Pesticides in Dust from Homes in an Agricultural Area

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Brief: Detections of 22 pesticides in dust and associations of local agricultural pesticide use, weather, and household variables with chlorpyrifos, diazinon, iprodione, DCPA, and permethrin dust levels.

ABSTRACT

We collected indoor dust samples from homes in the Salinas Valley of California. Of 22 pesticides measured in 504 samples, permethrins and the organophosphate, chlorpyrifos, were present in highest amounts. In multivariate Tobit regression models among samples from 197 separate residences, reported agricultural uses of chlorpyrifos, a herbicide (2,3,5,6-tetrachloroterephthalate (DCPA)), and a fungicide (iprodione) on agricultural fields were significantly ($p<0.01$) associated, with 83%, 19%, and 49% increases, respectively, in dust concentrations for each kg applied per day, near participant homes, in the month or season prior to sample collection. However, agricultural use of diazinon, which was 2.2 times that of chlorpyrifos, and of permethrin were not significantly associated with dust levels. Other variables independently associated with dust levels included temperature and rainfall, farmworkers storing work shoes in the home, storing a diazinon product in the home, housing density, having a home less clean, and having an air conditioner. Permethrins, chlorpyrifos, DCPA, and iprodione have either a log octanol-water partition coefficient (K_{ow}) greater than 4.0, a very low vapor pressure, or both. Health risk assessments for pesticides which have these properties may need to include evaluation of exposures to house dust.

Introduction

Vast regions of the world are under agricultural cultivation *(1)*. Agriculturally applied pesticides may drift during application, volatilize post-application, suspend and re-suspend from air particles and earth surfaces, and move to locations distant from the application site *(2,3)*. Exposures to agricultural and home-use pesticides occur to residents of agricultural communities *(4-8)*. Urinary metabolites of broad-spectrum organophosphorous insecticides (OPs) are elevated among children during agricultural application spray seasons *(9)*, may exceed health risk guidance levels among women living in agricultural areas *(10)*, and are associated with poorer neurobehavioral functioning in young children *(11-13)*.

Pesticides appear to persist in indoor environments due to the absence of degradation routes *(14)*. As an exposure indicator, OP dust levels may be more temporally stable than biological metabolites *(14, 15)*. OP indoor dust concentrations are higher than outdoor soil concentrations and are correlated with measurements of indoor air, child and adult urinary metabolites, and children's hand and toy surfaces *(5, 14, 16-18)*. Dust concentrations of the herbicide, dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA), and the pyrethroid, *trans*-permethrin, are also correlated with levels on children's clothing *(18)*.

In many agricultural areas of California the growing season is nearly year-round. The Salinas Valley (SV) is a productive agricultural area due to rich river-bed soil that runs 110 km inland from the Pacific Ocean and through Monterey County. Row and vegetable crops are grown with a predominance of strawberries in the north, and warmer weather vegetable crops such as celery and onions in the south. There are vineyards and orchards along the edges and slopes of the 25-km-wide valley. California has a pesticide use reporting (PUR) system in which all agricultural applications are required to be reported, with applications geo-coded to section

areas of approximately 2.6 km^2 *(19)*. Approximately 3,600,000 kg of pesticides, with 472 active ingredients, are applied in the SV each year. Fumigants account for approximately half of this use; diverse insecticides, herbicides, and fungicides are also applied (Supporting Information (SI), Table S.1). Most agricultural pesticide applications are ground-based. Aerial applications are limited to helicopters during the wet, winter season. Landscape, structural, and other non-agricultural uses of OPs and permethrins are a minor percentage (<1-3%) of reported pesticide use in the SV (SI, Table S.2).

The Center for the Health Assessment of Mothers and Children of Salinas (CHAMACOS) project is a prospective cohort study of neurodevelopmental and respiratory outcomes among pregnant women and their children. Most CHAMACOS women are Latina, live with or are farmworkers, and tend be poor *(10)*. We present measurements of pesticides in dust samples collected from CHAMACOS study homes. The availability of PUR in California provided an opportunity to evaluate the relationship between agricultural pesticide use and dust levels. However, weather parameters modify air drift of pesticides *(2)* and may alter any relationship. Further, in an agricultural community, other factors, including farmworkers living in the home, and housing characteristics such as housing density, are associated with pesticide dust levels *(6,7,15,16)* and may also magnify or obscure any relationship. We use multivariate regression to estimate the independent, quantitative impacts on dust levels of reported agricultural use, weather variables, farmworker transport, household use of pesticides, and housing characteristics.

Methods

Sample Collection. Pregnant women were enrolled in the CHAMACOS study at SV health clinics between September 1999 and November 2000. They were interviewed at the clinic at

81 enrollment and when their children were six and twelve months old. Shortly after each clinic
82 interview, staff visited their homes and recorded: a geographic positioning system (GPS) reading,
83 distance to any agricultural field, number of household residents and rooms, whether residents
84 were farmworkers or worked in agriculture, where work shoes and clothes were kept, and an
85 inventory of pesticide products located in the home, garage or yard. Cleanliness was rated based
86 on household organization, overflowing trash, and presence of dust.

87 Dust samples were collected from one square meter of the living area where children spent
88 time playing. Similar to other dust studies *(14)*, we used a High Volume Surface Sampler
89 (HVS3) with a cyclone that extracted particles greater than 5.0 microns from the air stream of a
90 Royal vacuum cleaner (*20, 21)*. If no carpet was available, smooth surface floors were sampled
91 (5.6% of samples). If sufficient floor space was not available, a furniture attachment was used
92 (13% of samples). Of the 601 women enrolled in the study, 511 participant homes were visited.
93 From those 511 women, 168 were randomly selected, and the dust samples from the residences at
94 each of the three visits were identified for laboratory analysis (504 samples).

95

96 **Analytical Method.** Fourteen OPs and the organochlorines, *p,p′*-DDT, and *p,p′*-DDE were
97 selected for laboratory analysis to match biological monitoring analytes in the CHAMACOS
98 study. DCPA, two fungicides (iprodione and vinclozoline) and several insecticides (methomyl
99 and *cis*- and *trans*-permethrin) were also selected based on analytical capacity, agricultural use in
100 the SV, and physicochemical properties (e.g., semi-volatility) (SI, Table S.2).

101 Dust samples were first sieved to <150 µm. For most samples, two 0.5 g sieved mass
102 aliquots were taken. For samples with less than 1.0 g of sieved mass, the mass was either divided
103 equally (13% of samples), or if the sieved mass was less than 0.05 g (15% of samples), all sieved

104 dust was directed to the method for the larger number of analytes, gas chromatography/mass
105 spectrometry (GC/MS).
106 Seventeen pesticides (Table 1) were analyzed in a method that included ultra-sonication in
107 1:1 hexane:acetone, solid phase extraction (SPE) cleanup on silica and GC/MS analysis. Five
108 surrogate recovery standards (SRSs), matched to individual analytes based on polarity, were
109 added to each sample prior to extraction; analyte concentrations were corrected by the recovery of
110 the matched SRS in a manner similar to isotope dilution for biological samples *(22)*. The five
111 remaining targeted pesticides were either very polar and not amenable to the GC separation step,
112 or were sensitive to heated GC injection. For these five, the method included ultra-sonication in
113 9:1 hexane:acetone, solvent partitioning cleanup, and high performance liquid chromatography
114 coupled to electrospray tandem mass spectrometry (LC/MS/MS). Quantification Limits (QL)
115 were determined as the concentration yielding 10:1 signal:noise in a calibration curve solution.
116 Because population characteristics may be more strongly associated with dust loadings than
117 with concentrations *(14),* we reported both. We calculated loadings (ng/m^2) by multiplying the
118 concentration by the sieved sample mass and dividing by the area sampled.
119
120 **Analytical Method Performance.** For the GC/MS analysis, the average SRS recoveries in the
121 504 field samples were: $^{13}C_6$-*cis*-permethrin, 79 ± 22%; $^{13}C_6$-*trans*-permethrin, 79 ± 19%;
122 fenchlorphos, 79 ± 19%; and $^{13}C_1$-DEAA (diethylacetamido malonate), 83 ± 20%. The recovery
123 of the fifth SRS, $^{13}C_{12}$- *p,p′*-DDE, added specifically to track the recovery of *p,p′*-DDE which
124 largely eluted in the cleanup step; was 11± 6%. Generally, the SRS-corrected spike recoveries
125 were approximately 100% with deviation (Table 1), and the average relative percent difference
126 between duplicate samples, of < 35% (SI, Table S.3). For the LC/MS/MS analysis, due to

127 differences in polarity among the five analytes the extraction solvent was not optimal, and the
128 recoveries for more polar compounds (oxydemeton-methyl, methomyl, and methamidophos) were
129 low, around 50%, and for the moderately polar (bensulide, fenamiphos) the deviation between
130 spikes was high, > 35% (Table 1).
131
132 **Statistical Analysis.** We selected those pesticides detected in more than 5% of samples, for
133 which the average recovery of spikes was 85-115% and for which the variability between spikes
134 was less than ± 35%. Seven pesticides, analyzed by GC/MS, met these criteria: chlorpyrifos,
135 diazinon, phosmet (matched to the SRS fenchlorphos), *cis*-permethrin (matched to $^{13}C_6$-*cis*-
136 permethirn), *trans*-permethrin, DCPA, and iprodione (matched to $^{13}C_6$-*trans*-permethrin). Many
137 (72) of the 168 selected participants had moved between the three visits. To obtain a
138 representative sample of separate SV homes, we identified one sample from each of the 248
139 separate residences, selecting, when necessary, samples in the high mass aliquot category for
140 those homes from which more than one sample was collected. From these 248 samples, we then
141 eliminated samples that were not in the high mass aliquot category (n=7) and results for
142 compounds where the average batch recovery for the matched SRS was less than 75%. These
143 eliminations resulted in 197, 181, and 177 samples from separate residences for analytes matched
144 to the SRSs fenchlorphos, $^{13}C_6$-*cis*-permethirn, and $^{13}C_6$-*trans*-permethrin, respectively, with
145 average SRS recoveries of 86 ±6%; 87 ±8%; and 86 ± 8%.
146 To derive predictor variables, we first summed the agricultural pesticide use near the home
147 (i.e., in the ≈ 2.6 km^2 survey section within which the participant lived and the eight surrounding
148 sections, a total area of ≈ 23 km^2) in three mutually exclusive, lagged periods prior to sample
149 collection: days (days 1-3 prior to sample collection), month (days 4-33 prior to collection) and

150 season (days 34-133 prior to sample collection). Granular applications (approximately 25% of
151 the kg applied) were not included in the OP PUR sums, as granular products have lower volatility
152 *(23)*. We matched the location of study homes to one of two weather stations in the north and
153 south of the SV and averaged temperature and rainfall for each of the lagged periods. We
154 selected information obtained at sample collection based on a literature review and the estimated
155 impact on dust levels (*5-7, 14-17*). We eliminated a few variables due to very low response rate
156 (<4%). We also used the response rate to collapse the information into 11 dichotomous variables.
157 For example, as less than 3% of respondents had a housekeeping rating of "poor," ratings of
158 "poor" and "average" were collapsed into one category labeled "less clean." To adjust for
159 potential sampling artifact, we also selected one collection variable, whether the sample was
160 collected from furniture.

161 Initially, all of the independent variables (i.e., the summed lagged agricultural pesticide use
162 and weather variables, the 11 home-visit variables, and the one collection variable) were
163 individually examined for bivariate relationships with log-transformed pesticide concentrations.
164 We used Tobit regression which provides beta estimates using a log-likelihood function with two
165 components, one a linear regression on quantified values and one the probability of a value below
166 an upper bound. In the latter component, Tobit regression treats non-detects as values that arise
167 from the same distribution as the measured values and which lie between zero and an upper
168 bound, in our case the log-transformed solvent QL. When interest resides on regression
169 parameters, Tobit regression is preferred to linear regression with fill-in procedures for non-
170 detects *(24)*. However, the two components in Tobit regression result in different expected
171 values, and the explained variance cannot be calculated. Multivariate Tobit regression, with all of

172 the independent variables in the models, was then used to estimate beta regression coefficients
173 adjusted for other covariates.
174

175 ## Results

176 All 22 analytes were present in the 504 CHAMACOS dust samples (Table 1). Eight compounds
177 were detected in less than 5% of samples, but the QLs for these eight were mostly higher than for
178 the other compounds and some of these eight (acephate, azinphos-methyl) had maximum
179 concentrations among the highest quantified. The LC/MS/MS concentrations were generally
180 lower than the GC/MS concentrations and given the lower LC/MS/MS spike recoveries, the
181 LC/MS/MS concentrations may have been underestimates. Among the GC/MS analytes, the
182 hierarchy in the 95th percentiles of dust concentrations was: *cis*- and *trans*- permethrin > 5000
183 ng/g; chlorpyrifos ≈ 1000 ng/g; iprodione ≈ 750 ng/g, and diazinon, *p,p'*-DDT, DCPA, and
184 malathion range between 400 and 100 ng/g. This hierarchy has little apparent relationship with
185 agricultural use, with compounds in the last category having the highest agricultural use. Within
186 the dataset of samples from unique homes, the percentile distributions of dust levels (Table 2)
187 generally followed the same hierarchy as in the larger set of samples.
188 Distributions of the independent variables are given in Table 3 and, more fully, in the SI
189 Table S.6. Agricultural pesticide use for the lagged month prior to sample collection in the area
190 near the home was 0.27 (chlorpyrifos), 1.5 (diazinon), 1.0 (DCPA), 1.1 (iprodione), and 0.45
191 (permethrin) kg/day. A small percentage of participants (< 10%) lived very close (within 60 m)
192 to a field, had a professional pesticide application in the residence in the six months prior to the
193 home-visit, or an air conditioner. Very few (3%) had a product containing OPs at the residence,
194 but some (27%) had products containing permethrins at their home.

195 The overall multivariate Tobit models (Table 3) examining the relationship between potential
196 independent predictor variables and dust levels (concentrations and loadings) were all highly
197 statistically significant ($p<0.001$). Initially, the multivariate models for iprodione, which were
198 detected with lower frequency (49%), did not converge. The weather variables, which were not
199 expected to impact transport given the very low vapor pressure of iprodione (SI, Table S.2) and
200 which showed no significant associations in bivariate models (SI, Table S.6), were removed and
201 the models converged.

202 In the multivariate Tobit models, local agricultural chlorpyrifos use in the month prior to dust
203 collection was significantly associated ($p<0.01$) with dust concentrations with an 83% increase in
204 chlorpyrifos concentrations for every kg applied per day near the home (Table 3). DCPA dust
205 levels were also significantly associated with agricultural use in the season prior to sample
206 collection and iprodione dust levels with use in the prior month and season. Consistent with the
207 regression results, the geographical distribution of dust concentrations among CHAMACOS
208 homes, and among the subset of non-farmworker homes (Figure 1 and SI, Figures S.1-S.5),
209 mirrored that of agricultural pesticide use for those pesticides that showed significant associations
210 with use (chlorpyifos, DCPA, and iprodione) but not for those pesticides that showed no
211 significant association (diazinon and permethrin).

212 Among the remaining variables in the multivariate models, the corresponding betas were
213 particularly large or were significantly associated in more than one pesticide model for:
214 temperature in the days prior to sample collection, farmworkers living in the home, farmworkers
215 storing work shoes in the home, storing a diazinon product in the home, and having a home that is
216 less clean (Table 3). Having an air conditioner in the home was strongly associated with reduced
217 OP levels but also with increased permethrin levels. In separate bivariate models (SI, Table S.6),

218 associations with independent variables were nearly always stronger than the associations in
219 multivariate models, particularly for the farmworker variables (Table 3). All associations were
220 stronger in the *trans*-permethrin models than in the *cis*-permethrin models, and only the
221 multivariate models for *trans*-permethin are presented.

222 Multivariate models with loading levels as the dependent variable were generally similar to
223 the concentration models (Table 3). However, for some of the PUR variables, the associations
224 with concentrations were substantially stronger than those for loadings (e.g., chlorpyrifos
225 models), while for the home-visit variables (e.g., farmworkers wearing work shoes in the home),
226 loadings were almost always more strongly associated than concentrations.

227

228

229 ## Discussion

230 **Organophosphorous Insecticides.** Of the OPs agriculturally applied in the SV, agricultural use
231 of diazinon was the highest, more than double that of chlorpyrifos (Table 1). Yet, among dust
232 levels in our study homes, where very few participants stored OPs in the home, chlorpyrifos
233 concentrations were 2-3 fold higher than diazinon concentrations (Table 2). CHAMACOS
234 women living in these same residences also had higher exposures to chlorpyrifos: in 76% of urine
235 samples from these women the chlorpyrifos metabolite was detected with a median of 3.3 µg/L,
236 whereas the diazinon metabolite was detected in 2%, with a detection limit of 0.7 µg/L *(25)*.
237 Higher chlorpyrifos than diazinon concentrations were also found in dust from farmworker homes
238 *(16)* and in dust from four U.S. cities *(26)*.

239 In California's agricultural Central Valley, ambient air levels of chlorpyrifos and diazinon
240 were associated with local agricultural use in the days preceding sampling *(2)*. Here, chlorpyrifos

241 agricultural use in the month prior to sample collection was significantly associated, independent
242 of other covariates, with chlorpyrifos dust concentrations (Table 3). This use period was
243 consistent with previous estimates that agriculturally applied chlorpyrifos has an overall
244 persistence in the general SV environment of 24 days *(4)*. A similar persistence, 33 days, was
245 estimated for diazinon, yet we found no associations with agricultural diazinon use and dust
246 levels. One possible explanation is that in coastal fog conditions (an almost daily winter and
247 summer occurrence in the SV) chlorpyrifos may have a greater propensity for air transport: in SV
248 fog samples, 94% of chlorpyrifos, but only 26% of diazinon, was in the vapor phase of the fog
249 with the larger fraction of diazinon being in the liquid phase due to the greater water solubility of
250 diazinon *(27)*. Further, chlorpyrifos has a greater tendency to adhere to particles (log K_{ow}=5.0)
251 than diazinon (log K_{ow} =3.3) (SI, Table S.2) and, once bound to indoor dust, chlorpyrifos may
252 have a longer persistence.

253 The associations of reduced OP dust levels with increased temperature and rainfall in the
254 immediate days prior to sample collection (Table 3) suggest increased volatilization and co-
255 distillation with rainwater of OPs off of house dust. Researchers of semi-volatile compounds in
256 dust may need to obtain and evaluate these variables as they may obscure relationships with
257 independent variables such as region and season.

258 Chlorpyrifos has been detected on the work boots of farmworkers *(28),* but the separate
259 impacts of farmworkers storing work shoes and clothes in the home on pesticide levels in dust
260 have not been studied. In our multivariate modeling, of the three farmworker variables, wearing
261 work shoes in the home showed the strongest positive associations with OP dust levels, and these
262 relationships were stronger with loadings than concentrations, which suggests that wearing work
263 shoes indoors increased deposition onto surfaces.

264 Our modeling results (Table 3) were also consistent with studies reporting: higher OP dust
265 concentrations in homes where insect pesticide treatments had occurred *(26)*; higher pesticide
266 detection frequencies in dust from homes rated "difficult to clean," a rating that included housing
267 density and disrepair *(5);* and lower OP concentrations in dust from homes with an air conditioner
268 *(15).*

269 Other OPs (e.g., malathion, azinphos methyl, fonophos, and phosmet) have been detected on
270 surfaces of homes in agricultural communities *(6, 16).* In our samples, 11 OPs other than
271 chlorpyrifos and diazinon were detected (Table 1). Six of these 11 had substantial agricultural
272 use in the SV (greater than 6,000 kg per year) and, of these six, oxydemeton-methyl was in 62%
273 of samples while the others (bensulide, malathion, acephate, dimethoate, and methidathion) were
274 in a minority. Our QLs for these latter five were higher than for diazinon and chlorpyrifos, but all
275 five may more readily dissipate (e.g., malathion has a relatively high vapor pressure (SI, Table
276 S.2)). However, as only malathion may be used residentially in the U.S., even these few
277 detections suggest transport from agricultural fields.

278

279 **Other Analytes.** *p,p′*-DDT and *p,p′*-DDE were present in most samples of vacuum bag dust
280 from homes in four U.S. cities, in similar amounts and ratio (*p,p′*-DDT in higher concentrations
281 than *p,p′*-DDE) as in our samples (Table 1) *(26, 29)*. In addition, we measured several other
282 compounds—DCPA, methomyl, iprodione, *cis*- and *trans*-permethrin, and vinclozoline—which
283 had considerable agricultural use (> 6,000 kg per year).

284 The 94% detection frequency of DCPA and median of 22 ng/g observed here in an
285 agricultural community does contrast with a 5% detection frequency found in vacuum bag dust
286 from homes in four U.S. cities (n=1046, QL of 21 ng/g) *(29,30).* DCPA is not broken down by

287 sunlight and may move off-target in air up to 60 days after application *(31)*. The significant
288 associations shown here for seasonal agricultural use and temperature (Table 3) were consistent
289 with this persistence. In fact, the label for Dacthal® (trade name), the only pesticide product with
290 DCPA, warns of co-distillation and off-site movement when applied to hot soil surfaces after
291 irrigation or during wet weather *(32)*. In a previous SV study, DCPA indoor and outdoor air
292 levels were also correlated (r=0.92), suggesting air infiltration *(18)*.

293 Iprodione and permethrins have very low vapor pressures (SI, Table S.2). Other dust studies
294 have also found relatively higher levels of permethrins compared to other pesticides *(5, 14, 26)*.
295 Associations of agricultural use of iprodione and dust levels in regression analysis (Table 3) were
296 consistent with studies suggesting particulate drift from agricultural herbicide applications *(7, 33)*.
297 For iprodione, our multivariate results also suggested transport from farmworkers living in the
298 home.

299

300 **Exposure Reduction.** Most pesticides studied here are widely used. In 2007, chlorpyrifos
301 ranked 17th, of 900 pesticide active ingredients used in California agriculture *(34)*. Although the
302 human health effects associated with levels detected here have yet to be fully studied, *p,p'*-DDE
303 detections in house dust above 56 ng/g have been associated with non-Hodgkin lymphoma *(26,*
304 *29)*. Adverse child neurodevelopmental effects have been associated with low levels (< 100
305 nmol/L) of OP metabolites in prenatal maternal urine *(12, 13)* and with low pg/g levels in
306 umbilical cord blood *(11)*. Chlorpyrifos, diazinon, DCPA, and iprodione all have sufficient
307 toxicity to be on the high priority list for consideration as toxic air contaminants in California
308 *(35)*. Public health recommendations to reduce exposures to pesticides in dust warrant
309 consideration.

310 A simple measure, farmworkers storing work shoes inside the home, was associated with
311 increased dust levels of four of five pesticides examined (Table 3). Educational materials for
312 farmworkers *(36)* should be adapted to include information about storing work shoes outside the
313 home.

314 Our multivariate modeling and mapping results also suggested that agricultural use of
315 pesticides impacted pesticide house dust levels, independent of farmworker transport. Policies
316 restricting use of one OP, parathion, have been effective at reducing house dust levels in an
317 agricultural area *(28)*. However, there are gaps in exposure assessments for pesticide risk
318 evaluations, the primary process used to determine such restrictions. Notably, potential exposures
319 to pesticides in house dust were incorporated by the U.S. EPA into a recent evaluation of
320 permethrins but only included exposures on the day following indoor treatment *(37)*. For
321 chlorpyrifos, air transport from agricultural applications was not included because of predicted
322 photodegradation *(38)*. In our study, pesticides which were present in highest concentrations or
323 which showed associations with agricultural pesticide use (permethrins, chlorpyrifos, DCPA) had
324 log K_{ow} greater than 4.0, a very low vapor pressure (permethrins, iprodione), or both. Researchers
325 have long suggested that a log K_{ow} of greater than 3.0 predicts bioaccumulation *(39)*. Evaluation
326 of physicochemical properties may identify pesticides that require consideration of environmental
327 persistence in indoor environments in risk assessments.

328

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336

337 **Supporting Information Available**

338 The SI provides additional information on the PUR data, laboratory methods including QLs by
339 dust aliquot mass, data processing methods, selection of independent variables, and the mapping
340 of pesticide use and dust concentrations. This information is available free of charge at
341 http://pubs.acs.org/.

TABLE 1. Quality Control Samples and Pesticide Concentrations in Dust Samples from Homes of CHAMACOS Participants (ng/g) by Method and Maximum Detected.

Pesticide	class[a]	agricultural use[a] (kg/yr)	spike recovery, ave % ± SD		% > QL[b]	QL[b]	min[b]	95th percentile	max[b]
GC/MS analysis (n=504 samples)			**100 ng/g (n=13)**	**1000 ng/g (n=11)**					
trans-permethrin	pyrethroid	11,941	--[c]	101 ± 33	97	5	12	7040	**222,000**
cis-permethrin	pyrethroid	11,941	--[c]	100 ± 35	96	5	10	5430	**150,000**
chlorpyrifos	OP	25,913	106 ± 15	111 ± 15	82	2	0.3	1050	**9,810**
acephate	OP	33,625	--[d]	87 ± 28	2.6	40	15	--[e]	**9,190**
iprodione	fungicide	22,443	108 ± 29	94 ± 11	42	10	5.8	748	**8,808**
azinphos methyl	OP	203	--[d]	124 ± 80[f]	4.6	200	19	--[e]	**8,556**
phosmet	OP	1,183	109 ± 21	105 ± 19	7.5	10	1.0	89	**7,780**
diazinon	OP	57,222	105 ± 26	102 ± 12	82	2	1.8	357	**7,170**
malathion	OP	41,029	151[f] ± 38[f]	112 ± 13	11	10	32	254	**2,980**
p,p'-DDT	OC	not applied	--[c]	127[f] ± 63[f]	39	10	11	332	**1,850**
DCPA	herbicide	34,810	95 ± 23	103 ± 25	92	2	0.3	169	**1,400**
dimethoate	OP	16,684	--[d]	130[f] ± 25	0.4	50	45	--[e]	**789**
methidathion	OP	6,388	131[f] ± 63[f]	111 ± 13	1.6	10	28	--[e]	**721**
vinclozoline	fungicide	6,653	116 ± 22	107 ± 12	2.8	10	16	--[e]	**502**
chlorpyrifos oxon	OP	not applied	109 ± 93[f]	87 ± 18	0.2	20	491	--[e]	**491**
p,p'-DDE	OC	not applied	113 ± 57[f]	105 ± 13	35	2	4.8	93	**305**
fonofos	OP	1,564	91 ± 22	97 ± 15	0.4	4	0.5	--[e]	**44**
LC/MS/MS analysis (n=427 samples)			**50 ng/g (n=8)**	**500 ng/g (n=10)**					
bensulide	OP	14,417	97 ± 57[f]	91 ± 41[f]	22	30	1.0	98	**537**
methomyl	carbamate	26,919	96 ± 22	49[f] ± 16	32	60	16	146	**518**
fenamiphos	OP	1,357	96 ± 53[f]	103 ± 28	3.3	5	1.0	--[e]	**459**
methamidophos	OP	604	50[f] ± 21	47[f] ± 22	11	5	3.0	19	**115**
oxydemeton-methyl	OP	27,673	100 ± 41[f]	50[f] ± 15	62	5	0.3	43	**100**

Table 1: Footnotes

a) OP= organphosphorous insecticide; OC= organochlorine; Average annual (1999-2000) agricultural usage for the Salinas Valley from the PUR (SI provides information on the PUR). Permethrin amounts are total permethrin.

b) QL is the quantification limit. QL given is the QL for the 0.15-0.5 g aliquots, taken of most samples. Min and Max are the lowest and highest quantified values.

c) Not calculated; native level in dust is 3-18X spike level.

d) Not calculated; spike level or interference compound is close to QL.

e) Not calculated; less than 5% detection rate. Analyte not included in further statistical analysis.

f) Recovery > 125% or < 75% or standard deviation (SD) >35%. Analyte not included in further statistical analysis.

TABLE 2. Pesticide Concentration and Loading Distributions[a] in Dust Samples from Unique Homes of CHAMACOS Participants by 95th Percentile of Dust Concentrations.

			concentration (ng/g)					loadings (ng/m^2)		
pesticide[a]	**N**	**% >QL[a]**	**min[a]**	**25th pctl**	**50th pctl**	**95th pctl**	**Max**	**50th pctl**	**95th pctl**	**max**
trans–permethrin	181	98	146	164	467	**7,410**	265,000	1,450	52,300	346,000
cis –permethrin	177	98	16	136	344	**5,750**	168,000	1,060	36,220	251,000
chlorpyrifos	197	91	2.9	40	74	**1,130**	7,850	258	9,640	135,000
iprodione	181	49	4.4	--[b]	--[b]	**566**	4,720	--[b]	8,570	45,020
diazinon	197	86	4.7	12	26	**273**	2,870	80	2,650	26,700
phosmet	197	7.2	23	--[b]	--[b]	**159**	5,330	--[b]	553	20,400
DCPA	181	94	2.3	14	22	**124**	271	70	1,800	8,130

a) Pesticides with > 5% detection frequency in samples and meeting quality control criterion. QL is the quantification limit. Minimum is the lowest quantified value. Pctl is the percentile.

b) Not calculated; frequency above QL insufficient to calculate percentile.

TABLE 3. Multivariate Tobit Regression Results: Proportional Change[a] in Dust Concentrations and Loadings from Unique Homes of CHAMACOS Participants per Unit Change in Predictor Variables

		chlorpyrifos		diazinon		DCPA		iprodione		*trans*-pemethrin	
dependent variable:		**conc**	**load**	**conc**	**load**	**conc**	**load**	**conc**	**load**	**conc**	**load**
number of samples:		197	197	197	197	181	181	181	181	181	181
chi-square (full model vs. intercept only)		44 ***	51 ***	36 ***	41 ***	77 ***	67 ***	35 ***	27 ***	30 ***	26 ***
variables in model[b]											
agricultural pesticide use near home (kg/day) prior to sample collection:											
days 1-3		-0.03	-0.29	-0.02	0.01	-0.03	-0.08	-0.05	-0.13	0.15	-0.08
month (days 4-33)		0.83 **	0.58	-0.03	0.04	0.10	0.09	0.32 *	0.27	0.53	0.46
season (days 34-133)		0.02	0.30	0.02	0.08	0.19 **	0.30 *	0.49 **	0.90 **	-0.29	-0.36
rainfall (mm per day) prior to sample collection:											
days 1-3		-0.06	-0.05	-0.16 *	-0.18	-0.07	-0.07	--[c]	--[c]	-0.07	-0.06
month (days 4-33)		0.30 *	0.27	0.03	0.05	-0.03	-0.05	--[c]	--[c]	0.04	0.00
season (days 34-133)		0.28	0.30	0.17	0.06	0.23	0.00	--[c]	--[c]	0.40	0.26
temp (mean daily ^{o}C) prior to sample collection:											
days 1-3		-0.09 **	-0.08	-0.06 *	-0.09 *	-0.01	0.00	--[c]	--[c]	-0.06	-0.04
month (days 4-33)		0.08	0.06	0.02	0.05	0.01	0.00	--[c]	--[c]	0.00	-0.01
season (days 34-133)		0.03	0.07	0.04	0.04	0.11 **	0.09	--[c]	--[c]	0.10	0.10
household characteristics (Y/N)[d]	**% Yes[d]**										
residence within 60 m of a field	9	0.74	1.3	-0.12	0.02	0.17	0.31	0.04	0.07	0.17	0.31
farmworkers living in home	76	0.16	0.05	0.78	0.69	0.40	0.49	2.93 *	10.12 *	-0.31	-0.36
farmworkers: work shoes stored in home	22	1.09 *	2.15 **	0.43	1.53 *	0.46 *	1.19 *	-0.47	-0.37	0.52	1.36 *
farmworkers: work clothes stored in home	52	0.20	0.42	0.18	0.40	-0.09	-0.12	1.21	1.16	1.3 **	1.33 *
product with chlorpyrifos, diazinon, or pyrethroids, respectively, in home	3, 2, 27	0.27	0.69	9.08 *	12.72 *	--[c]	--[c]	--[c]	--[c]	0.27	0.15
housing density > 2 people/ room	25	-0.11	-0.07	0.78 *	1.19 *	0.35	0.33	-0.25	-0.61	0.19	0.12
home less clean	72	0.29	1.78 **	-0.29	0.25	0.13	1.10 *	0.28	1.36	-0.04	0.71
air conditioner in home	8	-0.78 **	-0.88 **	-0.43	-0.79 *	-0.91	0.00	-0.34	-0.71	2.89 **	2.18

Table 3: Footnotes

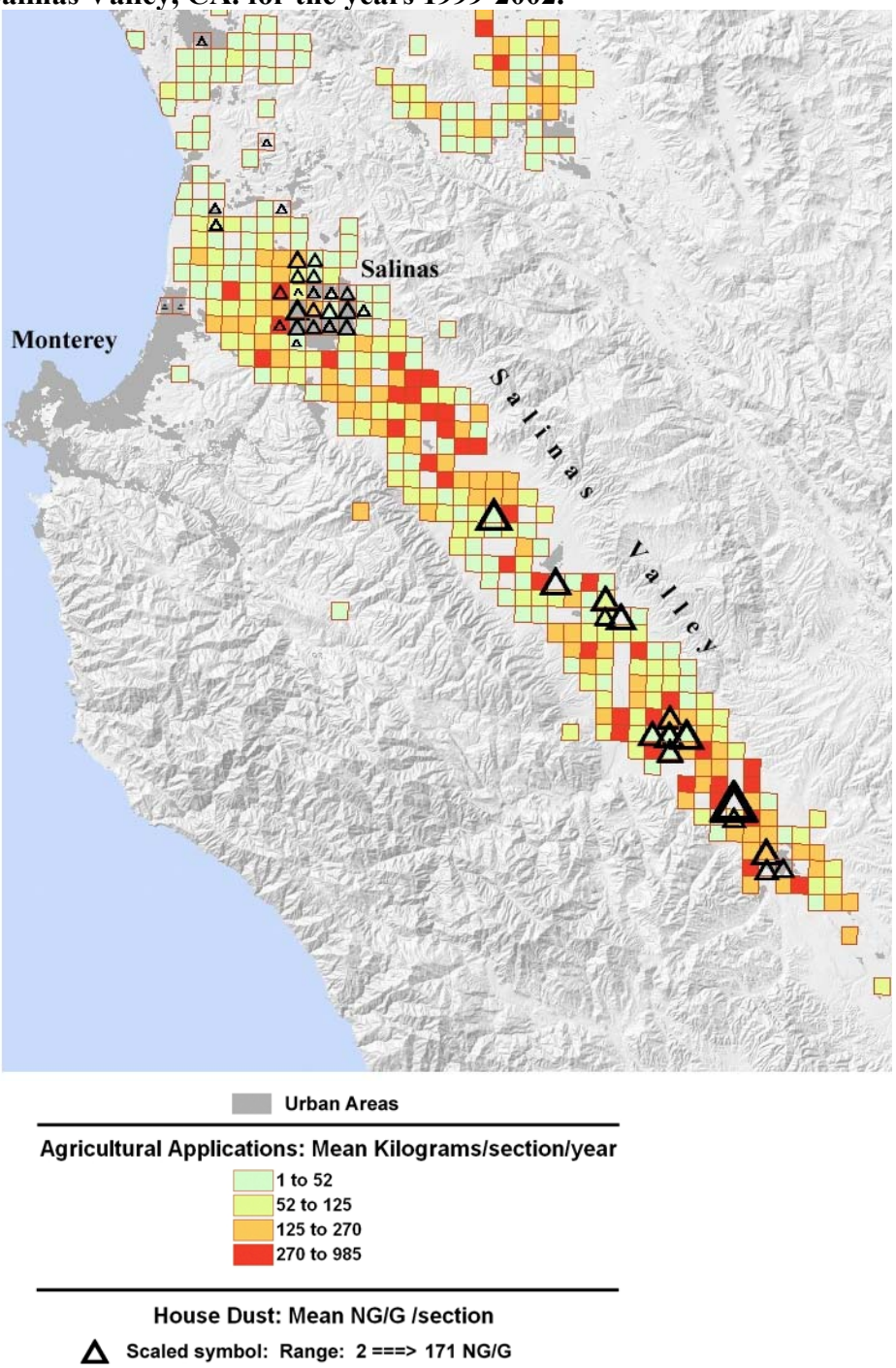
a) All dust levels are log transformed. Proportional change is equal to ((10^b) -1.0), where b is the beta regression coefficient;
* $p<0.05$, ** $p<0.01$, *** $p<0.001$.

b) In addition to the listed variables, all models included three other variables (whether the sample was collected from furniture, whether there was a professional application of pesticides in the home in the last 6 months, and whether there were pets in the home). The betas for these three variables were non-significant ($p>0.1$) in all bivariate (SI) and multivariate models.

c) Not included in model.

d) At sample collection. All variables coded 1=yes, 0=no; % Yes among unique houses, n=197 samples.

Figure 1: Chlorthal-dimethyl (DCPA): Agricultural applications and dust concentrations in CHAMACOS homes by survey sections (≈2.6 km^2) in the Salinas Valley, CA. for the years 1999-2002.[a]



a) Triangles are scaled to the mean level of the samples from CHAMACOS homes in each section. Samples were collected from 1999-2002 (n=181).

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