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3PP

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

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MEMORANDUM

SUBJECT: Review of Malathion Incident Reports
DP Barcode D247492, Chemical #057701, Reregistration Case #0248

FROM: Jerome Blondell, Ph.D., Health Statistician
Chemistry and Exposure Branch 2
Health Effects Division (7509C) Jerome Blondell

Monica F. Spann, M.P.H., Environmental Health Scientist
Chemistry and Exposure Branch 2 Monica F. Spann
Health Effects Division (7509C)

THRU: Susan V. Hummel, Senior Scientist
Chemistry and Exposure Branch 2 Susan V. Hummel
Health Effects Division (7509C)

TO: Paula Deschamp, Biologist
Reregistration Branch 2
Health Effects Division (7509C)

I. INTRODUCTION

Malathion is an organophosphate insecticide widely used in the United States. As a result of this widespread use, there have been numerous exposures and poisonings. Detailed analysis of the incident data identified specific use patterns that are more likely to be associated with pesticide poisoning. Depending on the type of use, risk mitigation measures are recommended to reduce the associated types of poisoning. In addition to acute poisoning, malathion and other organophosphate insecticides have been reported

to be associated with chronic effects in humans, including peripheral neuropathy, chronic neurobehavioral effects, and the reported development of a sensitivity to chemicals previously tolerated which is associated with a wide variety of symptoms. Evidence for these effects is also reviewed.

The purpose of this document is to summarize the case reports, case series, statistical surveys, and epidemiologic studies of acute and chronic health effects reported to be related to malathion. By its nature, such information suffers a number of limitations including inadequate documentation of exposure and effects, reporting biases, and absence of denominator information on the population at risk. Where consistent patterns of risk factors are identified, it is also the purpose of this document to recommend measures to mitigate those risks.

Malathion is a member of the class of organophosphate (OPs) insecticides. The organophosphate insecticides are among the most widely used agents for control of insects in agricultural and residential settings. Close to 40 organophosphates (OPs) are currently registered with the U. S. Environmental Protection Agency (EPA) and used in the United States with a widely varying range of acute toxicity.

Malathion and the other OPs poison humans and insects through their effects on nerve enzymes (Morgan 1989). Malathion combines chemically with the acetylcholinesterase enzyme and inactivates it. This enzyme is essential for control of nerve impulse transmission. Loss of acetylcholinesterase allows the accumulation of acetylcholine, the substance secreted by nerves that activates muscles, glands, and other nerves (Morgan 1989). Accumulation of sufficient levels of acetylcholine at junctions between nerves and muscles will cause muscle contractions or twitching. Accumulation of acetylcholine at junctions between nerves and glands results in gland secretion. And accumulation of acetylcholine between nerves in the brain will result in sensory and behavioral disturbances.

The principal signs and symptoms of acute malathion poisoning are headache, nausea, dizziness, pinpoint pupils, blurred vision, hypersecretion, tightness in chest, difficulty breathing, muscle weakness or twitching, difficulty walking, vomiting, abdominal cramping, and diarrhea (Namba 1971; World Health Organization 1986; Minton and Murray 1988; Karalliedde and Senanayake 1989; Morgan

1989; Gallo and Lawryk 1991). Hypersecretion of glands often results in profuse sweating and salivation, as well as tearing, runny nose, and bronchial secretions. Effects to the central nervous system may include confusion, anxiety, drowsiness, depression, difficulty concentrating, slurred speech, poor recall, insomnia, nightmares, emotional lability, or a form of toxic psychosis resulting in bizarre behavior. In any one poisoning episode, varying combinations of these symptoms may occur at different times after exposure, varying from a few minutes to several hours. The number of symptoms present also varies depending on the dose and mode of exposure. According to Morgan, unconsciousness (coma), incontinence, convulsions, or depression of respiratory drive are evidence that the poisoning is life-threatening (Morgan 1989). Pulmonary edema (fluid in the lungs), marked miosis (pinpoint pupils) with loss of pupillary reflex, loss of reflexes and extreme muscle weakness (flaccid paralysis), ataxia (jerky movements), slurring or repetitive speech are also signs of severe, life-threatening poisoning (Namba et al. 1971; Eskenazi and Maizlish 1988; Minton and Murray 1988; Gallo and Lawryk 1991).

Poisoning due to unrecognized dermal absorption (as well as other routes of exposure) can be easily misdiagnosed, which suggests that some individual cases of poisoning are missed (Midtling et al. 1985; Coye et al. 1986). Table 1 lists symptoms and signs commonly associated with acute organophosphate insecticide poisoning. These symptoms were selected based on a review of the literature (Morgan 1989, Minton and Murray 1988, Gallo and Lawryk 1991, Namba et al. 1971).

Table 1. Examples of symptoms and signs that may be reported in acute organophosphate insecticide poisoning. Note that the presence of one or more of these symptoms can occur from other diseases and differential diagnosis by a physician is needed.

Common early or mild signs/symptoms	Present in moderate or severe poisoning	Presence signifying life-threatening severity
Headache	Tightness in chest	Coma
Nausea/Vomiting	Difficult breathing	Seizures
Dizziness	Bradycardia*	Incontinence
Muscle weakness	Tachycardia	Respiratory arrest
Drowsiness/lethargy	Hypertension	Pulmonary edema
Agitated/anxiety	Hypotension	Loss of reflexes
	Pallor/cyanosis	Flaccid paralysis
	Abdominal pain	
	Diarrhea	
	Anorexia	
	Tremor/Ataxia	
	Fasciculations*	
	Lacrimation*	
	Heavy salivation*	
	Profuse sweating*	
	Bronchorrhea*	
	Blurred vision	
	Pinpoint pupils*	
	Poor concentration	
	Confusion/delusions	
	Memory loss	

* Presence of these signs and symptoms are considered relatively specific for organophosphate insecticide poisoning (Morgan 1989, O'Malley 1992).

II. BACKGROUND

The following data bases have been consulted for the poisoning incident data on the active ingredient Malathion (PC Code: 057701):

1) OPP Incident Data System (IDS) - reports of incidents from various sources, including registrants, other federal and state health and environmental agencies and individual consumers, submitted to OPP since 1992. Reports submitted to the Incident Data System represent anecdotal reports or allegations only, unless otherwise stated. Typically no conclusions can be drawn implicating the pesticide as a cause of any of the reported health effects. Nevertheless, sometimes with enough cases and/or enough documentation risk mitigation measures may be suggested.

2) Poison Control Centers - as the result of Data-Call-Ins issued in 1993, OPP received Poison Control Center data covering the years 1985 through 1992 for 28 organophosphate and carbamate chemicals. Most of the national Poison Control Centers (PCCs) participate in a national data collection system, the Toxic Exposure Surveillance System which obtains data from about 70 centers at hospitals and universities. PCCs provide telephone consultation for individuals and health care providers on suspected poisonings, involving drugs, household products, pesticides, etc.

3) California Department of Food and Agriculture (replaced by the Department of Pesticide Regulation in 1991) - California has collected uniform data on suspected pesticide poisonings since 1982. Physicians are required, by statute, to report to their local health officer all occurrences of illness suspected of being related to exposure to pesticides. The majority of the incidents involve workers. Information on exposure (worker activity), type of illness (systemic, eye, skin, eye/skin and respiratory), likelihood of a causal relationship, and number of days off work and in the hospital are provided.

4) National Pesticide Telecommunications Network (NPTN) - NPTN is a toll-free information service supported by OPP. A ranking of the top 200 active ingredients for which telephone calls were received during calendar years 1984-1991, inclusive has been prepared. The total number of calls was tabulated for the categories human incidents, animal incidents, calls for information, and others.

III. INCIDENT DATA SYSTEM

Please note that the following cases from the IDS do not have documentation confirming exposure or health effects unless otherwise noted. A small number of cases reported by United Industries Corporation involving only minor effects have not been included in this summary. The data reported from these cases did not include enough detail to prove useful. Other cases are marked (Calif.) because they occurred in California and are also reviewed according to their summary characteristics as part of section IV.

Incident#81-1

A report by the Toxics Epidemiology Program (TEP) in Los Angeles County reviewed 1,874 telephone calls to a hotline set up to take reports of adverse effects alleged to be related to malathion spraying for medfly. The report states "it is very unlikely that anyone could absorb enough malathion as a result of an aerial application to produce systemic poisoning with significant inhibition of cholinesterase enzymes, with a sizable margin of safety . . . However, illnesses not caused by a "poisoning" of cholinesterase enzymes, but rather by an allergy or "sensitivity" to the malathion bait might perhaps occur even at these low levels of exposure." The TEP staff notified physicians, hospital emergency rooms, public health clinics, and the general public during each medfly eradication campaign of their interest in receiving reports of any illness that appeared to be associated with exposure to malathion bait. Calls were classified by proximity to the spray application so that symptoms could be analyzed.

A number of limitations were noted in this study. Most of the symptoms reported are very common ones and it was difficult to determine what proportion of the symptom rate was due to background (normally occurring) and what proportion might be due to malathion bait. Also a number of factors may influence whether a person calls in to report an illness. Reporting bias and anxiety reactions undoubtedly influenced some of the illnesses reported. Symptoms that were relatively infrequent were less likely to reach statistical significance and therefore could be effects that were missed. The authors conclusions are quoted below:

> Because of the limitation of the data described above, conclusions from these data must be stated cautiously. Despite the limitations we discuss above, the data suggest

> that some individuals may have allergic or irritative symptoms following exposure to the malathion bait, perhaps in part to odors associated with the malathion bait. Such symptoms include headache, eye irritation, and skin rash in adults, and possibly angioedema, headache, nausea, and certain types of upper respiratory irritation in children. Some of these symptoms, particularly headache, may be caused in part by odors associated with the aerial applications. By and large, reported symptoms tended to be mild and transient, although not invariably so. Overall, the statistical associations described here are quite tenuous.

The Health Effects Division (HED) agrees with this conclusion. This document was previously summarized by HED (Blondell 1994).

Incident#256-13

A pesticide incident occurred in 1992, when an individual sprayed malathion and experienced respiratory difficulty and diarrhea. No further information on the disposition of the case was reported.

Incident#256-28

A pesticide incident occurred in 1992, when several applicators applied malathion with back pack sprayers but did not follow the label. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#371-6

Lawsuit with specific symptoms not mentioned.

Incident#524-1 through 524-3

A survey was conducted by a private individual during the 1989-1990 malathion spray season in California. Survey forms were left at homes for residents to fill out. Residents were asked if they were ill after the spraying and, if so, what symptoms they had and whether they saw a doctor. Forms were left at 1,439 homes and returned by 369 households representing 1,107 people. The results from this survey were similar to that carried out by the Toxics Epidemiology Program (TEP) in Los Angeles County (see Incident #81, above). The top six symptoms reported were headache, dry or sore throat, upset stomach, cough/sneezing, nausea, and eye irritation. There were 7 reports of asthma among the 1,107 people responding.

This survey was summarized earlier by the Health Effects Division (Blondell 1994).

Incident#524-4

A young school-age girl ran barefoot on the lawn five hours after an application of malathion bait to medfly. The report from her great-grandmother and from her medical records document her feet turning red and, later, developing blisters which lasted for several months. The child was reported to develop headaches, nausea, and loss of appetite after each spraying (nine total) and was taking allergy shots for trees, molds, weeds, and dust during this time. One doctor noted the allergies and reported the redness was a reaction to the malathion.

Incident#524-5

A woman in her 70s was exposed to malathion medfly application. She reported a rash on her face and neck, swollen eyes, cramps, flu-like symptoms, and nervousness. Her doctor's records show a diagnosis of psoriasis.

Incident#524-6

A father reported that his son experienced extreme fatigue, nausea, headache, and runny nose as a result of his exposure to malathion medfly application. Similar symptoms occurred after two subsequent applications of malathion. He was diagnosed with sinusitis and his doctor states "There is a possibility that the malathion spraying has been an irritant to his upper respiratory tract and could possibly have been a cause of his recurrent upper respiratory symptoms and episodes of sinusitis." His father also reported that he was diagnosed with Guillain Barre syndrome which caused temporary paralysis of his legs two weeks after a malathion application. He had to miss eight weeks of school and undergo sinus surgery. Whenever spraying is repeated, the son is taken out of the area and kept inside for three days when he arrives home.

Incident#524-7

An individual with multiple chemical sensitivity reports severe skin reactions and other symptoms (nerve disfunction and immune disfunction), but did not supply medical records to document her claim that malathion medfly applications were responsible for her illnesses.

Incident#533-1

A pesticide incident occurred in 1987, when a woman was exposed to malathion that was sprayed on a football field weekly for about six months. She reported being caught in the spray five times. She developed peripheral neuropathy with pains in her fingers, hands, arms, and feet, and hives. No further information on the disposition of the case was reported.

Incident#707-20

A pesticide incident occurred in 1993, when a sprayer got malathion in their eyes. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#707-23

A pesticide incident occurred in 1993, when a field worker, who was wearing short pants and a short sleeve shirt, entered a tobacco field before the plants dried. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#707-37

A pesticide incident occurred in 1993, when a grower was exposed to malathion that was applied to a tobacco field. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#904-1

A pesticide incident occurred in 1993, when a woman was exposed to malathion that was sprayed every eight days in the summer months for mosquito control. She experienced memory loss, loss of coordination, mental confusion, depression, and irritability. No further information on the disposition of the case was reported.

Incident#941-50

A pesticide incident occurred in 1994, when an individual experienced nausea. No further information on the disposition of the case was reported.

Incident#999-65

A pesticide incident occurred in 1994, when an individual experienced hypertension, tachycardia, diarrhea, fasciculations,

and diaphoresis from ingestion of malathion. No further information on the disposition of the case was reported.

Incident#999-123

A pesticide incident occurred in 1994, when an individual experienced dermal irritation and pain, and pruritus. No further information on the disposition of the case was reported.

Incident#999-141

A pesticide incident occurred in 1994, when an individual experienced bronchospasm, hyperventilation, tachypnea, coughing, and choking. No further information on the disposition of the case was reported.

Incident#1054-1 Calif.

A pesticide incident occurred in 1994, when a man attempted suicide and was hospitalized for three days. He experienced lethargy. No further information on the disposition of the case was reported.

Incident#1088-1 Calif.

A pesticide incident occurred in 1994, when a thirty-seven year old man allegedly attempted suicide and was hospitalized for twenty days. He experienced vomiting, diarrhea, delirium, and respiratory collapse. No further information on the disposition of the case was reported.

Incident#1160-1 Calif.

A pesticide incident occurred in 1994, when a man drank a bottle of malathion and died eight days later. This incident occurred after he had experienced a heart attack and a stroke. No further information on the disposition of the case was reported.

Incident#1280-28

A pesticide incident occurred in 1994, when an applicator got malathion in their eyes. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#1280-45

A pesticide incident occurred in 1994, when an applicator was exposed to malathion on a windy day. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#1358-1

A summary of calls to a Poison Control Center included 17 cases related to malathion. Most of the cases were minor with two exceptions that had a moderate medical outcome. No further information on the disposition of the case was reported.

Incident#1508-4 Calif.

A pesticide incident occurred in 1994, when ten workers at an automobile dealership were exposed to malathion that spilled from a cabinet. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#1669-9 Calif.

A pesticide incident occurred in 1994, when a sixty-five year old retired gardener attempted suicide by ingesting an unknown quantity of malathion from a twelve ounce container. He was hospitalized and died about thirty-eight ~~days~~ later. No further information on the disposition of the case was reported.

Incident#1839-1

A pesticide incident occurred in 1995, when a pet owner/breeder applied the pet dip to an animal without wearing gloves. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#1906-1

A pesticide incident occurred in 1995, when an individual was exposed to malathion after a bottle broke. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#2355-1

A pesticide incident occurred in 1995, when a worker experienced a bad cold. No further information on the disposition of the case was reported.

Incident#2355-3

A pesticide incident occurred in 1995, when an individual experienced headaches, and damage to the lungs and liver. No further information on the disposition of the case was reported.

Incident#2355-4
A pesticide incident occurred in 1995, when an individual experienced dizziness, nausea, swollen and discolored eyelids, fevers, random aches and pains, and chronic fatigue. No further information on the disposition of the case was reported.

Incident#2355-5
A pesticide incident occurred in 1995, when an individual experienced burning eyes, a sore throat, sniffles, coughing, sneezing, deep fatigue, and a high fever. No further information on the disposition of the case was reported.

Incident#2355-6
A pesticide incident occurred in 1995, when an individual experienced headaches, chest pressure, sinus pressure, and an upset stomach. No further information on the disposition of the case was reported.

Incident#2355-7
A pesticide incident occurred in 1995, when an individual was exposed to malathion that was sprayed in their area. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#2355-8
A pesticide incident occurred in 1995, when an individual experienced a cold, headaches, nausea, and eye effects. No further information on the disposition of the case was reported.

Incident#2355-9
A pesticide incident occurred in 1995, when an individual experienced sinus trouble and a lung infection. No further information on the disposition of the case was reported.

Incident#2355-10
A pesticide incident occurred in 1995, when a forty-six year old man experienced coughing, head congestion, sneezing, and sore throats. No further information on the disposition of the case was reported.

Incident#2355-11
A pesticide incident occurred in 1995, when an individual was exposed to malathion. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#2375-1 Calif.
A pesticide incident occurred in 1995, when a worker was installing a door and was exposed to malathion that was sprayed nearby by the property owner. The worker was hospitalized for an unknown amount of days and experienced ataxia, fasciculations, dysarthria, nausea, and vomiting about twelve to thirteen hours later. No further information on the disposition of the case was reported.

Incident#2420-1 Calif.
A pesticide incident occurred in 1995, when five workers were exposed to malathion that spilled onto the floor. Workers complained of nausea and having numb fingers. No further information on the disposition of the case was reported.

Incident#2430-1
A pesticide incident occurred in 1995, when students mixed malathion, urine, benzethonium chloride, and fish guts. The mixture gave off noxious odors and 14 people were sent to the hospital. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#2480-1
A pesticide incident occurred in 1995, when a backpack sprayer was spraying malathion and the hose broke. The sprayer experienced loss of bowel and bladder control, weakness, and poor muscle coordination in the legs for three weeks. No further information on the disposition of the case was reported.

Incident#2577-4 Calif.
A pesticide incident occurred in 1995, when an individual was exposed to malathion that spilled onto their hands. The individual was hospitalized for three days and experienced blurred vision and vertigo. No further information on the disposition of the case was reported.

Incident#2621-7 Calif.
A pesticide incident occurred in 1994, when a seventy-seven year old man experienced shaking, vomiting, diaphoresis, and fasciculations. He was hospitalized and died fourteen days later. No further information on the disposition of the case was reported.

Incident#2688-1
A pesticide incident occurred in 1995, when a man drove through an area that was being treated with malathion. He experienced burning and watery eyes. No further information on the disposition of the case was reported.

Incident#2794-1
A pesticide incident occurred in 1995, when a resident moved a box of malathion and was exposed to a small cloud of dust. He experienced respiratory arrest but completely recovered. No further information on the disposition of the case was reported.

Incident#2794-2
A pesticide incident occurred in 1995, when residents of a town poured two and a half gallons of malathion onto five bales of hay and set the bales on fire. Several residents of the town experienced hacking, wheezing, coughing, and bleeding inside the mouth. No further information on the disposition of the case was reported.

Incident#3263-14 Calif.
A pesticide incident occurred in 1995, when a thirty-six year old man, who was wearing a short sleeve shirt, jeans, and boots, applied malathion around the exterior of his home. While mixing the product some spilled onto his hands. He experienced dizziness, blurred vision, weakness, nausea, and the inability to drive. No further information on the disposition of the case was reported.

Incident#3263-28 Calif.
A pesticide incident occurred in 1994, when a thirteen year old boy, who has asthma, was exposed to malathion that was applied near his home. He was hospitalized for two days after having an asthma attack and experiencing an irritated throat, wheezing, coughing, and congestion. No further information on the disposition of the case was reported.

Incident#3377-2 Calif.
A pesticide incident occurred in 1996, when a twenty-eight year old woman attempted suicide by ingesting one teaspoon of malathion. She was hospitalized for an unknown amount of days and experienced nausea, vomiting, sweating, and drooling. No further information on the disposition of the case was reported.

Incident#3589-1
A pesticide incident occurred in 1995, when a couple was exposed to malathion that a neighbor sprayed in their yard. The neighbor mixed one ounce of malathion with nineteen gallons of water. The couple experienced breathing problems and burning eyes. No further information on the disposition of the case was reported.

Incident#3599-1
The Minnesota Department of Agriculture surveyed state enforcement agencies to determine what pesticides were involved in spray drift. Among the thirty-two states responding to the survey, there was a total of 2,681 cases of drift complaints related to specific pesticides. Malathion was responsible for 16 complaints or less than one percent of the total.

Incident#3609-1
A pesticide incident occurred in 1996, when two field workers drank from a pipe that contained malathion. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#4066-1 Calif.
A pesticide incident occurred in 1996, when a man ingested a pint of malathion and died. No further information on the disposition of the case was reported.

Incident#4419-1
A pesticide incident occurred in 1996, when an applicator was exposed to malathion that may have been stored at elevated temperatures for a week. The applicator experienced dizziness, nausea, and eye irritation. No further information on the disposition of the case was reported.

Incident#4419-2
A pesticide incident occurred in 1996, when several residents of a home were exposed to undiluted malathion that was sprayed

under their home. They experienced nausea and headaches. One resident was hospitalized for twenty-four hours. No further information on the disposition of the case was reported.

Incident#4419-3

A pesticide incident occurred in 1996, when two children were exposed to malathion and diesel oil from a nearby truck. The thirteen year old girl experienced vomiting and muscle spasms and the eleven year old boy experienced an asthma attack. The girl allegedly has a disease that causes seizures and the boy suffers from dyslexia and slight mental retardation. No further information on the disposition of the case was reported.

Incident#4419-5

A pesticide incident occurred in 1996, when a woman applied malathion by a truck and experienced headaches, sinus infection, nausea, diarrhea, trouble sleeping, and anxiety attacks. No further information on the disposition of the case was reported.

Incident#4419-6

A pesticide incident occurred in 1996, when a couple were exposed to malathion that was sprayed on a field adjacent to their home. They experienced physical and mental illnesses. No further information on the disposition of the case was reported.

Incident#4419-7

A pesticide incident occurred in 1996, when two workers experienced headaches and nervousness. No further information on the disposition of the case was reported.

Incident#4419-8

A pesticide incident occurred in 1996, when a man was exposed to malathion after a truck passed his house. He experienced tachycardia, sweating, and elevated blood pressure. No further information on the disposition of the case was reported.

Incident#4439-47

A pesticide incident occurred in 1996, when a sprayer used malathion and experienced nausea, sweating, and soreness. No further information on the disposition of the case was reported.

Incident#4533-1 Calif.

A pesticide incident occurred in 1996, when a thirty-eight year old woman attempted suicide by ingesting four to five ounces of malathion. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#5094-2

A pesticide incident occurred in 1997, when a man was working on his roof and was exposed to malathion that was sprayed on a nearby cotton field. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

Incident#5096-1

A pesticide incident occurred in 1997, when an eighteen year old boy was accidentally sprayed with malathion by a truck. He experienced nausea and weakness. No further information on the disposition of the case was reported.

Incident#5404-2

A pesticide incident occurred in 1997, when several recreation workers experienced headaches when they entered a building that houses tanks of malathion. No further information on the disposition of the case was reported.

Incident#6412-1

A pesticide incident occurred in 1997, when six hundred persons were exposed to malathion that was sprayed to control the Mediterranean fruit fly in Florida. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

IV. POISON CONTROL CENTER DATA

A more detailed review of the operation and data collection among Poison Control Centers can be found on pages 21-24 of the review of Diazinon incident reports (Blondell and Spann 1998).

Malathion was one of 28 chemicals for which Poison Control Center (PCC) data were requested. The following text and statistics are taken from an analysis of these data; see December 5, 1994 memo from Jerome Blondell to Joshua First.

The 28 chemicals were ranked using three types of measures: (A) number and percent occupational and non-occupational adult exposures reported to PCCs requiring treatment, hospitalization, displaying symptoms or serious life-threatening effects; (B) California data for handlers and field workers comparing number of agricultural poisonings to reported applications; and (C) ratios of poisonings and hospitalization for PCC cases to estimated pounds reported in agriculture for pesticides used primarily in agriculture.

A. Occupational and Non-occupational Exposure

There were a total of 10,637 malathion cases in the PCC data base. Of these, 679 cases were occupational exposure; 564 (83.1%) involved exposure to malathion alone and 115 (16.9%) involved exposure to multiple chemicals, including malathion. There were a total of 6,357 adult non-occupational exposures; 5,757 (90.6%) involved this chemical alone and 600 (9.4%) were attributed to multiple chemicals.[1] Another 3,601 exposures were reported in children under age six, reported below.

In this analysis, four measures of hazard were developed based on the Poison Control Center data, as listed below.

1. Percent of all accidental cases that were seen in or referred to a health care facility (HCF).

2. Percent of these cases (seen in or referred to HCF) that were admitted for medical care.

3. Percent of cases reporting symptoms based on just those cases where the medical outcome could be determined.

4. Percent of those cases that had a major medical outcome which could be defined as life-threatening or resulting in permanent disability.

Exposure to malathion alone or in combination with other chemicals was evaluated for each of these categories, giving a

[1] Workers who were indirectly exposed (not handlers) were classified as non-occupational cases.

total of 8 measures. A ranking of the 28 chemicals was done based on these measures with the lowest number being the most frequently implicated in adverse effects. Table 2 presents the analyses for occupational and non-occupational exposures.

Table 2. Measures of Risk From Occupational and Non-occupational Exposure to Malathion Using Poison Control Center Data from 1985-1992[a]

	Occupational Exposure	Non-occupational Exposure
Percent Seen in HCF		
Single chemical exposure	54.2 (68.2)	30.2 (44.0)
Multiple chemical exposure	56.3 (69.8)	31.7(46.1)
Percent Hospitalized		
Single chemical exposure	9.5 (12.2)	10.2(9.9)
Multiple chemical exposure	11.3 (14.3)	10.5(12.6)
Percent with Symptoms		
Single chemical exposure	84.0 (85.8)	68.8 (74.0)
Multiple chemical exposure	84.9 (85.8)	69.5 (75.2)
Percent with Life-threatening Symptoms		
Single chemical exposure	0.6[b] (0.0)	0.2[b] (0.0)
Multiple chemical exposure	0.5[b](0.5)	0.3[b] (0.05)

a Extracted from Tables 2, 3, 5 and 6 in December 5, 1994 memo from Jerome Blondell / to Joshua First; number in parentheses is median score for that category.

b For occupational exposure, the percent calculated here is based on two cases for a single and multiple chemical exposures. For non-occupational exposure, the percent calculated here is based on 11 cases for a single chemical exposure and 16 cases for multiple chemical exposures.

* Top 25% of chemicals are ranked with a superscript of 1 to 7

Compared to other organophosphate and carbamate insecticides, malathion had average or below average evidence of effects with the exception of life-threatening effects in occupational cases (exposed to a single product) or non-occupational cases (Table 2). For non-occupational exposure, 11 life-threatening cases were reported for exposure to malathion alone and 16 life-threatening cases were reported which involved exposure to malathion and other products. The percent life-threatening cases based on these numbers was well above the mean but not among the top 15% of the 28 pesticides that were ranked.

B. Ratios of poisoning - California Data

The incidence of **systemic poisoning cases** in agricultural workers reported to the California was compared to the number of applications of malathion. Those calculations, along with the median score for a total of 29 pesticides, are presented in the Table 3 below.

Table 3. Systemic Poisonings/1,000 Applications in Selected Agricultural Workers Exposed to Malathion in California, 1982-1989[a]

Pesticide	Number of Appl.	Poisonings/1,000 Appl. (N) Primary Pesticide Only			Poisonings/1,000 Appl.(N) Multiple Pesticide Exposure		
		Handlers	Field Workers	Total	Handlers	Field Workers	Total
Malathion	30,578	.36 (11)	.56 (17)	.92 (28)	.49(15)	1.05 (32)	1.54 (47)
Median		.21	.20	.41	.44	.50	1.02

a Extracted from Table A5 in December 5, 1994 memo from Jerome Blondell to Joshua First; number in parentheses is the observed number of poisoned cases.

Malathion had the seventh highest ratio of handler poisonings per 1,000 applications in California when exposures to mixtures were excluded, a value 71% higher than the median (See Table 7 in the December 5, 1994 memo). Malathion had the sixth highest ratio of field worker poisonings per 1,000 applications in California when exposures to mixtures were excluded, a value 2.8 times higher than the median. During the 1982-1989 time period there were four agricultural workers hospitalized for a total of 13 days, which

ranked sixth for number of workers and fifth for number of days. When these numbers are adjusted for the number of applications, malathion ranked sixth for number of days and fourth for number of days.

C. Exposure in Children

A separate analysis of the number of exposures in children five years of age and under from 1985-1992 was conducted. For malathion, there were 3,601 incidents; 3,371 involved exposure to malathion alone and 230 involved other pesticides as well. Compared to 14 other organophosphates and carbamates that 25 or more children were exposed to, malathion cases were just as likely to develop symptoms, be seen in a health care facility, or require hospitalization. However, malathion cases were twice as likely to involve life-threatening outcome based on 11 life-threatening cases reported in children under age six.

V. CALIFORNIA DATA - 1982 THROUGH 1995

A more detailed description of the California Illness Surveillance Program which describes how reports are received and investigated can be found on pages 29-31 of the Review of Diazinon Incident Reports (Blondell and Spann 1998).

Detailed descriptions of 539 cases submitted to the California Pesticide Illness Surveillance Program (1982-1995) were reviewed. In 395 of these cases, malathion was judged to be responsible for the health effects. Only cases with a definite, probable or possible relationship were reviewed. Malathion ranked 6th as a cause of systemic poisoning in California from 1982 through 1994 and 9th as a cause of hospitalization. Nineteen individuals were hospitalized between 1982 and 1994. Table 4 presents the types of illnesses reported by year. Table 5 gives the total number of workers that took time off work as a result of their illness and how many were hospitalized and for how long.

Table 4. Cases Due to Malathion Exposure in California Reported by Type of Illness and Year, 1982-1995

Year	Illness Type					
	Systemic[b]	Eye	Skin	Resp	Combination[c]	Total
1982	25	6	2	-	-	33
1983	17	6	3	-	-	26
1984	31	8	3	-	1	43
1985	19	4	1	-	-	24
1986	34	3	1	-	1	39
1987	12	3	-	-	-	15
1988	37	-	-	-	-	37
1989	34	1	1	4	-	40
1990	18	1	-	-	2	21
1991	13	3	-	1	1	18
1992	16	2	3	-	-	21
1993	26	2	1	-	-	29
1994	31	-	1	1	2	35
1995	12	1	-	-	1	14
Total	325	40	16	6	8	395

[b] Category includes cases where skin, eye, or respiratory effects were also reported

[c] Category includes combined irritative effects to eye, skin, and respiratory system

Table 5. Number of Persons Disabled (taking time off work) or Hospitalized for Indicated Number of Days After Malathion Exposure in California, 1982-1995.

	Number of Persons Disabled	Number of Persons Hospitalized
One day	28	3
Two days	21	4
3-5 days	11	6
6-10 days	9	1
more than 10 days	3	6
Unknown	47	18

A total of 325 persons had systemic illnesses or 82.3% of 395 persons. A total of 40 persons had eye illnesses or 10.1% of 395 persons. Of the 20 individuals that were hospitalized as a result of their intoxication, 11 were suicide cases. There were a total of 20 suspected suicides including at least four deaths. Two cases of attempted suicide involved ingestion of four ounces of 50% malathion. One of these cases developed life-threatening symptoms and the other just minor symptoms. The estimated dose from such an ingestion would be 56.7 grams (2 ounces active ingredient, 1 g/mL) divided by 70 kg or 810 mg per kg body weight.

There were nine people that required hospitalization from unintentional causes. Seven of these cases were applicators applying the product by hand or backpack sprayer. In two cases homeowners were mistakenly applying concentrated material that had not been properly diluted. Alcohol consumption was involved for one of the applicators and in one case of accidental ingestion which was fatal. One case involved an applicator who took off the top half of his protective suit because of the heat. Another case involved an asthmatic boy who reacted during an aerial application despite being indoors with the windows closed. A variety of worker activities were associated with exposure to malathion as illustrated in Table 6 below.

Table 6. Illnesses by Activity Categories for Malathion Exposure in California, 1982-1995

Activity Category	Illness Category					
	Systemic[b]	Eye	Skin	Resp/	Combination[c]	Total
Applgrou	11	7	-	-	-	18
Applhand	18	16	7	1	2	44
Applnon	2	1	-	-	-	3
Applother	1	-	-	-	-	1
Clean/Fix	1	-	-	-	-	1
Coinciden	16	4	-	-	-	20
Driftexp	24	-	-	1	2	27
Driftnon	7	-	-	1	1	9
Emerresp	26	1	-	-	-	27
Expotoco	68	3	4	3	-	78
Manuform	2	-	-	-	-	2
Mixload	3	1	-	-	-	4
Nonoccb	34	1	1	-	-	36
Other	30	1	1	-	-	32
Othernon	62	2	2	-	2	68
Pack/Proc	-	3	-	-	-	3
Resifield	1	-	-	-	1	2
Resinon	4	-	-	-	-	4
Resistru	15	-	1	-	-	16
Total	325	40	16	6	8	395

[a] Applgrou= ground applicator; Applhand= applicator, hand-held spray/dust equipment; Applnon= non-occupational application exposure; Applother= applicator, other spray/dust application methods; Clean/Fix= cleaning and/or repairing pesticide

contaminated equipment; Coincidental= exposed to application strength but not a handler; Driftexp= exposure to pesticide that has drifted from intended targets; Driftnon= non-occupational exposure to drift; Emerresp= emergency response personnel; Expotoco= persons handling pesticide products between packaging and end-use; Manuform= manufacturing/formulation plant workers; Mixload=mixer and/or loader of pesticide concentrates and dilute pesticides; Nonoccb= other non-occupational exposure; Other= other occupational exposure; Othernon= non-occupational miscellaneous exposure; Pack/Proc= packing, processing, or retailing commodities; Resifield= field worker exposed to residue in the field; Resinon= non-occupational residue exposure; Resistru= worker exposed to residue of structural treatment

[b] Category includes cases where skin, eye, or respiratory effects were also reported

[c] Category includes combined irritative effects to eye, skin, and respiratory system

The single largest category of malathion incidents occur even before the customer gets the product home. A careful review of the narrative for all 395 cases revealed that inadequate packaging was responsible for 27% of all incidents. Most of these incidents occurred in a store or warehouse where the container fell off a shelf and broke or the lid cracked or the container leaked. There were a total of 38 incidents involving 107 victims of exposure. Most had relatively mild symptoms and the overwhelming majority the cases appeared to be a reaction to the bad odor, rather than cholinergic poisoning. Sixteen of these incidents involved three or more people. In 1992 a bottle fell on the floor and broke resulting in the evacuation of 160 employees, though no one became ill.

Exposure to drift or odor from a nearby application was the second most common cause of incidents. There were approximately 50 individuals that reacted to applications nearby. Most of these cases developed only minor symptoms that appeared to be related to the noxious odor rather than cholinergic poisoning. In nearly half of these cases, the application occurred outdoors while the victims were indoors. Some of these cases occurred because the applicator sprayed too near an air intake or across an entry way. Improper use of malathion indoors that was intended for use outdoors was also involved in 14 cases.

Hand application of malathion with either a backpack or hand sprayer was the third most common cause of incidents. As noted above, these cases tended to be more serious and were the most common cause of hospitalization among the accidental cases. Sixteen cases occurred when applicators got malathion into eyes that were inadequately protected. Ten cases occurred because of equipment failure (e.g., hose breaks and leaks) and five cases each involved equipment maintenance and failure to use required personal protective equipment. Among the other sources of poisoning, improper dilution was involved in at least 15 cases.

Asthma attacks were reported by at least four individuals, one of whom required three days of hospitalization. One individual reported two asthma attacks that coincided with two malathion medfly applications. The second attack was so severe that medical assistance was required to get the individual to the hospital. Prior to these medfly applications this individual had not had any serious problems from asthma for several years.

One surprising finding was that persons treating victims of ingestion also became ill from exposure to odors of vomitus, body fluids, etc. in six incidents involving 18 people. One of these incidents, a suicide case that was ultimately fatal, resulted in six nurses becoming ill (Merritt and Anderson 1989).

Medfly incident investigations

Periodic applications of malathion bait to control medfly have led to investigations of complaints of illness by the public. These investigations have been summarized previously (See Memorandum: Review of adverse health effects attributed to Medfly spraying with malathion, April 22, 1994, from Jerome Blondell to Larry Dorsey). A review by Kahn et al. (1992) concluded that "the results indicate that aerial application of malathion bait caused no detectable increase in acute morbidity in the community." This assessment was based on indirect assessments and surveys that were relatively insensitive to rare effects that might occur in especially susceptible individuals. The Health Effects Division recommended that individuals with asthma or who may be unusually sensitive to chemicals be notified in advance so that they could take appropriate action to avoid exposure. Programs involving spraying malathion on communities (whether for medfly, mosquito or other purposes) should have surveillance programs in place to

monitor reports of illness and obtain medical documentation where feasible.

VI. NATIONAL PESTICIDE TELECOMMUNICATIONS NETWORK

On the list of the top 200 chemicals for which NPTN received calls from 1984-1991 inclusively, malathion was ranked 4th with 900 incidents in humans reported and 88 incidents in animals (mostly pets). Of the 900 incidents, 51 involved some type of unusual chemical sensitivity, mostly multiple chemical sensitivity. Malathion was the fourth ranked pesticide for this type of complaint and accounted for five percent of the total, though it only accounts for three percent of the use in the home (Whitmore et al. 1992).

From April 1, 1995 through March 31, 1998, the NPTN received 95 reports of incidents from humans alleging adverse health effects from exposure to malathion. The most common complaints related to odors from spray drift or accidental spills that resulted in minor symptoms such as headache, nausea, and respiratory problems. More serious cases resulted when concentrated malathion was improperly applied. One of these cases required hospitalization.

There were three reports of asthma attacks in the April 1995 through March 1998 data, two from aerial applications and one from a broken bottle spill. One unusual case reported was a 13 month old child who may have been exposed to spray drift and ingested contaminated water. This child experienced three months of diarrhea, behavioral changes and, later, was allegedly diagnosed with autism. Another unusual case involved application for head lice at three times the recommended rate in an adult woman. The product got in her eye and she couldn't see for a week. Three and a half years later she developed a brain tumor. This case should not be considered evidence of carcinogenicity of malathion without substantiation from other sources. The most serious case reported was a man 45 to 64 years old who was spraying malathion every week for four weeks and had complained of headaches and nausea. After this (timing not reported) he went into convulsions and suffered two heart attacks on the same day. There were no reports of cholinesterase tests taken in any of these cases to confirm poisoning.

VII. LITERATURE REVIEW

Older surveys have been conducted which measured mortality and morbidity nationwide. Hayes and Vaughn (1977) reported that for five years surveyed (1956, 1961, 1969, 1973, and 1974), malathion was responsible for 11 deaths due to accidental causes. Malathion ranked sixth as a cause of death for these five years, accounting for two percent of all accidental deaths related to pesticides. A survey of hospitalized pesticide poisonings in a six percent sample of the nation's hospitals estimated 66 non-occupational cases and 49 occupational cases per year over the six year period 1977-1982 (Keefe, Savage and Wheeler 1989). In this survey of hospital records, the identity of the specific pesticide was unknown in 32% of the cases, so the actual number of malathion hospitalizations was probably somewhat higher. Malathion ranked fifth as a cause of non-occupational cases and second as a cause of occupational cases in this hospital study (Blondell 1997). These rankings are primarily due to the widespread use of malathion. A survey of home use by EPA in 1976-1977 found that malathion was the ninth most common pesticide present in the home (Savage, Keefe and Wheeler 1980). A more recent survey conducted in 1990 found that malathion was the 16th most common pesticide (excluding disinfectants) present in 9.4% of all households (Whitmore et al. 1992). There was an estimated 2.4 million applications indoors and 16.6 million applications outdoors in the year prior to this survey based on respondent's recollection.

Afzaal et al. (1990) reported on a twenty-four year old woman who attempted suicide by ingesting 50 ml of malathion. She experienced abdominal pain, vomiting, breathlessness, and altered sensorium within two hours and was admitted to the hospital in a coma with pinpoint pupils. Her blood plasma cholinesterase activity was reduced to 30%. She was administered a high dose of atropine and was on a ventilator for eight days. The patient made a complete recovery.

Argiles et al. (1990) reported on a suicidal case involving a sixty-five year old white woman who was admitted to the hospital three or four hours after she ingested an estimated dose of 235 mg/kg of malathion. She experienced miosis, excessive salivation and sweating, slow heart rate, hypotension, respiratory distress, fasciculations, generalized weakness, and markedly reduced consciousness. Serum cholinesterase levels were undetectable but

she recovered with treatment after 12 days. Ten days after her ingestion, she experienced cardiac arrhythmias and her muscle strength began to deteriorate again and deep tendon reflexes were diminished. Weakness was more noticeable in the more distal muscles of the legs and she was diagnosed with peripheral neuropathy, confirmed by pathophysiological and electrophysiological studies. She started to improve after six weeks and was normal three months later. Analysis of the malathion residue identified significant amounts of an impurity from an old bottle that may have enhanced the toxicity in this case.

Baker et al. (1978) reported on an epidemic of malathion poisoning among Pakistan malaria workers. Workers who had previously used DDT were given malathion to use in its place. They were not properly warned about the dangers from poor work practices and exposure to malathion. Observation showed that some workers stayed in clothing wet with spray for days and some even mixed the formulation with their bare hand. Some of the formulations of malathion used contained high levels of isomalathion, a more toxic degradation product. Use of these formulations were correlated with more severely depressed red-cell cholinesterase. Out of 7,700 workers involved in the application for malaria control, an estimated 2,800 workers were affected. Poisoning was the suspected cause in five deaths (two mixers and three applicators). Three of the deaths were associated with normal application activities and one case resulted from eating treated food. The fifth case was poorly documented.

Burgess et al. (1990) reported on a fifty-three year old woman (weighing 51 kg) who drank an unknown quantity of malathion and was admitted to a hospital after experiencing a respiratory arrest, cyanosis, constricted pupils, urine and stool incontinence, and muscular twitching of her extremities. Her red blood cell cholinesterase was 50% below the lower end of the reference range. She required intensive treatment for ten days before recovery.

Chaudhry et al. (1998) reported an outbreak of food poisoning in India. A community kitchen with open bags of food stuffs was treated that morning with malathion spray. Sixty men aged 20-30 years attended lunch there and all developed nausea, vomiting, and abdominal pain in the next three hours. Four individuals developed muscle weakness and respiratory distress consistent with intermediate syndrome. One of the four had to be placed on

mechanical ventilation, but died from cardiac arrest after 10 days. It was later determined this patient ate more of the contaminated food than the others. Intermediate syndrome occurs 1-4 days after the initial exposure and is characterized by weakness of the proximal limb and neck muscles, motor cranial nerves, and respiratory muscles.

Dagli et al. (1983) reported on a prospective study of 75 patients, 47 women and 28 men, mostly between the ages of sixteen and thirty years old, to determine the incidence of pancreatic involvement in malathion poisoning. The cases were admitted to a general hospital with prior knowledge that they had ingested malathion. All 75 cases ingested between 2 teaspoons to two bottles of malathion in a liquid form. Forty-eight cases experienced abdominal pain, 52 cases experienced excessive salivation, forty-five cases experienced nausea and/or vomiting, thirty-one cases experienced epigastric tenderness, and eleven experienced restlessness. Out of the seventy five cases, forty-seven had raised serum amylase. Ten of the forty-seven cases had maximum serum amylase values (above 500 units) indicative of acute pancreatitis and the other 37 cases (milder elevation of amylase) may have developed mild pancreatic dysfunction and/or damage. All of the cases were treated within two hours of ingesting malathion and all of them fully recovered. The authors concluded that mild and transient pancreatic involvement in the forty-seven cases was due to malathion ingestion, but did not require special treatment.

Gallo and Lawryk (1991) reviewed the literature on accidental and intentional poisonings due to malathion. They cite a number of examples where 50% malathion used to treat head lice has led to typical poisoning symptoms in children. They suggest that certain conditions, namely unconsciousness, weakness in the limbs, convulsions, and prolonged illness, appear to be more common with malathion poisoning than with other organophosphates. Their examination of fatal and near-fatal doses in humans suggest that humans are more susceptible than the rat to malathion. Examples of this included doses ranging from 350 to 1000 mg/kg all of which proved fatal. One accidental ingestion was reported in a 75 year old man where the dose was estimated to be about 56 mg/kg. This case, reported in 1960, may be due to presence of isomalathion which would significantly potentiate the toxicity of malathion.

Grether et al. (1987) reported on a study from July 1981 through August 1982 to determine the association between exposure to low doses of malathion and the prevalence at birth of congenital anomalies and low birth weight. Malathion was applied aerially over more than 13,000 square miles in the San Francisco Bay area. Data on birth defects were obtained from hospital discharge records on 22,465 births in the exposed area. The congenital anomaly categories were not higher when exposed births were compared to unexposed births. Positive associations were found for other specific anomalies of ear (1981 only), bowing of long bones of leg (1981 only), various deformities (1981 only), clubfoot grouping (metatarsus varus excluded), and tracheoesophageal fistula (1982 only). However, further analysis of subcategories and comparisons with different years showed no consistent pattern that could be associated with malathion spraying. Low birth weight showed no significant association with malathion exposure. The authors concluded that there was no association between low dosage aerial application of malathion and the occurrence of congenital anomalies and low birth weight among liveborn infants. The study may have been confounded by misclassification of exposure status and the outcome data. About ten or fifteen percent of the exposed births were misclassified which would reduce likelihood of finding an effect of malathion exposure in the data. A similar study (available only in abstract) was based on 7,450 women registered with Kaiser-Permanente facilities (Thomas et al. 1990). This study looked at spontaneous abortions (n = 474), congenital defects (n = 163), growth retardation (n= 78), and stillbirth (n = 37). Only stillbirths and gastrointestinal defects had any marginal significance after adjustment for confounders. However, timing of exposure was not consistent with the development of this particular defect. The authors concluded "These data provide no convincing evidence that aerial spraying of malathion poses any serious risk to pregnancy."

Guillermo et al. (1988) reported on a thirty year old man who was admitted to the hospital after experiencing acute appendicitis. He was previously exposed to organophosphates during the past three years (March to May) and was seen for appendicitis after working with organophosphates for eleven weeks. He was given 100 mg of suxamethonium (neuromuscular blocking agent) to facilitate tracheal intubation and underwent surgery for forty minutes. After the initial dose of suxamethonium, the patient was not breathing on his own and received mechanical ventilation. An electromyographic

recording was taken and revealed a profound neuromuscular block. His serum cholinesterase level was only 10% of normal. Tests for genetically determined low levels of cholinesterase were negative. The authors concluded that asymptomatic persons previously exposed to organophosphates may want to have their blood cholinesterase levels in serum tested before suxamethonium is administered, which may cause apnoea.

Jusic et al. (1980) reported on 14 workers who applied a product containing malathion and trichlorfon for 4 to 6 months out of the year to kill mosquitos. A neurological examination and electromyographic neuromuscular synapse testing was performed on the 14 workers both pre-exposure and 45 days later, after their last use of the insecticide. No significant difference was seen between the two examinations. One of the 14 individuals did exhibit a cholinesterase level that was 61% of the pre-exposure value.

Manley et al. (1988) reported on a two year old male (weighing 12 kg) who ingested 30 cc of malathion. The estimated maximum dose had this been a 50% formulation and had the child weighed 12.4 kg would be 1,250 mg/kg. He was admitted to the hospital after experiencing unresponsiveness, fixed pinpoint pupils, respiratory depression, and bradycardia. The case experienced a grand mal seizures and was taken to an intensive care unit at another care facility. An intraosseous infusion was administered and discontinued when he arrived at the facility and was given an intravenous access. He was released from the hospital five days later.

Markowitz et al. (1986) investigated an incident where malathion escaped from an overheated tank at a manufacturing plant in New Jersey in 1984. A passing tanker was reportedly enveloped by the cloud of malathion. Seaman were kept below deck with the ventilation turned off when this occurred and were evacuated 40 minutes later and examined in a local hospital. Twelve days later, 22 of the 27 exposed seaman and 21 of 27 seaman from an unexposed tanker were questioned regarding symptoms and stress. Symptoms were requested since the event 12 days ago in the exposed group and over the past month in the unexposed group. The two groups were similar for demographics, social support, health rating, and knowledge of toxic chemicals. Exposed seaman reported a significantly higher percent of five of 18 symptom clusters:

1. Head effects such as headache, dizziness, blackouts or seizures.
2. Eye effects such as swelling, irritation, and blurring.
3. Nose/throat effects such as nosebleeds, stuffy nose, sore throat.
4. Digestive effects such as diarrhea, constipation, gas.
5. Changes in appetite.

On average the exposed seaman reported 6.3 symptom clusters compared to 2.1 for unexposed seaman.

Miller and Mitzel (1995) examined 37 cases of multiple chemical sensitivity associated with organophosphate or carbamate exposure. Six of these 37 (16%) were due to malathion; a number exceeded only by chlorpyrifos with 19 cases (51%) and diazinon with nine cases (24%).

Petros (1990) reported on nine cases of malathion poisoning admitted to a hospital in Ethiopia in the summer of 1986. The poisonings involved five cases of infants (ages 3, 6, and 8 months old, and two one year olds) from a low socioeconomic background and four young adolescents and adults that attempted suicide by ingestion. The children were treated with malathion by their mothers for scabies. The malathion-containing solution was applied by rubbing it into the skin over their entire body area. The children experienced productive coughing with difficulty expectorating, massive salivation, shortness of breath, altered consciousness with restlessness and part convulsion, and a case of vomiting with stool incontinence about six to twelve hours after exposure. The four adolescent and adult cases experienced severe intoxication which occurred within fifteen to thirty minutes of ingestion. All of the cases were discharged from the hospital after two to five days.

Pullicino et al. (1989) reported on a twenty-nine year old male, who experienced chronic paranoid schizophrenia for the past five years, and attempted suicide by ingesting a half-empty can of malathion. The man was unconscious upon admission to the hospital. He experienced muscle tone weakness, restlessness, aggressiveness, and ocular flutter on the second day and later developed opsoclonus (jerking eye movements) which returned to normal after two weeks. His serum pseudocholinesterase level was depressed 43% below normal on the first day and was normal on the sixth day.

Reeves et al. (1981) reported on seven cases of aplastic anemia and acute lymphoblastic leukemia in children possibly related to pesticide exposure. In one case, a twelve year old female developed aplastic anemia two weeks after exposure to malathion and died six months later. The other six cases were exposed to dichlorvos and propoxur.

Rivett and Potgieter (1987) reported on a suicide attempt involving ingestion of malathion, brodifacoum, and alcohol. The patient arrived at the hospital comatose and regained consciousness the next day. This patient experienced respiratory muscle paralysis and required mechanical ventilation for three months.

Zwiener and Ginsburg (1988) reported on 37 cases of severe toxicity in young children in Texas from organophosphates and carbamates. Two of the 37 (5%) were due to malathion. Of the 37 cases examined, 20 were transferred from other institutions and 16 of these 20 had an incorrect diagnosis initially. This finding highlights the difficulty of diagnosing organophosphate poisoning in young children. Likely there are many cases that go unrecognized.

A detailed summary of the evidence that exposure or poisoning from organophosphate insecticides can lead to chronic neurobehavioral effects can be found in the Review of Diazinon Incident Reports by Blondell and Spann (1998). This report concluded that available evidence did not support a finding that low-level exposure to organophosphates can cause neurological or neurobehavioral effects in the absence of poisoning. However, if poisoning occurs, the report concluded that some subset of organophosphate poisoned subjects probably would experience persistent neurobehavioral effects. This latter finding was supported by reviews by Karalliedde and Senanayake (1989), U.S. Congress, Office of Technology Assessment (1990), and the World Health Organization (1990).

VIII. CONCLUSIONS

Organophosphates are responsible for disproportionately more serious poisonings than other pesticides. In the 1990 survey of home and garden use (Whitmore et al. 1992, page 55 and Table G) 19% of the containers in U.S. homes were organophosphates. In the 1993 survey of non-agricultural pesticide use by certified and commercial applicators, 21% of the pounds active ingredient applied were organophosphates (Lucas et al. 1994, Table 13). Similarly, for Poison Control Centers, 15% of all unintentional pesticide exposures are due to organophosphates, but 18% of the symptomatic cases, 27% of the hospitalized cases, and 28% of the life-threatening or fatal cases were due to organophosphates (based on 1993-1996 data provided by AAPCC). National death statistics report that 40% of the accidental deaths from pesticides (where the type of pesticide is known) were due to organophosphates during the 1980s (Blondell 1997).

A similar pattern is seen in agriculture in California, where information is collected on both agricultural use and poisoning, organophosphate insecticides account for just 5% of the use (in pounds active ingredient for 1990-1994), but account for 30% of the systemic pesticide poisonings in agricultural settings (230 cases during the same time period, data provided by the California Pesticide Illness Surveillance Program). Thus, the excess risk from organophosphates for agricultural uses is six times (30/5) higher than would be expected given the percent use.

The Health Effects Division examined epidemiologic evidence linking organophosphate exposure to chronic neurobehavioral symptoms and concluded that available evidence did not support a finding that low-level exposure to organophosphates can cause neurological or neurobehavioral effects in the absence of poisoning. However, if poisoning occurs, some subset of poisoned subjects probably would experience persistent neurobehavioral effects.

The large majority of malathion incidents appear to involve minor symptoms which in many cases may be a reaction to the odor rather than cholinergic poisoning. Broken bottles and other inadequate packaging accounted for over a quarter of the cases in California from 1982 through 1995. Drift and exposure to odors was the second most common cause of incidents in California. And

again, these cases typically resulted in mild and transient symptoms.

In many cases it appears symptoms are brought on by the offensive odor of the compound. It should be recognized that individuals developing symptoms brought on by odor effects are poisonings by definition. Cholinesterase depression, though a useful indicator for exposure, does not have to be present to prove that poisoning has occurred. If odors are offensive enough to cause illness and to seek medical attention, then the circumstances that lead to such morbidity should be examined so that risk reduction measures can be identified and implemented.

More serious malathion cases typically involve application by hand or backpack sprayer and direct exposure to concentrate. Often, serious exposures result from equipment failure such as hose breaks or failure to exercise minimal precautions during maintenance or clean up. Though less hazardous than other organophosphates and carbamates on most measures, malathion had a higher incidence of life-threatening cases in Poison Control Center data for both children under age six and non-occupationally exposed adults. Extensive exposure to concentrates appears to be a likely risk factor in these cases. Follow-up on all life-threatening cases to determine the circumstances of exposure would be useful to confirm this suspicion.

Malathion applications to communities, which occur from medfly spraying and mosquito abatement, have been reported to lead to allergic or irritative symptoms in some sensitive individuals. There are several cases of asthma reactions, including two severe cases reported from California.

IX. RECOMMENDATIONS

1. A prospective epidemiologic study or statistically valid survey is recommended for the purpose of determining the extent (how common or rare), circumstances (intensity, duration, and type of exposure), and persistence and severity of chronic health effects. Study subjects should be those who experience acute adverse effects both with and without evidence of cholinesterase depression. Health effects to be surveyed include chronic neurobehavioral

effects, symptoms of peripheral neuropathy, and multiple chemical sensitivity.

2. The Health Effects Division recommends that registrant-sponsored training and education programs be developed and implemented for PCOs using malathion around homes and other structures where people are likely to be present. Training should focus on how to perform proper dilutions, avoidance of spraying around entry ways to structures or air intakes, methods to reduce drift, and proper maintenance of spray equipment to avoid failures that result in accidental exposure.

3. Labels should be amended to specify rates of application and minimum application intervals. Application rates and intervals should be based on efficacy and toxicity to humans and pets.

4. All applicators should be required to use proper eye protection when applying malathion by hand. Labels should warn about use of protective equipment when performing routine maintenance or when cleaning up spills.

5. Non-breakable packaging should be required for all malathion products. Packaging should be improved to reduce the likelihood of leaks or cracks. Clearly stated procedures should be specified on the label on how to clean up spills.

6. A pamphlet should be given to homeowners describing the application, advising on precautions, health effects including symptoms of adverse reactions, potential routes of exposure, protective measures for young children, what to do and who to contact in the event of a spill or other accident is recommended. Input from EPA, state regulatory agencies, university extension, and other interest groups should be solicited and the pamphlet field tested before being distributed.

7. HED recommends that consumers not be permitted to handle highly concentrated malathion products which must be diluted by the buyer before application. This restriction would not apply to hose-end sprayers.

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cc: Correspondence
Malathion file (chemical no. 057701)
SRRD - Susan Jennings (7508W)
HED - Diana Locke

RDI: BRSrSci:SHummel: