.2 ug/L). We present non-creatinine-adjusted values.

After home and vehicle dust collection, the vacuum bag and polyliner were removed and placed in a plastic bag and stored at −10°C for transfer to the laboratory at the UW for analysis. Dust was analyzed according to the extraction and gas chromatography procedures described by Moate et al.(20) for residues of six pesticides that are in the home or the vehicle; for this analysis we limit our investigation to levels of AZM.

### Statistical analysis

We calculated the frequency of demographic characteristics among our sample of farm workers with age-eligible children as well as farm workers' frequency in performing specific workplace and home practices. For each workplace or home behavior, we report the geometric mean concentration of DMTP for adult farm workers and their children. We also generated a categorical composite variable to indicate the number of worker-performed home practices recommended by the WPS (immediately, upon arriving home, removing shoes and boots, washing/showering with soap and water, shampooing hair, and putting on clean clothes; washing work clothes separately from other clothes before wearing them again; never holding children while wearing work clothes).(7)

For the purposes of statistical analysis, chi-square or Fisher Exact tests were performed comparing the observed and expected percentage of those reporting a variety of workplace and home practices. To evaluate factors affecting DMTP levels in urine, we used linear regression and generalized estimating equations with exchangeable correlation structure to account for potential correlation from the three urine samples collected on Day 1, Day 3, and Day 5 of enrollment during the thinning season. The logarithm transformation was applied to the urine DMTP levels. Since a single dust sample was available from each household, standard linear regression was used to evaluate factors affecting household and vehicle AZM dust levels. Prior to analysis, a logarithm transformation was applied to the dust level. A difference in proportions was deemed significant if associated p values were less than 0.05 and nominally significant if $p < 0.1$.

## RESULTS

The adult farm worker respondents were mainly young and married; three-quarters were women (Table 1). Annual household income was generally low, with nearly 80% of families earning less than $25,000. Most respondents were born in Mexico and spoke only Spanish. Slightly more than half lived in a single-family dwelling; the majority (70%) lived with at least one other farm worker. Nearly three-quarters reported working more than 10 days of

the prior two weeks. Nearly two-thirds reported that pesticides had been applied at their work during at least one of the past 14 days.

Urinary DMTP concentrations for farm workers in our study were much higher than those reported from a nationally representative sample of the U.S. population that participated in the National Health and Nutrition Examination Survey (NHANES) during a similar timeframe (Table 2).

### Workplace protective clothing

Workplace practices varied. Forty-two percent of respondents reported usually wearing boots, and 31% reported usually wearing gloves. Nearly all respondents wore long-sleeved shirts and a hat. Slightly more than one-quarter wore protective lenses. The majority generally did not wear coveralls or a mask. Eighteen percent had received pesticide-safety training in the past five years.

### Hand washing at work

Washing hands at work with water or a hand sanitizer was reported by 40% and 15% of our sample, respectively. Washing with a hand sanitizer was significantly associated with elevated concentrations of urinary pesticide metabolites ($p= 0.03$). Washing hands with water was unassociated with urinary metabolite concentrations.

### Metabolite levels in children and house and vehicle dust

There were no significant differences in urinary metabolite levels in children who lived in households in which a farm worker engaged in a variety of workplace practices. The urinary metabolite values were always higher in the adults than in the children. We found no significant associations of workplace practices with levels of AZM in house dust. Vehicle dust levels of AZM were unassociated with workplace practices; however lower levels were nominally associated with wearing coveralls ($p = 0.08$) and receiving pesticide-safety training ($p = 0.09$).

### Engagement in protective practices at home

Farm workers' frequency of engaging in home practices also varied (Table 2). Nearly two-thirds of respondents removed their shoes before entering the home. Over three-quarters changed out of work clothes within one hour of coming home, and a similar proportion washed their work clothes after a single wearing. Washing work clothes separately from family laundry was reported by 87% of respondents. Showering within one hour of coming home was reported by over half of respondents. The majority of respondents washed hands within one hour of coming home and usually or always washed hands before eating. Over two-thirds (68%) reported vacuuming carpets and 59% reported mopping floors at least 3 of the past 4 days.

When we examined the relation of glove use and hand washing practices to urinary DMTP concentrations of farm workers and their children and house dust levels of AZM, we found no significant differences in concentrations among workers who wore gloves only, washed hands only, or both wore gloves and washed hands, compared to those who did neither (data not shown).

Home practices were unassociated with concentrations of DMTP in adult farm workers, although usually or always washing one's hands before eating was nominally associated with lower concentrations of DMTP ($p = 0.08$;Table 2). Home practices were unassociated with concentrations of DMTP in children living in households with a farm worker. Those

who showered within an hour of arriving home had negligibly higher house dust levels of AZM ($p = 0.05$).

DMTP concentrations in adults and children did not correspond to the number of WPS-recommended home practices undertaken (Table 3). Similarly, house dust concentrations of AZM did not correspond to reported home protective behaviors.

We found no associations between child home practices and concentrations urinary DMTP nor did we find associations with washing fruit, washing hands before eating, going to work in the fields, sucking one's thumb, or attending school (Table 4). In contrast, attending daycare was strongly correlated with child DMTP concentrations, with those attending daycare having higher DMTP concentrations than those who did not (geometric mean: 22.25 ug/L vs. 13.07 ug/L; $p < 0.01$). This correlation remained after adjustment for child age and gender (data not shown).

## DISCUSSION

In this descriptive study of 95 farm workers and children in their households, we detected few differences in concentrations of DMTP, a biomarker of exposure to OP insecticides, between those who did and did not engage in behavior to mitigate pesticide transmission. Our data do not support our hypothesis; in fact, we did not find that workers who engage in workplace or home practices recommended as part of the WPS pesticide-safety training exhibit lower levels of pesticide exposure (as measured by their DMTP concentrations, child DMTP concentrations, and house dust levels of AZM).

A relatively high proportion of workers reported engaging in workplace and home practices thought to reduce pesticide exposures. Nearly all farm workers in our sample wore clothing as recommended in WPS pesticide-safety training, including long pants, long-sleeved shirt, and closed-toed shoes. Only 14% engaged in combined home practices of removing shoes/boots, changing out of work clothes and showering immediately upon arriving home, washing work clothes separately from the family's laundry and after each wearing, and not holding children while wearing work clothes. Moreover, a relatively low proportion of workers reported having received pesticide-safety training in the previous five years (19%). Our proportion was lower than was found in a California-based study, in which 45% of the 73 enrolled strawberry workers reported having received pesticide-safety training within the current agricultural season.(21)

We were particularly interested in a finding regarding hand washing that has not been previously demonstrated. Our data showed that DMTP concentrations were higher among workers who washed their hands at work using a hand sanitizer, an association that was not observed for workers who washed their hands at work with water. One plausible explanation is that hand sanitizers generally contain alcohol which may dry the hands, making them more susceptible to the transfer of pesticides into the skin. While water washes away residues on the skin, hand sanitizers apply agents (usually antibacterial) that may further attract dust and other residues.

Inconsistent with other studies of OP pesticide metabolite concentrations in farm workers, our study found no significant association of workplace practices with DMTP concentrations.(21) Our data could not confirm findings from Salvatore et al. showing lower dimethyl alkylphosphate (DMAP) levels in workers who both wore gloves and washed their hands with soap compared to those who did neither (DMAP: 155.0 nmol/g vs. 231.5 nmol/g). While Salvatore et al. reported lower urinary pesticide metabolite concentrations for workers who engaged in workplace practices involving wearing a long-sleeved shirt, pants, closed-toe shoes, and a hat,(21) the high number of workers in our study who wore all these

items prohibited direct comparisons. Salvatore et al.'s study collected a single spot urine sample after the expiration of the re-entry interval for strawberries; ours collected samples over a 5-day period during the thinning season for pome fruit, untimed to a spray event.

Children who attended daycare had higher concentrations of DMTP than children who did not, regardless of age or gender. This finding may suggest that daycares provide a less hygienic environment for children with regard to pesticide exposure; alternatively or additionally, it may be explained by parents collecting children from daycare directly after work while wearing work clothes. Moreover, food consumed in daycare setting may differ from that consumed at home. By comparison, parents whose children do not attend day care likely change out of work clothes or shower before interacting with their children. In our study, 60% of the 43 parents of children who attended daycare reported having held children while wearing their work clothes, compared to 46% of 50 parents of children who did not attend daycare ($p = 0.16$). However, our analysis found no association between home practices of adult farm workers and child concentrations of DMTP, suggesting that home practices may not effectively reduce exposure levels in children. Contrary to expectation, no other child practice, even having gone to work in the fields in the past 5 days ($n = 12$), correlated with DMTP concentrations.

Consistent with other studies of pesticide residues in farm worker households, our study found no relationship between AZM house dust levels and washing hands, removing shoes/boots, and changing out of work clothes within two hours of arriving home.(12) Findings from the previous study were based on interviews with only 24 tree farm owners or managers. Two previous studies reported higher AZM levels in households with increasing numbers of agricultural workers;(12;22) this finding was not confirmed with our data of 53 households ($p = 0.54$; comparing 1 vs. 2 or more). We observed elevated, though non-significant, AZM levels in vehicle dust of households with two or more farm workers compared to those with one (geometric mean: 3.16 ug/g vs. 2.83 ug/g) with a p value of 0.08 (data not shown).

Our previous analyses demonstrated that workplace and home protective practices were more common among workers who received pesticide-safety training in the past five years (compared to those who did not);(23) these include usually or always washing work clothes separately from family laundry, washing work clothes after a single wearing, and washing hands after work. We found similar patterns in our current study. However, we found no association of either of two practices—receiving pesticide-safety training and engaging in all the WPS recommended home protective practices—and urinary DMTP concentrations or dust levels of AZM; this suggests that additional types of interventions might be needed (e.g., pesticide labeling, showering in the workplace) to reduce personal and household exposures to pesticides.

It is important to note that our study enrolled a high proportion of female farm workers (e.g., Salvatore et al. enrolled 84% male workers) and is one of the few studies to focus on women. While we consider this a strength of our research, it may explain some differences between our findings and those of previous studies. When we examined gender differences in workplace practices in the present study, we found that a higher proportion of men reported usually wearing boots (90% vs. 32%), but a higher proportion of women usually wore gloves (72% vs. 50%). Several home practices were similar for men and women; however, removing shoes within one hours of coming home was reported by 68% of women and 35% of men (data not shown). Despite these differences, we were unable to stratify our data by gender given the uneven distribution of data for some practices.

### Limitations

This study has some limitations. Several issues have been raised regarding the measurement and interpretation of pesticide metabolites in urine, such as laboratory inconsistencies and potential contributions to urinary measurements from preformed metabolites (24) and differences in statistical methods for handling values below detection limits.(25) However, for this analysis, we report both urinary metabolite concentrations and levels of pesticides residues in house and vehicle dust, thereby facilitating a broader examination of associations across biological and environmental markers with a range of features. We used state-of-the-art measurement techniques that were the same as those reported by Salvatore et al.(21) Our sample is also notably larger than the samples in most published reports. We limited our study enrollment to farm workers who worked in apple and/or pear orchards, which led to greater consistency across participants in the general timing of workplace pesticide applications. Because we relied on self-reported data on workplace and home protective practices, social desirability bias may have led to an over-reporting of behaviors commonly believed to be protective.

## Conclusions

Promoting best practices to mitigate pesticide exposures among farm workers and children requires an understanding of exposure factors as well as consideration of social factors that influence interventions. In this descriptive study of 95 farm workers and children in their households, we found that relatively few workplace, home, or pesticide-safety training practices (recommended by EPA's Worker Protection Standard) were associated with higher pesticide exposure levels among orchard workers. Workers who used hand sanitizer had higher concentrations of DMTP, as did children who attended daycare. Additional well-controlled longitudinal studies are needed to assess a casual relationship of workplace or home practices to exposure levels and to confirm the correlations observed in our study.

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## Table 1

Demographic, housing, and workplace characteristics of selected adult farmworkers (n = 95)

| CHARACTERISTIC | Farmworker N = 95 | Adult DMTP GM (95% CI) | HOUSE AZM GM (95% CI) | VEHICLE AZM GM (95% CI) |
|---|---|---|---|---|
| **Age** | **N** | **Ug/L** | **Ug/L** | **Ug/L** |
| 18–24 | 10 | 51.3 (26.0, 101.4) | 2405 (491, 11792) | 2682 (477, 15066) |
| 25–29 | 18 | 51.5 (23.7, 112.0) | 556 (212, 1454) | 845 (293, 2430) |
| 30–34 | 46 | 80.7 (40.6, 160.5) | 576 (247, 1344) | 1206 (487, 2982) |
| ≥ 35 | 21 | 72.5 (42.6, 123.5) | 669 (343, 1304) | 1247 (616, 2522) |
| **Gender** | | | | |
| Female | 75 | 57.7 (30.7, 108.2) | 655 (281, 1528) | 1270 (513, 3141) |
| Male | 20 | 134.4 (77.1, 234.4) | 607 (288, 1280) | 901 (406, 1999) |
| **Marital status** | | | | |
| Married/ living with partner | 89 | 70.9 (24.9, 200.3) | 643 (447, 922) | 1194 (810, 1760) |
| Not married | 6 | 47.8 (17.5, 130.3) | 680 (106, 4369) | 777 (106, 5716) |
| **Annual household income** | | | | |
| < 15,000 | 36 | 78.8 (38.2, 162.6) | 966 (357, 2612) | 2095 (712, 6159) |
| 15,000 – 25,000 | 39 | 59.4 (29.2, 120.8) | 605 (252, 1455) | 926 (366, 2347) |
| > 25,000 | 20 | 69.4 (39.1, 123.5) | 461 (222, 957) | 1093 (502, 2379) |
| **Birthplace** | | | | |
| Mexico | 92 | 70.8 (27.5, 182.6) | 619 (48, 8019) | 1129 (73, 17547) |
| United States | 2 | 39.9 (16.1, 98.8) | 524 (42, 6616) | 761 (50, 11516) |
| **Language generally read and spoken** | | | | |
| Only Spanish | 81 | 75.3 (56.5, 100.2) | 655 (459, 935) | 1151 (781, 1695) |
| Some English | 13 | 44.3 (19.2, 102.1) | 236 (54, 1038) | 730 (146, 3663) |
| **Dwelling** | | | | |
| Single family home | 48 | 58.7 (30.7, 112.4) | 648 (252, 1671) | 1403 (517, 3804) |
| Apartment | 27 | 77.2 (40.6, 146.6) | 648 (223, 1887) | 1120 (355, 3533) |
| Mobile home | 20 | 87.1 (53.6, 141.6) | 626 (277, 1416) | 734 (309, 1742) |
| **Number of agricultural workers in home** | | | | |
| One | 28 | 59.1 (32.0, 111.1) | 541 (251, 1168) | 682 (300, 1551) |
| Two or more | 67 | 73.3 (53.9, 99.8) | 694 (455, 1060) | 1456 (941, 2253) |
| **Number of days worked in fields (of past 14 days)** | | | | |
| <=10 | 25 | 43.5 (25.7, 73.7) | 556 (257, 1201) | 1371 (599, 3138) |
| >10 | 70 | 81.4 (58.7, 113.0) | 686 (449, 1048) | 1099 (697, 1731) |
| **Crops worked** | | | | |
| Pome fruit only | 35 | 38.2 (25.4, 57.3) | 338 (196, 583) | 751 (402, 1406) |
| Pome fruit and other[a] | 59 | 100.1 (59.4, 168.7) | 873 (441, 1729) | 1385 (638, 3005) |
| **Job task** | | | | |
| Thinning | 46 | 48.7 (33.0, 72.0) | 444 (269, 733) | 1124 (642, 1968) |
| Thinning + other | 44 | 106.0 (62.9, 178.6) | 914 (459, 1819) | 1232 (571, 3658) |
| Other only | 4 | 43.6 (8.1, 234.9) | 260 (63, 1137) | 483 (93, 2514) |

| CHARACTERISTIC | Farmworker N = 95 | Adult DMTP GM (95% CI) | HOUSE AZM GM (95% CI) | VEHICLE AZM GM (95% CI) |
|---|---|---|---|---|
| **Number of days pesticides applied (of past 14 days)**[b] | | | | |
| None | 27 | 79.2 (49.9, 125.9) | 599 (303, 1182) | 763 (370, 1574) |
| One or more | 52 | 73.4 (40.9, 131.9) | 771 (342, 1735) | 1485 (626, 3522) |

[a] other crops include cherries (n = 40), grapes (n = 14), asparagus (n = 7), and other (n = 15); non-mutually exclusive

[b] data were missing for 16 participants

## Table 2

Selected work and home practices and their relationships to farm worker adult and child urinary metabolite concentrations of DMTP[a] and house and vehicle dust levels of AZM[b]

| WORK PRACTICES | | Adult DMTP[a] | | Child DMTP[a] | | | HOUSE AZM[b] | | VEHICLE AZM[b] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N = 95[c] | GM[d] | p-value | GM[d] | p-value | | GM[d] | p-value | GM[d] | p-value |
| | N | ug/L | | ug/L | | 54 | ng/g | | ng/g | |
| **NHANES (1999–2000)[e]** | | **1.62** | | **2.72** | | | | | | |
| **Use of protective clothing** | | | | | | | | | | |
| Wore boots[f] | | | | | | | | | | |
| At least once | 38 | 92.8 | | 17.8 | | 23 | 851 | | 1549 | |
| Never | 57 | 56.6 | 0.07 | 15.6 | 0.53 | 30 | 513 | 0.19 | 933 | 0.21 |
| Wore gloves[f] | | | | | | | | | | |
| At least once | 56 | 69.6 | | 18.3 | | 32 | 631 | | 1023 | |
| Never | 39 | 68.1 | 0.94 | 14.1 | 0.19 | 21 | 661 | 0.93 | 1479 | 0.36 |
| Wore protective lenses | | | | | | | | | | |
| Usually | 26 | 58.5 | | 22.6 | | 16 | 537 | | 955 | |
| Not Usually | 69 | 73.5 | 0.47 | 14.6 | 0.06 | 37 | 692 | 0.52 | 1288 | 0.47 |
| Wore coveralls | | | | | | | | | | |
| Usually | 4 | 25.3 | | 16.5 | | 2 | 407 | | 214 | |
| Not Usually | 91 | 72.1 | 0.24 | 16.4 | 0.99 | 51 | 661 | 0.63 | 1259 | 0.08 |
| Wore a mask | | | | | | | | | | |
| Usually | 13 | 49.8 | | 13.5 | | 7 | 468 | | 1047 | |
| Not Usually | 82 | 72.7 | 0.30 | 17.0 | 0.36 | 46 | 676 | 0.51 | 1202 | 0.84 |
| **Hand washing practices** | | | | | | | | | | |
| Washed hands at work w/water[f] | | | | | | | | | | |
| At least once | 40 | 64.6 | | | | 21 | 933 | | 1738 | |
| Not Usually | 55 | 72.3 | 0.68 | 14.9 | 0.38 | 32 | 501 | 0.1 | 933 | 0.12 |
| Washed hands at work w/sanitizer[f] | | | | | | | | | | |
| At least once | 15 | 133.9 | | 19.2 | | 8 | 1072 | | 2399 | |
| Not Usually | 80 | 60.8 | 0.03 | 16.0 | 0.52 | 45 | 589 | 0.23 | 1047 | 0.16 |

| WORK PRACTICES | | Adult DMTP[a] | | Child DMTP[a] | | | HOUSE AZM[b] | | VEHICLE AZM[b] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N = 95[c] | GM[d] | p-value | GM[d] | p-value | | GM[d] | p-value | GM[d] | p-value |
| | N | ug/L | | ug/L | | 54 | ng/g | | ng/g | |
| **Pesticide-safety training** | | | | | | | | | | |
| Received pesticide training in past 5 years[g] | | | | | | | | | | |
| Yes | 18 | 60.5 | | 16.5 | | 11 | 562 | | 617 | |
| No | 77 | 71.1 | 0.67 | 16.4 | 0.99 | 42 | 676 | 0.69 | 1380 | 0.09 |
| **WORK PRACTICES (Adults)** | | **Adult DMTP[a]** | | **Child DMTP[a]** | | | **HOUSE AZM[b]** | | | |
| | **N = 95** | **GM[c]** | **p-value** | **GM[c]** | **p-value** | **N=54** | **GM[c]** | **p-value** | | |
| Removed shoes/boots before entering home[f,g] | | | | | | | | | | |
| At least once | 58 | 60.9 | | 16.6 | | 34 | 661 | | | |
| Never | 37 | 83.9 | 0.25 | 16.3 | 0.93 | 19 | 617 | 0.85 | | |
| Changed out of work clothes[g] | | | | | | | | | | |
| Within one hour | 74 | 68.9 | | 15.7 | | 41 | 661 | | | |
| More than one hour | 21 | 69.2 | 0.99 | 19.3 | 0.39 | 12 | 575 | 0.75 | | |
| Washed work clothes[g] | | | | | | | | | | |
| After wearing once | 74 | 70.2 | | 15.9 | | 43 | 692 | | | |
| After wearing more than once | 21 | 62.9 | 0.74 | 18.3 | 0.51 | 10 | 468 | 0.40 | | |
| Washed work clothes separately from family laundry[g] | | | | | | | | | | |
| Usually / always | 82 | 66.6 | | 16.3 | | 43 | 676 | | | |
| Sometimes / rarely / never | 13 | 85.8 | 0.53 | 17.5 | 0.81 | 10 | 501 | 0.51 | | |
| Showered at home[g] | | | | | | | | | | |
| Within one hour | 49 | 81.0 | | 16.2 | | 27 | 912 | | | |
| More than one hour | 46 | 58.1 | 0.23 | 16.7 | 0.87 | 26 | 447 | 0.05 | | |
| Held children while wearing work clothes[g] | | | | | | | | | | |
| Never | 46 | -- | | 16.1 | | -- | -- | -- | | |
| At least once | 49 | -- | -- | 16.8 | 0.84 | -- | -- | -- | | |
| Washed hands after coming home | | | | | | | | | | |
| Within one hour | 82 | 63.3 | | 16.1 | | 44 | 631 | | | |
| More than one hour | 13 | 117.8 | 0.20 | 19.1 | 0.58 | 9 | 741 | 0.71 | | |

| WORK PRACTICES | | Adult DMTP[a] | | Child DMTP[a] | | | HOUSE AZM[b] | | VEHICLE AZM[b] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N = 95[c] | GM[d] | p-value | GM[d] | p-value | | GM[d] | p-value | GM[d] | p-value |
| | N | ug/L | | ug/L | | 54 | ng/g | | ng/g | |
| Washed hands before eating | | | | | | | | | | |
| Usually / always | 84 | 62.9 | | 16.6 | | -- | -- | -- | | |
| Sometimes / rarely / never | 11 | 139.9 | 0.08 | 15.7 | 0.86 | -- | -- | -- | | |
| Number of times carpets vacuumed in past 4 days[h] | | | | | | | | | | |
| 3 – 4 | 40 | 65.4 | | 14.8 | | 28 | 871 | | | |
| <= 2 | 18 | 66.1 | 0.98 | 16.3 | 0.70 | 10 | 631 | 0.51 | | |
| Number of times floors were mopped in past 4 days | | | | | | | | | | |
| 3 – 4 | 54 | 60.5 | | 15.2 | | 33 | 692 | | | |
| <= 2 | 36 | 90.8 | 0.14 | 19.9 | 0.19 | 16 | 692 | 0.97 | | |

[a] dimethylthiophosphate

[b] azinphos-methyl

[c] DMTP values are from 95 adults and 94 children that provided urine samples

[d] geometric mean based on generalized estimating equations

[e] National Health and Nutrition Examination Survey (NHANES) adults aged 18–59; children/youth aged 6–11

[f] in the past 3 days

[g] recommended as part of WPS pesticide-safety training

[h] among households with carpet (n = 62)

**Table 3**

Number of practices recommended as part of WPS pesticide-safety training and urinary DMTP[a] and house dust levels of AZM[b] among farm workers

| NUMBER OF PRACTICES[c] | Adult DMTP[a] | | Child DMTP[a] | | HOUSE DUST AZM[b] | | |
|---|---|---|---|---|---|---|---|
| | N = 95[d] | GM[e] | | GM[e] | | N = 53 | GM[e] | |
| | N | ug/ L | p-value | ug/ L | p-value | N | ng/ g | p-value |
| 0 – 2 practices | 14 | 75.3 | 0.77 | 14.4 | 0.76 | 10 | 522.5 | 0.60 |
| 3 – 4 practices | 39 | 71.0 | 0.77 | 13.7 | 0.51 | 19 | 676.6 | 0.99 |
| 5 – 6 practices | 42 | 65.2 | Ref | 15.6 | Ref | 24 | 675.6 | Ref |

[a] dimethylthiophosphate

[b] azinphos-methyl

[c] WPS home protective practices included: removing shoes/boots before entering home, changing out of work clothes within one hour, washing work clothes after wearing once, washing work clothes separately from family laundry, showering at home within one hour, and not holding children while wearing work clothes.

[d] DMTP values are from 95 adults and 94 children that provided urine samples

[e] geometric mean based on generalized estimating equations

## Table 4

Selected home practices and their relationship to farm worker child urinary metabolite concentrations of DMTP[a] (n = 94)

| | | Child DMTP[a] | |
|---|---|---|---|
| | N = 94[b] | GM[c] | |
| | N | ug/L | p-value |
| **CHILD PRACTICES** | | | |
| Child washed fruits before eating | | | |
| Usually / always | 92 | 16.6 | |
| Sometimes / rarely / never | 2 | 17.0 | 0.94 |
| Washed hands before eating | | | |
| Usually / always | 77 | 15.7 | |
| Sometimes / rarely / never | 17 | 21.3 | 0.16 |
| Child came to work in fields[d] | | | |
| Yes | 12 | 14.6 | |
| No | 80 | 17.6 | 0.46 |
| Sucked thumb | | | |
| Yes | 7 | 23.3 | |
| No | 87 | 16.1 | 0.14 |
| Child attends school | | | |
| Yes | 30 | 15.6 | |
| No | 64 | 17.1 | 0.65 |
| Child attends daycare | | | |
| Yes | 43 | 22.3 | |
| No | 50 | 13.1 | 0.007 |

[a] dimethylthiophosphate

[b] DMTP values are from 94 children that provided urine samples

[c] geometric mean based on generalized estimating equations

[d] in the past 5 days