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PESTICIDE EXPOSURE IN DWELLINGS NEAR BULB GROWING FIELDS IN THE NETHERLANDS: AN EXPLORATIVE STUDY

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Abstract: An explorative field study was conducted to assess residential exposure to pesticides, regularly applied in bulb farming. House dust floor samples were taken from homes of bulb farmers (n = 12) and from homes in close proximity to a bulb field (i.e. non-farmers) (n = 15). Samples were analysed for 7 pesticides used by bulb growers in the sampling period. Of these pesticides, chloropropham, flutolanil and vinchlozolin could be detected in non-farmers homes. All pesticides were detected in farmers' homes, except metamitron. Median concentrations for chloropropham were significantly higher in farmers' homes (0.05 *vs.* 0.20 μg/m^2, p = 0.03). Logistic regression analyses showed that the odds for detecting pesticides were higher in farmers' compared to non-farmers' homes and remained higher after correction for potential confounders. Results showed no significant effect of proximity of a residence to a bulb field for median concentrations of pesticides; however, logistic regression analysis showed a borderline statistically significant effect for detecting chloropropham above the detection limit (OR = 10, p = 0.08). These findings demonstrate that, as expected, risk of exposure is higher for bulb farmers than for non-farmers. They also indicate that exposure to pesticides is not limited to bulb farmers only, and this warrants further investigation.

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INTRODUCTION

Only few studies are available that describe the exposure to pesticides and associated potential health risks in populations that live in agricultural areas, but have no occupational exposure to pesticides. Some studies have suggested that exposure to pesticides may occur in dwellings bordering on or in the vicinity of areas with intense agricultural activity and pesticide spraying. It is well known that so-called take-home exposures exist among agricultural workers and their families [1, 2]. These studies clearly show that the take-home exposure pathway contributes to residential pesticide contamination in agricultural homes where young children or other family members are present. It is less well established whether people living in agricultural areas, without a family member directly involved in agriculture and pesticide spraying activities or re-entry of contaminated field or orchards are also exposed to pesticides. Several exposure opportunities exist: drift from fields into houses, gardens or yards, take-home exposures from contaminated dust from fields, gardens or streets, home use of pesticides and consumption of vegetables from the garden. Recently a series of long-term studies have been conducted [3] in

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Table 1. Characteristics of the 27 participants from the rural district of Zijpe.

	Total population (N = 27)		Farmers (N = 12)		Non-farmers (N = 15)	
	n	%	n	%	n	%
Floor covering/tapestry	19	70.4	8	66.7	11	73.3
Smooth floor	8	29.6	4	33.3	4	26.7
House bordering bulb field	19	70.4	11	91.7	8	53.3
Distance >20m	8	29.6	1	8.3	7	46.7
No pets	21	77.8	8	66.7	13	86.7
One or more pets	6	22.2	4	33.3	2	13.3
More than 2 persons living in the house	13	48.1	8	66.7	5	33.3
1–2 persons living in the house	14	51.9	4	33.3	10	66.7

which there were observed elevated concentrations of chlorpyrifos and parathion in house dust from applicator homes, farm-worker homes and non-agricultural reference homes. Child urinary metabolite concentrations did not differ across parental occupational classifications. Homes in close proximity (<60 m) to pesticide-treated farmland had significantly higher chlorpyrifos and parathion house dust concentrations than did homes further away, but this effect was not reflected in the urinary metabolite data. In another study from the same group it was shown that median pesticide concentrations in house dust and metabolite concentrations in urine from agricultural families were significantly higher in the children living near treated orchards (<60 m) than those living more distant [5]. Ten of 61 agricultural children had detectable OP pesticide levels on their hands, whereas none of the reference children had detectable levels. These findings indicate that children living with parents who work with agricultural pesticides, or who live in proximity to pesticide-treated farmland, have higher exposures than do other children living in the same community. House and street or garden dust, are considered important sources of pesticide exposure [4].

This study was conducted in a bulb growing area in the North Holland province in the northwest part of the country. The study was initiated by a group of inhabitants of a small rural village. The inhabitants requested the study because the total bulb growing area in the village had increased during recent years, and as a result pesticide spraying had intensified and bulb fields were in very close proximity from residential homes. Concerns therefore existed about potential health risks from spraying in the vicinity of the houses. This study was undertaken as a first step to evaluate whether exposure to pesticides is likely to occur among people living in agricultural areas. Both farm worker homes and non-agricultural homes were included in the study.

MATERIAL AND METHODS

Population. Individuals eligible for participation in the study were selected on the basis of their address and location of the house in relation to bulb fields. The selected population, consisting of 200 individuals from the rural district of Zijpe, was approached by mail. Of those who responded and were willing to participate (n = 48), a random sample of 27 was selected and approached by telephone to make an appointment for a site visit and to take dust samples. Of the selected 27 houses, 12 were inhabited by bulb growers (i.e. farmers) and 15 by individuals living in close proximity of the bulb field (10–400 m). There was no reason to assume that the participants were more likely to be exposed to pesticides in household dust than non-participants living in the same area. Floor dust samples were taken in all 27 houses. All participants gave approval to participate in this study by informed consent.

Dust sampling. House dust was sampled by vacuuming 2 m^2 of smooth or 1 m^2 of covered floor, according to an internationally standardized protocol [6]. Samples were taken from smooth and wall-to-wall textile floor covers during a 2-minute period. Dust was collected on glass fibre filters that were placed in special filter holders in the tube of the vacuum cleaner (Schleicher & Schuell, Ć 70 mm). The samples were placed in a sterile plastic tube after sampling (Greiner, 50 ml). Samples were taken in living rooms on 2 occasions with a 1–2 week interval. The samples were combined into 1 sample for extraction. Filters were weighed, before and after sampling, on an analytical balance in a preconditioned room of 20ºC and 50% relative humidity. Dust samples were stored at -20ºC until extraction. The detection limit of this method has been established before and is 18 mg dust, computed by the mean plus twice the standard deviation of 20 blanks. Samples below the detection limit were considered as being two-thirds of this limit.

Information on home characteristics, such as distance from and position relative to bulb fields, sort of floor covering, presence of pets, information on wearing work clothes in the house, was collected with a checklist during the house dust sampling (Tab. 1).

Pesticide analysis. Pesticides were selected for analysis using the most recent information available from the Dutch Central Bureau of Statistics and from the bulb

Table 2. Pesticide concentrations for farmers and non-farmers in the rural district of Zijpe.

	Non-Farmers (N = 15)				Farmers (N = 12)				Kruskall-Wallis (p)
	n	pesticide concentrations (µg/m²)			n	pesticide concentrations (µg/m²)			
		median	max	min		median	max	min	
chloridazon	0	-	-	-	6	0.33	1.2	0.20	-
chloroprofam	6	0.05	0.17	0.02	11	0.20	1.9	0.03	0.03
flutolanil	1	0.28	-	-	6	0.15	0.83	0.06	0.62
metamitron	0	-	-	-	0	-	-	-	-
procymidon	0	-	-	-	6	0.10	1.4	0.02	-
tolclofos-met	0	-	-	-	10	0.18	3.0	0.04	-
vinchlozolin	1	0.02	-	-	3	0.50	3.7	0.17	0.18
dust per m² *	15	774.4	1492	24.9	12	815.6	2894.9	108.5	0.41

N: population size; n: # observations above the LOD; * in mg per m² floor surface

growers themselves. The following pesticides were measured in the floor dust samples; chloridazon, chloroprofam, metamitron (herbicides), flutolanil, procymidon, tolclofos-methyl, and vinchlozolin (fungicides). To facilitate analysis, filters were placed in sterile glass vials (30 ml, Packard BioScience) and extracted in 20 ml ethyl acetate (Baker Resi Analysed, Art. 9260-03) by rigorous shaking for 1 hour and ultrasonic treatment during 15 minutes (Elma Transsonic 460). The sample was subsequently centrifuged for 15 min, at 2,400 rpm (Megafuge 1.0, Heraeus Sepatech). The clear top fluid was pipetted and transferred to another glass vial (30 ml snapcap, Boom BV). Again, 20 ml of ethyl acetate was added, extraction repeated, and the second abstract was combined with the first. The ethyl acetate volume was reduced to 1 ml under nitrogen in a bain-marie at 35–40ºC. The resulting extract was placed in calibrated tubes (1–2 ml vial, Bester BV) and brought to a volume of 1.5 ml with ethyl acetate. Extracts were analysed using Gas Chromatography Mass-Spectography at the TNO institute in Zeist, The Netherlands. The limit of detection for all pesticides was 0.05 mg/l; expressed per m^2 this is equivalent to 0.04 µg/m

The recovery was evaluated in a small validation study. The spread in recovery was on average 100% with a range between 50–200%.

Statistical analysis. Statistical analysis was performed using SAS statistical software. Pesticide exposure levels were strongly skewed to the right. Because a considerable number of samples were below the detection limits and the number of samples is low, only median values and the range is given.

Because of the high number of samples below the detection limit, relationships with potential determinants were evaluated in a logistic regression analysis. A pesticide level above the detection level was considered exposed (1) and a level below this limit was considered non-exposed (0). The odds ratio of being exposed for farmers versus individuals living in close proximity of the sprayed bulb fields was calculated using logistic regression analysis and corrected simultaneously by potential confounding variables, such as type of floor covering or presence of pets. This was carried out because the type of floor covering and presence of pets are known determinants of indoor floor-dust levels, and these variables may not have been evenly distributed over the different (sub-) populations. The same approach was applied for a comparison of pesticide exposure levels between individuals living in close proximity of the fields and those living at a somewhat greater distance.

RESULTS

Of the 27 participants, 12 were bulb growers (i.e. farmers), and 15 were living in close proximity (between 10–400 m) of a bulb field (Tab. 1). None of the non-farmer participants or their family members ever applied any pesticides occupationally or for personal use.

Of the 7 pesticides measured, 3 were detectable in non-farmers' homes, and 6 in farmers' homes. Metamitron was never measured above the detection limit. There was a significant difference in the median concentration of chloroprofam, which was 4 times higher in farmers' homes ($p = 0.03$). Because there were so many samples below the detection limit, combinations of potential determinants could only be evaluated in a logistic regression analysis. For chloridazon, procymidon and tolclofos-methyl Odds Ratios and p values were estimated by setting the number of samples above the detection limit at 1 (Tab. 2).

The only determinant to show any substantial effects on the presence of pesticides above the detection limit was whether a participant was a farmer or not (Tab. 3). For instance, the chance of detecting chloroprofam in household dust from the home of a farmer is 16 times higher than finding this pesticide in a sample from a non-farmer's home. Even though in some cases determinants such as floor covering, number of people living in the house or presence of pets had a minor effect on the estimate of the comparison of farmers with non-farmers, given the confidence intervals, these changes could not be

Table 3. Odds Ratios of floor dust level above the detection limit for farmers in comparison to non-farmers.

	OR	p
chloroprofam	16	0.02
flutolanil	14	0.03
vinchlozolin	5	0.21
chloridazon	15	< 0.005
procymidon	15	< 0.005
tolclofos-methyl	75	< 0.005

interpreted as confounding effects (results not shown). Because of the limited number of observations for chloridazon, procymidon and tolclofos-methyl the possible confounding effects of floor covering, etc., could not be determined; however, it seems very likely that the presence of these pesticides in household dust is mainly influenced by the "farmer" determinant.

Influence of proximity on pesticide exposure. Because of the clear influence of the "farmer" determinant on the presence of pesticide in household dust, only samples from non-farmer homes were compared in order to assess if there was an effect of the distance between the home and a bulb field (N = 15). Proximity was labelled close if the distance from a bulb field was not greater than 20 m (arbitrary limit). Chloroprofam was detected 5 times in a home close to a bulb field, and once in a more distant home. There was no significant difference in mean concentration of chloroprofam (p = 0.77). Vinchlozolin and flutolanil were both detected once in homes close to a bulb field, but never in one of the more distant homes. None of the other pesticides were detected either. Results of the logistic regression analysis showed a borderline statistically significant effect of proximity on detecting chloroprofam in house dust (OR = 10, p = 0.08).

DISCUSSION

Agricultural chemicals could be detected in the homes of both farmers and non-farmers. There are some factors that may have influenced the measured pesticide concentrations. First of all, it is not known if the method used to collect the dust samples affects pesticide concentrations, for instance, the use of a vacuum cleaner may cause some pesticides to vaporize. Also, it was not entirely possible to estimate the effect of the matrix (house dust) on the success of the extraction method. A very substantial effect seems unlikely, because the results of the small validation study showed that the spread in recovery was considerably smaller than the spread in measured pesticide concentrations. However, validation studies are urgently needed to evaluate the recovery in greater detail in relation to sample characteristics and conditions.

The exact exposure to pesticides cannot be calculated from these results, since we only measured levels in a reservoir in the home and did not evaluate uptake of pesticides. Therefore pesticide exposure via household dust can only be estimated, based on a series of assumptions and ignoring other potentially relevant pathways. To get some insight of potential exposure risks and resulting health risks relative to ADI values a simple calculation was made for chloroprofam. For this pesticide the median concentration was 0.20 µg/m^2 in farmer households. The corresponding value for dust per m^2 was 815.6 mg under average environmental conditions (humidity, temperature) corresponding to approximately 500–600 mg dry weight. The estimated concentration of chloroprofam would be ranging between 0.3–0.4 µg chloroprofam/g household dust. The ADI for chloroprofam ranges between 0–0.03 mg/kg bodyweight per day. In a study by Van Wijnen *et al.* [7] soil ingestion by children was estimated. Under normal living conditions, the amount of soil ingested by young children is in the order of 0–90 mg (dry weight) as a geometric mean and up to 190 mg/day as a 90th percentile value. For children vacationing at campsites, higher soil ingestion valued up to 300 mg/day. In this "worst case scenario", and assuming that the soil dust consisted completely of house dust, the estimated intake of chloroprofam would be between 0.09–0.12 µg. For a child weighing 25 kg, the estimated doses of chloroprofam would be between 0.0036–0.0048 µg/kg bodyweight. Assuming that these numbers are representative and valid estimated of uptake, the actual intake for this agent would be about 6250–8250 times lower than the ADI. Given these results, health effects are unlikely to occur. However, these figures should be interpreted with caution. The sampling period was relatively short and results may not be representative of the exposure over a longer period, the method employed in this study has not been previously evaluated and other routes of exposure (inhalation, dermal uptake) are completely ignored. Also only one particular agent was evaluated and combined effects might occur.

Future studies should therefore include a thorough evaluation of the methods used. To calculate the total exposure to pesticides other routes of exposure should be taken into account. In this study, household dust samples were taken in March-April, a time of the year when many people spend a lot of time indoors, and application of pesticides on the fields is not very intense. During the summer, when people spend more time outdoors and spraying intensity is at its highest, exposure via inhalation and ground particles may be of great importance. Because it may be very difficult to calculate total exposure via all the different routes, biological monitoring (ie. blood and / or urine samples) might be a useful tool in determining pesticide intake.

CONCLUSIONS

In this study, it was shown that agricultural chemicals could be detected in the homes of both farmers and non-farmers. A significant difference in mean concentration of chloroprofam was found, the mean concentration was 4

times higher in farmers' homes than in non-farmers' homes. All pesticides (with the exception of metamitron) were detected more often in farmers' homes. This difference is statistically significant, except for vinchlozolin. No confounding effects of floor covering, presence of pets, or number of people living in the house were found. Furthermore, the results suggest that there may be an effect of proximity to a bulb field. However, because of the small population size and the low p-value, this result was only borderline statistically significant.

Further steps in the assessment of the exposure of residents to pesticides should include a larger population with sufficient power to calculate potentially relevant effects of proximity on domestic pesticide levels. Also parameters of internal exposure may be included to allow for a more precise exposure and risk assessment.

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