Published in final edited form as:
J Occup Environ Med. 2011 August ; 53(8): 884–891. doi:10.1097/JOM.0b013e318222f03a.

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Organophosphate Pesticide Exposure and Residential Proximity to Nearby Fields: Evidence for the Drift Pathway

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Abstract

Objectives—Residential proximity to pesticide-treated farmland is an important pesticide exposure pathway.

Methods—In-person interviews and biological samples were collected from 100 farmworker and 100 non-farmworker adults and children living in Eastern Washington State. We examined the relationship of residential proximity to farmland to urinary metabolite concentrations of dimethylphosphate (DMTP) and levels of pesticide residues in house dust.

Results—DMTP concentrations were higher in farmworkers than non-farmworkers (71 μg/L vs 6 μg/L) and in farmworker children than non-farmworker children (17 μg/L vs 8 μg/L). Compared to non-farmworker households, farmworker households had higher levels of azinphos-methyl (643 ng/g vs 121 ng/g) and phosmet (153 ng/g vs 50 ng/g). Overall, a 20% reduction in DMTP concentration was observed per mile increase in distance from farmland.

Conclusions—Lower OP metabolite concentrations correlated with increasing distance from farmland.

Keywords

PESTICIDES; DRIFT; RESIDENTIAL PROXIMITY TO FARMLAND

INTRODUCTION

Exposure to organophosphate pesticides (OPs) is reported to cause harmful health effects in both adult farmworkers (1-4) and their children (5-10). Children's exposure to pesticides is thought to occur through a variety of pathways including the paraoccupational or take-home pathway, dietary intake of pesticide-treated produce, and a lifestyle pathway that encompasses the influence of protective behaviors on exposure levels. Another important pathway, known as the environmental pathway, focuses on exposures resulting from the off-target settling of pesticide spray drift in residential communities (11-12). Such pesticide drift is thought to have its greatest impact on individuals living near pesticide-treated farmland. Pesticide drift is thought to be a source of pesticide exposure for agricultural and non-agricultural families alike.

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No conflicts of interest were reported by any authors of this manuscript.

Previous investigations that have examined pesticide exposure levels in relation to proximity to pesticide-treated farmland have reported mixed results. Several studies have measured air concentrations of pesticides from monitors set up near treated fields (13-14). In general, studies that have timed their collection to pesticide spray events have reported higher concentrations of pesticide on monitors that are nearer treated fields compared to those farther away (13-14). Other studies have applied statistical models that consider a variety of factors (such as meteorological conditions, and toxicity of applied pesticides) to compute concentrations and impact from off-target deposits of pesticides (EPA Fugitive Dust Model FDM) (15). The findings from these studies have generally been consistent in documenting evidence that pesticides sprayed in the fields are drifting off-target and that the amount of off-target drift depends upon several factors, including wind speed, wind direction and other weather conditions and type of application equipment used.

A limited number of previous investigations have examined the influence of residential proximity to treated farmland on levels of pesticide residues in house dust. Lu et al. used data from 60 agricultural families living in an agricultural region of Central Washington State and showed that median concentrations of azinphos-methyl in house dust were significantly higher in households within 200 feet of treated orchards than those more distant ($P<0.01$). A small number of other studies have reported similar associations (16-18). However, this relationship was not observed in our previous analysis of data from Eastern Washington involving a much larger sample size (over 200 households) (unpublished data), where we found no relationship between levels of pesticides in house dust samples and Global Positioning Device-measured distances from nearby farmland.

Few previous investigations have examined the association between residential proximity to treated farmland and markers of human exposure to pesticides. Data from the same study conducted by Lu et al. collected urine samples from 60 children aged 6 and under and found significantly higher concentrations of urinary pesticide metabolites in children living in households that were within 200 feet of treated orchards compared to those living farther away (11). In contrast, at least one study reported no significant association in this relationship (19).

The Center for Child Environmental Health Risks Research’s Community-Based Participatory Research Project, For Healthy Kids!, examined the pathways by which children are exposed to pesticides. This longitudinal study collected samples of house and vehicle dust, and urine, saliva and blood from farmworker and non-farmworker families at three points during the agricultural season: the thinning, harvest, and non-spray season. For this analysis, we used data from the thinning season as it is thought to coincide with the highest worker exposures. We report on the association between urinary OP metabolite concentrations of farmworker adults, non-farmworker adults, and their children between the ages of 2 and 6 and residential distance from the nearest field. We also report on the association between residential distance from farmland and house dust concentrations of two of the regions’ most commonly used OPs, azinphos-methyl and phosmet. We tested the hypothesis that adults and children living in homes that are more proximal to farmland would have higher urinary metabolite concentrations of OPs and higher levels of azinphos-methyl and phosmet in their homes than those living more distant.

METHODS

Setting

The study took place in the Lower Yakima Valley of Washington State. The setting has been described previously (20). Briefly, the Yakima Valley is comprised of many small agricultural communities and has the greatest percentage of Hispanics in Washington State.

An estimated 50,000 people in the region work in agriculture. The region leads the nation in the production of apples and sweet cherries. Other major agricultural crops are pears, peaches, grapes, and hops. 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 include OPs such as azinphos-methyl and phosmet, among others (21).

Community-based participatory research

Because the project was a community-based participatory research project, a community advisory board (CAB) was formed as part of the previous grant; details on the members of the CAB and their opinions about pesticides are described previously (22). In the preparation for this study, the CAB was asked to provide input on next steps for research in the community. The CAB was very interested in knowing whether farmworkers and non-farmworkers living in the Yakima Valley communities differed in their exposures to pesticides. They were particularly interested in the take-home and drift pathways.

Study procedures

All respondents signed informed consent forms to participate. Adults signed informed consent for their child's participation. The study protocol and data collection procedures were reviewed and approved by the Institutional Review Boards (IRB) at the Fred Hutchinson Cancer Research Center (IRB # 5101) and at the University of Washington.

Hispanic farmworker and non-farmworker families who had a child between the ages of 2 and 6 were recruited for the study at community events and worksites. To be eligible, all farmworkers had to have worked in either apple or pear crops during the past week, as we were interested in assessing their occupational and environmental exposures. We chose to limit recruitment to individuals who worked in apples or pears for two reasons. First, because we were interested in assessing adult and child exposures that occur through a variety of pathways, we desired a group of workers who had relatively similar workplace exposure patterns; this meant exposures to the same types of pesticides at the same time of year. Apples and pears are grown and harvested on a very similar cycle, they are both classified by the US Department of Agriculture as pome fruit, and on each similar pesticides are applied. Second, our previous analyses showed that those who worked in pome fruit has higher levels of pesticide exposures than those who worked in other crops, thus limiting our recruitment to pome fruit workers would allow us to achieve high variation in exposure levels in farmworker and non-farmworker groups. Where a given household had more than one eligible child (between the ages of 2 and 6), the child with the first birthday after April 1 was selected as the referent child for the study. Trained bilingual, bicultural study staff recruited participants at retail outlets, churches, and through door-to-door solicitation. Flyers were posted in community organizations and commercial outlets.

Data were collected at three different time periods, which coincided with the agricultural growing season. The first data collection period took place between April and July 2005 and corresponded to the thinning season for apples and pears. During the thinning season, farmworkers 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 task results in much direct contact with treated foliage. Thus, the thinning season is thought to coincide with the highest worker exposures to pesticides. The second data collection period occurred between September and October 2005, which was the harvest season for apples and pears. The third data collection period took place between December 2005 and February 2006. Interviews were conducted and samples were collected from the same families at each season. All adult participants and referent children were asked to provide urine, blood, and saliva samples. Dust samples were collected from participants' homes and vehicles. For this analysis, we report on urine and dust data from the thinning season only, as this is the season during which most spray activity occurs. Families were given $175 for their participation in all aspects of the study.

Survey instrument

A survey was administered in-person during each of the three seasons by trained bilingual, bicultural project staff. The survey was a 60-item schedule that addressed general pesticide exposure, work practices, employer practices, personal exposures, family protective practices, and eating behaviors. In addition participants answered questions regarding demographic information. All survey questions were reviewed by members of the CAB, and their feedback was incorporated into the final version.

Distance measurements

For all households in the study, project staff measured actual distance using car odometer reading, pedometers, and GoogleEarth®. They also recorded the type of crop that was nearest a given household.

Urine collection and analysis

Our bilingual urine collectors attended three six hour training sessions. 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, and rules for documenting household contacts and dispositions. Sample collectors were tested and certified. Sampling protocols for urine were based on standard operating procedures developed at the University of Washington and reported in detail by Curl et al.(21) For urine, we collected a series of three independent spot voids (separated by two days) each from one child and one adult in each eligible household. Once collected, urine was stored at -10° C. The urine was thawed and approximately 15 mL from each urine sample was transferred into a small tube and shipped on ice to the Centers for Disease Control (CDC) National Pesticide Laboratory for analysis. Samples were analyzed using a modification of the method of Olsson et al.(23) Briefly, 2-mL urine samples were hydrolyzed by enzymes to liberate the glucuronide- or sulfate-bound conjugated metabolites. Hydrolysates were extracted using a mixed-mode solid-phase extraction cartridge. Concentrated extracts were analyzed using high-performance liquid 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) that corresponded to the pesticides most commonly used in the Valley. For the purposes of this paper, we limit our analysis to DMTP, as it was the most commonly detected metabolite in our sample. The limit of quantitation for this metabolite was 0.2 ug/L.

Dust collection and analysis

Using a Nilfisk vacuum cleaner, house dust samples were collected from the residences of the farmworkers and non-farmworkers. A cleaned vacuum and fresh polyliner bag, 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 (21). 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. Dust samples were analyzed for OP residues according to the procedures described by Moate et al. (24), including azinphos-methyl and phosmet, the OPs in most common use in the Valley. The limit of quantitation was 15 ug/g for azinphos-methyl and phosmet.

Each household that provided samples with a sufficient quantity of dust (N = 109) were analyzed for diazinon, methyl parathion, malathion, chlorpyrifos, phosmet, and azinphos-methyl compounds measured as ug/g of dust. Four of the compounds, malathion, chlorpyrifos, phosmet, and azinphos-methyl provided enough data above the level of quantification (LOQ) for analysis. For the purposes of this report, we provide data on azinphos-methyl and phosmet, as they were the two dimethyl compounds in most common use in the Valley.

Statistical Analysis

We limited our analysis to data from the thinning season as our previous data suggest that the highest dimethyl exposure occurs during that time. We also report on house dust concentrations for two dimethyl pesticides; azinphos-methyl and phosmet, as they are the most commonly found in the home environment, and they are metabolized to DMTP (as well as DMP, and DMDTP).

For the purposes of statistical analysis, we report the frequency of socio-demographic characteristics of our study sample. To evaluate the potential relationship between distance of a given household to the nearest field, linear regression of the DMTP measurements in urine (log transformed) was conducted with covariate “distance from the nearest field” (in miles). We opted not to log transform our distance variable; though this has been performed in previous studies (16, 25), as distance was treated as a covariate in our analysis and a variance stabilizing transformation was not needed. Using thinning season data, we included all three urine samples from each study subject and used generalized estimated equations (GEE) methods with an exchangeable correlation structure to account for potential correlation within individuals due to the repeated measures. In addition to analyzing repeated measures urinary metabolite data with GEE, analyses using mixed effect with individual within household were conducted. An unstructured correlation matrix was used to account for any residual correlation not accounted for by the random effects structure. The results of the GEE and mixed effects analysis are virtually identical. We also report the frequency of the crop that was determined to be the most proximal to a given residence. We performed a sub-analysis using a sample restricted to crops where OPs are generally applied (cherries, apples, or pears).

To evaluate the potential relationship between distance from the household to the nearest field, linear regression of the various compounds in dust measured in the household (log base 10 transformed) were conducted with covariate “distance from the nearest field” (in miles). The relationship between house dust concentrations and distance from a given household to the nearest field was analyzed adjusted for occupation (farmworker vs. non-farmworker). To assess confounding, variables were added to a model that contained the predictor variable of interest and occupation. Only gender was determined to be a confounder. In a combined model (of adults and children), an indicator variable denoting adult or child sample did not change the risk estimate. No differences were found in association when log-transformed and non-log-transformed values were used. For these models, we report the absolute change using log-transformed data, resulting in an overall percent change in our effect estimates.

RESULTS

Response rate

A convenience sample of 101 farmworker families and 100 non-farmworker families participated in the study. For the thinning season, urine samples were collected from 200 adults and 199 children. House dust samples were analyzed from 109 homes; belonging to 54 farmworkers and 55 non-farmworkers. Dust samples only were analyzed for households that had sufficient quantities collected of both house and vehicle dust (> 1 gram).

Socio-demographic characteristics

The average age of respondents was 31 (Table 1). Over three-quarters of our sample was female. Ninety-two percent of farmworkers and over three-quarters of non-farmwokers reported being married or living with a partner. Household income distribution varied by occupational status, with 39% of farmworkers and 31% of non-farmworkers earning $15,000 per year or less. Number of children was relatively similar across occupational group. Nearly all farmworkers were born in Mexico; this compared to two-thirds of non-farmworkers. Slightly more than one-half of farmworkers and 80% of non-farmworkers lived in a single family dwelling.

Socio-demographic characteristics and distance—When we examined socio-demographic characteristics across categories of residential distance from the nearest field, we found no difference across age groups. Females comprised nearly 90% of those living within 200 feet of farmland and about two-thirds of those living more than one mile away. No associations were noted between distance and marital status, household income, number of children, or birthplace. Three-quarters of those who lived within 200 feet of farmland lived in a single family dwelling, and that percentage was lower (65%) for those who lived farther away. Contrary to expectation, among those who lived within 200 feet of farmland, slightly more than one-half (54%) were non-farmworkers.

Socio-demographic characteristics and urinary metabolite concentrations and house dust levels—We examined socio-demographic characteristics across categories of urinary DMTP concentrations and house dust levels of azinphos-methyl and phosmet (Table 2). In regard to DMTP concentrations, no differences were found across categories of age, income, or number of children. Gender, marital status, birthplace, and type of dwelling were all associated with DMTP concentrations. House dust levels of azinphos-methyl and phosmet were not significantly associated with gender, number of children, and type of dwelling. Azinphos-methyl and phosmet levels were associated with income and birthplace, with higher levels found among those with lower incomes and who were born in Mexico. Age was associated with levels of phosmet, but not azinphos-methyl. Martial status was associated with levels of azinphos-methyl, but not phosmet.

Concentrations of DMTP and house dust levels of pesticides among farmworkers and non-farmworkers

Consistent with expectation, concentrations of DMTP were higher in farmworkers (71.1 ug/L) than in non-farmworkers (5.5 ug/L) (Table 3). Both groups had higher DMTP concentrations than a nationally representative sample of adult participants in NHANES. Similarly, concentrations of DMTP were higher in children of farmworkers compared to non-farmworkers (16.5 ug/L vs. 7.5 ug/L). Both groups had higher concentrations than a nationally representative sample of youth participants in NHANES. House dust levels of azinphos-methyl and phosmet were also significantly higher in farmworker compared to non-farmworker homes.

Crops and distance from nearest field

When we examined the type of crop that was nearest to our selected households, we found that corn, hay, and wheat were most commonly observed (42%), followed by apples or pears (14%), cherries (11%), grapes (10%), and asparagus (8%)(Table 4). The remaining 16%, categorized as “other”, included hops, mint, onions, peas, and potatoes. For the 28 households that were situated within 200 feet from farmland, the nearest crops were corn, hay, or wheat (59%); smaller proportions were found to have apples or pears (15%), cherries (7%), or asparagus (4%). The remaining 15% were categorized as “other”.

Distance from farmland and urinary metabolite and house dust concentrations

In linear regression analysis adjusted for occupational status and adult gender, a significant 20% reduction in DTMP concentration was observed for each mile distance from the nearest field (in combined data from adults and children) (Table 5). Reductions in DMTP concentrations were observed with increasing distance from the nearest field in data stratified by adults, children, farmworkers and non-farmworkers, though the relationships were not significant. No significant associations of azinphos-methyl and phosmet levels and distance from farmland. When we restricted our analysis to the 28 households for which the nearest crop was one where OPs are generally applied, we found no association of residential proximity to DMTP concentrations or to dust levels of AZM or phosmet.

DISCUSSION

The goal of our analysis was to examine spray drift, not from a model perspective, but from a human impacts perspective. We were not interested in spray drift per se, but in whether or not among families living in agricultural region such drift is entering homes and coming into contact with children. The results of this report provide support for our hypothesis that individuals who live closer to farmland have higher urinary metabolite concentrations than individuals who live farther away. However, our findings do not support our hypothesis that individuals who live closer to farmland have higher levels of pesticide residues in their house dust. Our data contribute to a growing body of knowledge about the relative contribution of sources of pesticides exposure among individuals living in agricultural communities.

We found that urinary pesticide metabolite concentrations were associated with distance from nearby farmland, in a model that combined adults and children. To our knowledge, only one previous study has reported on this association. Findings from Lu’s et al. study of 60 households located in central Washington State showed that median DMTP concentrations were significantly higher among children living in homes that were 200 feet or closer to treated farmland, compared to those living in homes that were over 200 feet from treated farmland (median DMTP concentration 30 ug/L among children <=200 feet vs. 10 ug/L among children > 200 feet; $p = 0.01$) (11). Notably, both values are above the 4 ug/L reported for the general US population of individuals aged 6–11(29).

Notably, Lu’s study reported analysis of 45 (75% of the sample) households that were within 200 feet of treated farmland and our study included 28 (14% of our sample) households within this range. Previous research has suggested that pesticide drift diminishes sharply with increasing distance from fields. Carlsen et al., for example, examined drift from 10 herbicides using passive dosimeters (25). Spray was detected up to 150 meters off-target. However, the highest concentrations were found within a short distance from treated fields: 0.1–9% of amounts applied was found within 2 meters, and 0.02–4% of amounts applied was found within 3 meters. The amount decreased exponentially with increasing distance from the treated field. In Lu’s study, of the 47 total agricultural families that lived within

200 feet, 35 lived within 50 feet. By comparison, only 4 of the households in our study were within 50 feet of the nearest field. Moreover, Lu's study examined treated farmland, and it is unknown whether or not the nearest fields in our study were pesticide treated.

Another important difference in Lu's study compared to ours is that Lu's study only looked at proximity in agricultural workers, most of whom were pesticide applicators. Reference families for the study all lived more than ¼ mile from treated farmland and did not work in agriculture. In our study, nearly equal numbers of farmworker as non-farmworkers lived within 200 feet of farmland, allowing us to examine in the non-farmworker group the influence of proximity with minimal confounding from workplace sources of exposure. In our previous analyses, we report higher urinary metabolite concentrations and house azinphos-methyl residues in pome fruit workers, compared to non-pome fruit workers, underscoring the importance of workplace sources of exposure (30). Nevertheless, when we limited our analysis to non-farmworkers, we found no relationship between household proximity to farmland and house dust concentrations of azinphos-methyl or phosmet, nor urinary OP metabolite concentrations. Our study included over twice the number of participants as Lu's and notably, while we achieved 98% detection of DMTP from our urine analysis, Lu's study achieved 67% detection of the same metabolite among agricultural families and 53% detection of DMTP among non-agricultural families (adults and children combined).

Our finding that dust levels of azinphos-methyl and phosmet were not associated with proximity to farmland was inconsistent with four previous investigations (11, 16-18). Lu et al. reported significantly higher dust concentrations of azinphos-methyl in homes that were within 200 feet of treated farmland, compared to homes that were 200 feet or farther away ($p = 0.01$) (11). McCauley et al. examined azinphos-methyl levels in 25 homes in the Hood River Valley of Oregon State that were located between 3 and 305 meters of farmland. Findings from her study showed a significant log-linear association; azinphos-methyl concentrations dropped 18% when the distance from fields doubled ($p=0.04$)(16). Ward et al. reported on a study that examined concentrations of herbicides in 112 homes in an agricultural community in Iowa (where pesticides are likely to be applied via aerial spray). Findings from this study showed a direct association between increasing acreages of corn and soybean within 750 meters of participants' homes and dust residues of herbicides found in the home (17). In a study conducted in North Carolina and Virginia where dust samples were collected from 41 homes, Quandt et al. reported that homes that were judged to be adjacent to agricultural fields (using maps drawn by project staff) were 18 times more likely to have detectable levels of agricultural pesticides in their house dust, compared to homes that were judged not to be adjacent to agricultural fields (18). Notably, a fifth study, conducted by Weppner et al., measured methamidophos levels in indoor and outdoor air samples, playground equipment and toys and hands of 8 children in Eastern Washington prior to and shortly after a scheduled aerial spraying of potatoes. Findings from the study showed that no methamidophos was found on indoor surfaces, suggesting that children's exposure generally occurred outdoors (14).

Notably, previous research suggests that the amount of drift and the distance it travels is influenced by the application method, meteorological conditions, topography, characteristics of the crop or area being sprayed, and decisions made by applicators (26). The vast majority of orchards in our sample are sprayed using airblast sprayers and it is likely that there is less drift with this application method than with aerial applications. Workplace practices such as using one-sided application methods on the last 3 rows of crops or planting tall trees that capture the residue are also thought to mitigate the quantity of pesticides that are carried through the air. It is unclear to what extent growers in this region are engaging in these practices.

Other factors contribute to the complexity of assessing the influence of proximity on in-home pesticide exposure levels. In Washington State, the growing season is relatively short, and pesticide applications are episodic events, which complicate measurements of the impact of exposures to children. While some states have mandatory reporting of pesticide spray events, Washington State does not, thus designing a controlled study that examines drift generally requires voluntary sharing of information from growers or the often inaccurate reporting of such events from workers. In our study, we relied on distance to the nearest field as a proxy for a pesticide-treated field, even though we had no information to suggest whether or not the field was pesticide treated or when the most recent pesticide application had occurred. We had no information on wind direction and speed or other meteorological, field, or human factors that may influence the impact of spray drift, though some of these factors have been considered in some previous studies on this topic.

Limitations and strengths

There are some important limitations of this study. First, our urine and dust collection was not timed to coincide with spray activity, thus we may have missed peak exposures that were captured in some previous investigations. Second, our participants were limited to those who worked in apples and pears and our specimen analysis was limited to the detection of OPs. It is possible that non-OPs were used in some nearby fields and we did not test for these in the homes. Our data on crops show that a large proportion of nearby crops was corn, hay, or wheat, on which herbicides are generally applied and we did no testing for the presence of these. Nevertheless, when we restricted our analysis to homes that were near crops that are generally treated with OPs, we still found no evidence for associations. Further, use of distance as a surrogate for proximity does not account for wind direction, topography or other factors that are known to influence exposure levels. Our measurement distance, as gathered mostly by odometer readings, reflects “road distance” and may overestimate the actual distance. Unlike other studies that select households based on their distance from the nearest field, a relatively small proportion of homes in our study were immediately adjacent to fields. Nevertheless, our relatively large sample size meant that we had similar numbers of “adjacent” homes as in previous studies.

Environmental Protection Agency (EPA) models suggest that a variety of factors influence the likelihood of being exposed to drift from nearby pesticide applications, including wind and temperature, among others. Our analysis only considered proximity. Future research may benefit from the inclusion of additional factors thought to influence spray drift.

Barr and others have noted several limitations to the interpretation of urinary metabolite concentrations for monitoring pesticide exposures (31). Interpretation can be complicated by the short biological half-lives of most pesticides and the associated difficulty in specifying the timing of applications and the types of chemical applied. Spot urine samples are thought to be less precise than 24 hour urine samples and there exists inter-individual variability in the speed of excretion and routes of elimination. In our study, we collected three spot urine samples and used general estimating equations to minimize intra-person variability. Several different pesticides produce the same metabolites and many organophosphate metabolites can be derived from exposures to pre-formed metabolites themselves (32), further complicating inferences about levels of exposures to parent compounds. Nevertheless, inclusion of house dust data means that our analysis does not rely solely on data from urinary metabolites.

The strength of this study is that we did not rely on self-reported data, which may be limited by individual differences in perceptions of and facility with measurements of distance (i.e. recent immigrant may not yet think in US measurements such as miles, and block distances can vary dramatically depending on whether one lives in an urban or rural area). Instead, we measured distances from nearest field. Our urine samples were analyzed at the National Pesticide Laboratory at the CDC and we achieved a substantially higher percentage of detection than in previous studies. We enrolled a sample of farmworkers and non-farmworkers that was substantially larger than most previous investigations, and by enrolling non-farmworkers, we were able to examine the influence of the environmental pathway in the absence of occupational and paraoccupational exposures. Given that we enrolled a community-based sample of households with varying distances from the nearest field, our analysis represents a real-world scenario of community exposure.

Conclusion

Our data appear to suggest that living farther from farmland is associated with a 20% reduction per mile in concentrations of DMTP in adult farmworkers, non-farmworkers or their children in combined analysis. Given the complexity of factors that influences personal and in-home exposures and factors that influence the opportunity for pesticides sprayed on nearby farms to enter residential sites, additional research to examine the contribution through the proximity pathway is warranted. Future research might examine pesticide residue levels in house dust and urinary metabolite concentrations among farmworkers and non-farmworkers that are located close distances from farmland, specifically within 50 feet. Future research might also examine the location of schools and day care centers, and the influence of the environmental pathway of children’s exposures in these settings.

Acknowledgments

The authors acknowledge members of our community advisory board for their collaborative assistance designing and carrying out the project.

FUNDING

Although the research described in this article has been funded in part by the by the US Environmental Protection Agency through R826886 and the National Institutes of Health through grant number P01 ES09601, it has not been subjected to either agency’s required peer and policy review and therefore does not necessarily reflect the views of either agency and no official endorsement should be inferred. Funding agency representative had no role in the study design; in the collection, analysis and interpretation data; in the writing of the report; or in the decision to submit the paper for publication.

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Table 1

Socio-demographic characteristics by occupation and measured distance for nearest field

	Occupation		Distance from nearest field			
	Farm worker (n = 100)	**Non-farm worker (n = 100)**	**< 200 feet (n = 28)**	**200 feet < 0.5 miles (n = 105)**	**0.5 miles ≤ 1 mile (n = 39)**	**More than 1 mile (n = 28)**
Age (mean)	31.6	31.3	30.9	31.0	32.9	32.0
< 25	11	15	14.8	15.2	5.1	14.3
25–29	20	27	22.2	21.9	28.2	25.0
30–34	46	28	37.0	41.9	30.8	28.6
35 or more	23	29	25.9	21.0	35.9	32.1
Gender						
Female	79	81	89.3	81.0	79.5	67.9
Marital status						
Married / living as married	92	76	85.7	87.6	76.3	82.1
Widowed / divorced	6	15	10.7	8.6	15.8	10.7
Never married	2	8	3.6	3.8	7.9	7.1
Income						
< 15,000	39	31	35.7	30.8	41.0	42.9
15,000–25,000	40	32	35.7	39.4	30.8	32.1
> 25,000	21	36	28.6	29.8	28.2	25.0
Number of children						
1	11	14	14.8	11.4	12.8	14.3
2	25	32	25.9	31.4	20.5	32.1
3	30	23	37.0	25.7	30.8	14.3
4 or more	34	30	22.2	31.4	35.9	39.3
Birthplace						
Mexico	97	64	78.6	83.8	79.0	75.0
US	2	36	21.4	16.2	21.1	25.0
Type of dwelling						
Single family home	52	80	75.0	62.9	66.7	67.9
Apartment	28	15	17.9	22.9	25.6	14.3
Mobile home/ trailer	20	5	7.1	14.3	7.7	17.9

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	Occupation		Distance from nearest field			
	Farm worker (n = 100)	**Non-farm worker (n = 100)**	**< 200 feet (n = 28)**	**200 feet < 0.5 miles (n = 105)**	**0.5 miles ≤ 1 mile (n = 39)**	**More than 1 mile (n = 28)**
Occupation						
Farmworker	--	--	46.4	53.3	48.7	42.9
Non-farmworker	--	--	53.6	46.7	51.3	57.1

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Table 2

Socio-demographic characteristics by DMTP* concentrations and house dust levels of AZM** and Phosmet

	DMTP* concentrations		House dust levels			
	Adult (n = 200) Ug/L		AZM** (n = 109) ng/g		Phosmet (n = 109) ng/g	
	GM* (95%CI)**	**P value**	**GM*** (95%CI)**	**P value**	**GM*** (95%CI)**	**P value**
Age						
< 25	12.2 (6.2, 24.1)		198.0 (62.9, 623.7)		49.3 (19.2, 127.1)	
25–29	12.9 (6.9, 24.2)		157.3 (69.8, 354.2)		54.8 (28.0, 107.0)	
30–34	29.7 (16.3, 54.0)		397.0 (184.8, 852.9)		109.0 (57.5, 203.0)	
35 or more	19.8 (12.9, 30.5)	NS	350.3 (200.1, 613.2)	NS	127.9 (80.7, 203.0)	.02
Gender						
Male	33.2 (18.5, 59.7)		214.2 (103.8, 442.3)		99.7 (54.4, 182.7)	
Female	17.0 (9.0, 32.1)	.04	293.9 (131.7, 655.5)	NS	84.5 (43.2, 165.3)	NS
Marital status						
Married / living as married	23.4 (11.3, 48.5)		310.2 (81.8, 1175.4)		97.2 (31.5, 300.3)	
Widowed / divorced	11.6 (4.7, 28.5)		295.1 (57.7, 1510.4)		53.6 (13.4, 213.4)	
Never married	3.1 (1.6, 6.2)	<0.001	51.7 (14.2, 188.0)	<.005	40.2 (13.5, 119.8)	NS
Income						
< 15,000	17.8 (10.2, 31.4)		324.1 (153.4, 684.9)		105.9 (59.8, 187.5)	
15,000–25,000	26.3 (14.9, 46.4)		285.1 (131.3, 619.4)		102.7 (57.4, 184.0)	
> 25,000	15.2 (10.2, 22.8)	NS	224.5 (128.2, 393.3)	NS	55.7 (39.1, 79.3)	.05
Number of children						
1	18.1 (8.5, 38.5)		322.3 (117.5, 884.1)		65.8 (28.3, 153.1)	
2	17.2 (9.4, 31.6)		217.7 (98.8, 479.7)		75.4 (38.9, 145.9)	
3	16.8 (9.3, 30.3)		215.7 (95.6, 487.0)		85.7 (43.4, 169.2)	
4 or more	25.5 (17.5, 37.3)	NS	392.7 (231.5, 666.4)	NS	113.7 (73.1, 176.9)	NS
Birthplace						
Mexico	26.4 (17.6, 39.6)		348.7 (169.6, 716.8)		105.5 (60.1, 185.5)	
US	5.3 (3.9, 7.3)	<0.001	104.3 (55.0, 197.6)	0.001	34.6 (21.0, 57.1)	<0.001
Type of dwelling						

	DMTP* concentrations		House dust levels			
	Adult (n = 200) Ug/L		AZM** (n = 109) ng/g		Phosmet (n = 109) ng/g	
	GM*** (95%CI)	P value	GM*** (95%CI)	P value	GM*** (95%CI)	P value
Single family home	13.7 (7.1, 26.4)		230.1 (88.4, 598.8)		77.4 (34.8, 172.0)	
Apartment	33.2 (15.6, 70.6)		466.4 (143.7, 1514.3)		156.5 (58.6, 418.1)	
Mobile home/ trailer	51.2 (28.2, 92.8)	<0.001	436.5 (179.9, 1059.3)	NS	83.4 (39.8, 174.7)	NS

* DMTP: dimethylthiophosphate

** AZM: azinphos-methyl

*** Geometric mean

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Table 3

Concentrations of DMTP* and house dust levels of AZM** and Phosmet among farmworker and non-farmworker adults and children.

	DMTP* concentrations		House dust levels			
	Adult (n = 200) Ug/L		AZM** (n = 109) ng/g		Phosmet (n = 109) ng/g	
	GM*** (95%CI)	P value	GM*** (95%CI)	P value	GM*** (95%CI)	P value
NHANES**** (ages 20 - 59)	1.47 (1.1, 1.9)		--		--	
Farmworker adult	71.1 (44.1, 114.5)		643.1 (376.3, 1102.1)		152.8 (95.0, 246.0)	
Non-farmworker adult	5.5 (4.6, 6.5)	<0.001	121.4 (83.1, 177.3)	<0.001	50.2 (35.9, 70.2)	<0.001
NHANES**** (ages 6 - 11)	2.72 (1.9, 4.0)					
Farmworker child	16.5 (9.5, 28.4)					
Non-farmworker child	7.5 (5.9, 9.5)	<0.001				

* DMTP: dimethylthiophosphate

** AZM: azinphos-methyl

*** Geometric mean

**** National Health and Nutrition Examination Survey

Table 4

Distribution of study participants by measured distance from nearest field and the nearest crop

	Distance from nearest field			
	< 200 feet (n = 28)	**200 feet < 0.5 miles (n = 105)**	**0.5 miles ≤ 1 mile (n = 39)**	**More than 1 mile (n = 28)**
Nearest crop	**%**	**%**	**%**	**%**
Apples / pears	14.8	15.2	15.4	3.9
Corn / Hay / Wheat	59.3	36.2	33.3	57.7
Cherries	7.4	13.3	12.8	0.0
Grapes	0.0	9.5	18.0	7.7
Asparagus	3.7	2.9	10.3	30.8
Other*	14.8	22.9	10.3	0.0

*other included hops, mint, onions, peas, and potatoes

Table 5

Percent change in DMTP [a] concentrations and AZM [b] and phosmet levels with increasing residential distance from farmland.

	Percent change in DMTP [a] concentration or house dust level with increasing residential distance (miles) from farmland
	% change (95% CI)
DMTP [a] concentrations	
Overall [c]	**-20 (-34, -4)**
Adult [d]	-23 (-42, 3)
Child [d]	-18 (-33, 0)
Farmworker [e]	-16 (-32, 2)
Non-farmworker [e]	-22 (-45,11)
House dust levels	
AZM [b]	-15 (-57, 67)
Phosmet	-9 (-50, 66)

[a]DMTP: dimethylthiophosphate

[b]AZM: azinphos-methyl

[c]adjusted for occupation (farmworker vs. non-farmworker), adult gender, and adult vs. child

[d]adjusted for occupation (farmworker vs. non-farmworker) and adult gender

[e]adjusted for adult gender and child vs. adult