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Short Note

Common Pesticide Residues in Rural Homes of New York State

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Abstract

Adverse health effects occur from human exposure to pests in homes, including allergic reactions, asthma attacks and depression. Despite the existence of chemical-free methods to eradicate pests, Americans use over one billion pounds of pesticides per year. Residues of these pesticides enter homes through tracking with shoes, bare feet, clothing, or animal fur; airborne entry; and soil gas entry. Because of spray drift and volatility, adjacency and proximity to agricultural operations can be responsible for residential pesticide residues. Pesticide use in and around homes is another factor responsible for these residues. Numerous health problems occur from exposure to pesticides, such as cancer, birth defects, leukemia, and ocular toxicity. Because of crawling and hand-to-mouth behaviors, children are more vulnerable than adults to adverse health effects from pesticide exposure. This paper examines exposure risks from pesticide residues in homes and presents results from a study of pesticide residues in rural homes in New York State. Policy implications of findings from this study include home maintenance guidelines for prevention of and safe eradication of accumulated pesticide residues of which consumers may not be aware.

INTRODUCTION

Human exposure to pests in the home, including cockroaches, mice, dust mites, and mold, can aggravate allergies and asthma, especially in children [1]. Pest infestations in the home have also been associated with depression [2]. Integrated Pest Management (IPM) is an approach through which pests are controlled through preventive measures and monitoring processes that exclude or limit chemical pesticide use [1]. In spite of this, Americans use over on billion pounds of pesticides per year; worldwide that figure is 5.6 billion pounds [3].

Exposure to pesticides poses health risks to humans, especially infants and children [4]. *Babayigit, Tekbas, and Cetin* [5] reported that these risks include cancer, birth defects, nervous system disorders, and endocrine system disorders. Obendorf et al. [6], listed adverse health effects from exposure to organophosphate pesticides and carbamates as depressed cholinesterase in red blood cells and death at high enough exposure levels. Ocular toxicity from pesticide exposure has been observed. Jaga and Dahrmani [7] described pesticide-related damage to the cornea, retina, lens, conjunctiva, and optic nerve. Pesticide exposure during pregnancy has been linked to autism spectrum disorders [8]. Wang, Costello, Cockburn, Zhang, and Bronstein [9] observed an increased risk of developing Parkinson's disease from exposure to pesticides. Childhood leukemia has also been positively associated with residential pesticide exposure [10].

Because of crawling and hand-to-mouth behaviors, children can ingest large amounts of pesticide residues, not only inside the home but also in yards. The purpose of this study is to examine the extent to which commonly used agricultural pesticides accumulate as residues in rural homes.

Studies of pesticide residues in homes have documented entry routes that include tracking with shoes, bare feet, clothing, or animal fur; airborne entry; and soil gas entry [11,12]. Adjacency and proximity to agricultural operations have also been cited as factors responsible for residential pesticide residues because of spray drift and volatility [13]. Lawn-applied pesticides can follow these same transport routes [12]. Once inside a home, pesticide residues accumulate in dust and degrade at a lower rate than they do outdoors because they are shielded from the effects of rain, sun, and soil microbial activity [14].

METHODS

To examine the extent of indoor pesticide pollution in rural homes, pesticide sampling and analyses were conducted as part of a larger effort that studied pollutants in homes and childcare facilities [15]. Fifteen pesticides with a likelihood of accumulation in the interiors of rural homes were selected for this study.

A two-stage random sampling procedure was used to obtain a representative sample of households in all non-metropolitan counties in New York State. A hierarchical cluster analysis using average linkage methods [16] was performed on the twenty-four non-metropolitan counties in the state. The analysis was conducted in order to determine similar groupings of counties to be used as categories in a stratified sampling design. The counties were grouped based on six housing characteristics: average number of persons per household, proportion of housing units in multiple family dwellings, proportion of housing units occupied by renters, proportion of housing units built before 1979, and proportion of housing units built after 1980. The cluster analysis resulted in six groupings of counties. When one county was randomly selected from each group, the resulting selection comprised Chenango, Columbia, Essex, Franklin, Wyoming, and Hamilton counties.

Budget constraints limited the sample size to approximately 350 homes. Weighted random sampling based on population was conducted in each county. The final sample size was n=328. Telephone surveys of the 328 were conducted with an adult head of household to determine demographic and housing characteristics. Each household was given the opportunity to have pollutant tests conducted; and 132 households agreed to this. Table (1) gives the household demographic profiles for the sample.

A technician visited the 132 houses to conduct these tests during the heating season of 2000 - 2001, and two wipe samples were collected from each participant home. One sample was taken from a carpeted floor area and one from a non-carpeted ("smooth-floor") area. When possible sample areas were selected from main living/traffic areas of the home (living, dining, family room, main entrance hall). The pesticides were selected based on those commonly used in the agricultural practices in the counties that were studied.

Pesticides were analyzed using a GC-MS method [17]. The non-acid pesticides (methamidophos, carbaryl, atrazine, methyl parathion, alachlor, pendimethalin, metolachlor, diazinon, malathion, tetramethrin, trifluralin, resmethrin, and chlorpyrifos) were extracted from dust with ethyl acetate: cyclohexane (3:1) which was replaced with dichloromethane. The extract was filtered and collected with Size Exclusion Chromatography(SEC) using a high-resolution SEC polyvinyl benzene/polystyrene column (Envirosep-ABC column) protected by an Envirosep-ABC guard column (Phenomenex, Torrance, CA) on a HP1090 HPLC (Agilent Technologies, Sunnyvale, CA) equipped with diode array detector (DAD). Hong et al. [17], present detailed SEC conditions. The effluent was manually collected and condensed for GC/MS analysis. Acetone was used to extract filter paper samples for GC/MSD analysis. Pesticides were analyzed on a HP5890 Series II gas chromatograph coupled to a HP 5971A MS (Agilent Technologies, Sunnyvale, CA). Hong et al. [17], detail the operating conditions. Characteristic MS fragment ions and chromatographic retention times were used to identify pesticides by matching. Quality assurance methods described by Hong et al. [17], were followed.

The acid pesticides (picloram, 2,4-D-acid, dicamba, and mecoprop) were extracted from dust three times with distilled water and Ca(OH)2 (weight ratio of dust: Ca(OH) 2 was adjusted to 1:0.1). The pH was adjusted to 1 to 2 and the effluent was cleaned up by SPE with a polyvinyl benzene/polystyrene cartridge (Oasis

Table 1: Demographic characteristics of households in the sample.

Characteristic	Minimum	Maximum	Mean	Standard Deviation
Age of household Head	22	86	53.61	14.25
Education level	Grade school	Postgraduate	Technical or vocational school	
Household income	<$5,000	>$50,000	$23,900	$9,750
Number of Children	0	3	0.58	0.91

Table 2: Pesticide residues from non-carpeted areas.

Pesticide	Valid	Missing	Mean	Minimum (μg/m^2)	Maximum (μg/m$^{2)}$
Chlorpyrifos	132	0	0.00641565	0.000027	0.035563
Methamidophos	132	0	0.01534285	0.000022	0.091044
Malathion	132	0	0.02316181	0.000019	0.595709
Picloram Acid	132	0	0.02505954	0.000522	0.983467
Methylparathion	132	0	0.00119004	0.000026	0.044459
Atrazine	132	0	0.00081807	0.000029	0.040208
Diazinon	132	0	0.00715122	0.00002	0.077364
Carbaryl	132	0	0.00305338	0.00003	0.185368
Prowl	132	0	0.01606887	0.000026	0.147364
Resmethrin	132	0	0.00056852	0.000025	0.01974
Tetramethrin	132	0	0.01515323	0.000029	0.086751
Alachlor	132	0	0.00798413	0.000003	0.049125
Trifluralin	132	0	0.00209427	0.000017	0.043156
Metolachlor	132	0	0.01935394	0.000028	0.136299
2,4D-acid	132	0	0.00853624	0.00035	0.226174

Table 3: Pesticide classifications, targets, and uses.

Pesticide	Classification	Targets	Uses
Chlorpyrifos	Organophosphate	insects, worms	crops, animals,
Methamidophos	Organophosphate	insects	potatoes, rice, cotton tomatoes
Malathion	Organophosphate	insects, lice	fruits, vegetables, trees, shrubs
Picloram Acid	Pyridine	Weeds	herbaceous weeds, woody plants
Methyl Parathion	Organophoshate	boll weevils, sucking insects	cotton, soybeans, vegetables
Atrazine	Triazine	broadleaf and grassy weeds	corn, sugarcane, turf
Diazinon	Organophophate	Insects	fruits, vegetables, nuts, field crops
Carbaryl	Carbamate	aphids, fire ants, fleas, ticks, spiders	home gardens, commercial agriculture, forestry, rangelands
Prowl	Pendimethalin	Weeds	corn, soybeans
Resmethrin	Pyrethroid	flying, crawling insects	in and around homes, food-handling facilities, pets, livestock
Tetramethrin	Pyrethroid	mosquitoes, flies, cockroaches, wasps, hornets, fleas, ants	houses, public health situations
Alachlor	Chloroacetanilide	grasses, weeds	corn, soybeans
Trifluralin	Dinitroaniline	grasses, weeds	tree fruits, nuts, vegetable and grain crops
Metolachlor	Chloroacetanilide	grasses, weeds	corn, soybeans, peanuts, grain sorghum, potatoes, cotton, safflower, stone fruits, pod crops, nuts
2,4D-acid	Phenoxy	weeds	pastures, rangelands, residential lawns, roadways, crops

HLB 6 mL, Waters Co. Milford, MA). The cartridge was washed with distilled water at pH 2 and eluted with methanol in MTBE. Diethyl ether was used to extract the solution, and the extract was dried, followed by addition of methanol and trimethylsilyl diazomethane to methylate the carboxylic acid pesticides.

Acidified acetone (3 mM H3PO4) was used extracted with filter paper samples. The extract was condensed, methylated, and injected into the GC in the same way as dust extract except SPE cleanup was not used. Optimized GC/MS conditions were similar to those for non-acid pesticides [17].

Our approach to direct sampling in homes differs from a sewage epidemiology approach, in which samples are taken from wastewater to examine pesticide residues excreted by humans [18]. While sewage epidemiology is less costly than the direct approach that we used, it may underestimate exposure by toddlers. In addition, because of the rural nature of our sample, sewage epidemiology would have required sample extraction from septic tanks. Devault and Bristeau [18] used the sewage epidemiology approach to examine chlordecone exposure in the French West Indies. They detected no chlordecone and concluded that French sanitary and environmental policies were effective in preventing human exposure to this pesticide. Rousis et al. [19], used sewage epidemiology, which they referred to as wastewater epidemiology, to assess human exposure to pesticides in eight European cities. They found different exposure levels across those cities [Table 2,3].

DISCUSSION

The fact that pesticide residues were found in every house tested in our sample indicates the ubiquitous nature of these chemicals in the rural environment. Similar findings were also reported by Obendorf et al. [6], Smith et.al. [20], and Starr et al. [21].

Our study showed residues of five organophosphate pesticides in homes. This class of pesticides is known to disrupt renal functioning in humans [22]. Picloram Acid is classified by the U.S. Environmental Protection Agency (EPA) as a Restricted Use Pesticide that has been shown to be of moderate to low acute toxicity [23]. Atrazine has been shown to cause reproductive problems [24]. Human exposure to large amounts of carbaryl can be toxic to nervous and respiratory systems [25]. Prowl is classified by the EPA as a possible human carcinogen [26]. Pyrethroids are associated with nervous system damage [27]. Alachlor has the potential to cause cancer in laboratory animals [28]. Trifluralin can cause allergic dermatitis from prolonged exposure [29]. Metolachlor is slightly toxic if ingested [30]. 2,4 D may cause birth defects at high doses [31].

McCaule et al. [32], reported that residential cleaning practices can significantly reduce pesticide residues, but those practices are specific to different surfaces. This indicates that educators involved in pesticide education programs may want to include program elements that include home maintenance guidelines for prevention of and safe eradication of accumulated pesticide residues of which consumers may not be aware. This could be an important component of public health education efforts.

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