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A Study of Residential Exposure to Pesticides in Two Urban Areas of the United States

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This multi-season study was conducted in two East coast urban areas of the United States during the period of August 1986 through March 1988. The study utilized the Total Exposure Assessment Methodology (TEAM) approach in the collection of 24-hour air samples in indoor, outdoor, and personal microenvironments. In addition, limited water and dermal contact samples were collected from selected homes. This paper will discuss the results of the study with a principal emphasis on the air route of exposure as it relates to total human exposure.

INTRODUCTION

In 1984, Congress appropriated FY85 monies to the U.S. Environmental Protection Agency (EPA) to assess the level of pesticide exposure experienced by the general population. Occupational exposure of specific groups of pesticide users, such as farm workers and pest control operators, had been examined and characterized by previous studies. However, little was known about the general distribution of nonoccupational exposures to household pesticides. To begin to overcome this lack of knowledge, the Nonoccupational Pesticide Exposure Study (NOPES) was designed to provide initial estimates of nonoccupational exposure levels and to address the nature of the variability in exposure.

The NOPES was the first attempt to develop a methodology for measuring the potential exposure of specified populations to common pesticides. In this study, as in other studies utilizing the Total Exposure Assessment Methodology (TEAM), an attempt was made to relate the exposures to actual use patterns. The Agency began developing the TEAM approach in 1979 for measuring human exposure to various environmental contaminants. In a TEAM study, probability-based survey sampling procedures are combined with questionnaire data collection and modern personal monitoring techniques to obtain statistically defensible estimates of exposure levels in a selected population. The initial application of this innovative approach[1] was in the estimation of exposures to volatile organic compounds (VOCs). The list of 32 household pesticides evaluated in both cities during this study is shown in Table 1.

Air samples were collected over a 24-hour period in indoor, outdoor and personal microenvironments. In addition, limited water and dermal contact samples were collected for selected homes. The study households were selected from stratified random population samples in two urbanized areas. The samples were collected over several seasons in areas contrasting a relatively high and low use of pesticides. Dietary recall, activity pattern, and pesticide use data were collected through survey questionnaires.

This paper discusses the results of the study with an emphasis on the air route of exposure and its relative contribution to total human exposure.

PROCEDURE

Work on the design phase of NOPES began in 1985. Southwest Research Institute (SwRI), of San Antonio, Texas, developed the methodology for collecting air samples and analyzing them for 32 selected pesticides and pesticide degradation products. Emphasis was placed on both identifying and quantitating the target compounds. Research Triangle Institute (RTI) of Research Triangle Park, North Carolina developed the probability-based sampling design and the questionnaires needed to collect information about pesticide use and activity patterns. The questionnaires, and monitoring and analysis procedures were tested in a pilot study conducted in Jacksonville, Florida in August and September 1985.

To permit assessment of regional and seasonal variations in exposure levels, the main NOPES data collection was conducted in three phases:

- Phase I: Summer 1986 in Jacksonville, Florida.
- Phase II: Spring 1987 in Jacksonville, Florida, and Springfield and Chicopee, Massachusetts.
- Phase III: Winter 1988 in Jacksonville, Florida, and Springfield and Chicopee, Massachusetts.

The findings of EPA's National Urban Pesticide Applicator Survey (NUPAS) and earlier studies were used to select the two study areas. Jacksonville was selected as representative of an area of the country with relatively high pesticide use, and the Springfield region was selected to represent an area of low to moderate pesticide use. In both study areas, some sample members were asked to participate in all seasons of the study, whereas others were recruited only for a single season. Monitoring some people in more than one season permitted assessment of whether the overall differences observed between seasons were due to true seasonal variations or due to random sampling variations. Short-term temporal variations were addressed by monitoring some respondents twice in the same season.

The following activities were performed for each sample member who agreed to participate in the study:

- A study questionnaire was administered.

- A personal air sampler was given to the participant to wear or keep in close proximity for 24 h.
- Two or more fixed-site air samplers were set up and run for 24 h. At least one sampler was run in the respondent's home, and at least one was run outside the home.
- At the end of the 24 h. monitoring period, an activity log questionnaire was administered.

In some households, drinking water samples were collected for analyses. Dermal exposure during pesticide application events was estimated for a small number of respondents by analyzing cotton gloves worn during typical application events following the regular monitoring period.

RESULTS AND DISCUSSION

Table 2 reflects the percent detectable and the range of the mean concentration for the seven most prevalent pesticides. Table 3 portrays the range in diversity of the number of pesticides detected within the different microenvironments and seasons for both cities.

Mean outdoor air concentrations were almost always lower than mean indoor and personal concentrations. Mean personal air and indoor air concentrations were usually similar. Seasonal patterns were somewhat inconsistent. However, the pesticides found at higher concentrations in Jacksonville were highest in summer, followed by spring and then winter. For Springfield/Chicopee, the majority of the pesticides found at higher levels had higher concentrations in the spring than in the winter. For a majority of the pesticides, indoor and personal air concentrations were higher in Jacksonville than in Springfield/Chicopee, as expected. Differences between the sites were less consistent for outdoor air concentrations.

CONCLUSIONS AND RECOMMENDATIONS

Water sampling was by design only a small component of NOPES. Routine sampling of public water supplies by Jacksonville and Springfield prior to NOPES had not identified any contamination by the target compounds and water samples collected and analyzed during the NOPES pilot study also did not contain detectable levels of any analyses. Therefore, a minimal sampling effort was believed to be sufficient for estimating water exposure to the target compounds.

The dermal exposure component of NOPES was primarily a pilot study of a method for quantifying dermal exposure levels during acute exposure events. Chronic dermal exposure was not addressed. The number of events monitored was small, and events were not randomly selected, so estimated population exposure levels cannot be developed.

The NOPES air exposure data were evaluated with regard to potential chronic health effects for both cancer and non-cancer risks and no risks of major concern were identified.

Table 1. PESTICIDES AND/OR THEIR BREAKDOWN PRODUCTS MONITORED IN NOPES

Disinfectant	Insecticides
ortho-Phenylphenol	*Aldrin
	*alpha-BHC
Fungicides	Bendiocarb
	Carbaryl
Captan	*Chlordane
Chlorothalonil	Chlorpyrifos
Folpet	**4,4'-DDD
Hexachlorobenzene	**4,4'-DDE
	*4,4'-DDT
	Diazinon
Herbicides	Dichlorvos
	Dicofol
Atrazine	*Dieldrin
2,4-D (methyl & butoxyethyl esters)	gamma-BHC (lindane)
Dacthal	*Heptachlor
	**Heptachlor epoxide
	Malathion
	Methoxychlor
	**Oxychlordane
	Permethrin (cis/trans)
	Propoxur
	*Ronnel
	Resmethrin

*Use banned or discontinued in the United States
**Breakdown products of pesticides banned or discontinued

Table 2. ESTIMATED PERCENT OF POPULATION WITH DETECTABLE LEVELS OF TARGET COMPOUNDS IN PERSONAL AIR FOR ALL SEASONS

Pesticide	Jacksonville % Detectable	Jacksonville ng/m³	Springfield/Chicopee % Detectable	Springfield/Chicopee ng/m³
Chlorpyrifos	83-97	118-280	30-40	6-7
Propoxur	88-94	141-316	32-38	11-16
o-Phenylphenol	71-90	40-80	82-86	27-43
Diazinon	79-87	89-322	10-17	1-10
Chlordane	50-93	191-212	50-87	36-253
Heptachlor	41-90	64-134	50-66	5-35
Dichlorvos	11-35	21-148	1-2	2-4

Table 3. COMPARISON OF TOTAL MEAN AIR CONCENTRATIONS

	Jacksonville Number of Pesticides Detected	Jacksonville µg/m³	Springfield/Chicopee Number of Pesticides Detected	Springfield/Chicopee µgm³	JAX/SPG RATIO
SPRING:					
Indoor	25	1.2	21	0.38	3.2
Personal	24	0.93	21	0.40	2.3
Outdoor	11	0.03	10	0.03	1.0
SUMMER:					
Indoor	27	2.3	--	----	---
Personal	26	1.6	--	----	---
Outdoor	18	0.11	--	----	---
WINTER:					
Indoor	26	0.81	19	0.10	8.1
Personal	26	0.73	18	0.10	7.3
Outdoor	15	0.06	7	0.02	3.0

Evaluation of the NOPES results, in addition to providing important insights about the nature and magnitude of nonoccupational pesticide exposure, suggests a number of possible avenues for further research. Specific recommendations are:

1. Develop guidance for conducting exposure monitoring studies and associated methodologies for assessing human non-dietary exposure to pesticides in residential settings. These follow-up studies will be designed to permit a more comprehensive analysis of the health risks associated with exposure to pesticides from different routes.

2. Conduct prospective studies to estimate pesticide concentrations in household dust in order to explore the relationship between pesticide use and exposure, and the relative importance of the dust pathway to total human exposure, especially for infants and toddlers.

3. Refine the dermal exposure sampling and analytical method required for quantifying dermal exposures and the estimation of acute and chronic pesticide exposures. These studies will attempt to estimate transfer coefficients between surface applications and the dermal and inhalation routes of exposure.

REFERENCES

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