

Potential Exposure and Health Risks of Infants following Indoor Residential Pesticide Applications

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Abstract: Air and surface chlorpyrifos residues were measured for 24 hours following a 0.5 percent Dursban[®] broadcast application for fleas inside a residence. Two of the three treated rooms were ventilated following application. Maximum air concentrations were measured 3–7 hours post-application. Peak concentrations in the infant breathing zone were 94 $\mu\text{g}/\text{m}^3$ in the nonventilated room and 61 $\mu\text{g}/\text{m}^3$ in the ventilated room, and were substantially higher than concentrations in the sitting adult breathing zone. Concentrations of approximately 30 $\mu\text{g}/\text{m}^3$ were detected in the infant breathing zone 24 hours post-application. Surface residues available through wipe sampling were 0.7–1.6 $\mu\text{g}/\text{cm}^2$ of carpet on the day of application and

0.3–0.5 $\mu\text{g}/\text{cm}^2$ 24 hours post-application. Estimated total absorbed doses for infants were 0.08–0.16 mg/kg on the day of application and 0.04–0.06 mg/kg the day following application, with dermal absorption representing approximately 68 percent of the totals. These doses are 1.2–5.2 times the human No Observable Effect Level (NOEL). Exposures to cholinesterase inhibiting compounds following properly conducted broadcast applications could result in doses at or above the threshold of toxicological response in infants, and should be minimized through appropriate regulatory policy and public education. (*Am J Public Health* 1990; 80:689–693.)

Introduction

The health risks associated with residual pesticides in air and on surfaces in residences have only recently been examined from a public health perspective. The Committee on Urban Pest Management established by the US National Academy of Sciences noted that 5,000 health-related incidents involving pesticides were reported as occurring in homes in the US from 1966 to 1979.¹ Home pesticide applications may pose health risks for occupants, particularly infants and children. A study of 20 adult residents exposed to dichlorvos following crack-and-crevice treatments found a slight decrease in group mean serum cholinesterase, with three residents reporting a feeling of illness 24 hours post-application.² Six of 21 children admitted to Arkansas Children's Hospital for organophosphate intoxication were judged to have been exposed following insecticide spraying inside the home.³ A review of 37 hospitalized pesticide poisonings among infants and children at the Children's Medical Center in Dallas, Texas revealed that five cases were due to pesticide absorption following spraying or fogging inside residences.⁴ California State agencies reviewed 44 illness reports in 1984 associated with residential pesticide use,⁵ and subsequently conducted a hazard assessment for acute intoxication potential among infants following indoor pesticide treatments.⁶ Concern also exists regarding the chronic health effects of children's exposure to pesticides.⁷

Residential monitoring studies have focused primarily on ambient air concentrations of pesticides following several types of applications, including termiticide applications,^{8–13} DDVP resin strips hung in households,^{14–16} and crack-and-crevice or baseboard treatments.^{17–22} Recently the US Environmental Protection Agency initiated a major study of

pesticide air concentrations in homes.²³ Limited studies of two additional application methods have been conducted. Broadcast applications,^{24,25} involve the hand spraying of an aqueous mixture directly onto target surfaces (e.g., rugs, floors, furniture), while total aerosol release applications (foggers)^{26–28} involve activation of a pressurized canister in an unoccupied room, with the pesticide aerosol covering all surfaces (walls, floor, ceiling). Both of these methods produce residues on surfaces to be contacted by occupants. Flea treatment by broadcast application was selected for study here because of the potential for both high air concentrations and substantial dermal exposure. A preliminary risk assessment has been conducted for crawling infants (9–10 months of age).

Methods

Sampling was conducted according to guidelines developed by the Canadian government's Department of Health and Welfare.²⁹ The study was conducted in three rooms of an unoccupied apartment in New Jersey in June 1987, and extended for 24 hours following application. All rooms were carpeted wall-to-wall with 1.2 cm thick nylon pile. Total surface area treated was 45.27 m². No heating or air conditioning systems were in operation during the study. Windows or doors were open in two of the three rooms, while no ventilation occurred in the third room.

Chlorpyrifos application for flea treatment was conducted by a licensed pest control applicator. The formulated product, Dursban[®] L.O. (EPA Registration No. 464-571), contains 41.5 percent chlorpyrifos (O,O-diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate). The formulation was applied approximately 40 cm above the carpet as a 0.50 percent aqueous spray (40 ml/3.785 L water) with a hand-held fan broadcast nozzle attached to a CO₂ pressurized tank. Applications in the three rooms were identical, covering the entire floor and lasting 5–7 minutes per room.

Air samples were collected in duplicate in each room prior to application and at the following time intervals post-application: 0–0.5 hours, 0.5–1, 1–1.5, 1.5–3, 3–5, 5–7. An additional two-hour sample was collected 24 hours post-application. The samplers were placed in the center of each room mounted 100 cm and 25 cm above the treated surface, approximately 1.5 m apart. Battery-powered port-

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ble air sampling pumps with flow rates of 2 L/min were calibrated with the sampling train in line prior to and following the sampling period. Chlorpyrifos vapors were collected with ORBO-44 tubes (Supelpak 20). Tubes were capped and stored in an ice chest for transport to the laboratory.

Aluminum foil squares (10 cm × 10 cm) were placed in the rooms before treatment to measure residues deposited on the carpet surface. Five squares were collected from each room immediately following application (5 minutes). The wipe procedure was based on the standard method of the US Occupational Safety and Health Administration.¹¹ Sets of three wipes were collected in each room at eight time intervals post-application: 20, 40, 80, 100, 170, 260, 380 minutes, and 24 hours. All areas to be wiped were marked by disposable cardboard frames with 10 cm × 10 cm cut-out interiors. A new plastic glove was worn for each wipe sample to avoid cross-contamination of samples. The wipe consisted of three strokes across the surface with a 7.5 × 7.5 cm surgical gauze pad sprayed lightly with distilled water. This procedure was repeated with a second gauze pad, changing the wipe orientation 90°. Pads were placed in glass storage jars in an ice chest for transport to the laboratory.

All samples were stored at -20°C until analysis. Granular contents of the Orbo-44 tubes were transferred into serum vials filled with 10.0 ml of pesticide-grade toluene. A subset of the samples were analyzed for breakthrough into the secondary section of the tubes, but such breakthrough was negligible. Capped vials were shaken at high speed (100 cpm) for 5 minutes on a mechanical shaking table, allowed to sit for 30 minutes and the extracts transferred to GC vials for analysis. Both the foil and the pads were extracted in 30 ml of toluene on the shaking table at high speed for 30 minutes and the extracts transferred into GC vials.

Samples were analyzed on a Hewlett Packard 5890A gas chromatograph equipped with an electron capture detector. Heptachlor epoxide was added to all samples as an internal standard. The limit of detection for 1-μl injections was 1 picogram/μl. The limits of detection for the sampling media were as follows: air samples, 83 ng/m³; foil and gauze samples, 0.6 ng/cm². Solvent blanks run with each set of samples had no detectable chlorpyrifos. Fortification/recovery studies were conducted for all sampling media. The mean and standard deviation from these studies were as follows: air samples, 85.3% C6.0; aluminum foil squares, 98.6% ±2.5; gauze wipes, 84.0% ±10.1. Data have been adjusted on the basis of these recovery values. Two air samples, three foil and three wipe samples were collected in

each room prior to application. No background chlorpyrifos levels were detected.

Results

Chlorpyrifos levels on aluminum foil samples collected immediately (5 minutes) following application averaged 13.6 μg/cm² (±6.1) and levels in the three rooms were not significantly different. Measured deposition corresponded well with the 13 μg/cm² value calculated from label recommendations.

Chlorpyrifos residues available by wipe sampling in the ventilated rooms dropped by more than one-half within 30 minutes, averaging 0.7 μg/cm² throughout the remainder of Day 1 and 0.3 μg/cm² 24 hours post-application (Table 1). Surface residues in the nonventilated room followed the same pattern, but were significantly higher at all time intervals.

Chlorpyrifos vapors measured in the sitting adult breathing zone (100 cm above the carpet) increased over time (Figure 1). While concentrations in the ventilated rooms never exceeded 20 μg/m³, levels >60 μg/m³ were measured in the nonventilated room 3–5 hours post-application. The effect of ventilation was further reflected in samples 24 hours post-application: >40 μg/m³ with no ventilation compared to <10 μg/m³ with ventilation.

Substantially higher chlorpyrifos concentrations were measured in the infant breathing zone (25 cm above carpet), with ventilation having far less impact (Figure 2). Concentrations reached 94 μg/m³ 5–7 hours post-application in the nonventilated room and exceeded 60 μg/m³ 3–5 hours post-application in the ventilated rooms. After 24 hours an equilibrium concentration in all rooms of approximately 30 μg/m³ was reached. It thus appears that a vertical concentration gradient developed following the application, with the treated carpet serving as a source of volatilized chlorpyrifos. Open windows provided mixing and dilution of air one meter above the carpet, but had much less effect on concentrations near the floor.

Time-weighted averages for the 24 hour post-application period in the infant breathing zone were 41.2 and 66.8 μg/m³ for ventilated and nonventilated rooms, respectively, substantially higher than the corresponding values of 12.3 and 45.7 μg/m³ for the adult breathing zone. All of these concentrations exceeded the National Academy of Sciences (NAS) interim guideline of 10 μg/m³ for chlorpyrifos in indoor air following termiticide treatments.³¹

A risk assessment was conducted based on the scenario of a 9–10 month old infant playing in a carpeted room beginning at least one hour after a 0.5 percent chlorpyrifos

TABLE 1—Chlorpyrifos Residues Available by Wipe Sampling: Effects of Time and Ventilation

Sample Time (hr)	Ventilated Rooms			Nonventilated Room		
	N	Mean Residue ^a (μg/cm ²)	Percent Initial Deposit ^b	N	Mean Residue ^b (μg/cm ²)	Percent Initial Deposit
<0.5	6	1.69	12.4	3	3.90	28.6
Immediate						
0.5–6.5	35 ^c	0.69	5.0	18	1.56	11.4
Day 1						
24	6	0.28	2.0	3	0.48	3.5
Day 2						

a,b: all ventilated room values significantly lower than nonventilated room values (ANOVA: Student-Neuman-Keuls Test; p < .01)

^cdeposition following application = 13.6 μg/cm²

^d25.2 μg/cm² value excluded as outlier

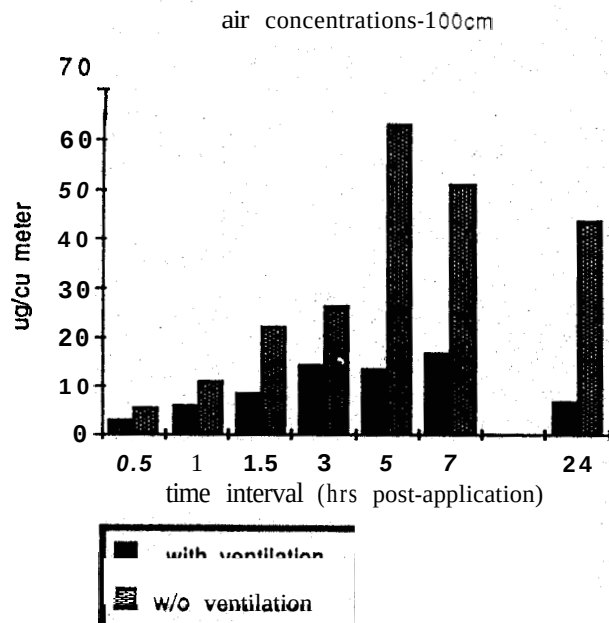


FIGURE 1—Chlorpyrifos Air Concentrations in the Sitting Adult Breathing Zone (100 cm)

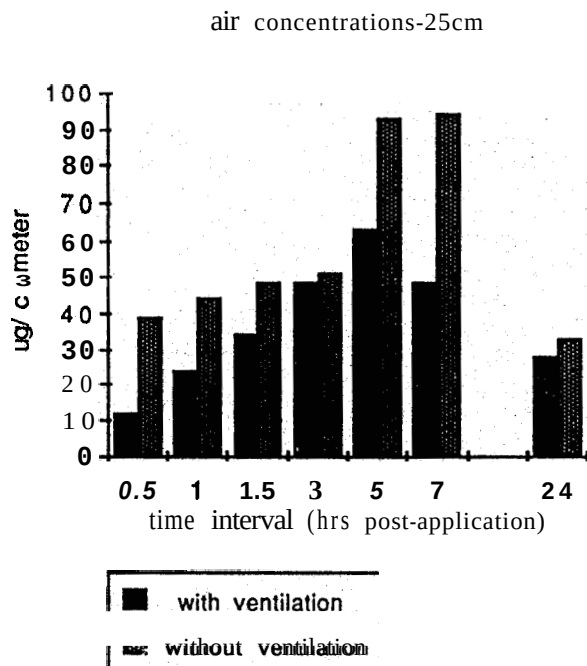


FIGURE 2—Chlorpyrifos Air Concentrations in the Infant Breathing Zone (25 cm)

broadcast application. The following assumptions were employed:

1. Infant weight = 9.0 kg³²
2. Infant respiratory volume = 2.1 L/min resting (16 hours/day); 6.3 L/min active (8 hours/day)³³

3. 100% respiratory absorption of chlorpyrifos vapors
4. Total carpet contacted in one day = 2.3 m² (25 ft²)
5. 100% transfer of available residues (wipe samples) to skin
6. 3% dermal absorption of chlorpyrifos^{6,34}

Estimated absorbed dermal doses for infants (Table 2) are the product of surface area contacted, available residues (Day 1 and Day 2 in Table 1) and percent absorbed, divided by body weight. The estimated dose in the nonventilated room is 0.120 mg/kg on Day 1, 3.2 times the dose for Day 2. Ventilation reduced the dose estimates approximately two-fold. Estimated absorbed respiratory doses are the product of time-weighted air concentrations, respiratory volume and percent absorbed, divided by body weight. Estimated Day 1 dose with no ventilation is 0.038 mg/kg, more than twice the Day 2 dose. Ventilation reduced the dose on Day 1 by approximately one-third, but had little effect on Day 2 estimates. Total absorbed dose estimates for the day of application are 0.075 and 0.158 mg/kg for ventilated and nonventilated rooms, respectively. Day 2 estimates are approximately 2-3 times lower. Dermal exposure represents on average 68 percent of the total absorbed dose.

Discussion

Chlorpyrifos residues following broadcast application were substantially higher than those reported for other types of residential applications. Total release aerosol applications have produced deposition levels of approximately 2 µg/cm² and maximum air concentrations following ventilation of 14 µg/m³.²⁸ Crack-and-crevice or baseboard applications have resulted in deposition levels of from 1-3 µg/cm²,^{18,22} and air concentrations of 1-2 µg/m³.^{20,21} Termiticide applications have produced air concentrations of <1-8.5 µg/m³.¹¹⁻¹³ Broadcast applications thus appear to produce deposition levels 5-10 times higher and peak air concentrations approximately one to two orders of magnitude higher than other application procedures. Of further concern is the finding that vapor concentrations increase over the first few hours, peaking 3-7 hours post-application.

The extent to which indoor pesticide applications might produce intoxications among residents is largely unknown. A recent risk assessment calculation of a 2.68 mg/kg absorbed dose for infants in chlorpyrifos-treated residences was based on several conservative assumptions, including complete (100 percent) absorption of chlorpyrifos through the skin.⁶ The risk assessment presented here avoids such worst-case assumptions, but includes major uncertainties in the dermal exposure estimates. The rate of transfer of pesticides from treated surfaces to skin and the amount of surface contacted over time are not known. Research has been initiated to adapt fluorescent tracer and video imaging techniques used in occupational exposure studies to address these issues.^{35,36} Several factors not included in the dose calculations suggest that chlorpyrifos absorption could be substantially higher. First, a 3 percent dermal absorption estimate may be low. The conventional topical dose for pesticide absorption studies is approximately 40 µg/cm²,³⁷ whereas the average dose applied to the skin in the chlorpyrifos absorption study was >4000 µg/cm².³⁴ High topical doses result in relatively low percent absorbed values.^{38,39} An estimate of the rate of chlorpyrifos penetration through the skin is needed to more accurately estimate absorbed dermal dose. Second, infant skin may be more permeable than the adult skin used to estimate chlorpyrifos absorption. Although the stratum cor-

TABLE 2—Total Estimated Absorbed Chlorpyrifos Dose for Infants: Day of Application (Day 1) and Day following Application (Day 2)

Room Condition	Dermal Dose (mg/kg)	% Total	Respiratory Dose (mg/kg)	% Total	Total Dose (mg/kg)	Percent of NOEL ^a
Day 1						
Ventilated	0.052	69	0.023	31	0.075	250
Nonventilated	0.120	76	0.038	24	0.158	527
Day 2						
Ventilated	0.022	58	0.016	42	0.038	127
Nonventilated	0.037	67	0.018	33	0.055	183

^aHuman No Observable Effect Level = 0.03 mg/kg/day

neum of the infant is considered to be fully developed, the permeability of infant skin in humans has not been measured.³⁹ Studies in infant rats have demonstrated increased percutaneous absorption of chlorpyrifos relative to adults.⁴⁰ Third, ingestion from deposits on hands would increase the estimates, since chlorpyrifos is absorbed by the oral route more efficiently than by the dermal route.³⁴ Finally, skin conditions to which infants may be particularly susceptible (e.g., dryness and rashes) are known to reduce the barrier properties of the skin.³⁹

The no observable effect level (NOEL) for chlorpyrifos is based on measurable changes in plasma acetylcholinesterase. The NOEL in humans is 0.03 mg/kg/day.⁴¹ All of the absorbed dose estimates in Table 2 exceed the NOEL, with doses 2.5–5 times the NOEL on Day 1, declining to 1.2–1.8 times on Day 2. The US Environmental Protection Agency has derived a "human reference dose" of 0.003 mg/kg/day for chlorpyrifos by applying a 10-fold safety factor to the human NOEL.⁴² The dose estimates in this study exceed the human reference dose by 10–50 times.

NOEL values are commonly employed to determine standards for human safety, but are based on an assumption of continuous exposure (e.g., Acceptable Daily Intakes of pesticide residues in foods). A similar assumption underlies the NAS guideline for indoor air concentrations.³⁰ Since the potential exposures calculated here would be intermittent, their toxicological significance is difficult to interpret. As yet no short-term toxicological measure analogous to the NOEL is available.

Despite uncertainties in exposure/absorption estimates and toxicological interpretation, the dose values derived in this study raise a public health concern. Broadcast applications and possibly total release aerosol/fogging applications of acutely toxic insecticides may result in dermal and respiratory exposures sufficient to cause measurable toxicological responses in infants. While such exposures are not likely to produce recognizable symptoms of cholinesterase inhibition, the possibility of cases with subclinical effects cannot be ruled out. Confirmation of such exposures would require biological monitoring (e.g., detection of 3,5,6-trichloro-2-pyridinol in the urine for chlorpyrifos).

The potential for exposures greater than those reported here should also be noted. The training of many urban pesticide applicators is minimal and surveillance of application performance is nonexistent in most states. It is not unreasonable to assume that accidents and cases of inadvertent over-application will occur under these circumstances, albeit with low frequency. Furthermore, repeated applications for fleas and other household pests are not uncommon.

Current federal regulatory requirements for indoor pes-

ticide applications are limited to label instructions. The label for broadcast applications of the compound under study here is typical (K. Lunchick, USEPA; personal communication); i.e., the premises should be vacated during application, and humans or pets should not contact treated surfaces until the spray has dried. These instructions are normally communicated by the applicator to occupants as a 1–2 hour reentry period. The finding of elevated air concentrations 3–7 hours post-application and the potential for dermal contact indicate that this reentry period is inappropriate for infants and small children.

Several strategies are available to reduce the risks associated with indoor pesticide applications. First, notification requirements could be established to inform occupants of potential health risks and means for minimizing exposure. Recommendations for broadcast applications of acutely toxic compounds such as chlorpyrifos might include thorough ventilation prior to reentry regardless of seasonal conditions, and well-defined reentry periods beyond 1–2 hours with special warnings regarding contact with treated surfaces by infants and small children. Second, more rigorous training and licensing procedures for applicators and application surveillance programs could be developed. Finally, product registrations could be modified or withdrawn for specific applications if an acceptable level of risk cannot be demonstrated.

ACKNOWLEDGMENTS

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REFERENCES

1. National Academy of Sciences: Urban Pest Management. Washington, DC: National Academy Press, 1980.
2. Gold RE, Holcslaw T, Tupy D, Ballard JB: Dermal and respiratory exposure to applicators and occupants of residences treated with dichlorvos (DDVP). *J Econ Entomol* 1984; 77:430–436.
3. Woody RC: The clinical spectrum of pediatric organophosphate intoxications. *Neurotoxicology* 1984; 5:75.
4. Zwiener RJ, Ginsburg CM: Organophosphate and carbamate poisoning in infants and children. *Pediatrics* 1988; 81:121–126.
5. Knaak JB, Schreider J, Berteau P: Hazard assessment of indoor use of chlorpyrifos, dichlorvos, propoxur and other organophosphates and N-methyl carbamates. Worker Health and Safety Branch Report No. HS-1423. Sacramento, CA: California Department of Food and Agriculture, 1987.
6. Berteau PE, Knaak JB, Mengle DC: Insecticide absorption from indoor surfaces: hazard assessment and regulatory requirements. In: Wamp RGM,

- Franklin CA, Honeycutt RC, Reinert JC (eds): Biological Monitoring for Pesticide Exposure. ACS Symposium Series 382. Washington, DC: American Chemical Society, 1989.
7. Lowengart RA, Peters JM, Cicioni C, Buckley J, Bernstein L, Preston-Martin S, Rappaport E: Childhood leukemia and parents' occupational and home exposures. *JNCI* 1987;79:39-46.
8. Livingston JM, Jones CR: Living area contamination by chlordane used for termite treatment. *Bull Environ Contam Toxicol* 1981;27:406.
9. Wright CG, Leidy RB: Chlordane and heptachlor in the ambient air of houses treated for termites. *Bull Environ Contam Toxicol* 1982;20:617.
10. Wright CG, Leidy RB, Dupree HE, Sheets TJ: Subterranean termite control: chlordane residues in soil surrounding and air within houses. *In: Honeycutt RC, Zweig G, Ragsdale NN (eds): Dermal Exposure Related to Pesticide Use. ACS Symposium Series 273. Washington, DC: American Chemical Society, 1985.*
11. Moya HA, Malagodi MH: Levels of airborne chlordane and chlorpyrifos in two plenum houses: saranex S-15 as a vapor barrier. *Bull Environ Contam Toxicol* 1987;39:533-540.
12. Anderson DJ, Hites RA: Chlorinated pesticides in indoor air. *Environ Sci Technol* 1988;22:717-720.
13. Wright CG, Leidy RB, Dupree HE: Chlorpyrifos in the ambient air of houses treated for termites. *Bull Environ Contam Toxicol* 1988;40:561-568.
14. Gillet JW, Harr JR, Linstrom FT, Mount DA, St. Clair AD, Weber LJ: Evaluation of human health hazards on use of dichlorvos (DDVP), especially in resin strips. *Residue Rev* 1972;44:115-159.
15. Gillet JW, Harr JR, St. Clair AD, Weber LJ: Comments on the distinction between hazards and safety in evaluation of human health hazards on use of dichlorvos, especially in resin strips. *Residue Rev* 1972;44:161-184.
16. Leary JS, Keane WT, Fontenot C, Feichtmeier ES, Schultz D, Koos DA, Hirsch L, Laver EM, Roan CC, Hine CH: Safety evaluation in the home of polyvinyl chloride resin strip containing dichlorvos (DDVP). *Arch Environ Health* 1974;29:308-314.
17. Wright CG, Jackson MD: Propoxur, chlordane and diazinon on porcelain china saucers after kitchen cabinet spraying. *J Econ Entomol* 1971;64:457.
18. Wright CG, Jackson MD: Insecticide residues in non-target areas of rooms after two methods of crack and crevice application. *Bull Environ Contam Toxicol* 1975;13:123.
19. Wright CG, Jackson MD: Insecticide movement following application to crevices in rooms. *Arch Environ Contam Toxicol* 1976;4:492.
20. Wright CG, Leidy RB: Chlorpyrifos residues in air after application to crevices in rooms. *Bull Environ Contam Toxicol* 1978;19:340.
21. Wright CG, Leidy RB, Dupree HE: Insecticides in the ambient air of rooms following their application for control of pests. *Bull Environ Contam Toxicol* 1981;20:548.
22. Wright CG, Leidy RB, Dupree HE: Chlorpyrifos and diazinon detection on surfaces in dormitory rooms. *Bull Environ Contam Toxicol* 1984;32:259-264.
23. Hsu JP, Wheeler HG, Camann DE, Schattenberg HJ, Lewis RG, Bond AE: Analytical methods for detection of nonoccupational exposure to pesticides. *J Chromatogr Sci* 1988;26:181-189.
24. Maddy KT, Lowe J, Saini N: Indoor air concentration of ethylene glycol monoethyl ether following application of propetamphos insecticide emulsifiable concentrate. Report No. HS-1264. Sacramento, CA: Worker Health and Safety Unit, C-4 Department of Food and Agriculture, 1985.
25. Naffziger DH, Sprengel RJ, Mattler MP: Indoor environmental monitoring of Dursban L.O. following broadcast application. *In: Down To Earth*, No. 41, Midland, MI: Dow Chemical Company, 1985.
26. Maddy KT, Edmiston S, Fredrickson AS: Monitoring Residues of DDVP in room air and on an horizontal surface following use of a room fogger. Report No. HS-897. Sacramento, CA: Worker Health and Safety Unit, CA Department of Food and Agriculture, 1981.
27. Maddy KT, Edmiston S, Ochi E: Dissipation of DDVP and propoxur following the release of an indoor fogger—a preliminary study. Report No. HS-1259. Sacramento, CA: Worker Health and Safety Unit, CA Department of Food and Agriculture, 1984.
28. Kreiger R, Ross J, Thongsinthusak T, Fong H: Measuring potential dermal transfer of surface pesticide residue generated from indoor fogger use. Worker Health and Safety Branch Report. Sacramento, CA: California Department of Food and Agriculture, 1988.
29. Health and Welfare Canada: Guidelines for Indoor Occupant Exposure Assessment following Pesticide Applications in Indoor Environments. Ottawa, Ontario: Pesticides Division, Department of Health and Welfare, 1989.
30. Occupational Safety and Health Administration: Sampling for surface contamination. *In: Industrial Hygiene Technical Manual, Chapter VIII, US Department of Labor. Washington, DC: US Government Printing Office, 1984.*
31. National Academy of Sciences: An assessment of health risks of seven pesticides used for termite control. National Research Council Committee on Toxicology. Washington, DC: National Academy Press, 1982.
32. National Center for Health Statistics: NCHS Growth Charts. Monthly Vital Statistics Report, 25(3), Suppl (HRA) 76-1120. Rockville, MD: Health Resources Administration, 1976.
33. US Environmental Protection Agency Office of Health and Environmental Assessment: Development of statistical distributions or ranges of standard factors used in exposure assessments. Springfield, VA: National Technical Information Service PB85-242667/AS, 1985.
34. Nolan RJ, Rick DL, Freshour NL, Saunders JH: Chlorpyrifos: pharmacokinetics in human volunteers. *Toxicol Appl Pharmacol* 1984;73:8-15.
35. Fenske RA, Leffingwell JT, Spear RC: A video imaging technique for assessing dermal exposure—I. instrument design and testing. *Am Ind Hyg Assoc J* 1986;47:764-770.
36. Fenske RA, Wong SM, Leffingwell JT, Spear RC: A video imaging technique for assessing dermal exposure—II. fluorescent tracer testing. *Am Ind Hyg Assoc J* 1986;47:771-775.
37. Feldmann RJ, Maibach HI: Percutaneous penetration of some pesticides and herbicides in man. *Toxicol Appl Pharmacol* 1974;28:126-132.
38. Noonan PK, Wester RC: Percutaneous absorption of nitroglycerin. *J Pharm Sci* 1980;69:365-366.
39. Wester RC, Maibach HI: *In vivo* percutaneous absorption. *In: Marzulli FN, Maibach HI (eds): Dermatotoxicology, Third Edition. Washington, DC: Hemisphere, 1987.*
40. Shah PV, Fisher HL, Sumler MR, Monroe RJ, Chernoff N, Hall L L: Comparison of the penetration of 14 pesticides through the skin of young and adult rats. *J Toxicol Environ Health* 1987;21:353-366.
41. FAO/WHO: 1972 evaluations of some pesticide residues in foods. WHO Pesticide Residue Series No. 2. Geneva: World Health Organization, 1973.
42. US Environmental Protection Agency: Integrated risk information system data base (IRIS). Washington, DC: USEPA, 1988.

'Late Breaker' Session on Injury Control Invites Abstracts

The Injury Control and Emergency Health Services special primary interest group of the American Public Health Association has announced it will again feature a "late breaker" session during the APHA upcoming 118th annual meeting in New York City. The session will be held on Tuesday, October 2, 8:30 am-10:00 am, and will feature work completed within the last few months—the deadline for consideration in the regular symposia of the APHA annual meeting.

Abstracts of 250 words or less will be accepted by the Injury Control SPIG until August 15, 1990. Please send the abstract, title of the paper, authors' name, address and telephone number to: Richard Waxweiler, Division of Injury Control, Centers for Disease Control, Mail Stop F-36, Atlanta, GA 30333. Tel: 404/488-4695.