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Seasonal pesticide use in a rural community on the US/Mexico border

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An environmental measurement and correlation study of infant and toddler exposure to pesticides was carried out in a *colonia* south of the city of Laredo, Texas. As part of the study, homes were visited during the late spring or summer, and during the winter of 2000–2001. At each visit, families reported on their use of pesticides in and around the home and floor wipe samples were collected and analyzed for 14 organophosphate and triazine pesticides. Selection of homes was based on the presence of infants and toddlers. A total of 27 homes participated in both seasonal visits. The interval between visits was 6 ± 1.4 months. Univariate and multivariate nonparametric analyses were carried out using SPSS® statistical software. Pesticide use within the home was more often reported than outside use and showed seasonal variation in use patterns. Indoor use was primarily associated with ants and cockroaches, and secondarily with rodents. The primary room treated was the kitchen, and the primary structures treated were the floors, lower walls, and dish cupboards. Seasonal variations were not found in the use of pesticides used outside the home and outdoor use was primarily associated with ant control. Based on parent reports, most pesticides used in the homes were pyrethroids. Several of the pesticides measured in floor wipe samples, Azinphos methyl, Fonofos, and Simazine, also showed seasonal variations. However, these pesticides are used in agriculture and were not associated with reported house and yard use patterns.
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Introduction

Regular use of pesticides to control household pests is wide spread (Savage et al., 1981; Davis et al., 1992). The EPA Non-Occupational Pesticide Exposure Study (NOPES) found elevated levels of pesticide residues from household use in nearly all houses sampled (Whitmore et al., 1994). Communities adjacent to agricultural fields have the potential for exposure to pesticides greater than for the general population due to drift and track-in from farm fields and orchards (Simcox et al., 1995; Fenske et al., 2000; Lu et al., 2000; Shalat et al., 2002). The Minnesota National Human Exposure Assessment Survey (NHEXAS) Children's Pesticide Exposure Study evaluated residential use patterns of pesticides in an area of the country with a fairly narrow period of insect activity and a single agricultural season (Lioy et al., 2000), while the studies from Fenske's group in Washington (Simcox et al., 1995; Fenske et al., 2000; Lu et al., 2000) dealt specifically with agricultural pesticides among agricultural families. This study evaluates multiple sources of pesticide exposure with a group of families with young children. Examination of pesticide use patterns in a Texas border community addresses the issue of seasonal use of residential pesticides in a subtropical temperate climate where insects do not become dormant in winter. The proximity of this community to agricultural growing areas may also produce seasonal pesticide exposures related to crop rotations.

Methods

A 3-year environmental measurement and correlation study was conducted near Laredo, Texas, in the mid-Rio Grande Valley (Shalat et al., 2003). The colonia in which the study took place is a long, narrow community, approximately 500 m wide and 6000 m long, running in an east–west direction terminating at the Rio Grande. There are three streets that run the length of the community, a 4th linear street in the western section of the colonia and the majority of cross streets are in the eastern section of the colonia. Agricultural fields abut the community along its southern border, with additional fields at a distance along both linear sides of the community as well as across the river in Mexico.

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The prevailing winds are usually from the south and would therefore expose most the community to dust from the agricultural fields.

Local *promotoras* for lay health education in the community were trained to conduct a community wide census, administer a questionnaire, and collect floor wipe samples from homes. Additional activities included collection of urine samples and hand rinses from the children, and videotaping the children in and around the home. The results of those activities are reported elsewhere (Shalat et al., 2003; Black et al., submitted).

Since the primary objective of the study was to assess exposure of infants and toddlers to pesticides, a door-to-door census was conducted to identify all households with children between 6 and 48 months of age. The study community contained 920 residences, of which 870 were occupied at the time of the census. Households were selected for possible participation on the basis of the census results. Approximately 14% (91) of the 643 homes contacted had at least one child under the age of 3 years. Initially, only homes with two or more children within the target ages were invited to participate, although several families with only one child within the target range did participate.

The interviews and sampling were timed to coincide with one of the two growing seasons in the mid-Rio Grande valley. The initial round began in the Spring of 2000, late March, with environmental sampling commencing in May and continuing through early August. The second round of the study was conducted in December 2000–February 2001. At each round of the study, the same questionnaire was administered and floor wipe samples were collected from an area near the front door. The area selected for sampling was one that was common to all homes, would most likely capture track-in, and was a common area where the children played.

The questionnaire was administered in Spanish, the primary language of the residents of the community. The questionnaire was derived from the baseline questionnaire used in the National Human Exposure Assessment Survey (Lioy et al., 2000), and contained additional questions about pesticide use patterns drawn from NOPES (Whitmore et al., 1994) and the National Home and Garden Pesticide Use Survey (Savage et al., 1981).

Floor dust was collected by a wipe sample from an area approximately $1\,m^2$. The house dust floor sample was obtained as close as possible to the front door, on tile or linoleum. A prepared glass fiber filter was wet with isopropyl alcohol and wiped over the floor surface (Shalat et al., 2003). The samples were wrapped in aluminum foil, then placed into a polyethylene collection bag, and shipped to the laboratory for analysis.

Pesticide analysis of house dust samples was performed at a contract laboratory (TDI — Brooks International) located in College Station, Texas. Analysis was carried out for the presence of organophosphate (OP) and Triazine pesticides. The following pesticides were selected for analysis based upon information obtained from the local office of the Texas Agricultural Extension Service: Azinphos-Methyl, Chlorpyrifos, Demeton O, Demeton S, Diazinon, Disulfoton, Ethion, Fenithrothion, Fonofos, Malathion, Ethyl Parathion, Methyl Parathion, Simazine, and Atrazine.

Quantification of pesticides was carried out with a HP5890 gas chromatograph (Hewlett-Packard, Palo Alto, CA, USA) with a nitrogen phosphorous detector (GC/NPD). Triphenyl Phosphate was added as a surrogate standard for OP pesticides and Triazine herbicide to the samples before extraction and used to assess the extraction and concentration efficiency of the procedure.

Calibration solutions were prepared at five concentrations ranging from 0.5 to $10\,\mu g/ml$ by diluting a commercially available solution containing the analytes of interest. A calibration curve was established by analyzing each of the five calibration standards (0.5, 1.0, 5.0, 8.0, and $10.0\,\mu g/ml$), and fitting the data to a linear equation. Lowest level of detection was $0.5\,\mu g/ml$. Triphenyl Phosphate recoveries averaged $80 \pm 11.8\%$. Replicate analyses found a mean difference of $6.5 \pm 3.8\%$. The details of the analytic method are described elsewhere (Shalat et al., 2003; Carrillo-Zuniga et al., submitted). Analyte measures were adjusted for recovery values of the internal standard. Data on floor wipe pesticides are presented in micrograms of pesticide per square meter of floor area.

Statistical analysis was carried out on questionnaire responses and pesticide measures. Both univariate and multivariate nonparametric analyses was carried out with SPSS statistical software (version 10.1). Nonparametric tests were used throughout because the character of the questionnaire data, the lack of normality or log normality of many of the pesticide measures, and the relatively small sample sizes in the study (Siegel, 1956). The statistics computed included the percent of reported use activities, and median and mean pesticide levels.

Sign test was used to assess significance in changes in use patterns across seasons for families participating in both visits. Many of the pesticide levels were low, either lognormally distributed or neither normally distributed or lognormally distributed, with many nondetects. In order to include homes with no detectable pesticides, in some analyses the nondetects (BDL) were treated as zeros. Comparison of pesticide levels across seasons was carried out with the Wilcoxon matched pairs tests, Kruskal–Wallace test was used for the exploratory analysis of pesticide levels across sampling months, and comparisons of pesticide levels by reported pesticide uses was carried out with Mann–Whitney tests.

Results

A total of 29 homes were enrolled in round one and 39 homes in round two. The total number of households

enrolled in both seasons was 27. Wipe samples from all homes were not successfully collected, so that a total of 62 samples were analyzed from the two rounds of the study, 25 from round one and 37 from round two, with dust samples collected and analyzed from 22 households enrolled in both seasons. The period of the first sampling ranged from May ($n=7$) through August 2000 ($n=7$), with the majority (72%) of first visits from June–August. The second visits were held between December 2000 and February 2001, with the majority of sampling visits (73%) conducted in January and February. The mean interval between sampling visits was 5.7 months $\pm$ 1.4, range 4–8 months.

As reported previously, few of the families had members who worked on farms (Shalat et al., 2003). While none of the men reported worked directly in mixing or loading of pesticides during the spring and summer, the one individual who reported driving a tractor during the first visit, reported pesticide application during the winter. Only three women in the study households worked outside the home, with one working in a farm-related activity (packer).

Comparison of indoor use of pesticides within the 6 months prior to the survey for the families participating in both rounds of the study was reported by 82% of the families during round 1 of the study and 63% during round 2 of the study. One-third of respondents did not know what pesticide was used. Several of the pesticides used were reported to have been obtained in Mexico. The most frequently reported pesticides were Raid ($n=15$) and Green Light ($n=6$) pyrethroid formulations for ants and roaches. Rodenticides were also reported to be used in the home ($n=3$).

Parents were asked where they used pesticides. Most of the families reported using the pesticides in the kitchen (Table 1). For those families participating in both rounds of the study, the kitchen was the room where pesticides were most likely to be used in both seasons; however, the proportion of families using it was less during the winter compared to the summer. There was a similar decline in pesticide use in other rooms of the home in winter compared to summer, although the decline only reached statistical significance for the bathroom and family room.

For the 27 homes participating in both rounds, the most common areas in rooms where the pesticides were used were the floor (56% during round one and 44% during round two), lower walls (48% during round one and 33% during round two), and cupboards where dishes were stored (44% during round one and 15% during round two). Seasonal declines in structural areas treated with pesticides was consistent with that reported for rooms treated (Table 1). All applications were performed by the resident, and none done by professional exterminators. Most of the users reported using pesticides three to six times in the last 6 months (61%). Most reported that they used pesticides on an "as needed" basis (87%).

Table 1. Percent of homes that participated in both sampling periods reporting pesticide use by season, locations of use, and structures treated ($n=27$)

Location	Summer	Winter	*P*-value*
Use pesticides indoors	81.5	63.0	0.096
Use pesticides outdoors	48.1	48.1	n.s.[a]
Kitchen	77.8	48.1	0.021
Living room	59.3	40.7	n.s.
Bathroom	55.6	33.3	0.109
Dining room	51.9	48.1	n.s.
Bedroom	44.4	37.0	n.s.
Family room	44.4	18.5	0.020
Structural use			
Floor	55.6	44.4	n.s.
Lower wall	48.1	33.3	n.s.
Dish cupboards	44.4	14.8	0.021
Storage cabinets	29.6	22.2	n.s.
Windowsills	29.6	14.8	0.102
Closets	29.6	11.1	0.059
Baseboard	25.9	22.2	n.s.
Food cupboards	18.5	3.7	0.102
Ceiling	18.5	3.7	0.046
Upper wall	11.1	0	0.083

*Sign test for significance of changes in pesticide use pattern, only *P*-values <0.11 are reported.
[a]n.s., no statistical significance.

Outdoor use of pesticides was reported by approximately half of all families in rounds one and two, but only 34% of families who participated in both rounds of the study reported using outdoor pesticides in both rounds. The group as a whole and the subset participating in both rounds did not show changes in outside use from round one to round two of the study. Outdoor use was usually two to three times in the last 6 months (45.5% of users). Less than one-third of the homes have lawns so that lawn treatment was infrequently reported (10%). The majority of participants reported that they purchased pesticides for their house and yard at the supermarket (76%). Pesticides were also purchased at hardware stores (10%) and farm supply stores (10%) during round one and sources did not change across study rounds. In total, 42% of families reported having at least one dog. There were seasonal variations in the number of dogs reported with two families having major increases in the number of dogs suggestive of the birth of litters. Flea collars were used by half of the families with dogs, typically by those families with the fewest dogs. Use of flea powders and dips were not reported.

OP pesticides were found in the majority of homes. Seasonal variations were found in the levels for Azinphos methyl, Simazine, and Fonofos, all agricultural pesticides (Table 2) in homes participating in both rounds of the study. In addition, slight but not significant differences were found

Table 2. House dust loadings of pesticides ($\mu g/m^2$) in paired samples ($n = 22$)

Pesticide	Round 1			Round 2		
	Mean (SD)	Median	Interquartile range	Mean (SD)	Median	Interquartile range
Demeton O[a]	0.80 (2.27)	0.00	0.00–0.25	0.04 (0.09)	0.00	0.00–0.00
Demeton S	0.41 (0.96)	0.08	0.00–0.47	0.23 (0.30)	0.19	0.00–0.35
Fonofos[b]	0.02 (0.03)	0.00	0.00–0.04	0.01 (0.02)	0.00	0.00–0.00
Diazinon	9.32 (36.8)	0.05	0.00–0.31	0.26 (0.31)	0.12	0.05–0.49
Disulfoton	0.05 (0.11)	0.00	0.00–0.07	0.03 (0.05)	0.00	0.00–0.04
Parathion Methyl	0.19 (0.31)	0.05	0.00–0.36	0.19 (0.31)	0.09	0.03–0.21
Fenithrothion	0.13 (0.37)	0.03	0.00–0.06	0.08 (0.11)	0.03	0.00–0.14
Malathion	0.03 (0.06)	0.00	0.00–0.04	0.07 (0.15)	0.00	0.00–0.07
Chlorpyrifos	0.13 (0.20)	0.04	0.00–0.15	0.47 (1.22)	0.10	0.02–0.41
Parathion Ethyl	0.94 (3.65)	0.00	0.00–0.36	0.05 (0.15)	0.01	0.00–0.05
Ethion	0.08 (0.11)	0.05	0.00–0.11	0.09 (0.25)	0.00	0.00–0.08
Azinphos Methyl[c]	0.32 (0.63)	0.06	0.00–0.34	0.02 (0.06)	0.00	0.00–0.00
Simazine[d]	0.05 (0.11)	0.02	0.00–0.04	0.31 (0.53)	0.12	0.03–0.24
Atrazine	0.06 (0.25)	0.00	0.00–0.01	0.01 (0.01)	0.00	0.00–0.01

Wilcoxon matched pairs signed rank tests, samples BDL (Below Detection Level) given value of 0 for test.
[a]Round 1 > round 2 $P = 0.075$.
[b]Round 1 > round 2 $P = 0.050$.
[c]Round 1 > round 2 $P = 0.001$.
[d]Round 1 < round 2 $P = 0.009$.

between round 1 and round 2 in the presence of Diazinon and Demeton O. The variations in Diazinon were attributed to two homes that had exceptionally high levels of diazinon (170 and 29 $\mu g/m^2$). Review of the questionnaire responses found that these families had used yard pesticides within the month prior to dust sampling. However, neither of the families reported on the specific pesticide used. Both families were large, having 10 and eight family members. The large family size would potentially increase track-in of pesticides used outdoors.

As each of the rounds spread over several months, comparison of pesticide levels was conducted across pairs of months (December–January, etc.), and by month. The rationale behind this is that agricultural use patterns of pesticides are not all the same. Some pesticides will be applied during a short time period, while others may be used repeatedly over a longer time period. By dividing the floor samples into time periods other than round 1 and round 2, we were able to identify some differences in agricultural use patterns near this border community (Table 3). Based on these analyses, Azinphos methyl was found to be used over a large period of the Summer. In contrast, Simazine was used primarily in the Winter, specifically in December and January. Several pesticides, Disulfoton, Malathion, Demeton S, Ethion, Atrazine, Ethion, and Methyl Parathion, showed no differences in levels across the various time periods. In the case of Atrazine, this is probably due to there having been few samples with detectable levels. However, low levels are not the entire explanation, since other pesticides such as Fonofos also had low levels but showed seasonal variations.

Since we had heard reports of misuses of agricultural pesticides in the community and many families did not report what pesticides they used in the home, comparisons were conducted of pesticide levels in house dust and reported use patterns of the families. No differences were found in pesticide levels for nearly all of the pesticides analyzed in the homes based on family reports of pesticide use in the home or yard, or for any of the rooms or structures indoors. This was true for those homes that participated in both rounds, and for all homes from which floor samples were collected and analyzed.

One pesticide, Demeton O, repeatedly showed up as slightly elevated based on reported use of pesticides in the living room, kitchen, bathroom, on the floor, lower walls, cupboards, and cabinets. For the most part, the P-values were marginally significant ($0.05 < P < 0.10$), and would have been considered chance occurences were it not for the consistency of the outcome. A variable based on the number of places that people used pesticides was developed ranging from 0 for no reported use to 6 for all rooms in the home. Spearman correlation of Demeton O values and number of locations in which pesticides were used found a weak association ($rs = 0.244$, $P = 0.075$), suggesting that those families who vigorously treated their home may be using a range of chemicals beyond those reported.

Discussion

This study examined the use of pesticides by families with young children who resided in a border community. While

Table 3. Differential loadings ($\mu g/m^2$) of pesticides by time periods ($n = 62$)

Pesticide	Parameter	*P*-value	Elevated period
Azinphos-Methyl	Round	0.001	Round 1 > round 2
	Month pair1	0.005	May–June, July–August > November–December, January–February
	Month pair2	0.001	June–July
	Sampling month	0.001	June, July > December, January
Fonofos	Round	0.006	Round 1 > round 2
	Month pair1	0.014	May–June > January–February, November–December
	Month pair2	0.075	April–May > February–March
	Sampling month	0.083	June > January, February
Demeton O	Round	0.030	Round 1 > round 2
	Month pair1	0.044	May–June, July–Aug, November–December > January–February
	Month pair2	0.050	August–September, June–July > February–March
	Sampling month	0.029	June, August > January, February
Fenithrothion	Round	0.060	Round 1 > round 2
	Month pair1	0.003	May–June, November–December > January–February
	Month pair2	0.020	June–July > February–March
	Sampling month	0.010	June, December > February
Parathion Ethyl	Month pair1	0.016	May–June > January–February, July–August
	Month pair2	0.032	April–May > June–July, February–March
	Sampling month	0.001	May > February, June, July
Diazinon	Round	0.093	Round 1 > round 2
	Sampling month	0.067	February > July
Simazine	Round	0.022	Round 2 > round 1
	Month pair1	0.038	November–December > May–June
	Month pair2	0.001	December–January
	Sampling month	0.002	December, January > February, May
Chlorpyrifos	Month pair1	0.034	November–December, July–August > May–June
	Month pair2	0.061	August–September, December –January > April–May

Round comparisons: Mann–Whitney test, all other comparisons: Kruskal–Wallace test.
Round: round 1 $n = 25$, round 2 $n = 37$.
Month pair1: January–February $n = 27$, May–June $n = 12$, July–August $n = 13$, November–December $n = 10$.
Month pair2: December–January $n = 24$, February–March $n = 13$, April–May $n = 7$. June–July $n = 11$, August–September $n = 7$.
Month: January $n = 14$, February $n = 13$, May $n = 7$, June $n = 5$, July $n = 6$, August $n = 7$, December $n = 10$.

few members of the study households worked in farm-related activities, the majority of homes contained measurable quantities of agricultural OP pesticides. The seasonal fluctuations of agricultural pesticides in house dust are consistent with the crop rotations observed in this region of the Rio Grande valley.

Pesticides reported to be used by families tended to be pyrethroids or propoxur for which floor dust sample analysis was not done. Using the questionnaire responses to test for use of OP pesticides indoors found very few significant associations between reported pesticide use and pesticide levels found in house dust. Reports of pesticides used did not provide insight into where Demeton O came from or if it was used by the householder. Since some families reported purchasing pesticides in Mexico, it may be that it was a formulation purchased across the border. An alternative suggestion was that the association of Demeton O and house use may have occurred by chance.

OP pesticides in homes have been previously associated with reported home uses (Whitmore et al., 1994). However, that study was conducted at a time when OPs were common in home-use pesticide formulations. Changes in pesticide formulations for home use over the last 10 years means that measurements for pyrethoids and other non-OPs should have been done in order to capture the full range of exposures for these families. From questionnaire responses, we can state with some confidence that there is the potential for increased ingestion of pesticides used in the homes based on the families' pesticide use patterns. Many of the families reported using pesticides in the kitchen, specifically in dish cabinets. In addition, spraying walls with pesticides, a commonly reported practice, acts to aerosolize the pesticides at least

within the room where spraying occurred. The contamination of eating surfaces would contribute to ingestion of pesticides. Spraying floors with pesticides was also commonly reported. The young children in these homes spend much time on the floor, often wearing only diapers and T-shirts (Black et al., in submission) and would be exposed to any pesticides on the floor independent of whether the pesticides were from home use or agricultural infiltration and track-in. The residence-generated exposures may be seasonal since families were more likely to use pesticides during the spring and summer rather than in the winter. However, we only visited the homes at 6 month intervals and therefore do not have information about usage patterns during other seasons.

Residential exposure to agricultural pesticides has been previously documented for families of agricultural workers (Simcox et al., 1995; Fenske et al., 2000; Lu et al., 2000; McCauley et al., 2001). The majority of families in this Rio Grande community did not work on farms, but merely lived in community adjacent to farm fields. We found that both the reported frequent use of pesticides in the home and levels of OP pesticides in the house associated with the proximity to agricultural fields provide abundant potential exposure to a wide range of pesticides for these families with young children.

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