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Pilot Study of a Cotton Glove Press Test for Assessing Exposure to Pesticides in House Dust

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It is necessary to determine total pesticide exposure in the home from dust as well as air, food, and water to assess health risks. House dust contributes especially to children's exposure because of ingestion and dermal pathways into the body. Because of their lower body weight (one-fifth) and higher dust intake (2.5 times, or more), children are estimated to have at least 12 times more risk from toxics in dust than adults (Hawley, 1985). Their exposure to pesticides and risk are increased by greater dermal contact with dust, permeable skin, a larger surface area to weight ratio, as well as the stage of development of their nervous and immune systems.

A sizable number of persons in California required medical attention or contacted a poison control center after use of pesticides in the home. Knaak et al. (1987) report that children and adults may be at risk from the use of cholinesterase-inhibiting pesticides such as chlorpyrifos, propoxur, and dichlorvos. They relate a study by Naffziger et al. (1985) which showed a surface concentration of chlorpyrifos of 109 and 11.4 ug/cm^2 for a vinyl floor and plush carpet respectively one hour after application. They recommend that safe levels be established for residuals on surfaces after application of flea bombs.

Childhood leukemia appears to be related to pesticide exposure of the child and parents. Increased risk of leukemia in children was associated with the use of pesticides in the home garden (odds ratio [OR]=6.5, P=0.007) and inside the home on a regular basis (OR=3.8, P=0.004) as well as father's employment use of chlorinated solvents (OR=3.5, P=0.01), dyes or pigments (OR=4.5, P=0.03), and spray paint (OR=2.0, P=0.02) in a

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study of 123 matched pairs (Lowengart et al., 1987). In a study of acute nonlymphoblastic leukemia in 204 children and matched controls Buckley et al. (1989) found the risk of this leukemia was consistently associated with the pesticide exposures of the child and either parent: in jobs held longer than 1000 days for father (OR=2.7, trend P=0.06), for mothers (seven cases and no controls, trend P=0.008), if a child was under 6 years and either parent was exposed over 1000 days (OR=11.4, trend P=0.003), for direct exposure of a child in a house on most days (OR=3.5, trend P=.04), and for maternal exposure to household pesticides at the time of pregnancy (eight case mothers vs. no controls for exposure most days, trend P=0.05).

Studies with lead have demonstrated the importance of dust to the total exposure of children. The lead loading in ug Pb/m^2 in surface dust and on children's hands correlates better with lead body burden than the amount in the air (Roels et al., 1980; Davidson and Elias, 1986). Davidson and Elias (1986) estimate that a two year old child could take in forty times as much lead from ingesting dust contaminated by air pollution as from directly inhaling lead particulate matter.

Studies of house dust (Davies et al., 1975; Starr et al., 1974) have found relatively high levels of pesticides in the house dust. Davies (1975) found levels of chlordane at 100+ ppm in the homes of pesticide applicators. Significant levels of chlordane and heptachlor were found in carpet swatches placed on the floor in the homes treated with these pesticides (Wright and Leidy, 1982).

Pentachlorophenol (PCP) and lindane have been found in house dust in German homes where wood preservatives had been used (Krause et al., 1987). The dust concentrations of PCP were observed to be correlated to air concentrations in homes where the application had occurred within the past two years, but the correlation was absent if the application was older than two years. The concentrations of PCP in the dust tended to remain relatively high, while the concentrations in the air dropped by about a factor of four after two years. The ease of sampling, high pesticide content, and ability to relate to long term exposure justified reliance only on dust samples to estimate PCP exposure in this study.

The High Volume Surface Sampler (HVS2) has recently been developed to collect at least two grams of dust from a home carpet in a repeatable way. Such a sampler could be used for bioassays and chemical analysis for total dust, pesticides, other organics, and heavy metals (Roberts and Ruby, 1988). The HVS2 was field tested in nine homes in Jacksonville, Florida in February 1988 in the Non Occupational Pesticide Exposure Study (NOPES).

A quick low cost, low technology, screening method which can be sent easily through the mail, would facilitate measuring the level of exposure to pesticides in house dust. A cotton glove press test could be used as a surrogate for direct hand contact with a surface. Cotton gloves have been used in NOPES to measure the dermal exposure of home owners when applying pesticides. Cotton swatches are also used to measure dermal exposure of farm workers to pesticides. The goal of the pilot study was to test if cotton gloves can be used to show the quantity of dislodgeable pesticides in carpets with house dust containing different pesticide concentrations.

MATERIALS AND METHODS

House dust was collected in new paper bags with a Hoover upright vacuum cleaner from four houses in two residential areas of Seattle, WA. The dust was stored at -18°C within ten days after collection. A reference dust (RD0) was prepared by sieving the dust, rolling the fraction less than 150 μm in a glass jar, and stirring it with a clean rod.

A new standard plush carpet (Bradbury by Tuftex of California, 100% heat set nylon, RN:43289, Scotchguard-treated) was divided into five 0.5 m^2 sections. The mixed fine house dust (< 150 um) was split, portions were spiked with two pesticides, and 5 g of the dust was embedded as described elsewhere (Roberts and Ruby, 1988) into each carpet section denoted by G1 through G5:

G1. House dust RD0 with no added pesticide (5 g).

G2. and G3. House dust RD2 spiked with 2 ppm of dieldrin and chlordane (5 g each).

G4. and G5. House dust RD10 spiked with 10 ppm of dieldrin and chlordane (5 g each).

Six pairs of natural cotton jersey gloves which had been cleaned with ether hexane extraction and sealed in clean glass containers were used in the hand press test. A pair of the cotton gloves worn over a clean pair of powderless surgeon's gloves were pressed 100 times into a dust-spiked carpet section. Different pairs of cotton gloves (denoted G1 through G5 to match the carpet section on which they were pressed) were used for each of the five rug sections. The technician weighed 150 lb and his hands had 322 cm^2 of surface area in contact with the carpet. Each hand press consisted of simultaneously placing both hands on the rug and leaning from the shoulders over the hands for approximately two sec, while kneeling as though to crawl across the floor. A control pair of gloves (G6) was handled exactly as the other gloves, except that it was not pressed into the carpet. Each exposed cotton glove pair was wrapped in clean aluminum foil, replaced in its clean glass bottle, and stored at -18°C.

The fine house dust and gloves used in the press test were analyzed for the 33 target pesticides monitored in the NOPES using methods described by Hsu et al. (1988). Briefly, each dust (2 g) or glove pair sample was extracted in a soxhlet apparatus with 6% diethyl ether in hexane and concentrated to a final volume of 20 mL (dust) or 10 mL (gloves). Samples were spiked with octachloronaphthalene prior to extraction; the average recovery efficiency was 98%. Extracts were split into two equal aliquots for analysis by gas chromatography with electron capture detection (GC/ECD) and by gas chromatography/mass spectrometry (GC/MS) with multiple ion detection. Twenty-five chlorinated pesticides were analyzed by dual column GC/ECD, with secondary confirmation and quantification by GC/MS for all except chlordane. Eight other pesticides were analyzed only by GC/MS. The quantitation limits for most GC/ECD target compounds were from 400 to 4,000 ng (dust) and 200 to 2,000 ng (gloves). The quantitation limits of GC/MS target compounds ranged from 2,000 to 10,000 ng (dust) and 500 to 2,500 ng (gloves). The detection limit was generally about one-fifth of the quantitation limit.

RESULTS AND DISCUSSION

The results of analysis of the samples are shown in Table 1. The mean is shown for the unspiked pesticides. Fifteen pesticides were found in the background dust before spiking. The recoveries of the amounts spiked into RD2 and RD10 after subtracting the background were 110% and 162% respectively for dieldrin and 93% and 130% for chlordane.

Significant quantities of pesticides were present in the combined sample of fine dust taken from vacuum cleaner bags in four Seattle homes. Chlorpyrifos, carbaryl, PCP, and propoxur were found at mean levels of 80, 54, 4.8, and 3.4 ppm respectively. The high residues of chlorpyrifos and carbaryl may have resulted from the use of flea bombs by one home owner six months before the sample was collected. The PCP may have come from two home owners who had treated outside decks with PCP three and five years before the sample was collected.

Table 1 Pesticides in house dust from four houses shown in ppm

	RDO	RD2	RD10	MEAN
CARBARYL	77	40	45	54
CHLORDANE	2.3*	4*	16	spiked
CHLORPYRIFOS	77	72	90	80
CIS-PERMETHRIN	2.6	1.6*	2.4	2.2
2, 4-D BUTOXYETHYL	1.2*	1.3*	1.6*	1.4
4, 4' DDT	1.6	1.8	2.3	1.9
DIELDRIN	1.1	3.4	18	spiked
FOLPET	0.63*	0.43*	0.43*	0.5
HEPTACHLOR	0.16*	0.13*	0.82	-
LINDANE			0.08*	-
METHOXYCHLOR	0.52	0.7	0.82	0.7
O-PHENYLPHENOL	0.49*			-
PENTACHLOROPHENOL	6.0*	3.8*	4.5*	4.8
PROPOXUR	5.2	2.5	2.6	3.4
TRANS-PERMETHERIN	0.53*	0.7*	0.74*	0.7

Notes:
RDO: reference dust collect from four Seattle homes
RD2: RDO spiked with 2 ppm dieldrin and chlordane
RD1O: RDO spiked with 10 ppm dieldrin and chlordane
*: Value shown is less than quantitation limit. These values are less precise than others.

Chlordane (2.3 ppm), dieldrin (1.1 ppm), and DDT (1.9 ppm) were present even though no home owner could remember using such chemicals. The source of the chlordane, dieldrin, and DDT may be the soil around the homes. EPA has prohibited the use of DDT around homes since 1972. Subsurface ground insertion for termite control has been the only use of dieldrin permitted since 1974 and Seattle has practically no termites. It is probable that the carpets in the four homes have been vacuumed 100 to 2000 times or that new rugs were installed since dieldrin and DDT were last available. A significant source would be required to maintain a concentration above one ppm with such repeated cleaning activity and/or the installation of new rugs. Contaminated soil in the garden or around the foundation of the house is one likely source. The persistence of dieldrin in food also suggests soil as a source (Misra et al., 1985).

Field blank gloves G6 showed no detectable level of pesticide. The percentage of the pesticide recovered by each glove pair from the dust added to the carpet is shown in Table 2. Of the fifteen pesticides detected in RDO sample only chlorpyrifos (77 ppm) and carbaryl (77 ppm) could be detected in glove G1 because of the approximately 1% pickup and the detection limit of the equipment.

Table 2 Recovery efficiency of pesticides in cotton glove press test, %

	G1	G2	G3	G4	G5	Mean
CARBARYL	0.17	0.42	0.40	0.27	0.44	0.34
CHLORDANE	ND*	1.6	1.4	0.39	0.70	1.02
CHLORPYRIFOS	0.91	1.1	1.1	0.84	1.3	1.03
DIELDRIN	ND	0.49	0.53	0.27	0.49	0.45
HEPTACHLOR	ND	ND	ND	ND	0.15	-

* ND: Not detected

From 0.15% to 1.6% of the carbaryl, chlordane, chlorpyrifos, dieldrin, and heptachlor present in the rugs were recovered from the cotton gloves. Chlordane and chlorpyrifos were recovered with greater efficiency than dieldrin, carbaryl, or heptachlor. The cotton glove press test can be used to detect the presence of chlordane (4 ppm), dieldrin (3.4 ppm), chlorpyrifos (72 ppm), and carbaryl (40 ppm) at the levels shown. It was not successful in identifying PCP (4.8 ppm), chlordane (2.3 ppm), dieldrin (1.1 ppm), DDT (1.9 ppm), propoxur (3.4 ppm), and cis-permethrin (2.2 ppm) at these lower levels with the extraction method used.

The detection limit of the glove sample analysis can be reduced by concentrating the split sample extract to 1 mL for GC/ECD analysis and to 0.5 mL for GC/MS analysis, as is done in analyzing air and water samples. This would decrease the detection limits by a factor of 5 for the GC/ECD analysis and by a factor of 10 for the GC/MS analysis. At these lower detection limits, the cotton glove press test should be able to screen for moderate pesticide levels in dust down to about 1 ppm. The HVS2 or a similar sampling system would be required for greater sensitivity or to collect a larger sample for multiple chemical tests or bioassays.

The cotton glove press test has the advantage of being easy to understand, to use, and to send out in the mail. The test with the extraction modification described above could be used to screen for exposures to pesticides that are present at the ppm level in house dust.

Studies need to be conducted to determine 1) if the pesticide amounts measured in the press test correlate with the pesticide amounts on an adult volunteer's hands, in the soil, and in the dust in the carpet as measured by the HVS2, 2) a standardized method of applying pressure in dislodging pesticide from a surface, 3) an optimum number of hand presses, 4) variation in repeated sampling of the same surface with the same loading as well as different loadings and surfaces, and 5) if alternate materials and methods are more effective in collecting pesticides. Research is also needed to determine 1) if soils from the home garden and near the foundation are significant sources of track-in of chlordane, dieldrin, and DDT that persist in house dust despite change of carpets and weekly cleaning of floors and 2) if removal of shoes at the door or use of a long walk-off mat are cost effective control measures.

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