ORIGINAL ARTICLES

Pesticide Take-Home Pathway among Children of Agricultural Workers: Study Design, Methods, and Baseline Findings

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Farmworkers are exposed to pesticides and may take home pesticide residues to their families. In this paper, self-reported pesticide exposure and home practices to reduce the amount of pesticide residues taken home were examined among 571 farmworkers. Urine samples from a subsample of farmworkers and children and dust samples from households and vehicles also assessed pesticide exposure. Overall, 96% of respondents reported exposure to pesticides at work. Many employers did not provide resources for hand washing. Farmworkers' protective practices to keep pesticide residues out of the home were at a low level. In a subset of respondents, pesticide levels above the limit of quantitation were seen in the urine of children and adults

and in house and vehicle dust. The results support the take-home pathway of pesticide exposure. Ways must be found to reduce this pesticide exposure among children of **farmworkers**.

Introduction

Children are a sensitive sub-population regarding environmental toxicant exposures, [1] and have become the focus of new prevention efforts. [2] Given that children have increased risk of harm because of their higher rates of metabolism, less mature immune systems, and different hand to mouth behaviors than adults, this is particularly true for pesticide exposure. [3] In epidemiologic studies, elevated risks of cancer, [4] [5] [6] [7] [8] [9] neurobehavioral deficits, [10] [11] congenital malformations, [12] and other health risks, such as leukemia and neoplasms [11] [13] are linked to pesticide exposure among children.

Studies indicate parents bring chemicals from the workplace to the home, resulting in children's increased body burden of toxicants such as lead, beryllium, asbestos, and mercury. [14] Other studies suggest pesticides may also be taken into the home by a take-home pathway. [15] Pesticide applicators and farm workers accumulate agricultural chemicals on their clothing and skin, and can carry these chemicals into their homes. [16] [17] [18] This take-home pathway plays an important role for children of agricultural workers.

In Washington State, the homes of agricultural workers have higher pesticide concentrations in house dust than other homes in the same agricultural community. [19] Children living in such homes have elevated urinary metabolites of the organophosphorus pesticides, the most commonly used insecticides in these regions. [20] Thus, it appears that the take-home pathway can contribute to children's exposure to pesticides in these communities. [21]

Agricultural workers may be exposed to pesticides during planting, cultivation, weeding, harvesting, pesticide mixing, and pesticide application. Although there is agreement that pesticide handlers are likely to be exposed to pesticide, therefore having opportunities to take residues home, [19] [21] it is less clear that agricultural workers not directly involved in pesticide application may also carry residues home to their families. A Washington State study, however, found that although only 23% of **farmworkers** had ever mixed, applied, or helped apply pesticides, 47% of **farmworkers** worked in fields within 2 days of pesticide treatment, and 43% were exposed by spraying accidents or drift. [22]

In 1999, we began a study to reduce the take-home pesticide exposure among children of **farmworkers**. The data reported in this paper are the baseline reports of perceived pesticide exposure, current protective practices used by **farmworkers** to prevent take-home pesticide exposure, and a summary of pesticide biomarkers in children of agricultural workers and residues of pesticides in house and vehicle dust. [23]

Methods

Setting

In Washington State, much of the Hispanic population is concentrated in Yakima County, where it constitutes 24% of the total population. [24] In the Lower Yakima Valley, a region that includes many small agricultural communities, the percentage of Hispanics is estimated at over 50%. [25] The Lower Yakima Valley is an agricultural region where apples, pears, peaches, cherries, grapes, and hops are the primary crops. [26] [27] Many members of the Hispanic population are involved in agricultural work, specifically, in harvesting, pruning, thinning, and other care of the many crops grown in the Lower Yakima Valley. The pesticides used on the

fruit group include organophosphate (OP) pesticides such as azinphos-methyl, phosmet, parathion, chlorpyrifos, and carbaryl. [28]

Design

Unlike many other studies of pesticide exposure, we are using a group randomized trial design. Group randomized trials focus on change in the group—in this case, communities. Advantages of such an approach are the potential to reach large numbers of people, disseminate messages about a behavior across a diverse population, change community norms about behavior, and integrate new behavioral practices into existing community structures and organizations. [29] [30] Part of our study design required involvement of individuals from the communities to guide us in planning intervention activities. [31] This approach is commonly known as a community organization or participatory action approach and has received much credence in the scientific field. [32] [33] [34]

Group randomized trials face a number of challenges, including whether to use a cross-sectional (snapshot) design or a cohort (longitudinal) design. [35] We are using a cross-sectional design for two reasons. First, a cohort design was considered infeasible for this population given its mobility. We were concerned that a loss to follow-up would introduce serious bias if the nature of dropout differs between treatment arms. In addition, a cohort design is also more expensive because it is necessary to track the participants for retention of the cohort. Some community trials have lost great proportions of their cohort due to this latter difficulty. [36] [37]

Figure 1 summarizes the study design. Recruitment occurred through three strategies. Before initiating the pesticide study, we received funding for and began a large population-based cancer prevention intervention study in the 20 communities in the same Valley. [38] Information related to cancer was collected from a random sample of 1795 adults in 20 participating communities in the Lower Yakima Valley. A sample of 160 households was drawn from each community, with the expectation of having at least 100 usable households per community. Because of the cancer project goals, household selection was structured to oversample Hispanics. We obtained household addresses from a bulk mailing company or collected them in person by driving throughout the town noting addresses, then plotted the addresses on 1990 census maps. Within each community, we listed census blocks hierarchically based on percentage of Hispanics, then divided the list into three equal parts (tertiles). Fifty percent of the community sample was randomly selected from the tertile with the highest proportion Hispanic residents, 33% of the sample was drawn from the second tertile, and 17% of the sample from the tertile with the lowest percentage Hispanic. In six communities, fewer than 160 housing units were available and all the households were surveyed. The questionnaire included an item asking if the respondent had worked in agriculture in the past 12 months.

Fig   Study Design.

For this pesticide project, we returned to the agricultural workers identified from the baseline survey of the cancer study and invited them to participate in a study about pesticide exposure. Only about a third of the agricultural workers in our original sample met the eligibility criteria for this pesticide study. Four of the 20 communities participating in the cancer study had no agricultural workers at all and were not included in the present study. To increase the sample size, we recruited additional households for participation in the study. First, project staff with the help of local informants identified areas within our existing communities where agricultural workers are known to live. Project staff listed all addresses within the identified areas. A random sample of addresses was drawn and those households added to our sample. Second, local informants identified eight labor camps in the area, and a census of housing units in each camp was included in our

sample. In the agricultural worker households where children between the ages of 2 and 6 were present, we also collected urine, house dust, and vehicle dust samples.

After baseline assessment, communities were blocked into pairs based on community size, percent Hispanic in the community, and treatment arm of the cancer study (to control for general behavioral changes that might occur as a result of being involved in an intervention community in the cancer project), and then randomized within a pair to intervention or control status. After 2 years of intervention, a new cross-sectional survey of **farmworkers** will be conducted in the 24 participating communities. Outcomes will include: (1) differences between intervention and control communities in urinary organophosphate metabolites of children between the ages of 2 and 6 who reside with **farmworkers** (primary); (2) differences in urinary organophosphate metabolites of **farmworkers** (secondary); (3) differences in house dust and vehicle dust in the environments of the farm workers (secondary); and (4) differences in self-reported knowledge, attitudes, and practices of **farmworkers** regarding protection of their children from pesticide exposure (secondary).

Study Participants

From randomly selected households, all adult agricultural workers were identified and their first names and birth dates listed on a questionnaire roster. One adult was selected (based on the adult with the first birthday after April 1) from each eligible household to complete an in-person interview. All respondents who gave verbal consent to participate were given a small incentive (a $5 coupon to a local grocery store chain). Respondents in households with children between the ages of two and six were asked if they would participate in an additional aspect of the study. This included collection of urine from the **farmworker** and child and collection of dust from the home and the household vehicle used for commuting to work. Adult respondents who agreed to participate in this part of the study were given $50 and the referent child was given a small stuffed toy. Adult respondents signed informed consent to participate. The study protocol and data collection procedures were reviewed and approved by the Human subjects Review Board at the University of Washington (Number 98-6567-C) and the Institutional Review Board (IRB) at the Fred Hutchinson Cancer Research Center (IRB #5101).

Survey Procedures

Introductory letters written in both English and Spanish were delivered to each household thought to be eligible to participate in the study. The letters described the study and allowed potential respondents the opportunity to telephone the project office if they had questions. Addresses were deleted if they were not valid (eg, business, vacant lot, empty dwelling).

Interviewing.

In-person interviews were conducted by 22 locally hired and trained bi-lingual interviewers. Bi-lingual project staff conducted three training sessions of 6 hours each. The training addressed strategies for approaching households, methods for asking questions in a standard manner, methods of editing questionnaires, and rules for documenting household contacts and survey dispositions. Interviewers were tested and certified. Interviewing took place between June 1, 1999 and September 30, 1999.

Interview Instrument.

The interview instrument was a 73-item schedule that included questions about agricultural tasks, general pesticide exposure in job tasks, personal perceived health effects of pesticide exposure, **farmworker** protective practices at work, employer practices at work, family protective practices, and demographics.

Agricultural Job Tasks and Pesticide Exposure.

Respondents were given a list of agricultural job tasks (eg, harvesting, pruning, thinning, mixing pesticides, applying pesticides) and asked which tasks they had performed in the past 3 months. The 3-month window excluded **farmworkers** who were unlikely to have had recent exposure to pesticides. For each job task answered in the affirmative, respondents were asked whether they had come into contact with pesticides while performing the task ("yes" or "no"). They also were asked, in general, how frequently when working, pesticides touched their clothing, touched their skin, they breathed in pesticide dust or chemical fumes, and they were dusted or sprayed with pesticides ("almost every day, once in a while, rarely, or never").

Employer Protective Practices At Work.

Respondents were asked about the presence of worksite facilities required by the Occupational Safety and Health Administration (OSHA) and the Worker Protection Standards (WPS) of the U.S. Environmental Protection Agency. [39] [40] OSHA requires the presence of a bathroom. The WPS regulation is aimed at reducing the risk of pesticide poisonings and injuries among agricultural workers and pesticide handlers. Employers must provide drinking water, bathrooms, water for washing hands, soap for washing hands, towels for drying hands, eyewash stations (water for flushing eyes), and showers (this latter is required only for pesticide handlers) for all workers who enter any field in which pesticides have been used. Response categories for the presence of such facilities included "always, sometimes, rarely, or never."

Home Protective Practices by Farmworkers

Home protective practices were assessed by questions developed from studies with **farmworkers** conducted by the National Institute for Occupational Safety and Health. [41] Questions asked respondents to report if they washed hands immediately after work, took off boots immediately after returning home from work, washed work clothes separately from the rest of the family laundry, and held or hugged their children before changing from work clothes. Response categories were "always, usually, sometimes, rarely, or never." **Farmworkers** were also asked how soon after returning home from work they removed their work clothes, and showered or bathed ("less than 1 hour, 1 to 2 hours, more than 2 hours").

Sociodemographic Characteristics.

Most of the sociodemographic variables were assessed by 1990 census questions. Gender was determined by self-report. Age was ascertained from the rostering information that obtained birth day, month, and year, for each adult member of the household. Respondents could state how many years of education they had received; these were later collapsed into 4th grade or less, 5th through 8th grade, 9th through 12th grade (no diploma), high school graduate or more. Ethnicity was self-reported. Marital status was self-reported as married (or living as married), widowed, divorced/separated, never married. Annual household income was self-reported as less than $10,000, $10,001 to $15,000, $15,001 to $25,000, or more than $25,000. Respondents self-reported the number of children (under 18 years of age) in the household.

Interview Data Quality Control.

To ensure the quality of the data, all coding and editing was checked by project staff at the Fred Hutchinson Cancer Research Center (FHCRC). In addition, a 10% random sample of completed surveys was selected from each interviewer. Study participants from this random sample were re-contacted and asked to verify that the interviewer had spoken with the respondent listed and to verify the validity of household rostering

information. No discrepancies were found in selecting the appropriate respondent for interviewing. In some cases where only one **farmworker** lived in the home, birthdate was not recorded. Complete questionnaires were sent to the FHCRC in Seattle and entered into a database using RODE-PC. [42]

Biomarker and Dust Data

Farmworkers who agreed to an interview and had a child between the ages of 2 and 6 residing in their households were asked to participate in the urine and dust collection portion of the study. Sampling protocols were based on standard operating procedures developed at the University of Washington and are reported in detail by Curl et al. [23] For urine, we collected two or three independent voids separated by a minimum of 3 days and a maximum of 2 weeks from one child and one **farmworker** in each eligible household. The independent urine samples (approximately 15-mL each) were pooled for each individual, then small tubes of pooled urine were drawn and shipped to the laboratory for analysis. Our bilingual interviewers attended three additional training sessions of 6 hours each conducted by project staff and laboratory personnel. The training addressed the importance of obtaining sufficient urine, of freezing the urine immediately after the sample was provided, of the timeline for sample collection, rules for documenting household contacts, and form dispositions. Sample collectors were tested and certified. Urine samples were stored at −10°C, shipped on ice to the laboratory at the University of Washington, and again stored at −10°C.

House dust was collected from the residences of the **farmworkers** with a Nilfisk vacuum cleaner, and new vacuum and polyliner bags, along with a clean vacuum hose and wand, were used for each household. Procedures for house and vehicle dust sampling were also developed by the University of Washington. [23] Areas were vacuumed in a standardized manner. A square half-meter by half-meter template was used as a guide. Depending on flooring type, 4 to 8 templates were vacuumed. The area vacuumed was where the parent reported "the child played most frequently." After 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 University of Washington for analysis. Vehicle dust was collected in the same way. The footwells, front and rear (except in the case of trucks without rear footwells), of the household vehicle were thoroughly vacuumed. After 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 University of Washington for analysis.

Analysis
Self-Reported Data.

Percentages were used to compare the demographic characteristics of pesticide handlers and nonhandlers by ethnicity (Hispanic and non-Hispanic White). Four respondents whose race were recorded as "other" or were missing were excluded from subsequent analyses. A small portion of the respondents ($n = 14$, 2.5%) did not work in agriculture in the past three months and they were also excluded from further analysis. Percentages involved in worksite job tasks were compared for Hispanics and non-Hispanic Whites. Available worksite facilities were examined by job task, and for home protective practices, variables were dichotomized and percentages given, and comparisons made for all households, and households with children by job task. In bivariate comparisons, we used the chi-square test to evaluate statistical significance. [43]

Urine Sample Analysis.

Because many OP pesticides can be metabolized to one or more of six dialkylphosphate (DAP) compounds, dimethylphosphate (DMP), dimethylthiophosphate (DMTP), dimethyldithiophosphate (DMDTP), diethylphosphate (DEP), diethylthiophosphate (DETP), and diethyldithiophosphate (DEDTP), we analyzed

urine for these compounds using procedures described by Moate et al. [44] DEDTP was not analyzed because none of the pesticides targeted in this study metabolize into DEDTP. Procedures used for urine analysis are reported by Curl et al. [23] Mean recoveries for the metabolites ranged from 85.2% ± 20.4% for DMP to 109.8% ± 38.6% for DEP, and limits of quantitation (LOQs) ranged from 0.6 to 7.4 µg/L. [44]

Dust Sample Analysis.

Dust was also analyzed for six OP pesticide residues, including four dimethyl pesticides (azinphosmethyl, malathion, methyl parathion, and phosmet) and two diethyl pesticides (chlorpyrifos and diazinon) following the procedure described by Moate et al. [45] These six pesticides represent the majority of commercial organophosphates applied in the lower Yakima Valley. Procedures for the dust analysis are reported by Curl et al. [23] Mean recoveries for the metabolites ranged from 63.5% ± 7.5% for malathion in household dust to 110.8% ± 18.5% for phosmet in vehicle dust, and LOQs ranged from 0.08 to 0.17 µg/g. [45]

Urine and dust data were log-normally distributed; thus, analyses were conducted with log-transformed data. Linear regression analyses were used to assess the association between adult and child urinary pesticide metabolites, as well as house and vehicle dust residues (see Curl et al. [23]).

Results

Response Rates

As shown in Fig. 1, of the 1264 farmworker households identified for the overall study, 651 were ineligible because they were not agricultural workers ($n = 627$) or could not be reached ($n = 24$). Of the remaining 613, 571 were interviewed, providing a response rate of 93.1% of the known eligibles. If the percentage of households that could not be reached is included in the response rate, the overall response rate is 89.6%. Of the 571 respondents, 236 households (41.3%) included children aged 2 through 6. Of these, 18 households (7.6%) refused to provide child urine samples.

Characteristics of the Population

Hispanics outnumbered non-Hispanic Whites (86.3% and 10.5%, respectively). A few respondents from other ethnicities made up the remaining sample. Overall characteristics of the sample, and characteristics by job task and ethnicity are shown in Table 1. A greater percentage of non-Hispanic Whites (71.7%) were pesticide handlers compared to Hispanics (25.8%). Hispanic agricultural workers were younger, less likely to be male, had a lower annual household income, and had completed fewer years of education compared to their non-Hispanic White counterparts. The vast majority of Hispanics (95.1%) completed the questionnaire in Spanish. Nearly 80% of Hispanics interviewed had children under age 18, compared to about 40% of non-Hispanic Whites. Marital status was approximately the same between the two groups. There were no differences between intervention and control communities in general characteristics.

Table 1. Characteristics of the Sample by Ethnicity and by Type of Occupation [*]

Characteristic				Pesticide handlers

	= 571)	Hispanics (N = 127)	Non-Hispanic White (N = 43)	farmworkers Hispanics (N = 366)	Non-Hispanic Whites (N = 17)
Age[±]					
18–24	61 (13.0)	9 (8.3)	1 (2.4)	47 (15.5)	4 (23.5)
25–34	152 (32.3)	43 (39.8)	2 (4.9)	103 (33.9)	4 (23.5)
35–49	167 (35.5)	38 (35.2)	17 (41.5)	109 (35.9)	3 (17.7)
50+	90 (19.1)	18 (16.7)	21 (51.2)	45 (14.8)	6 (35.3)
Gender					
Male	406 (73.4)	123 (96.9)	53 (86.9)	231 (63.1)	12 (70.6)
Education					
4th grade or less	182 (32.9)	43 (33.9)	1 (2.3)	138 (37.7)	0 (0.0)
5th to 8th grade	188 (34.0)	42 (33.1)	2 (64.7)	142 (38.8)	2 (11.8)
9th to 12th grade	116 (21.0)	34 (26.8)	8 (18.6)	70 (19.1)	4 (23.5)
High school graduate or more	67 (12.1)	8 (6.3)	32 (74.4)	16 (4.4)	11 (64.7)
Income					
Less than $10,000	142 (26.8)	16 (12.7)	3 (88.8)	122 (34.4)	1 (6.7)
$10,001 to $15,000	131 (24.7)	41 (32.5)	0 (0.0)	86 (24.2)	4 (26.7)
$15,001 to $25,000	164 (30.9)	51 (40.5)	2 (5.9)	109 (30.7)	2 (13.3)
More than $25,000	93 (17.5)	18 (14.3)	29 (85.3)	38 (10.7)	8 (53.3)
Marital Status					
Married, living as married	450 (81.4)	107 (84.3)	38 (88.4)	291 (79.5)	14 (82.4)
Widowed	7 (1.3)	0 (0.0)	0 (0.0)	7 (1.9)	0 (0.0)
Divorced, separated	18 (3.3)	3 (2.4)	1 (2.3)	14 (3.8)	0 (0.0)
Never married	75 (13.6)	17 (13.4)	0 (0.0)	51 (13.9)	3 (17.6)
Other	3 (0.5)	0 (0.0)	0 (0.0)	3 (0.8)	0 (0.0)
Children (<18 years)					
None	135 (24.6)	21 (16.5)	27 (62.8)	77 (21.3)	10 (58.8)
1	85 (15.5)	24 (18.9)	7 (16.3)	53 (14.7)	1 (5.9)
2 to 3	223 (40.7)	61 (48.0)	9 (20.9)	150 (41.6)	3 (17.6)
4 to 5	88 (16.1)	19 (15.0)	0 (0.0)	67 (18.6)	2 (11.8)

| More than 5 | 17 (3.1) | 2 (1.6) | 0 (0.0) | 14 (3.9) | 1 (5.9) |

* Percentages based on the number of valid responses for each item

† Age is missing for 101 respondents because interviewers did not always collect birth year when rostering households with only one farmworker.

Crops, Job Tasks, and Pesticides

The majority of respondents worked in one or more fruit crops in the past 3 months; specifically, apples (62.9%), pears (30.7%), cherries (45.3%), and grapes (25.0%). Other crops included alfalfa, asparagus, corn, green beans, hops, onions, peppers, and tomatoes. A total of 553 respondents reported performing specific farm job tasks within the past 3 months. Of these, 170 were pesticide handlers; that is they mixed, loaded, or applied pesticides. The majority of handlers were non-Hispanic Whites (71.7%) compared to Hispanics (25.8%), a difference that was significant ($P < 0.001$).

Of the 383 nonpesticide handling **farmworkers**, 366 (95.6%) were Hispanic compared to 17 non-Hispanic Whites (4.4%). Approximately half or more of Hispanic respondents reported they thinned, weeded, or harvested fruits or vegetables within the past 3 months (see Table 2). The number of non-Hispanic White general **farmworkers** is small and the major farm tasks reported by them was harvesting, irrigating, loading, and weeding. Significant differences were seen between Hispanics and non-Hispanic Whites involved in thinning and in irrigating. A number of **farmworkers**, both Hispanic and non-Hispanic White, reported having contact with pesticides while performing their tasks. Harvesting, thinning, loading, and irrigating had the highest percentage of respondents reporting pesticide contact; no differences between Hispanics and non-Hispanic Whites were significant.

Table 2. Job Tasks of the Respondents by Ethnicity and Number (%) Perceiving Contact with Pesticides in Conducting Tasks by Ethnicity*

	Number Performing Task‡	Performed task in past 3 months		P value	Total Number with Contact	Had contact with pesticides while performing task		
		Hispanics N (%)	Non-Hispanic Whites N (%)			Hispanics N (%)	Non-Hispanic Whites N (%)	
	276	265 (72.4)	11 (64.7)	0.49	132	127 (47.9)	5 (45.5)	
	231	226 (61.7)	5 (29.4)	0.01	117	116 (51.3)	1 (20.0)	0.15
	137	129 (35.2)	8 (47.1)	0.32	40	37 (28.7)	3 (37.5)	0.64
	183	176 (48.0)	7 (41.2)	0.58	67	65 (36.9)	2 (28.6)	0.62
	124	121 (33.1)	3 (17.6)	0.18	31	31 (25.6)	0 (0.00)	0.30
	150	143 (39.1)	7 (41.2)	0.86	68	66 (46.2)	2 (28.6)	0.53
	68	64 (17.5)	4 (23.5)	0.52	21	20 (31.3)	1 (25.0)	0.76

Job Task	Number Performing Task[±]	Performed task in past 3 months		P value	Total Number with Contact	Had contact with pesticides while performing task		P value
		Hispanics N (%)	Non-Hispanic Whites N (%)			Hispanics N (%)	Non-Hispanic Whites N (%)	
Sort/grade crops	99	95 (26.0)	4 (23.5)	0.82	41	40 (42.1)	1 (25.0)	0.48
Irrigate plants	70	59 (16.1)	11 (64.7)	<0.001	28	23 (40.0)	5 (45.5)	0.72

* Percentages based on the number of valid responses for each item.

† **Farmworkers** did multiple tasks; numbers reflect those responding to having done any of the tasks during the past 3 months. Totals = 383 Hispanics and 17 non-Hispanic Whites.

Close to two-thirds (63.4%) of respondents said that pesticides touch their clothes daily (33.0%) or once in a while (30.4%); 53.3% said pesticides touched their skin daily (28.6%) or once in a while (24.7%); 51.6% said they breathed in pesticide dust daily (19.7%) or once in a while (31.9%); and 17.3% said they were dusted or sprayed daily (2.5%) or once in a while (14.8%). There was a significant difference between pesticide handlers and nonpesticide handling **farmworkers** in being dusted by pesticides (26.5% and 13.5%, respectively, $P < 0.001$)

Protective Practices

A substantial percentage of both pesticide handlers and nonpesticide handling workers reported having access to required worksite cleaning and safety facilities within a short distance of their worksites (see Table 3). Most reported drinking water and bathrooms were always or sometimes available. Pesticide handlers were significantly more likely than nonpesticide handlers to have equipment available such as water for hand washing, soap for hand washing, towels for hand washing, and showers. Although required by law, 17.6% of pesticide handlers reported that eyewash stations were not available.

Table 3. Availability of worksite safety and washing facilities by job task performed in the past 3 months

Worksite facility	Pesticide mixers, loaders, and applicators (N = 170) always/sometimes N (%)	Nonpesticide handling farmworkers (N = 383) always/sometimes N (%)	P value
Drinking water	157 (92.4)	338 (88.3)	0.10
Bathrooms	160 (94.1)	360 (94.0)	0.75
Water for hand washing	149 (87.6)	280 (73.1)	<0.001
Soap for hand washing	134 (78.8)	228 (59.5)	<0.001
Towels for hand washing	134 (78.8)	227 (59.3)	<0.001

Worksite facility	Pesticide mixers, loaders, and applicators (N = 170) always/sometimes	Nonpesticide handling farmworkers (N = 383) always/sometimes	P value
Eyewash station	140 (82.4)	113 (29.5)	<0.001
Showers *	78 (45.9)	65 (17.0)	<0.001

* Required only for pesticide handlers.

We asked about home protective practices thought to reduce pesticide residues carried into the home (see Table 4). When examining job task, pesticide handlers were significantly more likely to wash their hands immediately after work regardless of presence of children in the household. For all households, pesticide handlers were significantly more likely to wash their work clothes after one wearing and to remove their work clothes before holding children. This latter factor was close to significance for pesticide handlers in households with children present ($P = 0.08$). We examined the responses by presence of children in the home and by job task. There were no significant differences in home practices by presence of children in the home (data not shown).

Table 4. Home protective practices of farmworkers by presence of children in the home and job task performed in the past 3 months (always or usually use practices) *

Home protective practices	All households		P value
	Pesticide handlers N (%)	Nonpesticide handling farmworkers N (%)	
Wash hands right after work	135 (79.4)	186 (48.6)	<0.001
Remove boots before entering home	105 (61.8)	208 (54.3)	0.10
Remove work clothes within 1 hour of returning home	101 (59.4)	212 (55.3)	0.37
Shower/bathe within 1 hour of returning home	87 (51.2)	174 (45.4)	0.21
Wash work clothes separately	141 (83.9)	312 (82.8)	0.74
Wash work clothes after one wearing	128 (75.3)	238 (62.5)	0.003
Remove work clothes before holding children	119 (86.9)	253 (78.6)	0.04

* Numbers and percentages based on the respondents who provided information on specific items

Urine and Dust Samples

Useable quantities of urine were collected from 211 children and 213 adults. There were 156 useable house dust samples and 190 useable vehicle dust samples. Urine was analyzed for five DAP compounds. As shown in Table 5, DMP, DMTP, DMDTP, and DETP compounds were found in most of the child samples and adult samples. DMTP was found in 88% of the child samples and 92% of the adult samples and DMDTP was found in roughly half of the child and adult samples. As found by Curl et al., [23] child urinary metabolites were significantly associated with metabolite levels in the urine of adults residing in the same house ($r = 0.42$; $R^2 = 0.18$; $P < 0.0001$).

Table 5. Percentages of child and adult urine levels above the LOQ[*] and percentages of house and vehicle dust about the LOQ[†]

Compound	Child ($N = 211$)	Adult ($N = 213$)	House dust[‡] ($N = 156$)	Vehicle dust[§] ($N = 190$)
Urine				
Percent above the LOQ[‡]				
DMP	19	20		
DMTP	88	92		
DMDTP	45	54		
DEP	0.9	0.0		
DETP	37	48		
Dust				
Percent above the LOQ				
Azinphosmethyl			85	87
Malathion			15	16
M-parathion			13	12
Phosmet			14	22
Chorpyrifos			26	18
Diazinon			3.8	2.1

* Percentage of total samples.

† Limits of quantitation (µg/L) for urine are: DMP = 7.4; DMTP = 1.1; DMDTP = 0.6; DEP = 2.9; DETP = 1.3

‡ Limits of quantitation (µg/L) for house dust are: azinphospmethyl = 0.09; malathion = 0.16; m-parathion = 0.12; phosmet = 0.13; chlorpyrifos = 0.15; diazinon = 0.17.

§ Limits of quantitation (µg/L) for car dust are: azinphospmethyl = 0.11; malathion = 0.08; m-parathion = 12; phosmet = 0.09; chlorpyrifos = 0.11; diazinon = 0.11.

Dust residues are also summarized in <u>Table 5</u>. Azinphosmethyl was found in the majority of the 156 house dust samples (85%) and in 165 of 190 vehicle dust samples (87%). Levels of other pesticide residues were quite small; however, the levels were fairly evenly matched for house dust and vehicle dust. A significant association between house dust and vehicle dust for azinphosmethyl residues was ($r = 0.64$; $R^2 = 0.41$) was also found by Curl et al. [23]

Discussion

To better understand the take-home pathway, we examined the work and home practices of **farmworkers** that might be related to the take-home pesticide pathway. Specifically, we looked at **farmworkers'** tasks, their self-reported overall contact with pesticides, the cleaning and other safety facilities available to them as part of their jobs, and their home practices that might reduce the amount of pesticide residues taken into the home. We found a substantial proportion of our sample reported having been exposed to pesticides. We also found that **farmworkers** had different perceptions of exposure to pesticides depending on the farm tasks they did.

Biomarker and dust samples of pesticide exposure were collected among a subset of participants in our survey. We present only a summary of that work here; for details, see Curl et al. [23] The urine data indicated that both children and adults in the Valley had pesticide metabolites consistent with pesticide use in the Valley. Similarly, pesticide residues were found in both house and vehicle dust. Further, there was a significant association between child and adult urinary dimethyl metabolites. All this is consistent with other work that has been conducted in Washington State. [19] [20] [21]

A number of studies that have emphasized pesticide handling (ie, mixers, loaders, applicators) find pesticide handlers to report exposure to pesticides and to have biological markers of pesticides in their bodies. [11] [46] [47] Similarly, in our study, 100% of pesticide handlers reported being exposed to pesticides while performing that job task. Worker protective standards are designed to prevent exposure by providing protective equipment; however, a high percentage of our respondents reported pesticides touched their skin or clothing, they were sprayed with pesticides, or they breathed in pesticides. Others have reported similar findings. [48] [49] [50] In the Agricultural Health Study, 14% of licensed pesticide applicators reported a high exposure event while working. [13] [51]

Although few studies have looked at **farmworker** reports of overall pesticide exposure, our findings appear to be consistent with those that have. [22] [47] [49] [52] [53] Agricultural fieldworkers are at higher risk for pesticide exposure than the general population. [54] Pesticide residues on plants may linger for many weeks and may be a source of continuous exposure for field workers. [47] A high percentage of migrant workers interviewed by Vaughn reported being exposed to pesticides while doing fieldwork. [49] This is consistent with results of our study. More than half of our respondents reported dermal contact with pesticides and breathing in pesticides. Among nonpesticide handlers, 13.5% reported that they were dusted or sprayed on occasion.

Rather than asking respondents only about fieldwork overall, we asked about specific tasks and whether **farmworkers** believed they were exposed to pesticides while conducting those tasks. This allowed us to identify tasks in which **farmworkers** reported having differential exposure to pesticides. Thinning is often

associated with pesticide exposure, [47] and over half of our respondents reported contact with pesticides while thinning. Harvesting was also associated with pesticide contact; increasingly, the EPA is re-evaluating pesticides and lengthening the pre-harvesting interval during which pesticide application is not allowed. Chlorpyrifos, for example, may no longer be applied to apple orchards postbloom, [55] and voluntary agreement to reduce azinphosmethyl use has also been reached. [56] These standards are intended to reduce risk to **farmworkers**, as well as dietary risk to children. Of those who loaded crops, a high percentage reported contact with pesticides. Unfortunately, our data were not collected in a manner that would permit us to examine self-reported contact with pesticides by specific job tasks. Nevertheless, it is instructive to see the wide variance in self-reported exposure by job tasks. Little work has been published in this area and it deserves further research.

A number of pesticide handlers and **farmworkers** reported their workplaces were out of compliance with the Worker Protection Standards. Pesticide handlers are required to have a complete decontamination site available; equipment must include water for washing and eye-flushing, soap, single use towels, shower, and clean change of clothes. Nonhandlers, that is, people working in areas treated with pesticides at some time during the growing season must have water for washing and eye-flushing, soap, and single use towels available. [57] Compliance with available facilities for pesticide handlers tended to be high compared to facilities for nonpesticide handlers. In the Valley, as in other agricultural settings, there appears to be high awareness of the danger of a high level of exposure to pesticides as may occur among handlers. For a variety of reasons, there is less concern about **farmworkers'** exposure. Perhaps the major reason for the lower level of concern for **farmworkers** lies in the lack of knowledge of the long-term effects of chronic low-level exposures. [58] [59] While the effects of acute exposure have been well documented, [11] [58] [59] little is known about disease outcomes that might be attributed to ongoing low exposure levels. Further, the risk of an overexposure is far greater among handlers, which may lead to more enforcement of the WPS among that occupational group. [60] [61] In a qualitative study using interviews with **farmworkers**, the statement was made that WPS enforcers were never seen in the fields. [31]

There were no differences in home protective practices between households with children and all households combined. As children are more susceptible to exposure to pesticides than adults, our findings of no difference overall between households with children and overall households in practices to reduce the take-home pathway of pesticide exposure to children suggest a need to educate **farmworkers** with children about the importance of taking steps to reduce take-home pesticide exposure. Such education is the focus of the intervention portion of this project, currently in process. Pesticide handlers did better in protective practices than **farmworkers** in washing hands immediately after work, washing work clothes after one wearing, and removing work clothing before holding children. Pesticide handlers are required to have training and certification for their job tasks. Some of the training includes information on the hazards of pesticides and how to prevent take-home exposure, which likely accounts for this difference between handlers and **farmworkers**.

Limitations

This baseline survey of 571 **farmworkers** is one of few that have been able to conduct in-depth examination of **farmworkers**. Every attempt was made to obtain a representative sample of **farmworkers**; however, it is possible that some groups were missed. This may be due to the living conditions of some workers who come to the Valley and live in vehicles, tents, or other situations. We did not attempt to enumerate that group.

Although our refusal rate of known **farmworkers** was small, it is possible some **farmworkers** misrepresented their work status out of fear. The Valley has a number of undocumented workers. They may have been unwilling to speak with us for fear that we represented Immigration and Naturalization Services (INS). We engaged in considerable effort to assure **farmworkers** we were not with the government and not concerned with documentation; nevertheless, some may have avoided us. Because we had no way of documenting this, our refusal rate is based only on the known eligible **farmworkers** who refused to

participate in the interviews.

Pesticide exposure is assessed by self-reports of pesticide handlers and **farmworkers**. As such, the estimated exposures are unlikely to be accurate. Further, we asked respondents about exposure over a 3-month period, which is essentially exposure during a growing season. Nevertheless, the vast majority of respondents (96.8%) reported being exposed at least once during the season. This self-reported assessment should be investigated in future research.

Worker reports of exposure to pesticides are predicated on many factors, including the worker's comprehension as to what a pesticide is and is not; for example, many diverse agents (eg, pesticides, fungicides, herbicides) may be applied to crops during the growing season. **Farmworkers** are unlikely to be familiar with the different agents and may group them together into one category called "pesticides" as has been found in other studies. [62] [63]

Finally, the absence of a nonagricultural worker control group weakens the very premise we sought to support: that is, the take home pathway. In the absence of nonfarmworkers, it is difficult to know whether the general environment, family lifestyle practices, or some other factors may attribute to the associations we have seen. These are areas to be explored in future research.

Conclusion

This study is among the first to conduct a large, in-depth exploration of **farmworkers**, both pesticide handlers and nonhandlers, and their perceptions of exposure to pesticides. Further, we obtained information on the facilities available to **farmworkers** at work and the protective practices engaged in by the **farmworkers** when at home. The data suggest that many of the **farmworker** practices are consistent with taking pesticides into the home where children may be exposed. These data indicate that much needs to be done to reduce the take-home pesticide exposure pathway.

Acknowledgments

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