

# Acute Organophosphate Poisonings in Washington Apple Orchards

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## Abstract

*During the summer of 1993, a major problem with the organophosphate insecticide, mevinphos (Phosdrin), occurred in Washington state apple orchards. At least 27 individuals required emergency room treatment or hospitalization from June 13, 1993, through August 18, 1993. Cases were identified and investigated through the state's pesticide surveillance program.*

*This paper discusses the pesticide reporting system in Washington which has been in existence since 1990. It describes the toxicology of mevinphos and how its use in orchards created an environment conducive to human poisonings. Finally, it illustrates how a coordinated agency response eventually led to the suspension of mevinphos use on tree fruits and to better protection of the public health.*

## Introduction

The Washington State Department of Health (DOH) instituted a pesticide surveillance program in 1990. The DOH role as defined by mandate is to:

- investigate all suspected cases of human pesticide poisoning;
- establish procedures to prevent the recurrence of poisonings;
- notify other regulatory agencies of the results of investigations; and,
- educate and alert healthcare providers regarding recognition and management of pesticide poisonings.

Since 1990, reporting systems have been established between DOH and the Washington Poison Center (WPC), the Department of Labor and Industries (L&I), the Washington State Department of Agriculture (WSDA), and healthcare providers. These reporting relationships have increased the number of DOH case investigations from 281 in 1991 to 365 in 1992 and 632 in 1993.

During an investigation, DOH staff interview claimants, healthcare providers, and employers. Medical and spray records are obtained and reviewed to assist with case determinations. Evidence of exposure, such as contaminated clothing, is collected and analyzed, if possible. After DOH completes an investigation, a decision is made regard-

ing the relationship between the illness and the pesticide exposure. Table 1 shows the eight classifications used by DOH to characterize case investigations. Since 1991, approximately 50% to 60% of case investigations have been determined to have a definite, probable, or possible relationship to pesticides.

During the summer of 1993, the effectiveness of Washington's surveillance system was tested when the organophosphate (OP) insecticide, mevinphos (Phosdrin), was selected for use in apple orchards. This event and the subsequent poisonings highlighted the importance of the DOH's surveillance program and illustrated how agency coordination can lead to better protection of the public health.

## The "Minor Use" Crop Dilemma

"Minor use" refers to a pesticide use on a crop which does not provide sufficient profit for the pesticide registrant to justify the expense of registration of the pesticide for such use. Registration requirements are mandated by the Federal Insecticide Fungicide and Rodenticide Act (FIFRA). In 1984 and 1988, FIFRA increased the data requirements for registration of new pesticides and re-registration of older products. These amendments dramatically increased the cost of registering

new products and re-registering older ones, thus affecting the availability of some pesticides (1).

Washington ranks third in the United States in production value of minor crops (over 230 at present). Of the top ten crops grown in Washington, wheat is the only one which is considered a major crop. Because Washington agriculture is dominated by minor crops, current federal registration and re-registration requirements have dramatically affected the pesticides available to growers. For the Washington apple grower the impact of the FIFRA regulations hit home during the summer of 1993 when aphid infestations became a problem requiring treatment. Aphids produce a sticky excrement (called honeydew) which can buildup on the outside of the fruit. This honeydew makes it difficult to work in the trees and provides a medium for the growth of mold. The preferred pesticide for aphid control was phosphamidon (Dimecron). However, the previous year the manufacturer of phosphamidon chose not to re-register its use in orchards because it was no longer cost effective to do so. After this voluntary cancellation, many Washington orchardists resorted to a more toxic alternative, mevinphos, for aphid control.

## The Toxicology of Mevinphos

The U.S. Environmental Protection Agency (EPA) has established toxicity categories for pesticides reflecting the Lethal Dose<sub>50</sub> (LD<sub>50</sub>) which is the lethal dose for 50% of test animals. Pesticide labels contain signal words based on the relative LD<sub>50</sub> of the active ingredients. Table 2 shows how these categories are defined and what signal word appears on the pesticide label (2). For example, *Danger-Poison* on a label designates the most toxic class and is often accompanied by a skull and crossbones.

Mevinphos is a Category I organophosphate (OP) which had not been used in Washington apple orchards for years. It is a

**Table 1. Washington Department of Health Pesticide Incident Relationship Classifications.**

<b>Definite</b>	High degree of correlation between pattern of exposure and resulting symptomatology. Requires in most cases both medical evidence (cholinesterase, serum, or urinary metabolites, allergy tests, etc.) and physical evidence (foliar samples, work history, noticeable spill on clothing, etc.) to support the conclusions.
<b>Probable</b>	Relatively high degree of correlation exists between the pattern of exposure and the illness/injury experienced. Medical and/or physical evidence unavailable or inconclusive.
<b>Possible</b>	Some degree of correlation evident. Work history and/or application history ambiguous.
<b>Unlikely</b>	A correlation cannot be ruled out absolutely. Work history and/or application history ambiguous.
<b>Unrelated</b>	Definite evidence of cause other than pesticide exposure.
<b>Asymptomatic</b>	Exposure occurred, but did not result in illness/injury.
<b>Indirect</b>	Pesticide exposure is not responsible, but pesticide regulation contributed in some way (e.g., heat stress while wearing chemical resistant clothing).
<b>Unknown</b>	There is insufficient information available to be able to classify in one of the above categories.

direct and potent cholinesterase inhibitor and is lethal at low doses. Mevinphos is readily absorbed through the skin. Dermal absorption of even a small amount of the concentrate requires immediate medical attention. Table 3 compares the oral and dermal LD<sub>50</sub> of a single rat dose for mevinphos and three other OPs which have commonly been used in apple orchards—ethyl parathion, azinphos methyl, and phosphamidon. Of these four OPs, mevinphos is most acutely toxic. Ethyl parathion was banned from orchard use by the EPA in 1991 because of unacceptable incidence of human illness. Azinphos methyl is widely used in Washington orchards but has not been associated with any life-threatening poisonings or hospitalizations since the state surveillance system began in 1990. When mevinphos is compared to phosphamidon, the insecticide it largely replaced in 1993, animal toxicity studies show it to be five times more toxic via the oral route of exposure, and 20 times more toxic via the dermal route.

When AMVAC Chemical Corporation (AMVAC), the registrant of mevinphos, learned that their highly toxic products,

Phosdrin IPA 4 and Phosdrin 4 EC, would be widely used by apple growers in 1993, the company asked WSDA to require additional safety measures. Emergency rules were adopted as of June 14, 1993. These rules required the following:

- an observer be present during mixing and loading activities to assist in the event of a spill or other inadvertent exposure;
- the restricted entry interval (REI) be extended from 48 to 96 hours (the REI is the time period between the application of a pesticide and when it is considered safe for workers to return to the treated site without protective clothing or equipment);
- safety training be required for mevinphos handlers; and
- warning signs be posted in all treated orchards.

DOH first became aware of a problem with this product in mid-July, when four workers from the same orchard operation developed symptoms after mixing or spraying mevinphos. Two of these workers were admitted to the hospital and two received care at an emergency room (ER). Of the three tested, all had significant depression of blood cholinesterase activity. In the next

five days, five additional cases of mevinphos-related illness were reported to DOH. DOH contacted WSDA about the poisonings and conducted a retrospective review of its 1993 database to determine if any mevinphos cases had occurred earlier in the summer.

### **Case Descriptions**

#### Source of DOH Reports

Table 4 provides a summary of 27 mevinphos cases identified by DOH between June 14 and August 19, 1993. (There were originally 28 reports, but one could not be investigated because of insufficient information.) Thirteen reports were received from L&I worker compensation claims, eight were received from WPC, four came directly from healthcare providers, and three were received from other sources. Many cases were reported by more than one source.

WPC and healthcare providers reported cases to DOH within five days of the incident, but L&I claims were typically received 16-29 days after the incident, with one reported 73 days after the event because of a delay in claims processing. In addition, several cases were not known to

**Table 2. Toxicity Categories for Pesticides (2).**

	Toxicity Categories (Signal Words)			
	I (Danger-Poison)	II (Warning)	III (Caution)	IV (Caution)
Oral LD <sub>50</sub>	Up to and including 50 mg/kg	From 50-500 mg/kg	From 500-5000 mg/kg	Greater than 5000 mg/kg
Inhalation LD <sub>50</sub>	Up to and including 0.2 mg/liter	From 0.2-2 mg/liter	From 2-20 mg/liter	Greater than 20 mg/liter
Dermal LD <sub>50</sub>	Up to and including 200 mg/kg	From 200-2000 mg/kg	From 2000-20,000 mg/kg	Greater than 20,000 mg/kg
Eye effects	Corrosive; corneal opacity not reversible within 7 days	Corneal opacity reversible within 7 days; irritation persisting for 7 days	No corneal opacity; irritation reversible within 7 days	No irritation
Skin effects	Corrosive	Severe irritation at 72 hours	Moderate irritation at 72 hours	Mild or slight irritation at 72 hours

**Table 3. Category I Organophosphates Used in Washington Apple Orchards (3).**

Single Dose Organophosphate	Oral LD <sub>50</sub> mg/kg* (Rat)	Dermal LD <sub>50</sub> mg/kg (Rat)
Mevinphos	3.7 - 7.0	4.2 - 4.7
Ethyl parathion	3.6 - 30	8 - 21
Azinphos methyl	11 - 26	90 - 220
Phosphamidon	24	107 - 143

\*LD<sub>50</sub> is the lethal dose for 50% of test population expressed as mg of pesticide/kg body weight of the test animal.

be mevinphos related until spray records were obtained weeks after the exposure. Subsequently, the extent of the mevinphos problem was not fully recognized. Adoption of effective preventive action was delayed, and exposure continued.

**Demographics**

From the 27 cases reported, ages ranged from 19-72 years with a median age of 35. Nineteen workers (70%) were Hispanic, and eight (30%) were non-Hispanic whites. Twenty-six were male, one was female. All incidents occurred in eastern Washington apple orchards.

**Exposure Activity**

Twenty-three of the 27 cases (85%) were exposed while mixing, loading, or applying mevinphos. Twenty-two of these were working on ground applications using an air blast system, one was involved in an aerial application.

Four of the cases reported exposure to mevinphos residues while working either in or adjacent to recently treated orchards. Two of these were drilling an irrigation well at the edge of an orchard within two hours of an application. Another worker was exposed by briefly entering a treated area three times within 24 hours of an

application. The fourth case of illness reportedly occurred when an apple tree thinner worked the same morning mevinphos was applied; however, the exact location of her work site relative to the treated area could not be identified. In all four cases, workers entered treated areas before the mandated 96-hour REI had expired.

Twenty-one of the 27 cases involved exposures to mevinphos in combination with less acutely toxic organophosphates. Azinphos methyl was most commonly used (14 cases).

**Symptoms and Treatment**

All 23 workers exposed during mixing, loading, and applying sought medical attention in ERs. Two cases involved only conjunctivitis or temporary miosis (pupillary constriction) secondary to direct eye exposure. The remaining 21 cases exhibited symptoms characteristic of systemic OP poisoning (see Table 4): nausea (81%), vomiting (62%), dizziness (43%), visual disturbances (43%), weakness (38%), abdominal pain (29%), headache (24%), sweating (24%), and excessive salivation (5%). Seven workers were hospitalized, four of them in intensive care.

Fourteen of the 16 cases (88%) tested for plasma and/or red blood cell (RBC)

**Table 4. Department of Health Phosdrin Case Summary, 1993.**

Date of Incident	Work Activity	Age/Gender/Race	Vomiting	Nausea	Dizziness	Weakness	Visual Disturbance	Miosis	Headache	Abdominal pain	Diarrhea	"Funny Taste"	Shortness of Breath	Hypersecretion	Treatment Type	%RBC AChE Depr.	%Plasma ChE Depr.	L&I Claim Paid?	DOH Finding
6/13	Mixer	30MW	x	x	x	x				x				x	Admit ER	-	25%	yes	def
6/13	Sprayer	30MH	x	x	x	x				x					ER	-	-	yes	def
6/18	Sprayer	30MH	x	x	x	x									ER	41%	-	yes	def
6/18	Sprayer	29MH	x	x	x	x		x						x	Admit ER	6%	-	yes	def
7/7	Mixer	53MH	x	x										x	ER	75%	97%	yes	def
7/7	Thinner	39FH	x					x							ER	-	-	yes	unk
7/8	Well Dr	24MW	x	x						x	x				ER	WNL	WNL	yes	pro
7/8	Well Dr	34MW	x						x						ER	WNL	WNL	N/A	pos
7/8	Sprayer	39MH	x	x	x	x		x							ER	-	-	yes	def
7/10	Sprayer	44MH	x	x				x					x		Admit ER	71%	58%	yes	def
7/12	Mix/spr	19MH	x				x		x						ER	43%	64%	yes	def
7/13	Mixer	31MH		x				x					x		ER	-	-	yes	def
7/19	Mixer	28MH	x	x	x			x	x						ICU	-	56%	yes	def
7/19	Mixer	20MH	x	x	x		x								ER	57%	-	yes	def
7/20	Sprayer	27MH	x					x				x			ER	-	-	yes	def
7/21	Mixer	47MH	x	x			x	x		x			x		ICU	54%	76%	yes	def
7/22	Sprayer	41MH	x	x	x	x		x		x					ER	28%	-	yes	def
7/22	Sprayer	68MW	x	x			x	x			x		x		ICU	51%	WNL	yes	def
7/27	Sprayer	24MH	x	x	x	x		x							ER	8%	WNL	yes	def
7/29	Sprayer	72MW	x		x										ER	59%	42%	yes	pro
7/29	Sprayer	23MH	x	x	x	x				x					ER	50%	59%	yes	def
8/3	Observer	38MW						x							ER	-	-	yes	pro
8/7	Sprayer	31MH	x	x	x										ER	90%	-	yes	def
8/7	Mixer	23MW													ER	-	-	yes	def
8/12	Reentry	32MH	x	x	x		x	x		x					ER	WNL	WNL	yes	pro
8/12	Mixer	25MH	x	x				x							ER	62%	76%	yes	def
8/18	Mixer	57MW	x				x						x		ICU	-	47%	yes	def

Race: W = non-Hispanic white, H = Hispanic

% RBC acetylcholinesterase depression: calculated as % lowest normal lab value

% plasma cholinesterase depression: calculated as % of lowest normal lab value

DOH Finding: def = definite, pro = probable, pos = possible, unk = unknown

ER = emergency room

ICU = intensive care unit

WNL = within normal limits

cholinesterase (ChE) activity showed depressions of at least 25%, including three workers with 75%-90% depressions and one worker with 97% depression in RBC cholinesterase activity. DOH calculated the percent of depression based on the lowest normal laboratory value. Since no baseline tests were available for comparison, the depressions in ChE are probably underestimates of actual depression.

Intravenous doses of atropine ranging from 2-10 mg were administered to all seven hospitalized cases. Atropine ( $\leq 2$  mg)

was given to four of the 14 cases who were treated in the ER and released. Two of those receiving intensive care were coworkers in the same orchard; the other five hospitalized cases worked in five different orchards. Of the hospitalized cases, four were mixing and three were spraying mevinphos.

The three workers who had documented entries into recently treated areas exhibited mild symptoms consistent with systemic OP poisoning. All received ER care. Two of the three were tested for blood cholinesterase activity and had normal results. None

received atropine.

### Factors Contributing to Mevinphos Poisonings

Follow-up interviews conducted by DOH, WSDA, and L&I revealed that personal protective equipment (PPE) had been available to all mixers, loaders, and applicators. However, reports indicated the label requirements for use of protective equipment had not always been observed. Examples included removal of respirator, gloves, or goggles during pesticide handling and the use of leather rather than rubber boots.

Other factors which contributed to the incidents included:

- lack of proper supervision by licensed applicators;
- deficient hazard communication and training;
- poor respirator maintenance;
- lack of awareness of the extreme toxicity of mevinphos on the part of handlers;
- no recent experience in apple orchards handling a product as toxic as mevinphos; and
- use of air blast pesticide sprayers which contributed to dermal exposure despite PPE.

In several incidents where workers developed severe symptoms, WSDA investigators could find no apparent violations of the label or WSDA emergency rules. This suggested label language and rules may not have been protective enough for the use of mevinphos in orchards.

### Agency Response

Three state agencies joined efforts to identify and resolve the problems with mevinphos-related illnesses. In addition, the Washington State University Extension Office provided rapid dissemination of information to growers and conducted a risk benefit analysis of mevinphos use in Washington. The following is a brief description of each agency's role and actions taken.

Washington State Department of Agriculture was the lead agency in investigating violations of the mevinphos label, implementing emergency rules, and in changing regulations to protect human and environmental health.

At the registrant's request, WSDA had adopted additional safety restrictions for mevinphos use on tree fruits on June 14, 1993. When it became clear that mevinphos usage in apple orchards was causing ill-

ness, WSDA passed further restrictions effective August 19, 1993. These rules required dealers to provide a copy of the rules to purchasers of mevinphos and required all mixing, loading, and applying of mevinphos to be done by trained certified pesticide applicators. In addition, safety alerts about the hazards of mevinphos were issued to the general public, growers, and farmworkers. On August 30, 1993, emergency rules were implemented which placed a temporary ban on the use of mevinphos in orchards throughout the state of Washington. No incidents of mevinphos-related illness were reported after August 19. In early 1994, WSDA banned the use of mevinphos on tree fruits and allowed continued use on peas and selected seed and vegetables crops. Although all WSDA investigations have been completed, final legal decisions regarding violations and penalties are still pending.

*Labor and Industries* processed worker compensation claims related to mevinphos and investigated worker complaints regarding lack of safety at work sites. In addition, L&I referred all pesticide-related claims to DOH for further investigation.

Twenty-four out of 25 claims filed were compensated at a cost of almost \$45,000. Six claims involved time-loss, 18 involved benefits for medical treatment only, and one claim was rejected because the worker moved before processing was completed. Nine of the claims (36%) came from three farms; the remaining 16 claims came from separate farms.

The Safety and Health Division of L&I investigated complaints involving mevinphos. At one farm where four of the poisonings occurred, the employer was assessed an \$8,125 fine for the following citations: lack of adequate respirator training; lack of respirator fit-testing; failure to provide direct supervision of mevinphos handling by a certified applicator; inadequate hazard communication program; and failure to promptly transport a poisoned worker to a medical facility. The company appealed and a hearing has been scheduled with the Board of Industrial Insurance Appeals.

*Department of Health* investigated all reported cases of illness, alerted ERs and clinics to the problem, assisted WSDA in defining the extent of the outbreak, and collaborated on strategies for preventing

future cases of mevinphos poisoning.

Of the 27 cases investigated, 21 were classified as definitely related to the pesticide exposure, four were probable, one possible, and one was unknown (Table 1). In situations in which more than one organophosphate was involved, it was difficult to determine conclusively that mevinphos was the sole cause of illness. Definite cases had a confirmed exposure to mevinphos; displayed signs or symptoms consistent with OP exposure; had documented depressions in blood cholinesterase of at least 25%; and/or responded well to the antidote atropine. Cases classified as probable had the same high correlation between pesticide exposure and symptoms, but lacked conclusive medical or physical evidence.

DOH's database on pesticide poisoning incidents was used to determine that mevinphos-related illnesses were continuing to occur despite additional safety restrictions, and some of the illnesses were serious enough to require hospitalization. DOH's data also indicated illnesses were: not formulation specific but associated with both mevinphos products being used; occurring only in apple orchards in eastern Washington; and primarily seen in mevinphos mixers, loaders, and ground sprayers.

The directors of DOH, WSDA, and L&I also collaborated and wrote the governor urging an emergency suspension of mevinphos use in orchards. In addition, DOH and L&I prepared and presented testimony at public hearings sponsored by WSDA.

### **Implications for Agency Coordination**

The mevinphos outbreak illustrated the need for agencies to continually evaluate the effectiveness of coordination and highlighted areas for improvement. The primary problem identified during the mevinphos incident was delay in reporting between agencies. In some cases, regulatory agencies may have been able to prove violations had they been notified earlier.

Initially, there was a brief, all-too-human desire on the part of staff to blame other agencies for delays and misunderstandings. DOH felt WSDA should have notified them of the potential problems with mevinphos when the manufacturer, AMVAC, first requested additional safety precautions. Once

cases began to occur, WSDA believed DOH should have reported to them, as well as L&I. L&I had primary responsibility for regulating the PPE, while WSDA enforced the pesticide label, which also mandates appropriate PPE. This overlap in regulatory authority illustrated some previously unrecognized confusion on the part of DOH regarding WSDA and L&I roles.

To improve coordination, roles were clarified, mechanisms were established to routinely share information, and all agencies were kept fully informed of the extent of the problem. This eliminated finger pointing and promoted better collaboration on prevention strategies.

After the outbreak, some of the factors which led to delays were identified as follows.

### Source of Reports

Reporting of industrial insurance claims to DOH dramatically increased the number of known mevinphos poisonings and helped to define the extent of the problem. However, had cases been reported directly by healthcare providers within 48 hours as mandated, DOH could have identified the problem more rapidly. Strategies must be developed to improve recognition, treatment, and reporting of pesticide-related illnesses. To this end, DOH has recently hired additional staff to conduct outreach and education for healthcare providers.

### Record Retrieval

Additional delays occurred after requesting medical and spray records. DOH relies on spray records to determine and/or confirm the pesticide(s) involved, and uses information in medical records to evaluate cases. After DOH requested records, it took days or months to receive them. In particular, medical record departments do not have deadlines for responding to records requests. This created significant delays in case confirmation and reporting to WSDA.

### Farmworker Concerns

Many farmworkers are reluctant to report violations to WSDA or L&I because they fear employer reprisal. Therefore, these agencies depend on DOH for information regarding potential violations. During the mevinphos outbreak, DOH investigators needed to respect workers' rights to privacy, and yet regulatory agencies needed information to prevent future infractions.

Based on the mevinphos episode, DOH developed a written policy regarding hospitalized cases. Any case serious enough to require hospitalization is immediately reported as a formal complaint to WSDA and L&I. This rapid notification of enforcement agencies in serious cases should lead to better protection of the public health.

### Conclusion

It is sometimes difficult to balance the need to protect farmworkers from exposure to hazardous pesticides, and provide growers access to critical uses of farm chemicals. However, the risks associated with the use of mevinphos in Washington apple orchards were well documented during the summer of 1993, and clearly posed an unacceptable health hazard.

Occupational poisonings with mevinphos (including fatalities) had been previously reported in California and Florida (4,5). These experiences, along with those of Washington, received national attention.

On June 30, 1994, AMVAC requested a voluntary cancellation of mevinphos from EPA. Dealers were allowed to distribute existing stocks of mevinphos products manufactured prior to June 30 until December 31, 1994. Mevinphos products could originally be used through February 28, 1995. However, on January 13, 1995, AMVAC and the EPA renegotiated and the distribution, sale, and use of mevinphos was allowed until November 20, 1995. The following reasons were given for this extension.

- 1) Existing stocks of mevinphos had not been used as expected. An extension of sale and use was the safest way to clean up the inventory in the hands of distributors, dealers, and growers.
- 2) More time was required to develop alternative pest-management programs.
- 3) The registration of replacement chemistry had not occurred, and growers who relied on mevinphos would suffer serious economic hardship (6).

Although mevinphos may be allowed by the EPA, WSDA still prohibits its use in the state of Washington. Mevinphos will not return to Washington orchards, although concern exists that a special exemption for its use may be requested by pea and vegetable seed growers. DOH has written EPA urging the prompt review of safe and effective alternatives for these crops.

If the 1993 mevinphos poisonings had occurred prior to the establishment of Washington's pesticide surveillance program, it is difficult to hypothesize how accurately and quickly cases would have been documented. The reporting relationships which were in place with other agencies and healthcare providers ensured notification of DOH and prompt investigations. The information gathered from this basic public health assessment activity formed the basis for policy development by regulatory agencies at the state and national levels. Through this coordinated response, better protection of the public's health occurred.

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