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Pesticide Poisoning: Managing Risk and Recognizing Signs and Symptoms

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The potential for accidents with pesticides is real. Accidental exposure to pesticides can have serious consequences. While most pesticides pose relatively little risk to humans when their label directions are followed, some are extremely toxic and require special precautions.

American Poison Centers receive an average of 80,000 calls each year related to pesticide exposures, or one call every 6.5 minutes. Pesticides are involved in about 3 percent of all accidental exposures to children age 5 years and younger and about the same percentage of accidental exposures to adults. On average, one child death reported to the Poison Centers each year involves pesticide exposure.

Did You Know?

'Pesticide' is an umbrella term that includes herbicides, insecticides, fungicides, fumigants, antimicrobials, and more. Legally speaking, a pesticide is any "substance or mixture of substances intended to prevent, destroy, repel, or mitigate any pest" or "intended for use as a plant regulator, defoliant, or desiccant."

Routes of Exposure

Pesticides can enter the human body by three routes:

1. absorption through the skin or eyes (**dermal exposure**);
2. ingestion through the mouth (**oral exposure**); and
3. inhalation into the lungs (**respiratory exposure**).

Dermal exposure results in absorption immediately after a pesticide contacts the skin or eyes. Absorption will continue as long as the pesticide remains in contact with the skin or eyes. The rate at which dermal absorption occurs is different for each part of the body *(Figure 1)*. Maiback and Feldman (1974) measured the amount of the pesticide parathion absorbed by different parts of the human body over 24 hours. The forearm, which absorbed the least parathion, was assigned a '1' and became the baseline. An area that absorbed twice as much parathion as the forearm would be assigned a '2,' three times as much, a '3,' etc.

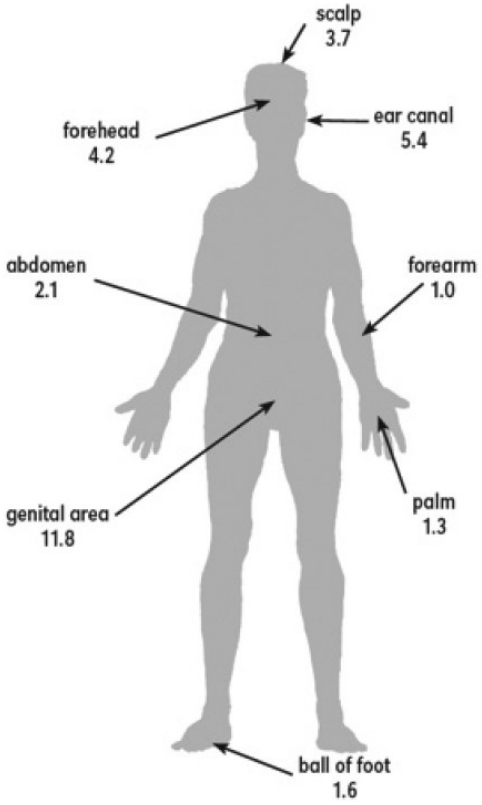

Figure 1. Relative dermal pesticide absorption rates for various parts of the body.

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It is easy to transfer pesticide residues from one part of the body to another part that is more absorptive. For example, an applicator who wipes their brow or uses the toilet during work may unintentionally transfer residue from their hands (1.3) to their forehead (4.2) or genital area (11.8). When this occurs, the applicator increases their potential for pesticide poisoning.

Oral exposure may result in serious illness, severe injury, or even death. Pesticides can be ingested by accident, through carelessness, or intentionally. For example, oral exposure may occur when an applicator neglects to wash their hands after using pesticides and then eats food or uses tobacco, transferring residue from their hands to their mouth. Large oral exposures often occur after a pesticide is taken from its original container and put into an unlabeled bottle, jar, or food container. A pesticide stored in a food or beverage container can be especially inviting to a child. When pesticides are stored properly, children should not be able to access them.

Table I. Basic toxicity profile of carbaryl (active ingredient in Sevin® and other insecticide products).

Toxicity Type	Caused By	Route of Exposure	Toxicity Level	Health Effects	Sign/ Symptom Development
Acute toxicity*	A single exposure, or multiple in a short time	Dermal	Slightly toxic (III)	Muscle weakness, dizziness, sweating, blurred vision, slurred speech, seizures, cardiopulmonary depression, coma†	Minutes, hours, or days
		Oral	Moderately toxic (II)		Minutes, hours, or days
		Respiratory	Relatively nontoxic (IV)		Minutes, hours, or days
Chronic toxicity	Repeated low-level exposure	Any or unknown	--	Not fully understood. Possible *in vitro* mutagenicity, possible carcinogenicity, other effects possible	Months, years, or decades

*The acute toxicity levels shown in this table are for carbaryl *by itself*. End-use pesticide products containing carbaryl may have different acute toxicity levels than those shown because they contain varying concentrations of carbaryl combined with other (active or inert) ingredients.

† Severe health effects are most likely from oral exposure and/or from large-dose exposures.

Inhalation or respiratory exposure is particularly hazardous because the lungs can rapidly absorb pesticides into the bloodstream. Some pesticides can cause serious damage to the nose, throat, and lung tissue if inhaled in sufficient amounts. Vapors and very small particles pose the most serious risks.

Both dry and liquid pesticides can be respiratory hazards. Concentrated wettable powders are easily inhaled prior to being mixed with water. The risk of inhaling pesticide spray droplets is usually low when using low-pressure application equipment. This is because most of the spray droplets produced are too large to remain airborne long enough to be inhaled. However, the risk of respiratory exposure increases when using high-pressure, ultra-low volume (ULV), or fogging equipment. Droplets produced during these operations are tiny and can hang in the air or be carried on air currents for considerable distances.

Follow these guidelines to reduce the risk of pesticide exposure at home and/or at work:

- Always store pesticides in their original labeled containers.
- Never use your mouth to clear a spray hose or nozzle, or to begin siphoning a pesticide.
- Always leave the work area and wash thoroughly before eating, drinking, using tobacco, or using the toilet.
- Read the pesticide label and wear the appropriate clothing and personal protective equipment (PPE) while handling pesticides. A pesticide product's label lists the product's potential health effects on humans and indicates whether these effects are likely to result from oral, dermal, or respiratory exposure.

Pesticide Toxicity

All pesticides are toxic to humans, but their *levels of toxicity* and the *ways in which they are toxic* vary widely. For example, *Table I* shows various ways in which the Environmental Protection Agency (EPA) assesses a pesticide active ingredient's toxicity, in this case for the active ingredient carbaryl. Note that we can broadly classify toxicity as either acute or chronic.

Acute toxicity of a pesticide refers to the effect from a single exposure or repeated exposure over a short time. These effects appear within minutes, hours, or days of the exposure. A pesticide with high acute toxicity can be deadly even if the body absorbs only a small amount. However, a pesticide may be more acutely toxic by one route of exposure than by another. In *Table I*, we can see that carbaryl is more toxic to humans when ingested (oral exposure) than when inhaled (respiratory exposure). These findings determine the safety requirements and information that must appear on the labels of products that contain carbaryl.

Chronic toxicity of a pesticide refers to the effects of long-term or repeated low-level exposure. These effects do not appear immediately after the exposure(s): Years may

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pass before signs and symptoms develop. For this reason, it is much more difficult to assess a pesticide's chronic toxicity than its acute toxicity. Potential health effects related to chronic pesticide toxicity include:

- cancers;
- tumors (not necessarily cancerous);
- chronic illnesses;
- genetic changes;
- disruption of the endocrine system (glands that produce hormones to regulate many bodily functions);
- birth defects (following exposure of a pregnant person);
- reproductive disorders;
- liver damage;
- nerve damage; and
- sensitization or allergic reactions.

Repeated exposure to pesticides due to misuse or careless handling practices can greatly increase the risk of adverse long-term health effects.

Measuring Acute Toxicity

Assessing a pesticide's acute toxicity is not easy. Human test subjects cannot be used due to the risks involved. Therefore, researchers have historically used animals such as rats to estimate a pesticide's acute toxicity to humans.

An LD50 (lethal dose, 50 percent) describes the dose of a pesticide that will kill half of a group of test animals from a single exposure by a specified route of exposure. The LD50 is expressed as an amount of pesticide per unit of body mass (usually mg/kg). the smaller the LD50 number, the more toxic the pesticide is. For example, a pesticide with an oral LD50 of 10 mg/kg is much more toxic than a pesticide with an oral LD50 of 1,000 mg/kg.

In recent years, the EPA has prioritized a shift to toxicity-assessment methods that do not involve the use of test animals. These methods typically rely on computational modeling and existing data.

Signal Words

All pesticides (and practically any other substance known to humans) can be acutely toxic to humans in large enough doses. The vast majority of pesticide product labels carry one of three signal words that clearly indicate the degree of acute human toxicity associated with a given product *(Table II)*. (Note that the signal word "Caution" is not required to appear on the label of a relatively nontoxic pesticide, but it is required for slightly toxic pesticides.)

Table II. Signal words and relative acute toxicities used on pesticide product labels.

Toxicity Category	Signal Word	Toxicity Rating	Oral Lethal Dose (for a 150-lb. Human[a])
I	Danger[b]	Highly toxic	Few drops to 1 tsp
II	Warning	Moderately toxic	1 tsp to 1 Tbsp
III	Caution	Slightly toxic	1 Tbsp to a pint
IV	Caution (signal word optional)	Relatively nontoxic	More than a pint

[a]For a child or person under 150 lbs., the lethal dose is smaller than what is listed.

[b]The skull and crossbones symbol and the word "Poison" are sometimes printed with the signal word "Danger."

Read the Pesticide Label

Pesticide labels also include 'route-of-entry' statements accompanied by specific actions the applicator must take to avoid exposure. Route-of-entry statements indicate which routes of exposure are likely to result in negative health effects. For example, the pesticide label for Sevin® 5 RTU (active ingredient: carbaryl) reads, "*Harmful if swallowed. Harmful if absorbed through skin*." This indicates that the pesticide is a potential hazard through the oral and dermal routes of exposure but not the respiratory route. Specific action statements normally follow the route-of-entry statements and indicate what the applicator must do to prevent poisoning accidents. In the case of the product Sevin® 5 RTU, the specific action statements read, "*Avoid contact with eyes, skin, or clothing. Wash thoroughly with soap and water before eating, drinking, chewing gum, or using tobacco*."

These statements usually appear next to a label's first aid instructions *(Figure 2)*. Read the label's first aid instructions carefully before using the pesticide so you know what to do if accidental exposure occurs. By following instructions carefully, you will help limit the amount of exposure you or the victim receive after initial pesticide contact.

Another important section on a pesticide label provides instructions for pesticide applicators and other handlers on the use of PPE to help them limit their pesticide exposure. It lists specific protective clothing and equipment requirements. For example, the label for a moderately toxic pesticide might read, "*Applicators and other handlers must wear long-sleeved shirts and long pants, shoes plus socks, protective eyewear, and chemical-resistant gloves*."

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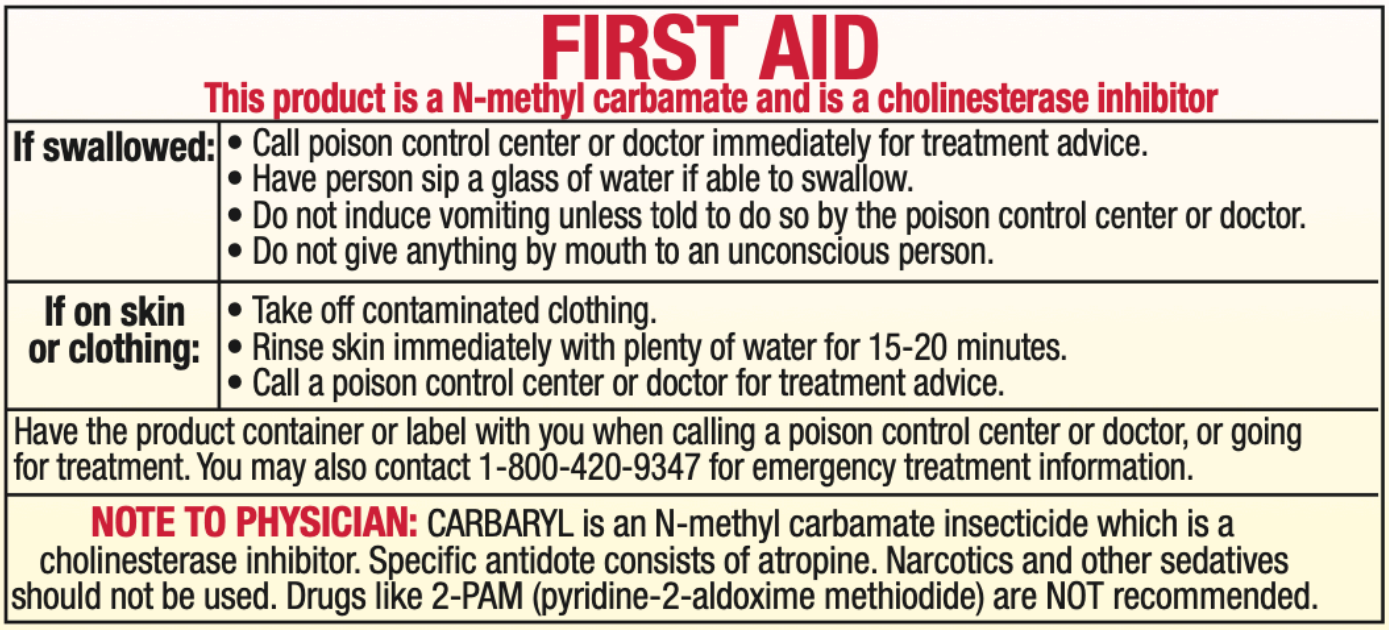

FIRST AID

This product is a N-methyl carbamate and is a cholinesterase inhibitor

If swallowed:	• Call poison control center or doctor immediately for treatment advice. • Have person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by the poison control center or doctor. • Do not give anything by mouth to an unconscious person.
If on skin or clothing:	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-800-420-9347 for emergency treatment information.

NOTE TO PHYSICIAN: CARBARYL is an N-methyl carbamate insecticide which is a cholinesterase inhibitor. Specific antidote consists of atropine. Narcotics and other sedatives should not be used. Drugs like 2-PAM (pyridine-2-aldoxime methiodide) are NOT recommended.

Figure 2. First aid statement from Sevin® 5 RTU label.

Manage Your Risk

Wear PPE required by the label when handling or applying pesticides to reduce your risk of pesticide exposure. If no requirements are listed, wear the following: a long-sleeved shirt, long pants, shoes, socks, and chemical-resistant gloves. Your **risk** of pesticide poisoning is directly related to the toxicity of the pesticide you are using and your level of exposure to it. This relationship is expressed by the Risk Formula:

Risk = Toxicity x Exposure.

Understanding pesticide product toxicity and the potential for personal exposure will help lower your risk. No matter how toxic a pesticide is, you can keep risk at an acceptably low level by minimizing your body's exposure to it. Likewise, while you cannot change a pesticide's toxicity, you can reduce your risk by selecting an alternative, less-toxic pesticide that is still suitable for the job at hand. For example, if two herbicide products are suitable for your weed management needs but one carries the "Caution" signal word and the other carries "Warning," select the "Caution" product to reduce your poisoning risk.

Recognizing Signs and Symptoms of Poisoning

Anyone who uses pesticides or may otherwise be exposed to them should be aware of the signs and symptoms of pesticide poisoning. Signs, such as vomiting, sweating, and pinpoint pupils, can be observed by others. Symptoms are any changes in normal condition that can be described by the victim of poisoning, including nausea, headache, weakness, dizziness, and others. Knowing these signs and symptoms will allow for prompt treatment and help prevent serious injury. People who are frequently involved with pesticides should be prepared to take the following steps.

Many people focus their concerns on the immediate effects of a pesticide exposure (acute toxicity). While this is important, realize that we might not understand or see chronic effects of some pesticides for years, if not decades. Since you cannot go back in time to reduce exposure and the chronic effects that could result, the most powerful action an applicator can take is to prevent chronic effects by acting today. Go overboard in protecting yourself from exposure, not just because the label tells you to, but because you can't predict which pesticide will result in a chronic disease in the future. Act today to protect yourself from all pesticide exposures.

1. Become familiar with the signs and symptoms of pesticide poisoning for the pesticides you most commonly use or encounter. Often, pesticide poisoning symptoms resemble flu symptoms.
2. If you suspect poisoning due to a pesticide, get immediate help from a local hospital, physician, or the Poison Center (800-222-1222). Provide responders with the product's EPA registration number and active ingredient(s), both of which are listed on the label.
3. Perform first aid according to label directions until help arrives or the victim can be taken to the hospital.

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4. Have a copy of the pesticide label available when medical attention begins. The label provides useful information to those assisting a victim of pesticide poisoning. The product's Safety Data Sheet (SDS) has helpful information as well; supplying the SDS to medical professionals is required when the Worker Protection Standard applies to a situation.

Recognizing Common Pesticide Poisonings

All pesticides in a given chemical group (e.g., organophosphate insecticides) generally affect the human body in a similar way. However, the severity of health effects depends on the toxicity of specific active ingredients, the way in which they are formulated into pesticide products (including their concentration), and the route of exposure involved. Nonetheless, it is important to know both the type of pesticide being used and the signs and symptoms associated with poisoning from it.

Pesticides presenting the greatest potential health risks and those for which the mode of action is better understood are covered in the following sections. Categories of pesticides with similar signs and symptoms are covered together. The listings of pesticides in *Tables III, IV, V*, and *VI* are not complete, nor do they indicate that an active ingredient or product is currently registered. They do, however, represent products that are or have historically been used in Nebraska. The EPA and Nebraska Department of Agriculture maintain registrations for pesticide products. The EPA sometimes discontinues the registrations of highly toxic products when less-toxic alternatives become available. Pesticides mentioned in this publication may not currently be registered for use in Nebraska but may still be found on storage shelves. Therefore, they still present risk, and signs and symptoms are included for these pesticides. Mention of trade names does not constitute endorsement of a product, nor does omission constitute criticism.

Included are some findings from the Agricultural Health Study (AHS), a cohort study involving 90,000 applicators and their spouses from Iowa and North Carolina with a focus on the long-term health effects (chronic toxicity) associated with agricultural pesticide use. The AHS states that the study "began in 1993 with the goal of answering important questions about how agricultural, lifestyle[,] and genetic factors affect the health of farming populations." The AHS relies mainly on participants self-reporting their pesticide use, pesticide exposure, and health conditions to identify associations between exposure to specific pesticides and long-term health outcomes. Keep in mind that an association does not automatically mean there is a cause-and-effect relationship. An association shows that more research is needed.

Some general findings of the AHS are listed below.

- Farmers have lower rates of many diseases compared with the rest of the population, perhaps because they are less likely to smoke and are more physically active.
- Farmers have a higher risk for developing certain cancers, including prostate cancer.
- Gloves matter. Use of chemical-resistant gloves when handling pesticides can reduce pesticide exposure by 50 to 80 percent.
- Accidental high-pesticide-exposure events may affect health later in life.

Insecticides

Insecticides have many different modes of action. Some act on an insect's nervous system. Others slow the production of energy that an insect needs to survive. Another type slows or stops production of chitin, a major component of an insect exoskeleton, so the insect can't molt. Insect growth regulators, another type, may also prevent an insect from molting, or keep it from maturing and reproducing. Some insecticides disrupt the water balance in an insect, causing rapid water loss and eventual death. Modes of action involving the nervous system and energy production may affect not only insects, but other animals as well. The following is a list of insecticides grouped by their chemical makeup.

Organophosphate and Carbamate Insecticides

Many cases of pesticide poisoning involve organophosphate or carbamate insecticides. Both these chemical groups affect humans by inhibiting acetyl cholinesterase, an enzyme essential for the proper function of the human nervous system. Without acetyl cholinesterase, nerve impulses continue and the victim experiences uncontrolled twitching. The AHS shows that allergic asthma in men and women may be associated with poisoning caused by these insecticides. Examples of organophosphate and carbamate insecticides used in Nebraska are listed in *Table III*. EPA registration has been cancelled for some; others are being phased out or are not used as much as other insecticides.

When humans are exposed, the effects of these pesticides, particularly the organophosphates, are rapid. Signs and symptoms begin shortly after exposure, and in cases of acute poisonings, during exposure. Exposure to either of these insecticide classes may pose special risks to people with reduced lung function, a history of seizures, or other conditions. In some cases, consuming alcoholic beverages after exposure may worsen the effects.

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Table III. Organophosphate and carbamate insecticides used or previously used in Nebraska. Examples of trade names are in parentheses. Italicized active ingredients and products have been discontinued. However, these products may still be present in outbuildings, sheds, or other storage areas.

Organophosphates			Carbamates
Acephate (Orthene®)	Dimethoate (Cygon®, Dimethoate)	Phorate (Thimet®)	Aldicarb
Azinphos-methyl (Guthion®)	*Disulfoton (Di-Syston®)*	Phosmet (Imidan®)	Carbaryl (Sevin®)
Chlorpyrifos (Lorsban®)	Ethoprop (Mocap®)	Pirimiphos-methyl (Actellic®)	*Carbofuran (Furadan®)*
Coumaphos (Co-Ral®)	Malathion (FyFanon®, Malathion)	Terbufos (Counter®)	Methomyl (Lannate®)
Diazinon	*Methyl Parathion (Penncap-M®)*	Trichlorfon (Dylox®)	Propoxur (Invader®)
Dichlorvos or DDVP (Vapona®)	Naled (Dibrom®, Trumpet®)		

The onset of symptoms in milder exposures usually occurs within four hours, but can occur up to 12 hours after exposure. Diagnosis of a suspected poisoning must be rapid. Signs and symptoms associated with mild exposures to organophosphate and carbamate insecticides include headache; fatigue; dizziness; loss of appetite with nausea, stomach cramps, and diarrhea; blurred vision associated with excessive tearing; contracted pupils; excessive sweating and salivation; slowed heartbeat, often less than 50 beats per minute; and rippling of surface muscles just under the skin. Some symptoms may be mistaken for those of flu, heat stroke, heat exhaustion, or upset stomach.

Moderately severe organophosphate and carbamate insecticide poisoning cases exhibit all the signs and symptoms found in mild poisonings listed previously. In addition, a victim may be unable to walk, complain of chest discomfort and tightness, have marked pinpoint pupils, exhibit muscle twitching, and have involuntary urination and bowel movements. Signs of severe poisonings include incontinence, unconsciousness, and seizures.

The order in which these symptoms appear may vary, depending on how contact is made with the pesticide. If the product is swallowed, stomach and other abdominal manifestations commonly appear first; if it is absorbed through the skin, gastric and respiratory symptoms tend to appear at the same time.

Fortunately, antidotes are available for victims of organophosphate or carbamate poisoning at emergency treatment centers, hospitals, and many physicians' offices. As with all pesticide poisonings, prompt assistance is critical. If a pesticide is swallowed, obtain medical treatment immediately. If dermal exposure has occurred, remove contaminated clothing, wash exposed skin, and seek medical care.

Organochlorine Insecticides

Once used widely in both agricultural and nonagricultural pest control, organochlorine insecticides have been phased out in the U.S. due to their persistence in the environment and the availability of safer alternatives. *Table IV* lists some previously registered organochlorines and the years in which their last approved uses were canceled by the EPA.

Table IV. Organochlorine insecticides and their year of final cancellation.

Active Ingredient	Final Cancellation*
DDT	1972
Kepone	1978
Mirex	1978
Benzene hexachloride	1984
Aldrin	1987
Dieldrin	1987
Chlordane	1988
Toxaphene	1990
Methoxychlor	2004
Lindane	2006
Dicofol	2013
Endosulfan	2016

*Many of these active ingredients had only a few approved uses remaining when they were fully canceled in the years shown.

Although this class of insecticide is no longer available for purchase, some may still be present in the barns, sheds, or storage areas of former users. In addition, organochlorines such as dioxins and polychlorinated biphenyls (PCBs) are present in the environment due to applications, spills, leaks, and improper disposal of industrial wastes. Because of the persistence of organochlorines, traces of them can still be found in sediment, water, and living organisms, even though most use was banned in the U.S. decades ago.

Some areas have advisories limiting the consumption of fish and shellfish due to the presence of these chemicals in their tissue. When fish and shellfish such as crabs and mollusks eat, they accumulate pollutants such as organochlorines and heavy metals present in their food, in tainted sediment, or in the water they filter to get food. This process, called bioaccumulation or bioconcentration, describes how pollutants accumulate or concentrate in living tissue. The potential for

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bioaccumulation increases as you go up the food chain, from tiny fish with organochlorines, eaten by larger fish, eaten by still larger fish, and finally eaten by humans.

Organochlorines affect the nervous system as stimulants or convulsants. Nausea and vomiting commonly occur soon after ingesting organochlorines. Other early signs and symptoms include apprehension (feelings of suspicion or fear of the future), excitability, dizziness, headache, disorientation, weakness, a tingling or pricking sensation on the skin, and twitching muscles. Loss of coordination, convulsions (violent seizures with involuntary jerky movements that cause the victim to stop breathing) similar to epileptic seizures, and unconsciousness often follow. When absorbed through the skin, the first symptoms may include apprehension, twitching, tremors, confusion, and convulsions. Chronic exposure may lead to cancer, birth defects, and genetic mutations. The AHS has found that the risk of developing diabetes and thyroid disease may increase for those who used certain organochlorine chemicals.

No specific antidotes are available for organochlorine poisoning. People assisting a victim should wear chemical-resistant gloves and be careful to avoid being exposed to the pesticide themselves. Remove contaminated clothing immediately and bathe and shampoo the person vigorously with soap and water to remove pesticides from the skin and hair. Seek medical attention immediately if the pesticide is swallowed or if convulsions occur. Lay the convulsing victim on their side away from hard objects and monitor their breathing.

Pyrethroid Insecticides

Pyrethroids are synthetically produced compounds that mimic the chemical structure of naturally occurring pyrethrins found in a specific type of chrysanthemum plant. As with organophosphates and carbamates, pyrethroids affect an insect's nervous system, but not as cholinesterase inhibitors. Some examples of pyrethroids are listed in *Table V*.

Table V. Pyrethroid insecticides, with trade names for some products in parentheses.

Bifenthrin (Sniper®)	Fluvalinate (Mavrik®)
Cyfluthrin (Decathlon®, Tempo®)	Permethrin (Pounce®, many others)
Cypermethrin (Cyper, Demon® Max)	Phenothrin or Sumithrin (Enforcer® premixes)
Deltamethrin (Delta Gold® 100, D-Fense®)	Tetramethrin (Enforcer® premixes)
Esfenvalerate (Asana® XL, Conquer®)	

In the U.S., pyrethroids enjoy widespread usage as they have replaced many more-toxic insecticides (e.g., organophosphates). Of all pesticides, pyrethroid exposures are the most-often reported, likely due to their widespread use. However, the risk of pyrethroid poisoning through inhalation and dermal absorption is generally low, and few actual poisonings of humans by pyrethroids have been documented. One exception is exposures associated with Total Release Foggers, which are discussed later in this publication. Dermal contact may result in skin irritation such as stinging, burning, itching, and tingling progressing to numbness. Some people experience a range of allergic reactions from pyrethroids. Repeated exposures may increase the intensity of these reactions.

Although some pyrethroids may be toxic orally, ingesting this type of insecticide usually presents relatively little risk. Occasionally, a large dose may cause loss of coordination, tremors, salivation, vomiting, diarrhea, and irritability to sound and touch. Most pyrethroids are promptly excreted by the kidneys.

Biological Insecticides

Insecticides produced from plant materials or bacteria are called biological insecticides.

Azadirachtin, derived from the neem tree, is an insect growth regulator that interferes with the insect molting process. For humans, exposure to azadirachtin causes skin and gastrointestinal irritation. Stimulation and depression of the central nervous system have also been reported.

Eugenol is derived from clove oil and is used as both an insect attractant and insecticide. In humans, exposure to the skin or eyes can cause irritation and burns. Ingestion of extremely large doses may result in liver problems and coma.

Pyrethrum and pyrethrins. Pyrethrum is found in the flowers of *Chrysanthemum cinerariifolium*. Crude pyrethrum is a dermal and respiratory allergen in humans; skin irritation and asthma have occurred following exposures. Refined pyrethrins are less allergenic, but appear to retain some irritant and/or sensitizing properties.

In cases of human exposure to commercial pyrethrum products, realize that other toxicants may be present in the formulation and listed on the label. Some insecticide products are formulated with multiple active ingredients, or with a 'synergist' that enhances the killing power of the active ingredient. Synergists such as piperonyl butoxide, discussed later, have low toxic potential in humans, but other active ingredients included in a product, especially organophosphates or carbamates, may have significant toxicity. Pyrethrins themselves do not inhibit the cholinesterase enzyme.

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Rotenone is a naturally occurring substance found in several tropical plants. Until 2011, it was formulated as dusts, powders, and sprays for use in gardens and on food crops. The AHS showed an association between exposure to rotenone and the incidence of Parkinson's disease. More research is needed to reach any conclusions on the specifics of that association. Rotenone manufacturers have voluntarily stopped producing the pesticide for all uses except to manage undesirable fish species. Rotenone is now a restricted-use pesticide.

Antibiotics include abamectin, *Bacillus thuringiensis* (Bt), spinosad, and streptomycin. These compounds are practically nontoxic to humans. In studies involving deliberate ingestion by human subjects, slight inflammation of the gut occurred. Antibiotic insecticides formulated as emulsifiable concentrates may cause slight to moderate eye irritation and mild skin irritation due to the solvents present. Antibiotic pesticides are different from the antibiotics taken by people to cure bacterial infections.

Inorganic Insecticides

Boric acid and borates. Boric acid, derived from borax and usually combined with an anti-caking agent, is commonly used to kill cockroaches. It can be harmful to humans if accidentally ingested, especially by children. Avoid inhaling the dust during application; the label may indicate that respiratory protection must be worn. Inhaled borax dust irritates the respiratory tract and causes shortness of breath. Borax dust is moderately irritating to skin. In cases of severe poisoning, infants have developed a red skin rash that most often affects the palms, soles of feet, buttocks, and scrotum. The skin developed a "boiled lobster appearance" followed by extensive skin peeling.

Diatomaceous earth (DE) is mined from the fossilized silica-shell remains of diatoms, which are microscopic sea animals. Labels may refer to this ingredient as 'silicon dioxide,' or 'silicon dioxide from diatomaceous earth.' DE is used commercially to control crawling insects, such as cockroaches, ants, and insects that infest grain. It is virtually nontoxic to humans, though it can irritate the eyes and lungs. Some grades of DE contain small amounts of crystalline silica which is known to cause cancer and a respiratory disease called silicosis. Cancer risk depends on the duration and level of exposure. Pesticide-quality diatomaceous earth and silica gel are non-crystalline ('amorphous') and do not cause cancer or silicosis.

Silica gel is a nonabrasive, chemically inert substance used as a dehydrating agent because the small particles absorb moisture and oils. Avoid inhaling the dust.

Sulfur is moderately irritating to the skin and has been associated with skin inflammation. Dust is irritating to the eyes and respiratory tract. If swallowed, it acts like a strong laxative.

Other Insecticides

Neonicotinoids were introduced in the 1990s. Chemically similar to nicotine, they are less acutely toxic to humans than organophosphates and carbamates. Imidacloprid and thiamethoxam are used to control termites, turf insects, and some crop insects.

Farm workers exposed to pesticides containing imidacloprid reported skin/eye irritation, dizziness, breathlessness, confusion, and/or vomiting. Similar symptoms, along with increased heart and breathing rates, were noted after a victim ingested a product containing imidacloprid; the victim suffered severe cardiac toxicity and death 12 hours after oral exposure.

Pyrazoles. Fipronil is a moderately toxic pyrazole that may cause mild irritation to the eyes and skin. It is used to control termites (Termidor®, Taurus®), cockroaches (Combat®, Maxforce®), certain insect pests of corn, and fleas and ticks on cats and dogs (Frontline®, Effipro®, PetArmor®). Lab animals exhibited reduced feeding, reduced urination, increased excitability, and seizures following a toxic oral dose. After ingesting fipronil, humans have reported sweating, nausea, vomiting, headaches, abdominal pain, dizziness, agitation, and weakness. Direct, short-term contact with skin can result in slight skin irritation. In one case, inhalation or dermal contact while spraying fipronil for five hours may have caused headache, nausea, dizziness, and weakness; symptoms developed two hours after spraying and then disappeared. The National Pesticide Information Center reports that signs and symptoms from a brief exposure to fipronil generally improve and clear up without treatment.

Pyrroles. Chlorfenapyr (Phantom®, Pylon®) is the only active ingredient in this group. It is formulated to control ants, cockroaches, termites, and some insect and mite pests on fruits and vegetables. It is slightly toxic if swallowed or absorbed dermally, and can moderately irritate eyes and skin.

Tetronic acids. Spiromesifen is the sole active ingredient in this group. It is used to control mites and whiteflies on some fruit and vegetable crops (Oberon®, Sepoy®). Spiromesifen has low acute toxicity to humans, and no indication of eye irritation has been reported.

Tetramic acids. Spirotetramat (Movento®, Senstar®) is a systemic insecticide that controls a number of major sucking insects and mites that are pests of trees, vegetables, potatoes, and other plants. Some products with tetramic acids may

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cause moderate eye irritation. Prolonged or repeated skin contact may cause allergic reactions in some individuals.

Insect Growth Regulators

Insect growth regulators (IGR) act on insects in different ways. Some mimic juvenile hormones to keep insects in immature stages and prevent reproduction. Chitin synthesis inhibitors prevent insects from molting and growing into adults. In general, IGRs are very low in toxicity and cause mild skin irritation with limited exposure. No human poisonings or adverse reactions in exposed workers have been reported. Some examples of insect growth regulators are listed in *Table VI*.

Table VI. Common insect growth regulators. Examples of trade names are in parentheses.

Diflubenzuron (Adept®, Clarifly®)	Methoprene
Hexaflumuron (Shatter™)	Noviflumuron (Recruit®)
Hydroprene (Gentrol®)	Pyriproxyfen (Fulcrum®, Pivot®)

Mosquito Repellents

Diethyltoluamide (DEET) was developed by the U.S. Army in 1946 as an insect repellent and has been available to the general public since 1957. Products containing DEET (OFF!®, Repel®) have been effective and generally well tolerated when applied to human skin. If left on skin for an extended period, some people have experienced irritation, redness, a rash, and swelling. Tingling and mild irritation have occurred following repeated application. In some cases, DEET has caused skin irritation and worsened preexisting skin disease. It is very irritating to eyes but not corrosive. When swallowed, it has caused nausea and vomiting.

Serious adverse effects have occurred when DEET was used under hot, humid conditions and not washed off before the user went to bed. The skin became red and tender, then blistered and formed ulcers that were slow to heal. Permanent scarring resulted from most of these severe reactions. Very rarely, DEET exposure has been associated with seizures. Most have occurred after a person drank a product containing DEET or otherwise used it in a way that was at odds with its label directions.

Exercise great caution when using DEET on children: only use products containing lower concentrations. The American Academy of Pediatrics (AAP) recommends against using **any** insect repellent on infants 2 months of age or younger. The AAP cautions parents not to use DEET on the hands of a child and to avoid applying it to areas around a child's eyes and mouth. Consider applying DEET only to clothing, using as little repellent as possible. Never allow children to apply repellents themselves. If a child experiences a headache or any kind of emotional or behavioral change, immediately discontinue using DEET. Most adverse responses to DEET reported to Poison Centers resulted from improper use or accidents.

Picaridin, a synthetic compound first made in the 1980s, resembles a natural compound found in the group of plants used to produce black pepper. Widely used as an insect repellent in Europe and Australia, picaridin has been available in the U.S. only since 2005. Although uncommon, some people have experienced skin irritation after exposure. Picaridin may also cause irritation if it gets into a person's eyes. Lab rats lost weight, and their kidneys were affected when fed large doses. The material is considered practically nontoxic if inhaled. While children may be especially sensitive to pesticides compared with adults, no data suggest that children have increased sensitivity to picaridin specifically.

Oil of citronella was registered in 1948 as an insect and animal repellent. It is found in many familiar insect repellent products, including candles, lotions, gels, sprays, and towelette wipes. These products vary in effectiveness and may repel various insects, such as mosquitoes, biting flies, and fleas. When used according to the label, citronella products are not expected to harm humans, pets, or the environment. The only concern in studies involving laboratory animals is skin irritation. The EPA requires precautionary labeling because some citronella products are applied to human skin. Citronella is not expected to pose health risks to people, including children and other sensitive populations, if used according to label instructions.

Fumigants

Fumigants operate in the form of a gas. Fumigants can completely fill a space, and many have tremendous penetrating power. They can be used to treat objects such as furniture, structures, stored grain, and soil to control insects and other pests. Fumigants are among the most hazardous pesticide products to use due to their high toxicity and the ease with which they can be inhaled.

Various fumigants produce differing physiological effects. Headache, dizziness, nausea, and vomiting are common early signs and symptoms of excessive exposure.

Prompt medical treatment is critical for fumigant poisoning. After donning appropriate PPE, immediately move a victim of fumigant inhalation to fresh air. Keep the individual quiet in a semi-reclining position, even if initial signs and symptoms are mild. If breathing has stopped, give mouth-

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to-mouth or mouth-to-nose resuscitation. If the victim has no pulse, immediately give cardiopulmonary resuscitation (CPR) using chest compressions. Specific fumigants, along with their signs and symptoms of poisoning, are listed below.

Chloropicrin causes severe irritation of the upper respiratory tract, eyes, and mucous membranes. Symptoms of exposure include burning eyes, tearing, coughing, difficulty breathing, headaches, nausea, and vomiting. Chloropicrin can cause eye irritation and tearing in concentrations as low as 0.15 ppm. Chloropicrin may be a stand-alone fumigant, or it may be combined with other fumigants to increase their potency. Its ability to cause irritation has also led to its use as a warning agent in fumigant formulations; the irritation alerts workers that a fumigant is present and the area is unsafe.

Sulfuryl fluoride (Vikane®) poisoning symptoms include depression, slowed walking pattern, slurred speech, nausea, vomiting, stomach pain, stupor, itching, numbness, twitching, and seizures. Inhalation of high concentrations may irritate the respiratory tract and may be fatal due to respiratory failure. Sulfuryl fluoride is almost always applied with chloropicrin, so the first signs of poisoning are often associated with severe irritation of the eyes and mucous membranes. Skin contact with gaseous sulfuryl fluoride normally poses no hazard, but contact with liquid sulfuryl fluoride can cause pain and frostbite due to cold temperatures from rapid evaporation.

Phosphine fumigants, such as aluminum and magnesium phosphide (Phostoxin®, Fumitoxin®), affect cell function in the liver and lungs. Mild exposure is signaled by a sensation of cold, chest pains, diarrhea, and vomiting. Exposures that are somewhat more serious will be accompanied by cough, tightness in the chest, difficulty breathing, weakness, thirst, and anxiety. Signs and symptoms of severe exposure include stomach pain, loss of coordination, blue skin color, pain in the limbs, enlarged pupils, choking, fluid in the lungs, and stupor. Severe poisonings can lead to seizures, coma, and death.

Methyl bromide (Metabrom, Meth-O-Gas®) affects the central nervous system, lungs, heart, and liver. People poisoned by methyl bromide experience the common signs and symptoms of fumigant poisoning along with abdominal pain, weakness, slurred speech, mental confusion, muscle twitching, and convulsions similar to epileptic seizures. Methyl bromide is corrosive to the eyes; damage may have a delayed onset after exposure. Some products, when still in liquid form, can cause skin injuries such as redness or blisters that rupture, leaving raw skin or deep ulcers.

Acrolein (Magnacide H®) is an extremely irritating gas used as an aquatic herbicide. Inhaling vapors causes irritation in the upper respiratory tract, which may lead to a buildup of fluids in, and narrowing of, a person's air passages. Acrolein is corrosive to the eyes. If ingested, it attacks the stomach lining, resulting in open sores and cell death. Contact with skin may cause blistering.

Dazomet (Basamid® G) is a granular soil fumigant. It is used to sterilize soil to eliminate weeds, nematodes, and soilborne diseases. Dazomet is highly toxic if swallowed and can be fatal. Frequent or prolonged exposure to skin can result in irritation or more serious skin problems for some individuals. Exposure to the eyes can cause irreversible eye damage. Inhalation can cause a variety of acute and chronic lung conditions, including local irritation, inflammation, fluid buildup, and lung disease.

Metam sodium (Vapam®) is a soil fumigant used to kill fungi, bacteria, weed seeds, nematodes, and insects. When combined with water, it produces a gas that is very irritating to respiratory mucous membranes, eyes, and lungs. Inhalation can cause severe respiratory distress, including coughing blood and frothy sputum. Metam sodium can only be used outdoors, and precautions must be taken to avoid inhaling the gas.

Dichloropropene (Telone®) is very irritating to the skin, eyes, and respiratory tract. Inhalation may cause spasms of the bronchi, where air passes into the lungs. Although limited data for humans exist, animals have experienced liver, kidney, and cardiac damage. Most dichloropropene products contain chloropicrin; severe irritation of the eyes and mucous membranes is an early sign of exposure. Apparently, risk for oral toxicity is low for humans unless large quantities of dichloropropene are ingested.

Rodenticides

Pesticides used for rodent control pose particular risks to humans: Since they are designed to kill mammals, their modes of action are toxic to humans as well. In addition, rodents often live near humans and their dwellings, so accidental exposure to baits is a real risk. Rodenticides fall into three categories:

- First-generation anticoagulants,
- Second-generation anticoagulants, and
- Non-anticoagulants.

Anticoagulants slow or prevent the blood's ability to clot. Death can result from excessive bleeding. First-generation anticoagulants were developed during World War II, with others appearing before 1970. Rodents die after eating a number of doses; death usually occurs within five to seven days.

Second-generation anticoagulants were initially developed in the 1970s. They are more hazardous—more likely to kill after a single feeding. Their increased toxicity means they pose a greater risk to humans. Also, second-generation

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anticoagulants remain in body tissues longer than first-generation anticoagulants. Second-generation anticoagulants are designed to poison a rodent as soon as it feeds (one dose), but death may nonetheless take several days. During that time, the rodent can feed many times, meaning that when the rodent finally dies, the amount of poison in its carcass might be much higher than the lethal dose. Predators or scavengers that eat the carcass might consume enough of the poison to suffer harm themselves. This is called secondary poisoning.

Non-anticoagulants affect the nervous system or other body organs. They do not have an effect on blood clotting. The first non-anticoagulant rodenticides were developed for use against rodents that were resistant to anticoagulants.

First-generation Anticoagulants

Coumarins slow blood's ability to clot and disrupt capillary and liver function. Examples include warfarin (Kaput®). The main signs and symptoms of human exposure are nosebleeds, bleeding gums, blood in the urine, tar-colored feces, and large, irregular, blue-black to greenish-brown spots on the skin. Vitamin K is an antidote.

Indandiones include chlorophacinone (Rozol®) and diphacinone (Ditrac®, d-CON® IX and XI, Kaput®-D, Ramik®). Signs and symptoms of exposure are similar to coumarin compounds, but some indandiones cause nerve, heart, and blood system damage in laboratory rats that leads to death before hemorrhage occurs. None of these signs and symptoms have been reported in human poisonings. Vitamin K is an antidote.

Second-generation Anticoagulants

Some **coumarins** are second-generation anticoagulants, developed with increased toxicity. Examples include brodifacoum (Jaguar®, Talon®) and bromadiolone (Contrac®, Maki®). The main signs and symptoms of exposure are nosebleeds, bleeding gums, blood in the urine, tar-colored feces, and large, irregular, blue-black to greenish-brown spots on the skin. Vitamin K is an antidote.

Non-anticoagulants

Benzenamines. Bromethalin (Prowler®, Rampage®, Tomcat®), the only chemical in this class of rodenticide, acts on the central nervous system. Possible signs and symptoms of exposure to this compound include skin and eye irritation, headache, confusion, muscle twitching, convulsive seizures, and difficulty breathing. Bromethalin poisoning in dogs usually results in paralysis or convulsions, and sometimes, abdominal swelling or bloating.

Cholecalciferol (Terad® 3, d-CON® XVI and XVII) is an activated form of vitamin D that affects the liver and kidneys. It causes elevated levels of calcium in the blood; rodents die due to problems such as blockages in the circulatory system. For humans, signs and symptoms of exposure include fatigue, headache, weakness, and nausea. This rodenticide has poisoned dogs and cats. A high dosage may cause death in humans. Labels caution against direct contact with skin; gloves are required when handling bait or retrieving exposed carcasses.

Strychnine is not easily absorbed through the skin, nor does it accumulate in the human body. When ingested, however, it acts on the central nervous system within 10 to 30 minutes. Convulsions may occur. Treatment of strychnine poisoning is geared toward eliminating outside stimuli. If strychnine poisoning occurs, place the victim in a warm, dark room to reduce outside stimuli that trigger convulsions. Bring medical help to the victim rather than transporting the victim since movement can trigger convulsions.

Zinc phosphide causes severe irritation if ingested. It reacts with water and stomach juices to release phosphine gas, which enters the bloodstream and affects the lungs, liver, kidneys, heart, and central nervous system. Zinc phosphide can be absorbed through the skin, or inhaled as fumes. With repeated exposure, it accumulates in the body to dangerous levels. Signs and symptoms of mild zinc phosphide poisoning include diarrhea and stomach pains. In more severe cases, nausea, vomiting, chest tightness, coldness, loss of consciousness, coma, and death can occur due to fluid buildup in the lungs and/or liver damage. No antidote for zinc phosphide poisoning exists. It is a slow-acting material, which allows time to get the victim medical assistance.

Wood Preservatives

Pesticides registered as wood preservatives extend the life of wood by protecting it from rot-causing fungi and/or wood-destroying insects. Some preservatives can leach slowly into the surrounding soil or water. Sometimes, touching treated wood can leave residue on exposed skin.

Creosote (coal tar) is typically found on railroad ties, which are sometimes used for landscaping. Exposure can cause skin irritation; prolonged exposure may lead to inflamed skin. Creosote vapors and fumes are irritating to the eyes and respiratory tract. Ingested creosote may cause severe liver damage. Creosote is considered a probable human carcinogen. Creosote-treated wood cannot be used in residential settings; it may only be used in commercial applications.

Pentachlorophenol (PCP, Penta) is a wood preservative typically used to treat utility poles that is being phased out of use in the U.S. due to its (acute and chronic) human

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toxicity and the availability of safer alternatives. Exposure irritates the eyes, skin, and respiratory tract, causing tearing eyes, stuffy nose, and scratchy throat. Prolonged exposure sometimes leads to an acne-like skin condition. Ingestion of PCP solutions, excessive skin contact, or inhaling concentrated vapors may cause fever, headache, weakness, dizziness, nausea, and profuse sweating. Extreme cases of exposure can lead to loss of coordination and seizures; high fever; muscle spasms and twitching; difficulty breathing; a sense of tightness in the chest; abdominal pain and vomiting; restlessness; and mental confusion. Intense thirst is also characteristic. Pentachlorophenol poisoning can be fatal.

Arsenical wood preservatives such as chromated copper arsenate (CCA) and ammoniacal copper arsenate (ACA) were used extensively in the past to treat construction lumber for decks, play sets, and fence posts. CCA is not well absorbed through the skin, but hand-to-mouth contact can result in exposures. If swallowed, arsenicals can cause nausea, headache, diarrhea, and abdominal pain. Signs and symptoms can progress to dizziness, muscle spasms, violent mental agitation, and seizures. Prolonged exposure to arsenical wood preservatives can result in persistent headaches, abdominal distress, salivation, low-grade fever, and upper respiratory irritation.

Herbicides

Herbicides kill plants by affecting their metabolic processes. Since mammals do not share these metabolic processes, the risk of human poisoning by herbicides is generally low. However, some herbicides can pose a poisoning risk if not handled according to their label directions. Regardless of their chemical structure, the vast majority of herbicides affect the human body in a similar way. In general, they can irritate the skin, eyes, and respiratory tract. Always read and follow label directions carefully to protect yourself and others. Herbicides that present the greatest potential health risks are covered in the next four sections.

Bipyridyl Herbicides

Diquat and **paraquat** are the most common bipyridyl herbicides. Paraquat is more toxic than diquat and produces chronic abnormal cell growth in the lungs, cornea and lens of the eyes, nasal mucous membranes, skin, and fingernails. Diquat affects the eye lens and intestinal tract lining, but it usually does not produce the often-fatal lung changes characteristic of paraquat exposure.

Ingesting diquat or paraquat causes severe irritation to the mucous membranes of the mouth, esophagus, and stomach. Repeated vomiting generally follows. Large doses of diquat also produce restlessness and reduced sensitivity to stimulation. When paraquat is ingested, it affects the kidneys, liver, adrenal glands, and lungs, with potentially fatal fluid accumulation in the lungs occurring in 24 to 72 hours.

Ingestion of smaller amounts of paraquat will cause decreased urine output because of kidney failure. Yellowing of the skin due to liver damage is sometimes observed. This initial phase is followed by an inactive period lasting up to two weeks, during which the victim's condition appears to improve. However, the victim may have permanent and gradually advancing lung damage caused by rapid growth of connective tissue. This prevents proper lung function and eventually leads to death through respiratory failure. The AHS has found an association between paraquat use and the development of Parkinson's disease later in life.

Skin exposure to paraquat and diquat concentrates may cause severe skin irritation and burning. Paraquat concentrates may cause nails to blacken and grow abnormally. Skin absorption of paraquat is slight. Diquat, however, is absorbed well, and after repeated contact will produce symptoms similar to those following ingestion.

Exposure to paraquat and diquat spray mist may produce skin irritation, nasal bleeding, irritation and inflammation of the mouth and upper respiratory tract, coughing, and chest pain.

No specific antidotes are available to counteract the effects of paraquat, diquat, and other bipyridyl herbicides once significant exposure and absorption has occurred. Seek medical attention immediately. If ingested, administration of an adsorbent such as activated charcoal or fuller's earth is the best way to mitigate the poison's effects. Flush affected eyes with water, and wash skin with soap and water.

Chlorophenoxy Herbicides

2,4-D and **MCPA** are examples of chlorophenoxy herbicides. These compounds are moderately irritating to skin and mucous membranes. Inhalation may cause a burning sensation in the nose, sinuses, and chest, which may result in coughing. Prolonged inhalation sometimes causes dizziness.

Stomach irritation usually leads to vomiting soon after ingestion. Victims may experience diarrhea and/or chest/abdominal pain. Headache, mental confusion, and bizarre behavior are early signs and symptoms of severe poisoning, which may progress to unconsciousness.

Arsenical Herbicides

MSMA, DSMA, CAMA, and cacodylic acid are examples of arsenical herbicides, although only MSMA is still registered for use in the U.S. Acute arsenic poisoning usually occurs within one hour of ingestion. Breath and feces that smell of garlic may help identify arsenic as the responsible

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toxicant in severe cases. Effects on the digestive tract include inflammation of the mouth and esophagus, burning abdominal pain, thirst, vomiting, and bloody diarrhea.

Arsenic may also affect the central nervous system. Effects include headache, dizziness, muscle weakness and spasms, low body temperature, sluggishness, delirium, seizures, and coma. Liver damage may lead to yellowing of the skin. Injury to tissues that form blood may reduce numbers of red and white blood cells and blood platelets. Death usually occurs one to three days after the onset of symptoms, usually the result of circulatory failure.

Chronic arsenic poisoning due to repeated skin exposure is also possible and may result in the development of cancer. Symptoms of chronic exposure include overgrowth of the eye's cornea; scaling off of dead skin; excessive fluids under the skin of the face, eyelids, and ankles; white streaks across the nails; loss of nails or hair; and brick-red coloration of visible mucus membranes.

Other Herbicides

Endothall (Aquathol® K, Hydrothol®) is commonly used as an aquatic herbicide or algaecide. It is irritating to the skin, eyes, and mucous membranes. In one case, a man died after ingesting endothall. In this case, bleeding and swelling were noted in the victim's gut and lungs.

Sodium chlorate (Defol®) is used as a defoliant, nonselective herbicide, and soil sterilant. It is irritating to the skin, eyes, and stomach. Even though sodium chlorate is poorly absorbed in the digestive tract, ingesting a large dose will cause severe poisoning. Irritation to the gut causes nausea, vomiting, and abdominal pain. Bluish skin is sometimes the only visible sign of poisoning. Dark brown blood and urine can also indicate sodium chlorate poisoning.

Fungicides

Fungicides are used extensively in industry, agriculture, and the home and garden; they vary in their potential to cause adverse effects in humans. According to the EPA manual, *Recognition and Management of Pesticide Poisonings* (Roberts and Reigart, 2013), ". . . most fungicides currently in use are unlikely to cause frequent or severe systemic poisonings for several reasons. First, many have low inherent toxicity in mammals and are inefficiently absorbed. Second, many fungicides are formulated as suspensions of wettable powders or granules, from which rapid, efficient absorption is unlikely. And third, methods of application are such that relatively few individuals are intensively exposed." Still, fungicides have probably caused irritant injuries to skin and mucous membranes, as well as some skin sensitization.

AHS scientists found that applicators with retinal degeneration were twice as likely to have used fungicides. The risk of retinal degeneration appeared to increase as the days of fungicide use increased. This trend was noted for five specific fungicides: benomyl, captan, chlorothalonil, maneb, and metalaxyl. In addition, researchers found that applicators reporting retinal degeneration were more likely to raise orchard fruit, where fungicides are commonly used. Those with retinal degeneration were more likely to use handheld spray guns, backpack sprayers, mist blowers, and/or foggers. These application methods tend to result in higher applicator exposure to pesticides.

As with any pesticide, always read and follow label recommendations carefully to avoid any health risks that a specific fungicide may pose.

Other Pesticides and Synergists

Many pesticides and synergists are not discussed in this publication. The following three chemicals are included because they have a relatively high potential for harming humans and nontarget animals.

4-aminopyridine (Avitrol®) is a highly toxic powder used as a bird repellent, often mixed with whole or cracked corn. It is toxic to all vertebrates. No human poisonings have occurred when used according to label directions. However, intentional ingestion has resulted in immediate abdominal discomfort, nausea and vomiting, weakness, dizziness, profuse sweating, and sometimes, death.

Metaldehyde (Deadline®) has been used to control slugs and snails for many years. Metaldehyde products are formulated as pellets or granules and are often used near homes and gardens. Children and animals (particularly dogs) occasionally experience poisoning after finding and swallowing the product. Ingesting a toxic dose is often followed by nausea and vomiting, then fever, seizures, and changes in mental status that sometimes lead to coma. Other signs and symptoms that can occur are excessive salivation, facial flushing, dizziness, rapid breathing, and high acidity in the blood. While most human metaldehyde poisonings are dramatic, they are rarely fatal. However, dog deaths are common when they eat a large amount of product.

Piperonyl butoxide (PBO) is not a pesticide; it is one of the most common synergists in use. Synergists enhance the effectiveness of a pesticide's active ingredient. Some insecticide products include PBO in their formulation; it is also available as a tank-mixing partner. PBO slows the ability of an insect to metabolize an insecticide. This reduces the chance that the insect will break down the insecticide before it can have an effect. As a synergist, PBO reduces the amount of a pesticide that is needed to be effective. Toxicity of PBO

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in mammals is low, although based on limited evidence of cancer in laboratory animals, it is considered a possible human carcinogen. PBO may trigger allergic responses in some people.

Application Method

In some cases, the application method itself is the root cause of increased risk. Using handheld spray guns, backpack sprayers, mist blowers, or foggers may result in higher pesticide exposure. A prime example of an application method increasing exposure risk is the Total Release Fogger (TRF). Also known as a bug bomb, a TRF is a pesticide product that uses an aerosol propellant to release an insecticide in an enclosed area. They are typically labeled to control fleas, cockroaches, and flying insects in homes, offices, etc. Pyrethrins or pyrethroids are common active ingredients found in TRFs.

A 2018 study by the Centers for Disease Control and Prevention (CDC) reported 3,222 exposures to TRFs in 10 states between 2007 and 2015. According to this study, the most commonly reported cause of exposure was failure to leave the treated premises during the application. The 2018 study stated, "Moderate or high severity illness was more common among males, persons over 60 years of age, those with preexisting asthma, and those who failed to vacate premises during application, or who were exposed to excessive TRFs."

A 2008 CDC study reporting 466 exposures in eight states from 2001–2006 found that many exposures resulted from not leaving the enclosed space before the TRF discharged, re-entering the site too soon after the discharge, discharging too many TRFs at once, or failing to notify others that TRFs were being used. According to this study, the most-often reported symptoms involved respiratory problems. Other symptoms included gastrointestinal, neurological, cardiovascular, eye, and skin problems. Although one death was reported, most exposures were not considered severe.

For TRF exposures, get the victim(s) to fresh air or administer oxygen if necessary. Flush the skin and/or eyes with water to wash out chemicals. Because of their limited effectiveness and the risks associated with their use, Extension generally does not recommend the use of TRFs.

What if a Pesticide Poisoning Occurs?

The key to surviving and recovering from a pesticide poisoning is rapid treatment. Take emergency action immediately when you suspect a pesticide poisoning has occurred. As time elapses after exposure, the toxic effects of a pesticide increase.

Immediately dial 911 whenever you suspect a pesticide poisoning. An advanced life support team will be dispatched to provide assistance. In addition, you may wish to contact the following:

1. The Poison Center (800-222-1222) will provide specific procedures to follow until a life support team arrives.
2. The nearest hospital or a physician. These can benefit from having preliminary information before the patient arrives.
3. Another source of medical and consumer information related to pesticides during non-emergencies is the National Pesticide Information Center (800-858-7378 or online at http://npic.orst.edu).

What a victim might think is a cold or the flu could be a fatal pesticide poisoning. Whenever possible, get answers to the following questions.

1. Has the victim been exposed to a pesticide?
2. If so, which one and how did the exposure occur?
3. What emergency actions are prescribed on the pesticide label?

After dermal exposure to a pesticide, always wash the victim's exposed skin with soap and plenty of water, then obtain medical treatment. Skin irritation can result from continuous exposure if not treated. If the victim's clothing has been contaminated by a pesticide that is readily absorbed by the skin, remove the clothing and wash or rinse the victim's skin.

Remember to protect yourself as you help the victim by wearing chemical-resistant gloves. If a pesticide has spilled, move the victim away from the spill. Assist the victim first; take action to clean up the spill after all first aid has been completed.

Even though most people are careful when working with pesticides, accidents can happen. Be prepared. Keep the telephone number for the Poison Center readily available. Do not hesitate to contact medical authorities if any symptoms of pesticide poisoning occur. It is better to be safe than sorry.

Many pesticides used by Nebraska farmers, ranchers, and people with lawns and gardens are less toxic than those discussed in this publication, but any pesticide can cause problems due to exposure. Fortunately, when applied according to label directions by a person wearing the required protective clothing and equipment, they are unlikely to cause problems for the user. Use all pesticides safely. **Federal and state laws require that you read the pesticide label completely and comply with all directions. Failure to do so may subject you to federal and/or state sanctions or penalties**.

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'Should I Induce Vomiting?'

For many years, inducing vomiting was considered an important part of treating a person who ingested poison. This was often accomplished by administering syrup of ipecac. Today, groups such as the American Academy of Clinical Toxicology and the American Academy of Pediatrics do not recommend ipecac, and its use as a treatment for poisoning has essentially ceased.

Never induce vomiting in a victim of poisoning unless directed to do so by the pesticide label, a Poison Center operator, or a medical professional. It can cause choking, and in some cases can worsen a poison's effects and/or make successful treatment more difficult.

Do not induce vomiting when:

- the victim is having or has had convulsions,
- the victim is unconscious, or
- the ingested pesticide contains petroleum products such as xylene.

To safely induce vomiting, lay the victim on their side, insert a clean finger into the back of their throat, and monitor their breathing.

Disclaimer

Reference to commercial products or trade names is made with the understanding that no discrimination is intended of those not mentioned and no endorsement by Nebraska Extension is implied for those mentioned.

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Pesticide Safety Telephone Numbers

Emergency Telephone Numbers

Any Emergencies	911
Poison Center For aid in human poisoning cases.	800-222-1222
Chemical Transportation Emergency Center (CHEMTREC) Available to clients 24/7 for technical assistance for pesticide incidents dealing with fires, spills, leaks, exposures, and accidents.	800-424-7930 (registration required)
Nebraska Department of Environment and Energy 8 a.m. to 5 p.m. Central Time, Monday through Friday. To report chemical spills or releases after hours or on holidays, contact the Nebraska State Patrol Dispatch.	402-471-2186 or 877-253-2603
Nebraska State Patrol Dispatch	402-479-4921

Nonemergency Telephone Numbers

National Pesticide Information Center 10 a.m. to 2 p.m. Central Time, Monday through Friday.	800-858-7378

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