ARTICLES

EXPOSURE OF MOSQUITO CONTROL WORKERS TO FENTHION [1]

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ABSTRACT. Values for potential dermal and respiratory exposure were determined for workers applying fenthion for mosquito control. Application was by hand gun power spray equipment, back-pack hand pressure sprayer and hand granular dispersal. Potential dermal exposure was much greater than potential respiratory exposure. Exposure was found to be greater during hand dispersal of dry granular formulation. Highest total dermal-respiratory exposure for any individual was calculated to be only 0.03% of a toxic dose per hour of work activity. Tests to determine hazard from smoking during application operations indicated greater contamination of cigarettes as a result of contact with unwashed hands following hand granular application than following spray application operations. There was no important change in erythrocyte cholinesterase activity; however, there was some decrease in plasma cholinesterase activity in certain workers.

Fenthion, O,O-Dimethyl O-(4-methylthio)-*m*-tolyl) phosphorothioate, has been used to some extent in the Pacific Northwest for mosquito control during recent years. Because it is more toxic to warm-blooded animals than many of the other compounds used, there has been some concern about hazard to workers who apply the pesticide. Published reports from other countries (Taylor 1963, Elliott and Barnes 1963) have stated that use of this pesticide as a residual spray in mosquito control operations has produced moderate depression of whole blood and plasma cholinesterase in spraymen and in inhabitants of sprayed dwellings.

During the last several years we have analyzed many blood samples from workers in mosquito abatement districts who had been exposed to fenthion. During this period we received several inquiries as to the potential health hazard from working with such a compound. Because of this interest we made observations of application practices and conducted the present studies to determine the potential exposure to fenthion during field application operations.

MATERIALS AND METHODS. Studies of potential dermal and respiratory exposure to fenthion involved measurement of exposure during application of 0.06% spray or hand dispersal of the 1% granular formulation. Of 33 different work periods studied over two work seasons, 12 were during operation of hand gun power spray equipment, 10 were during back-pack hand pressure sprayer operation, and 11 were during granular dispersal. Estimation of the amounts of dermal and respiratory exposure to which the workers would potentially be subjected followed the exposure pad and hand rinse techniques and procedures described by Durham and Wolfe (1962). Potential dermal contamination was measured primarily by attaching absorbent *a*-cellulose pads for spray exposure, or layered gauze pads for dry formulation exposure, to various parts of the worker's body or clothing and allowing them to be exposed during a timed period of work. However, dermal contamination of hands was measured by use of the bag rinse technique using 95% ethyl alcohol as the solvent. The amount of pesticide entering the body via the respiratory route was estimated from the contamination of special filter pads held in single-unit respirators worn by the subjects. The filter pads were covered with inverted plastic funnels modified to a specific aperture size to re-

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produce as nearly as possible the aerodynamics of air flow through the nostrils. The funnels also prevented direct impingement of spray droplets or particles onto the pad except for those carried through the apertures by respiratory action. This technique renders it unnecessary to measure total air volume because all inhaled air passes through the filter pads.

We have noticed that mosquito control workers often smoke cigarettes while applying spray or dispersing granules. To obtain information that might be useful in estimating potential health hazard from smoking during application operations, workers who did not wear gloves were given cigarettes to be exposed during their regular work activities. Near the end of a full work day they were allowed to remove a test cigarette from a package, light it, and smoke it to one-half the total length. The remaining portion was then analyzed to determine the amount of pesticide that had been imparted to the cigarette as a result of contact with the worker's hands.

In order that exposure estimations be based on the safe side, the total amount of fenthion found on and in the analyzed portion of a cigarette was considered to be the amount of potential exposure from smoking the cigarette. This is based on the assumption that the pesticide would be volatilized and drawn through the cigarette, and that none of the volatile or particulate pesticide would be lost into the air, broken down by burning, or trapped in the butt end or filter of the cigarette. However, all of these factors are undoubtedly involved, so one would expect the amount of pesticide actually drawn through a cigarette to be considerably less than the total amount on and in the cigarette.

A study of blood cholinesterase levels was made on 9 workers during one work season and 8 workers during another season. As many of each group as possible were checked at the pre-exposure period and at approximately monthly intervals for 4 samplings during the work season. Workers during the first season study occasionally used compounds less toxic than fenthion, so their total exposure to that compound was less than that of the second season workers who were involved in more intensive and exclusive use of fenthion.

Chemical analysis of samples for fenthion was by electron-capture gas-liquid chromotography. Blood cholinesterase activity determinations were carried out by the electrometric method of Michel (1949).

RESULTS AND DISCUSSION. As can be seen in Table 1, calculated potential exposure values for workers during operation of power sprayers or back-pack hand pressure sprayers were approximately the same. During hand granular dispersal the values were over 3 times greater than those for spraying activities. Mean dermal and

TABLE 1. Potential dermal and respiratory exposure of mosquito control workers to fenthion during three types of application.[a]

Method of application	Route of exposure	Exposure situations studied	Exposure (mg/hr)	
			Range	Mean
Power sprayer [b]	Dermal	12	0.1–11.4	3.6
	Respiratory	11	<0.001[d]–0.092	<0.016
Hand pressure sprayer [b]	Dermal	10	0.1–6.3	3.6
	Respiratory	6	<0.001[d]–0.067	<0.021
Hand granular dispersal [c]	Dermal	11	2.8–58.8	12.3
	Respiratory	10	0.004–0.186	0.088

[a] Calculated on the basis of the worker wearing a short-sleeved, open-necked shirt, no gloves or hat, and with his clothing giving protection of the areas covered.
[b] 0.06% spray.
[c] 1% granular material.
[d] Below lower limit of sensitivity of test.

respiratory exposure values during operation of power sprayers were 3.6 and <0.016 mg/hr of work, respectively, and for hand pressure sprayer operators the values were 3.6 and <0.021, respectively. Mean dermal exposure value for hand granular dispersal was 12.3 mg/hr and for exposure via the respiratory route the mean value was 0.088 mg/hr of work activity. In all three operations the unprotected body parts subjected to the greatest exposure were the hands, with only slightly less on the forearms. The combined hand and forearm exposure in the three types of application was from 73.9 to 87.5% of the total potential exposure to all exposed body parts. We believe this indicates that exposure as a result of direct hand and forearm contact with the pesticide formulations or with pesticide-contaminated equipment was probably a more important factor in total dermal exposure than was exposure from drift of spray droplets or dust from granules. Dust from the granular formulation was undoubtedly an important factor in respiratory exposure.

A wide range of potential exposure in different work periods or situations can be seen. However, the individual with the greatest potential exposure (58.8 mg/hr dermal and 0.186 mg/hr respiratory during hand granular dispersal) would be subjected to only 0.03% of a toxic dose of fenthion per hour of work as calculated by the method of Durham and Wolfe (1962). This maximum exposure level would probably rarely be maintained throughout a full work day considering the variation in values obtained.

Results of cigarette contamination tests in 18 different exposure periods involving workers applying spray by power machine or back-pack pressure hand sprayer showed contamination values from 3.2 to 78.5 micrograms of fenthion per cigarette with a mean of 28.3 micrograms. In 10 exposure periods involving workers dispersing dry granular fenthion, contamination was much greater, ranging from 137.2 to 233.0 micrograms of fenthion per cigarette with a mean of 161.4 micrograms. The reason for greater contamination of cigarettes during granular dispersal operations is not known for sure. However, we feel that one factor may be that workers tend to avoid excess exposure of hands to the dilute and concentrate liquid spray materials; whereas, in hand dispersal they deliberately handle the material with bare hands and thus build up more fenthion on the skin even though the granular formulation may be less concentrated than some of the liquid contacted. Also, dry particulate material from the granules is more dislodgeable from the hands and, if much of the material is transferred to the cigarette surface, this could be a factor in producing more contamination.

In a study of blood cholinesterase levels in 9 workers during a work season where other less toxic compounds, as well as fenthion, were included in the program, no significant effect on either the erythrocyte or plasma cholinesterase levels was found. During another work season where workers were subjected to more intensive and exclusive use of fenthion, a study of 8 workers showed no important change in the erythrocyte cholinesterase activity; however, plasma cholinesterase activity level did show a progressive decrease over the season, reaching the lowest level on August 9 (Table 2). Spraying operations became less active later in the summer and on August 29 there was some recovery in plasma enzyme levels. Among the workers there appeared to be good correlation between magnitude of cholinesterase decrease and apparent exposure to fenthion. Although not shown in the table, changes in plasma cholinesterase were more evident when only the more heavily exposed individuals were considered. At the August 9 sampling, 4 spraymen with heaviest exposure had a mean plasma cholinesterase level of 0.44 ΔpH/hr, representing 52% of the pre-exposure value while 5 men with intermediate or low exposure had a mean level of 0.74 ΔpH/hr (78% of the preseason level). Three employees who spent most of their time in the office and laboratory showed no important variation

TABLE 2. Mean erythrocyte and plasma cholinesterase activity levels for mosquito control workers exposed to fenthion.

Period	Date	No. of subjects		Cholinesterase activity (ΔpH/hr) Erythrocytes	Plasma
Pre-exposure	June 6	7	Range	0.45 – 0.97	0.45 – 1.25
			Mean±S.E.*	0.57±0.07	0.90±0.09
Exposure I	June 21	8	Range	0.56 – 0.83	0.39 – 1.10
			Mean±S.E.	0.67±0.03	0.75±0.08
Exposure II	July 11	6	Range	0.62 – 0.72	0.62 – 0.99
			Mean±S.E.	0.66±0.01	0.77±0.06
Exposure III	August 9	8	Range	0.61 – 0.81	0.15 – 0.99
			Mean±S.E.	0.70±0.02	0.59±0.09
Exposure IV	August 29	7	Range	0.43 – 0.75	0.49 – 1.04
			Mean±S.E.	0.57±0.06	0.68±0.09

* Standard error of the mean.

in cholinesterase level over the season. The lowest plasma cholinesterase levels were in 2 spraymen who had values of 0.15 and 0.37 ΔpH/hr, respectively, on August 9.

Lower plasma cholinesterase values in certain of these workers, although an indication of absorption of the pesticide, are not necessarily an indication of imminent hazard. We are not aware of any published records of poisoning symptoms in workers whose plasma value was lowered as long as the erythrocyte cholinesterase level remained in the normal range. Poisoning symptoms are more closely associated with erythrocyte cholinesterase level; thus, in this study the important point is that the erythrocyte cholinesterase levels were not significantly lowered. Workers whose plasma cholinesterase activity is found to be appreciably lowered, even though the erythrocyte level is in the normal range, should be observed for any work habits that might be causing excess exposure. They should be advised to be more careful in taking precautions to prevent such exposure. Although intensive study was not made of the health status of the men in this study, no illness or absence from work associated with their pesticide exposure was reported.

Results of the exposure tests do not indicate any appreciable hazard to workers applying fenthion for mosquito control under conditions of the present study. Nevertheless, in light of the lowered plasma cholinesterase values, efforts to keep exposure to a minimum should be maintained. The finding that the hands and forearms are subjected to the greatest amount of contamination indicates that efforts to prevent exposure in those areas could result in appreciable reduction of total exposure. Gloves should be worn whenever possible during application of fenthion. In recommending use of gloves, however, it is important to keep both the hands and the inside of the gloves as uncontaminated as possible, because covering of contaminated skin by impermeable protective material may create conditions which lead to increased absorption.

We have observed that some type of protective gloves are usually worn by spraymen but not by workers dispersing granules by hand. We understand that it is difficult to disperse properly the granular form of the pesticide while wearing any type of glove. Thus, where feasible, consideration should be given to the use of some type of dispersal mechanism which reduces direct hand contact with the pesticide. It is especially important to avoid direct hand contact if the hands have cuts or abrasions which allow a more direct route of entry into the blood stream.

Statements on the pesticide container

label concerning the need for washing pesticide-contaminated hands before smoking or eating offer sound advice. Heeding such advice is especially important following hand granular dispersal operations. Even though values for potential exposure through smoking fenthion-contaminated cigarettes may not appear to reflect any great hazard, two important points must be kept in mind: (1) Pesticide entering by the respiratory route is practically 100% absorbed, and (2) There is no assurance that a more toxic breakdown product will not be formed and inhaled as the high temperature of a burning cigarette reaches the contaminated areas rather than complete destruction of the compound by burning. If a pack of 20 cigarettes is smoked per day and all are contaminated with the maximum value of 233.0 μg per cigarette found in this study during granular application, the worker would theoretically be subjected to 4.7 mg of fenthion per day if all of the contamination was inhaled and absorbed. When this is added to the highest dermal and respiratory exposure values for an 8-hour work day, the combined potential exposure is 476.7 mg per day. Using the method of Durham and Wolfe (1962) to calculate the percent of toxic dose this represents for a 70 kg man, we find that, using the highest exposure values found in the study, a worker would be subjected to only 2.3% of a toxic dose per day. This low value reflects the history of no acute illnesses and minimal effect on blood cholinesterase in mosquito control workers in the Pacific Northwest.

It must be kept in mind that the relatively low exposure values obtained in this study are a result of what might be considered normal operations, and that excess exposure resulting from accidents, such as spillage of the emulsifiable concentrate formulation on the skin, could result in enough absorption to cause acute poisoning. In case of accidental gross contamination of skin, every effort should be made to cleanse the contaminated area as quickly and thoroughly as possible. The best recommendation at present is the use of plenty of soap and water. Wash by rubbing with the hands or with a piece of cloth. Do not scrub with a brush because the outer protective layer of the skin may be abraded enough to allow more rapid absorption of any pesticide not removed. A bar of soap, towel, and container of water for use in washing should be carried on every pesticide application machine or transportation vehicle in case a spillage should occur. If pesticide gets in the eyes they should be thoroughly flushed with water for at least 5 minutes. If a person should feel ill while working with fenthion he should stop work at once and get medical attention. If his illness is diagnosed as being caused by the pesticide, he should not return to work until a physician advises that it is safe to do so.

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