

CHAPTER 5

PESTICIDE HAZARDS AND FIRST AID

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Differentiate between types of harmful effects (allergic, acute, chronic, and delayed) associated with pesticide application.
- Identify common exposure routes for various pesticides and application methods.
- Explain the hazard level classification system for pesticides, including the corresponding signal words.
- Describe typical symptoms of pesticide exposure in humans.
- Discuss the appropriate first aid response to oral, ocular, dermal, and inhalation exposures to pesticides.
- List other health risks (such as heat stress) that may occur during pesticide application.



Pesticides are designed to be toxic to living organisms so they can control pests (e.g., plants, insects, rodents, fungi, and bacteria). At the same time, pesticides must be used with special care to avoid harming nontarget organisms, including pesticide applicators, handlers, and anyone else exposed to the product. Though many pesticides are toxic to humans, they vary significantly in the type and level of hazards they present. In many cases, something that is toxic to one species may also be toxic to other species of organisms. This is especially true if the organisms are closely related. For example, insects, rodents, and humans are all animals and have similarities in their nervous, circulatory, and respiratory systems. Because

of these similarities, pesticides can affect people as well as the target pest.

Pesticides can have both short-term and long-term effects on humans. The signal word on the product label and the information contained in the “Hazards to Humans and Domestic Animals” section of the label indicate the human toxicity concerns and the precautions you should take to minimize your own risk. Pesticides can pose additional physical and chemical risks by being explosive and/or combustible. If the product presents either a physical or a chemical hazard, this information is included in the “Precautionary Statements” section. Refer also to the Safety Data Sheet (SDS) for more information on toxicity and precautions.

Toxicity refers to the ability of a pesticide to cause short-term (**acute**) or long-term (**chronic**) injury. “Toxicity,” a measure of the pesticide’s capacity to cause injury or illness, is a combination of its chemical properties and concentration.

Exposure occurs when pesticides get onto or into the body through the skin (dermal), the lungs (inhalation), the mouth (oral), or by eye contact (ocular). Product formulations differ greatly in their exposure risk. Some routine pesticide-handling procedures present an especially high likelihood of exposure. Examples include handling opened containers; mixing and loading concentrates; working around contaminated application equipment; making spray, mist, or dust applications; cleaning up spills; and reentering a recently treated area before the spray has dried or the dust has settled.

Hazard, or risk, is the true concern for the applicator or handler. It is the potential or probability for harm (injury, illness, or allergy) to occur because of the combination of the product’s innate toxicity and the level of human exposure. “Hazard” reflects both the pesticide’s toxicity and the likelihood that you will be exposed to the product in a particular situation. As an applicator, you can reduce your risk by choosing a less-toxic product, by reducing exposure, or both. In situations when a different product cannot be used, you can still reduce the hazard (risk) by taking steps to reduce exposure. As a result, pesticide users need to be concerned with the hazards associated with exposure to the chemical and not exclusively with the toxicity of the pesticide. A good equation to remember is:

$$\text{Hazard} = \text{Toxicity} \times \text{Exposure}$$

The following two examples illustrate that risk takes into account both toxicity and exposure:

- Gasoline is extremely toxic to humans, especially if swallowed or inhaled. Yet every day, millions of people fill their gas tanks without incident. The toxicity is high, but gas pumps are designed to virtually eliminate human exposure. Therefore, the risk associated with filling a car’s gas tank is very low. If someone siphons gas, the risk is much greater because exposure is much more likely.
- Aspirin has a low toxicity to humans. However, if someone takes too many aspirin at one time, he or she can become very ill. In this case, toxicity is low but the potential for exposure is high, increasing the overall hazard or risk.

Engineering controls, such as gas pumps and childproof caps, are often designed to reduce exposure. Engineering controls that reduce handler exposure are also available for pesticide mixing and loading (see Chapter 11, Pesticide Application Procedures, for more information). Examples are lock-and-load devices and water-soluble bags containing formulated product.

Often, the greatest hazard to the applicator occurs while mixing and loading the pesticide concentrate. There is a significant risk of exposure to a chemical in its most concentrated, toxic form unless engineering controls are used. Hazards associated with the actual application are frequently much lower when diluted pesticides are handled or applied. The hazards may still be substantial, however, in the case of a single high exposure (such as when an accident occurs) or when many smaller exposures occur over an extended period.

The best way to avoid or reduce the risks of pesticide use is to understand what you are using and how to use it safely in a way that minimizes

your exposure. This means reading the label carefully and following instructions. The user's attitude is of utmost importance. If you assume that you know exactly how to use a pesticide without reading the product label or do not bother to take the precautions indicated on the label, you are more likely to experience excess exposure. Your risk may increase significantly.

Pesticide users have a legal and moral obligation to protect their own health and that of others when handling pesticides. Besides protecting yourself, you must be aware of other people, wildlife, or pets that may be in or near the treatment area and could be exposed to the pesticide during or after application. Taking adequate precautions

and following good safety practices will reduce the chance of exposure from pesticide application.

In Chapter 2 (Federal Pesticide Laws and Regulations), you learned that the pesticide registration process requires manufacturers to do risk-assessment studies. These studies gauge the risk to applicators during and unprotected people after application. Using the data from these studies, the manufacturer develops product labels that provide instructions on minimizing exposure, personal protective equipment (PPE), engineering controls, symptoms of overexposure, first aid, and postapplication restricted-entry intervals (REIs). ***Be sure to read and follow all label directions.***

POTENTIAL HARMFUL EFFECTS OF PESTICIDES

Effects from chemicals, including pesticides, may be classified into two broad types: local and systemic. **Local** effects are those that occur to the area of contact with skin, eyes, or respiratory tract. Local effects are often referred to as **contact** symptoms or effects. **Systemic** effects may occur once the substance is absorbed and distributed throughout the body. They may be acute or chronic.

Local effects (or contact symptoms) are localized to the area that the pesticide actually touches. Examples are:

- Skin irritation (dermatitis) or injury:
 - Itching, redness, rashes, blisters, burns, and discoloration.
 - Many herbicides and fungicides cause dermatitis. Fumigants can cause severe blisters.
- Eye irritation or injury:
 - Swelling, stinging, and burning.
 - Herbicides, fungicides, insecticides, and fumigants may cause eye irritation or injury through contact, sometimes resulting in irreversible damage.

- Nose, mouth, or throat irritation or injury:
 - Swelling, stinging, and burning.
 - Permanent respiratory damage occurs less often.

Systemic effects may occur once a pesticide has been absorbed and distributed throughout the body. These effects depend on the toxicological profile of the chemical itself, the amount absorbed, and the individual's ability to detoxify and eliminate the chemical. Examples are:

- Cholinesterase inhibition or neuropathies (damage to nerves).
- Impairment of the blood's clotting ability.
- Some cancers.
- Reproductive problems.
- Impaired metabolism (the body's ability to use energy).
- Hormonal effects.
- Damage to various organ systems, such as the kidneys or liver.

LOCAL EFFECTS

Injury at the point of contact, including skin discoloration and irritation (dermatitis) such as itching, redness, rashes, blisters, and burns. Also, swelling, stinging, and burning of the eyes, nose, mouth, or throat are contact effects.



SYSTEMIC EFFECTS

Poisoning effects that occur at sites other than the entry point into the body.



ALLERGIC EFFECTS/ ALLERGY

A hypersensitivity to a specific substance, often called the allergen.

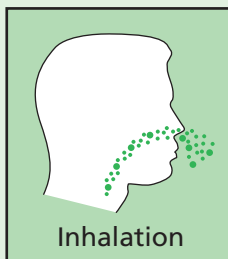
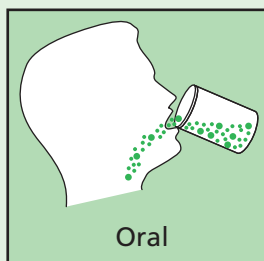
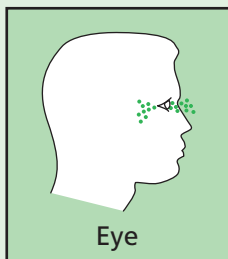
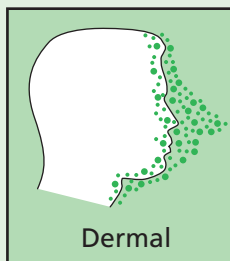
An allergy may cause dermatitis, blisters, hives, and itching of the eyes. It could also cause illness, asthma-like symptoms or life-threatening shock. Often the entire body is affected.

The U.S. Environmental Protection Agency (EPA) considers local and systemic effects when deciding whether to register a chemical. They are also used to set label restrictions, such as limiting the method, timing, or rate of application; to determine appropriate levels of PPE; or to establish REIs (in combination with exposure factors).

Allergic effects are harmful effects that occur in some people in reaction to certain substances. An allergy to a chemical contained in a

product formulation may cause dermatitis, blisters, hives, or more serious problems, such as asthma or even life-threatening shock. Pesticide allergy symptoms are similar to other allergy symptoms: red and/or itchy eyes, respiratory discomfort, and asthma-like effects. Unfortunately, there is no way to predict which people will develop allergies to a particular product. Having an allergic reaction does not predict whether someone would also be more sensitive to other effects of the pesticide, such as chronic or delayed effects (see below). These types of effects depend on different chemical reactions within the body.

Common ways in which pesticide handlers and other workers are exposed to pesticides



Dermal exposure

- Not wearing gloves or other protective clothing.
- Not washing hands after handling pesticides, product containers, or application equipment.
- Not washing hands before using the toilet.
- Splashing or spilling pesticide on skin.
- Being exposed to spray or dust drift.
- Applying pesticides in windy weather or above your head.
- Touching treated plants, soil, or livestock.

Eye exposure

- Rubbing eyes with contaminated gloves or hands.
- Splashing pesticide in eyes.
- Handling dry formulations when not wearing eye protection.
- Applying pesticides in windy weather.

Oral exposure

- Not washing hands before eating, smoking, chewing, or drinking.
- Splashing pesticide in mouth.

Inhalation exposure

- Handling pesticides in confined or poorly ventilated areas.
- Handling dusts or powders.
- Using an inadequate or poorly fitting respirator.
- Being exposed to spray or dust drift.

EXPOSURE—HOW PESTICIDES ENTER THE BODY

Pesticide exposure occurs when pesticides get onto or into the body. The four primary routes of exposure are: skin (dermal), eyes (ocular), lungs (inhalation), and mouth (oral).

Skin or Dermal Route

In most cases, the skin is the main route of pesticide entry onto or into the body. Some studies show that up to 97% of all body exposure to pesticides during a spraying operation is by skin contact. Dermal absorption or contact injury may occur from airborne dust, splashes, spills, or spray mist when mixing, loading, applying, or disposing of pesticides. Skin exposure may also result from contact with pesticide residues on treated surfaces or contaminated equipment during cleaning, adjustment, or repair.

Once a pesticide contacts the body, absorption, penetration, and distribution throughout the body depend on many factors. These include the chemical properties of the pesticide product, the area of contact and its rate of absorption, and the body's own detoxification and elimination capabilities. Some products that cause systemic injury are just as toxic when absorbed through the skin as when they are swallowed.

Parts of the body differ in their ability to absorb pesticides. Warm, moist areas, such as the groin, armpits, head, neck, backs of the hands, and tops of the feet, tend to absorb more than the palms and forearms (Figure 5.1). However, palms and forearms must still be protected because they get the most exposure. Cuts, abrasions, and skin rashes can increase absorption. Remember, the rate of absorption (i.e., how quickly the pesticide can get into the body) differs depending on the area contacted, but the rate is also a function of time. The longer a pesticide (or any other chemical) remains in contact, the more will be absorbed. So, protecting your skin is still important even if the area of the body most likely to contact a pesticide has a low absorption rate.

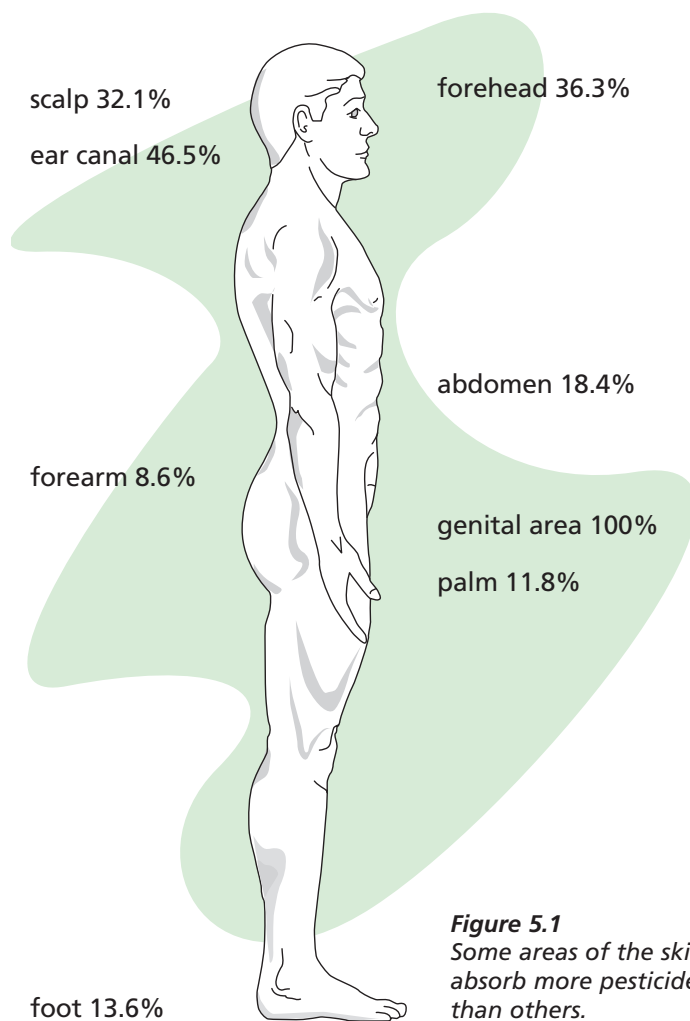


Figure 5.1
Some areas of the skin absorb more pesticide than others.

Pesticide formulations vary in how well they penetrate skin. In general, water-soluble liquids or powders, wettable powders, dusts, and granular pesticides do not easily penetrate skin. However, oil-based liquid formulations, such as emulsifiable concentrates, are readily absorbed.

Application techniques may also affect exposure levels for applicators. Making overhead applications, using blower application equipment for mists and dusts, using animal pour-ons, and dipping livestock and pets are all application methods that often have high dermal exposure levels. Additionally, contaminated hands or gloves can transfer pesticides to other body parts. Be sure to wash your hands and gloves after each pesticide-handling activity.

Eyes or Ocular Route

Eye tissues are extremely absorbent. Blood vessels are very close to the surface of the eye, so pesticides can be quickly and easily absorbed into the bloodstream. Under certain conditions when using certain pesticides, absorption through the eyes can be particularly hazardous. Eyes are very sensitive to many pesticides. For their size, they are able to absorb surprisingly large amounts of chemical. In addition to systemic concerns, some products are corrosive and can cause severe eye damage or even blindness. Significant eye exposure may result from airborne dusts or particles, splashes or spills, broken hoses, spray mists, or from rubbing the eyes with contaminated hands or clothing.

Breathing or Inhalation Route

Protecting the lungs is especially important when mixing, loading, or applying pesticides, particularly in confined areas. If inhaled in sufficient amounts, pesticides can cause contact damage to nose, throat, and lung tissue. Once breathed into the lungs, pesticides can enter the bloodstream very rapidly, eventually damaging other body organs (systemic illness). Another major concern is the aspiration (suction) of petroleum solvents (ingredients in emulsifiable concentrate formulations)

and other substances into the lungs while vomiting. As the person vomits, some of the material is aspirated into the lungs, where it can cause severe damage.

Swallowing or Oral Route

When people work around pesticides, oral exposure can occur when liquid concentrates splash into the mouth during mixing and loading of pesticides or while cleaning equipment. Never use your mouth to clear a spray line or to begin siphoning a pesticide. Eating, drinking, or smoking without first washing your hands may transfer product to your mouth.

Other people are most likely to accidentally swallow pesticides when chemicals are improperly stored in the home or when transferred into an unlabeled bottle or container normally used for food or beverages. Rodent baits may also pose an accidental exposure hazard if they are not properly placed. Unfortunately, children are the most common victims of these mishaps.

Mark all pesticide measuring cups and containers. Store them in a separate area away from measuring devices used for food and beverages so they are not used for water, drink, or food. Never store pesticides in beverage or other food containers. Practice good personal hygiene and wear proper protective equipment. Preventing exposure is key to the safe use of pesticides.

PRODUCT TOXICITY AND HEALTH CONCERNS

ACUTE TOXICITY

Injury or illness produced from a single exposure. LD₅₀ and LC₅₀ are common measures of the degree of acute toxicity.

CHRONIC TOXICITY

The ability of small amounts of pesticide from repeated, prolonged exposure to cause injury or illness.

Historically, the toxicity of pesticides and other substances has been determined by subjecting test animals (usually rats, mice, rabbits, or dogs) to various dosages of the active ingredient and to each of its formulated products. Toxicity, measured for both short-term (acute) and long-term (chronic) exposure, is evaluated at a range of doses: those that cause no immediate effects, those that cause some immediate effects, those that cause delayed or long-term effects, and those that

cause death. For some of the tests, the doses are administered only once to assess what effect(s) the pesticide may have from a single exposure. Other tests involve dosing the animals over several years to simulate exposure to small amounts throughout a lifetime. These tests can detect many different types of toxic effects ranging from subtle changes, such as weight loss or gain (which could indicate underlying problems), to specific illnesses, to death.

Today, agencies that regulate pesticides, prescription medications, over-the-counter drugs, and many other toxic substances are developing

tests that can identify and predict the same toxic endpoints as the earlier tests required. The newer methods use mathematical models and techniques without animal testing.

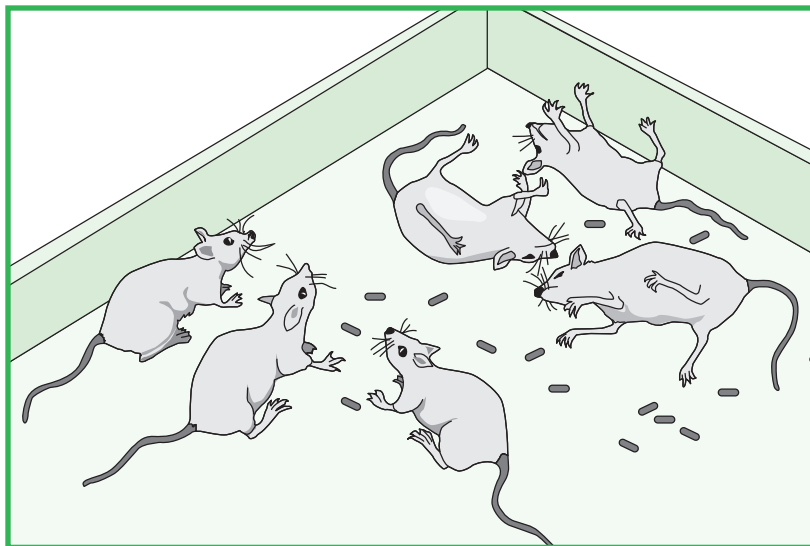
Acute Toxicity

Acute toxicity is the measure of harm (systemic or contact) caused by a single, one-time exposure event. Acute effects are determined after test animals have been exposed to a chemical through contact with their skin and eyes, through inhalation, or through ingestion. The harmful effects may be systemic or contact in nature (or a combination of both), depending on the product, formulation, dose, and route of exposure. Acute effects occur shortly after exposure, usually within 24 hours.

The following example of acute toxicity illustrates the damaging effects that can occur when people are exposed to a harmful dose of alcohol:

Alcohol consumption is fairly common. Each year, relatively few people die from lethal alcohol toxicity due to a single episode. Many people, however, experience varying levels of harmful effects after drinking too much, including headaches, digestive disorders, and disorientation. Symptoms from drinking alcohol depend on the dose, the exposure period, body chemistry, weight, diet and exercise, and other factors.

Acute systemic toxicity is the measure of illness or death resulting from a change in critical body function in a test animal. The common method used for comparing acute toxicity is the **LD₅₀**, or lethal dose 50%. The LD₅₀ is the dose of a toxicant required to kill 50% of the population of test animals under a standard set of conditions. For comparison purposes, LD₅₀ values of pesticides are recorded in milligrams of toxicant per kilogram of body weight of the test animal (mg/kg). When the animal is exposed to material by feeding, the result is referred to as the **oral LD₅₀**. When the material is tested by skin exposure, the result is called the **dermal LD₅₀**.



Another commonly used measure of acute toxicity is the **LC₅₀**, or lethal concentration 50%. This is the concentration of a substance in air or water required to kill 50% of the test population. The LC₅₀ is generally expressed as a ratio of the proportional amount of pesticide to a total volume of air or water. This is usually expressed in parts per million or milligrams per liter (mg/l). The LC₅₀ is a common measure of lethal effects of chemicals on fish and other aquatic organisms. The LC₅₀ values most directly applicable to human health are those expressing lethal concentration of chemicals in air.

The LD₅₀ and LC₅₀ values are useful in comparing the systemic toxicity of different active ingredients as well as different formulations of the same active ingredient. The lower the LD₅₀ value of a pesticide, the less it takes to kill 50% of the population of test animals and the greater the toxicity of the chemical. Table 5.1 summarizes the range of LD₅₀ and LC₅₀ values and their relationship to the different toxicity levels.

LD₅₀ and LC₅₀ values have limitations because they measure only one toxic effect—death. They do not indicate what dose may lead to other, less serious acute systemic effects or to other, possibly equally serious contact or delayed systemic effects. Also, they do not translate directly to humans because our body systems are slightly different from those of test animals. Lastly, the LD₅₀ and LC₅₀ are measures

LD₅₀ is the amount of pesticide that kills half of the test animals.

The lower the LD₅₀ value of a pesticide, the less it takes to kill 50% of the population of test animals. Therefore, the greater the toxicity of the chemical.

Table 5.1 Toxicity Categories

Signal Word & Symbol	Toxicity Level & Class	LD ₅₀ Oral (mg/kg)	LD ₅₀ Dermal (mg/kg)	LC ₅₀ Inhalation (mg/l)	Contact Injury Concern	Toxicity Concern
DANGER— POISON/ PELIGRO Skull & Crossbones	Highly toxic, Hazard Class I	Trace to 50	Trace to 200	Trace to 0.2	Signal word based on oral, dermal, or inhalation toxicity.	Very low dose could kill a person (a few drops to 1 teaspoon).
DANGER/ PELIGRO	Highly toxic, Hazard Class I				Corrosive— permanent or severe skin, eye, or respiratory damage.	Based on the corrosive or irritant properties of the product.
WARNING/ AVISO	Moderately toxic, Hazard Class II	50 to 500	200 to 2,000	0.2 to 2	Moderate skin, eye, or respiratory damage.	Small to medium dose could cause death, illness, or skin, eye, or respiratory damage (1 teaspoon to 1 ounce).
CAUTION	Slightly toxic, Hazard Class III	500 to 5,000	2,000 to 20,000	2 to 20	Mild skin, eye, or respiratory irritation.	Medium to large dose could cause death, illness, or skin, eye, or respiratory damage (1 ounce to 1 pint or 1 pound).
CAUTION or no signal word	Hazard Class IV	Greater than 5,000	Greater than 20,000	Greater than 20	Slight concern for skin, eye, or respiratory injury.	Slight to none (over 1 pint or 1 pound).

of a single exposure, not the potential sequence of effects resulting from multiple exposures.

Some pesticides produce acute toxic effects because of their corrosive or irritant properties. These can result in respiratory, skin, or eye irritation or damage. Some can cause severe burns or permanent blindness. Chemicals with these irritant or corrosive properties require extra care and special PPE. Fungicides, herbicides, and some insecticides may cause contact injuries. Manufacturers list nonlethal systemic and contact effects in addition to the signal word. Systemic and contact acute toxicity concerns are indicated by the signal word. They are further explained in the “Precautionary Statements” portion of the product label under the “Hazards to Humans and Domestic Animals” section.

EPA and the manufacturer take into account both systemic and contact toxicity measures in assigning the signal

word and toxicity category to a product. These are assigned on the basis of the greatest concern—be it oral, dermal, or inhalation systemic effects or skin, eye, or respiratory tract contact effects.

Signal Words and Skull and Crossbones Symbol

The Globally Harmonized System (GHS) for classification and labeling of chemicals is an international system for hazard communication. The goal of GHS is to help ensure more consistency in the classification and labeling of all chemicals, thereby improving and simplifying hazard communication. This improved communication system will alert the user to the presence of a hazard and the need to minimize exposure and risk. The result should be safer transportation, handling, and use of chemicals.

Under GHS, many substances—including paint, oven cleaner, dish soap, antifreeze, window cleaner, and others


—could eventually bear common signal words and pictograms. Signal words and pictograms will identify more types of hazards than the current signal words on pesticide labels. For instance, separate pictograms and/or signal words will provide information about chronic toxicity as well as acute toxicity. For the current status and implementation of GHS, go to <http://www.epa.gov/oppead1/international/globalharmon.htm>.

There are four distinct signal words found on pesticide labels: DANGER—POISON, DANGER, WARNING, and CAUTION. Signal words are based on the acute toxicity of the product. Depending on their acute toxicity, pesticide products are categorized into several hazard classes. Some very low toxicity products (Hazard Class IV) are not required to have a signal word.

Danger—Poison

Pesticides classified as highly toxic (Hazard Class I) with acute oral LD₅₀ values from a trace to 50 mg/kg must have the signal words DANGER and POISON (in red letters) and a skull and crossbones symbol prominently displayed on the package label. The lethal toxicity may be based on oral, dermal, or

DANGER-POISON
PELIGRO



Fatal if swallowed. May cause blindness if swallowed. May be fatal if inhaled or absorbed through eyes. Causes irreversible eye damage. Do not get in eyes, on skin, or on clothing. Do not breathe vapors or spray mist.



inhalation exposure, depending on which exposure route presents the greatest risk for that particular product.

PELIGRO, the Spanish word for DANGER, must also appear on the labels of highly toxic chemicals. As little as a few drops of a DANGER—POISON material taken orally could be fatal to a 150-pound person. Note that the human oral LD₅₀ of paraquat, a herbicide active ingredient, is 3 to 5 mg/kg, whereas the rat oral LD₅₀ is 150 mg/kg. Consult the precautionary statements that follow the signal word and symbol on the label to learn more about the product's hazard to humans. Most fumigants, some insecticides and rodenticides, and a few herbicides are assigned the DANGER—POISON signal word.

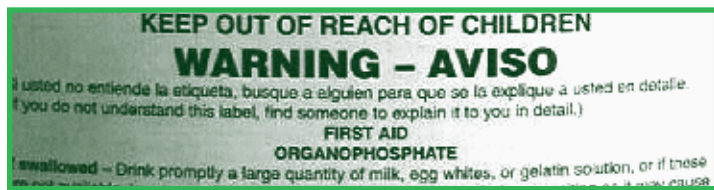
Hazard Class 1 pesticides that are highly toxic due to acute oral, dermal, or inhalation toxicity must have the signal words DANGER and POISON and the Spanish word for danger, PELIGRO, in red letters, and the skull and crossbones symbol prominently displayed on the package label.



Danger

Some highly toxic (Hazard Class I) pesticide products carry the signal word DANGER (without the word “poison” or the skull and crossbones symbol) because of their potential to cause acute contact injury. DANGER indicates the potential for permanent or severe damage to skin, eyes, or lungs. For products with this signal word, it has been determined that these contact effects are more dangerous than the acute systemic toxicity (LD₅₀) of the product. Several carry warnings of concern about the products' ability to cause irreversible eye damage at low exposures. Consult the precautionary statements that follow the signal word on the label to learn more about the products' hazard for humans. Some herbicides, insecticides, and antimicrobials carry the DANGER signal word.

Hazard Class 1 pesticides that are highly toxic due to acute contact toxicity must have the word DANGER but not the word POISON or the skull and crossbones symbol.



Hazard Class II pesticides must have the signal word **WARNING** (**AVISO** in Spanish) on the label.

Warning

A pesticide product considered moderately toxic (Hazard Class II) must have the signal words **WARNING** and **AVISO** (Spanish) on its label. If the concern is due to systemic toxicity, the acute oral LD₅₀ values range from 50 to 500 mg/kg; 1 teaspoonful to 1 ounce (2 tablespoons) of this material could be fatal to a 150-pound person. The concern could also be due to contact injury to skin, eyes, or respiratory tract. The **WARNING** signal word alone does not indicate whether the concern is systemic, contact, or both. Consult the precautionary statements that follow the signal word on the label to learn about the product's specific contact or systemic hazard for humans.



Hazard Class III pesticides are required to have the signal word **CAUTION** on the label.

Caution

Pesticide products classified as slightly toxic (Hazard Class III) are required to have the signal word **CAUTION** on the pesticide label. Acute toxicity may be systemic or contact in nature. If systemic, the acute oral LD₅₀ values are between 500 and 5,000 mg/kg. Contact effects are generally irritation of eyes, skin, or respiratory tract. Consult the precautionary statements that follow the signal word on the label to learn about the product's contact or systemic hazard to humans.

Chronic Toxicity

The **chronic toxicity** of a pesticide is determined by subjecting test animals to long-term exposure to an active ingredient. The length of exposure is typically two years, which represents

a lifetime for these test animals. The harmful effects that occur from small, repeated doses over time are termed chronic effects.

The following is an example of chronic toxicity:

In addition to acute toxicity of alcohol, chronic effects may also occur from alcohol exposure over long periods. Cirrhosis and other liver diseases, miscarriages, cardiovascular disease, neurological effects, and various cancers have been shown to be associated with long-term use of alcohol. As with acute effects, the illnesses and symptoms expressed in different people depend on the dose, the frequency of exposure, body chemistry, weight, diet and exercise, and other factors.

The general range of suspected chronic effects from pesticide exposure includes genetic changes, noncancerous or cancerous tumors, reproductive effects, infertility, fetal toxicity, miscarriages, birth defects, blood disorders, nerve disorders, and hormonal or endocrine-mediated diseases. Each pesticide has its own characteristic pattern of diseases and adverse effects that it might cause. However, no single pesticide is likely to be able to cause the entire range of harmful effects listed here. Remember that the tests used to characterize each pesticide's potential for harm are conducted at different doses. This helps regulators determine levels and conditions under which each pesticide could safely be used. **Minimizing the likelihood of chronic effects is one of the important reasons to follow all label directions and be cautious in handling and applying pesticides.**

If a product causes chronic effects in laboratory animals, the manufacturer is required to include chronic toxicity warning statements on the product label. This information is also listed on the SDS. The chronic toxicity of a pesticide is more difficult to determine through laboratory analysis than the acute toxicity and cannot be expressed by a single measure. Thus, there is no chronic toxicity measure equivalent to the acute toxicity LD₅₀.

Delayed Effects

Delayed effects are illnesses or injuries that do not appear immediately (within 24 hours) after exposure to a pesticide. They may be delayed for weeks, months, or even years. Whether you experience delayed effects depends on the pesticide, the extent and route

of exposure(s), and how often you were exposed. Under “Precautionary Statements,” the label states any delayed effects that the pesticide might cause and how to avoid exposures leading to them. Delayed effects may be caused by either an acute or a chronic exposure to a pesticide.

FACTORS AFFECTING RESPONSE

Like all living organisms, humans have built-in mechanisms to reduce the risks of toxic substances—including pesticides—and to eliminate them from the body. The liver is the primary organ that transforms toxic substances to non-toxic or less-toxic forms.

The chemical breakdown process performed by the liver also helps make most of these substances more water-soluble. They can then be eliminated from the body in urine. The kidneys are the most important organs in filtering water-soluble pesticides and other unwanted chemicals out of the blood and into the urine. Unwanted substances that cannot be made water-soluble eventually are stored in our bodies, primarily in fatty deposits throughout the body and in breast milk. Most of the pesticides in use today are more water-soluble than those of the past (before 1970). Most are eliminated relatively quickly (hours to days instead of months to years) in urine.

Some pesticides can cause changes, called mutations, to our DNA. DNA is the carrier of genetic information in our bodies. This information is stored as codes for all of the chemicals our bodies make to help them function properly. Some DNA mutations do not cause any effects. Others cause serious malfunctions and may lead to various types of illnesses or other problems, such as birth defects. Although our bodies constantly monitor and repair DNA mutations, over time our ability to repair the DNA decreases.

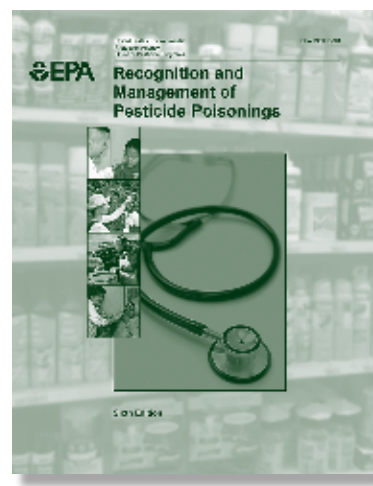
Our bodies continually manufacture the enzymes we need to help detoxify pesticides and other toxic substances. However, continual or very frequent exposures may overwhelm the body’s capacity for chemical breakdown and elimination. Keeping your exposure low and having periods of nonexposure between applications of the same class of pesticide can reduce the chance that your body will be overwhelmed.

SYMPTOM RECOGNITION

Symptoms can be correlated with certain groups of pesticides. For example, borates (insecticides) tend to irritate the skin, nose, and respiratory system. Some fungicides are irritants to the skin, eyes, and mucous membranes of the respiratory system. Anticoagulant-type rodenticides affect the blood’s ability to clot and may cause bloody noses and bleeding gums. Organophosphate and carbamate insecticides are cholinesterase inhibitors. They may cause certain systemic symptoms (*see sidebar*) that could

lead to respiratory failure and death. Symptoms associated with synthetic pyrethroid insecticides include nausea, dizziness, weakness, nervousness, and eye and skin irritation. Chlorophenoxy herbicides, such as 2,4-D and some related products (dicamba, MCPA, and MCP), are irritating to the skin and mucous membranes. They may also cause vomiting, headaches, diarrhea, and confusion.

Because symptoms of pesticide poisoning or exposure can vary widely, medical professionals need training



Reference material for toxicological symptoms.

to recognize this variability and treat appropriately. A manual entitled *Recognition and Management of Pesticide Poisonings* provides treatment guidelines for medical professionals. It may be obtained through the EPA Office of Pesticide Programs or from the EPA website, <http://www.epa.gov/>.

Cholinesterase Inhibition

Cholinesterase is an enzyme necessary for proper nerve impulse transmission and nervous system function. If the amount of this enzyme is reduced below a critical level, nerve impulses throughout the body can no longer be controlled. This may cause serious

health problems, affecting the ability of certain muscles, including the heart and breathing muscles, to function properly. Without medical attention, death may result.

Two classes of insecticides, organophosphates and carbamates, act as cholinesterase inhibitors. That is, they reduce the amount of cholinesterase available for the body's use. Cholinesterase inhibition can cause acute or delayed effects. Large exposures to organophosphate or carbamate insecticides can cause immediate illness. Although smaller exposures may not cause outward symptoms, small, repeated exposures over several days or weeks may continually reduce the body's cholinesterase level. This may ultimately trigger mild, moderate, or severe symptoms of overexposure.

In the case of cholinesterase inhibition, it is not always obvious whether a worker is showing symptoms from an acute exposure or experiencing delayed effects from repeated exposures. For

example, an applicator who is exposed to a single, large amount of an organophosphate may suffer acute effects. However, if over time the applicator is exposed to several small amounts, cholinesterase levels are slightly reduced at each exposure. Eventually, a small additional exposure may cause illness. In this case, the illness sets in soon after an exposure—but only following previous repeated exposures.

Cholinesterase Monitoring

Each person has a certain baseline level of cholinesterase enzyme that is considered normal for him or her. The blood cholinesterase test measures the effect of exposure to organophosphate and carbamate insecticides. A baseline must be established for each person before he or she begins working with cholinesterase inhibitors, or during the off-season. Always conduct baseline testing during the time of year when insecticides are not being used or at least 30 days from the most recent exposure. Establishing an accurate baseline value often requires that two tests be performed at least 72 hours (but not more than 14 days) apart.

If you regularly use organophosphate or carbamate insecticides, cholinesterase tests should be taken periodically and results compared with your baseline level. Also, anytime you feel ill or have mild or moderate poisoning symptoms, your medical professional should conduct a blood test to evaluate your cholinesterase level and compare it with the baseline level. The purpose of routine or emergency cholinesterase monitoring is to enable a medical professional to recognize the occurrence of excessive exposure to organophosphate and carbamate insecticides. A significant reduction in your body's cholinesterase level indicates poisoning. A medical professional normally suggests that the affected pesticide handler avoid further exposure until his or her cholinesterase level returns to normal. A drop in cholinesterase may require you to have no exposure to these chemicals for a certain period—usually three to five weeks—to allow your body time

Common symptoms associated with organophosphate and carbamate insecticide poisoning

Mild poisoning

- Fatigue
- Headache
- Dizziness
- Blurred vision
- Excessive sweating/salivation
- Nausea and vomiting
- Stomach cramps and diarrhea

Moderate poisoning

- Inability to walk
- Weakness
- Chest discomfort
- Constriction of pupils
- Mild symptoms more severe

Severe poisoning

- Unconsciousness
- Severe constriction of pupils
- Muscle twitching
- Running nose and drooling
- Breathing difficulty
- Coma and death

to build new cholinesterase. Medical professionals can help to establish the frequency of this testing program, which will depend on how often you use cholinesterase-inhibiting pesticides. Occupational and environmental

medicine specialists are most familiar with this type of testing program. Also, because different laboratories may use slightly different methods, the same laboratory should be used to collect and test all samples from any one individual.

FIRST AID FOR PESTICIDE POISONING

Get medical advice immediately if you or any of your fellow workers have unusual or unexplained symptoms that develop within 24 hours of a pesticide exposure. Be alert for the early symptoms of pesticide poisoning and contact (local) effects in yourself and others. Do not wait until you or someone else gets dangerously ill before calling a physician or going to a hospital. It is better to be too cautious than to act too late. To help the medical professional treat you appropriately and quickly, take the pesticide label with you. Bring either a duplicate copy or the one attached to the container (or, at a minimum, the EPA registration number of the product). To avoid contamination and exposure, do not carry pesticides in the passenger space of the vehicle.

The label is important because the medical professional needs to know the pesticide ingredients to determine the proper course of treatment. It is a good idea to print off extra copies of the label from the Internet. Place one copy in your service vehicle and one in your office in case of a medical emergency.

Keep in mind that even symptoms commonly associated with certain pesticides are not always the result of pesticide exposure. Common illnesses (e.g., the flu, heat exhaustion or heatstroke, pneumonia, asthma, respiratory or intestinal infections, and even a hangover) can cause symptoms similar to those of many frequently used pesticides. Contact with certain plants, such as poison oak or poison ivy, may also produce skin effects like those resulting from pesticide exposure. However, it is best to take every precaution. When symptoms appear after contact with pesticides, always seek medical attention immediately.

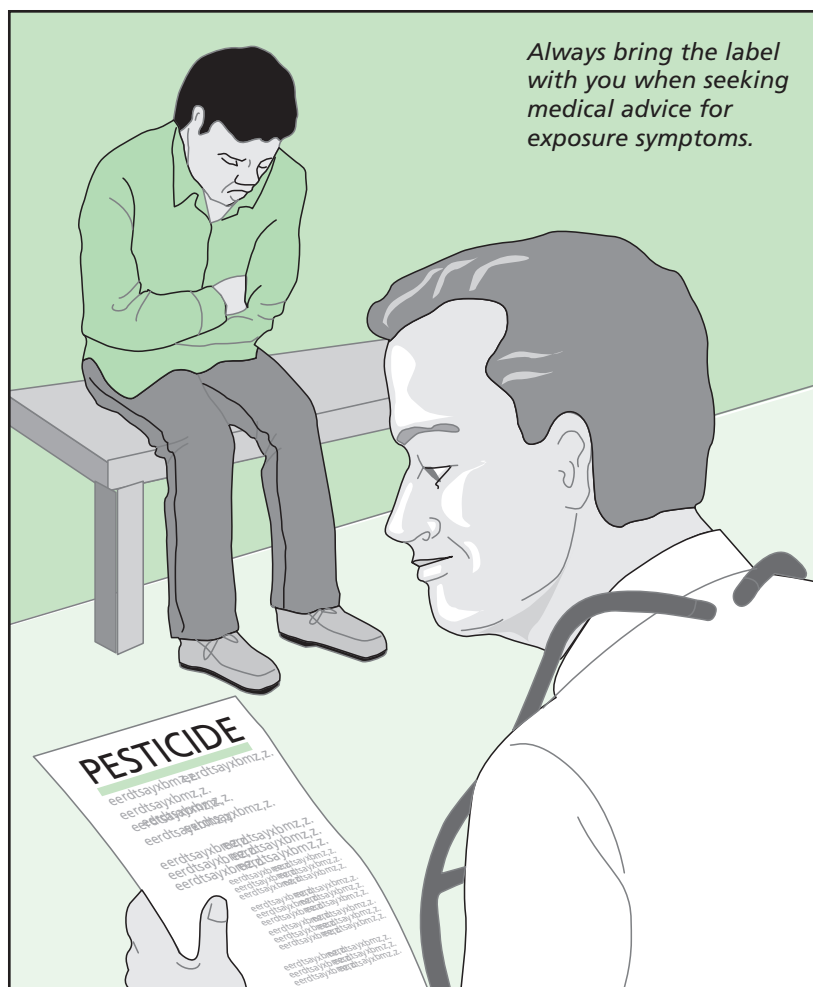
General First Aid

First aid is the initial effort to assist a victim while medical help is on the way. If you are alone with the victim, make sure he or she is breathing and is no longer being exposed to the pesticide before you call for help. Protect yourself from pesticide exposure before and while giving assistance. Make sure you wear the appropriate PPE, including a respirator if indicated, before assisting someone in an enclosed area. Administer artificial respiration if the victim is not breathing and is not vomiting.

American Association of Poison Control Centers
1-800-222-1222
(Staffed 24 hours)

Animal Poison Control Center (APCC)
1-888-426-4435

National Pesticide Information Center (NPIC)
1-800-858-7378



Immediate action can indeed be a life-or-death matter in a pesticide poisoning. The product label is the primary source of information. Follow the label's specific first aid instructions carefully. Beyond the label, call the American Association of Poison Control Centers (AAPCC) or a physician for additional advice. The AAPCC's poison help line (800-222-1222) is available 24 hours each day. First aid is only the first response and is not a substitute for professional medical help. It is very important to get the victim to a hospital, or contact 911 for emergency response, without delay. The following are a few key points to remember when administering first aid during a pesticide emergency:

- If oral or dermal exposure has occurred, the first objective is usually to rinse the exposed area with water to dilute the pesticide and prevent absorption.
- Always have a source of clean water available. In an extreme emergency, use water from a farm pond, irrigation system, or watering trough to rinse exposed areas and dilute the pesticide.
- Never try to give anything by mouth to an unconscious person.
- Do not induce vomiting unless the label tells you to.
- If inhalation exposure has occurred, get the victim to fresh air immediately.
- Become familiar with the proper techniques of artificial respiration. It may be necessary if a person's breathing has stopped or becomes impaired.
- If first responders are likely to be directly exposed to a pesticide, be sure they wear appropriate PPE.

In addition to the AAPCC, you can call the National Pesticide Information Center (NPIC). NPIC provides a variety of information about pesticides to anyone in the United States by

phone (800-858-7378 or online (search for "National Pesticide Information Center"). Post all emergency numbers near telephones and in service vehicles used by pesticide handlers.

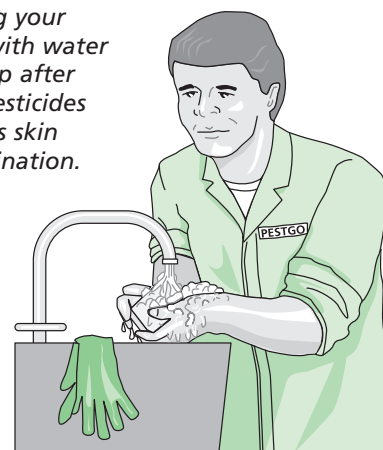
Pets, horses, and other livestock may also be poisoned by exposure to pesticides. For emergency information on treating pets or livestock harmed by pesticide contamination or poisoning, call the Animal Poison Control Center (888-426-4435).

Pesticide on the Skin

Proper hygiene helps protect the skin from pesticide exposure. Keep an adequate water supply with you whenever skin exposure is possible. Other key points:

- Remove all contaminated clothing immediately.
- Wash the affected area, including the hair, with water and soap. Rinse well. Showering is better than bathing to avoid prolonged contact with pesticide residues. Avoid harsh scrubbing, which could damage the skin and enhance pesticide absorption.
- Gently dry the affected area and wrap it in loose cloth or a blanket, if necessary.
- If the skin has chemical burns, cover the area loosely with a clean, soft cloth. Do not use ointments, greases, powders, and other medications unless instructed to do so by a medical authority.

Washing your hands with water and soap after using pesticides prevents skin contamination.



Wash and store contaminated clothing separately from the family laundry. If clothing is contaminated with a pesticide concentrate or if there is concern about getting contaminated clothing clean, it is often best to dispose of it. Place the clothing in a plastic bag, seal the bag, and write the name of the pesticide on it. Take it to a household hazardous waste collection.

Pesticide in the Eyes

Because eyes readily absorb material, fast action is required. Other key points:

- Hold the eyelid open and immediately begin gently washing the eye with drips of clean water. Do not use chemicals or drugs in the wash water unless instructed to do so by a medical professional or a poison control center.
- Drip the water across—not directly into—the eye, or use an eyewash dispenser.
- Continuously rinse the eye for 15 minutes. If only one eye is affected, be careful not to contaminate the other eye.
- Flush under the eyelid with water to remove debris.
- Cover the eye with a clean piece of cloth and seek medical attention immediately.

Inhaled Pesticide

The basic first aid procedure for someone who has inhaled a pesticide is to get him or her to fresh air. Other key points:

- Immediately carry the victim to fresh air (do not allow him or her to walk).
- Do not attempt to rescue someone who is in an enclosed, contaminated area unless you are wearing appropriate PPE.
- If other people are in the area, warn them of the danger.
- Have the victim lie down and loosen his or her clothing.

- Keep the victim warm and quiet. Do not allow him or her to become chilled or overheated.
- If the victim is convulsing, protect his or her head, turn the head to the side, and watch that breathing continues. Do not attempt to insert anything into the person's mouth during a seizure.
- Keep the person's chin up to ensure that air passages are open for breathing.
- If breathing stops or is irregular, give artificial respiration.

Pesticide in the Mouth or Swallowed

If pesticide is in someone's mouth but has not been swallowed, rinse the mouth with plenty of water. Then give the victim large amounts (up to 1 quart) of milk or water to drink. If the pesticide is swallowed, one of the most critical first aid decisions is whether to induce vomiting. Induce vomiting only if the label instructs you to do so. Several pesticides cause more harm when vomited than if they remain in the stomach. To provide first aid for a swallowed pesticide, you must know the appropriate treatment. The decision to induce vomiting must be made quickly and accurately—the victim's life may depend on it.

Never induce vomiting if the victim:

- Is unconscious or having convulsions.
- Has swallowed a corrosive poison, such as a strong alkali or acid. The material burns the throat and mouth as severely coming up as it did going down. Also, it can be aspirated into the lungs and cause more damage.
- Has swallowed an emulsifiable concentrate or oil solution product, which is dissolved in petroleum solvents. Emulsifiable concentrates and oil solutions may be fatal if aspirated into the lungs during vomiting.

Note: Ipecac syrup, used as an emetic for almost 50 years, is no longer recommended for routine use in most poisonings. Clinical studies have demonstrated no benefit from its use. Ipecac works too slowly (about 20 minutes) in inducing vomiting and results in only about one-third of stomach contents being voided.

How to Induce Vomiting (if appropriate)

Induce vomiting only as a first aid measure until you can get the victim to a hospital. Do not waste a lot of time trying to induce vomiting. Follow these steps:

- Make sure the victim is kneeling forward or lying on his or her side to prevent vomit from entering the lungs and causing additional damage.
- Give the victim at least two glasses of water to dilute the product. Do not use carbonated beverages.
- Put your finger or the blunt end of a spoon at the back of the throat. Do not use anything sharp or pointed. Do not give the victim saltwater.
- Collect some of the vomitus for the doctor, who may need it for chemical analysis.

Activated charcoal is another first aid treatment that can be administered

when a pesticide has been swallowed. It acts as a magnet to adsorb many chemicals. Pharmaceutical-grade activated charcoal is available from most drugstores. Activated charcoal prepared for cleaning up pesticide spills may be substituted in an emergency. Seek the advice of a medical professional or poison control center before administering activated charcoal. Take the victim to a physician or hospital.

Only general first aid practices have been discussed here. Contact a poison control center for more help in administering first aid. If necessary, get the victim to a medical professional or hospital. Take the pesticide label with you.

Antidotes

Antidotes are available for only a few classes of pesticides: anticoagulant-type rodenticides and organophosphate or carbamate insecticides. Because antidotes can be extremely dangerous if misused, they should be prescribed and administered only by a qualified medical professional. Antidotes should *never* be used to prevent poisoning.

HEAT STRESS



Avoid heat stress by taking breaks and drinking water throughout the workday.

Heat stress occurs when the body cannot cope with a certain level of heat. Heat stress may affect both pesticide handlers and other workers. A person suffering from heat stress exhibits symptoms that closely resemble poisoning symptoms of some pesticides. PPE worn during handling or early-entry activities may increase the risk of heat stress. The protective qualities of the PPE may restrict the evaporation of sweat, thus impeding the body's natural cooling system. If you are under a physician's care, consult him or her before working

in hot or humid conditions. Vests and headbands with special pockets for ice packs or other heat stress prevention devices may be worn with or beneath PPE. These will help maintain a cool body temperature.

Symptoms of Heat Stress

Mild forms of heat stress make people feel ill and impair their ability to do a good job. You may feel weak and get tired sooner than usual. You may also be less alert and less able to use good judgment. Severe heat stress, also known as heatstroke, is life-threatening. The normal human body temperature ranges from about 97°F to 99°F, with an average of 98.6°F. With heatstroke, body temperature may exceed 105°F. Staggering, loss of consciousness, or convulsions may result. Lack of sweating is a common symptom of heatstroke. Brain damage or even death

may occur if the heatstroke victim is not cooled down very quickly. More than 10% of severe heat stress victims die—including young, healthy adults. Sometimes victims remain highly sensitive to heat for months and cannot return to the same type of work.

Heat stress symptoms include:

- Fatigue, exhaustion, or muscle weakness.
- Dizziness and fainting.
- Clammy or hot, dry skin.
- Altered behavior: confusion,

slurred speech, quarrelsome or irrational conduct.

- Headache, nausea, and chills.
- Severe thirst and dry mouth.
- Heavy sweating: eventually, this can progress to a complete lack of sweating as the body loses the ability to control its temperature.

Act immediately to cool down if you suspect that you may be suffering from even mild heat stress. Drink plenty of water and take breaks in the shade throughout the workday. In hot conditions, watch for symptoms of heat stress in other workers as well.

SUMMARY

Pesticide risk can be summarized by the equation **hazard (risk) = toxicity x exposure**. “Toxicity” is the capacity of the pesticide to cause either short-term (acute) or long-term (chronic) injury or illness; “exposure” is the means by which the pesticide gets into or onto the body. These two factors determine the likelihood that harm (i.e., hazard) will come to a person who handles pesticides.

Harmful effects of pesticides may occur at the area of local contact or after uptake into the body (i.e., systemic effects). Pesticides can enter the body by any of four routes: through the skin (dermal), eyes (ocular), lungs (respiratory), or mouth (oral). Some adverse effects may occur within 24 hours after a single (usually large) exposure (acute effects). Others may occur many years after exposure (delayed effects), typically from small exposures over a long period (chronic effects). Pesticide handlers can minimize exposure—and reduce risk—by following label directions, using the proper application and handling procedures, and wearing appropriate personal protective equipment.

The toxicity of a pesticide product is measured in test animals by the LD₅₀ and LC₅₀ values. These values

determine the signal word that occurs on the pesticide label. Signal words—DANGER–POISON, DANGER, WARNING, and CAUTION—help the user recognize how acutely toxic the pesticide is and what precautions to take. Remember, however, that the signal word only provides information about the acute toxicity of the product. Chronic and delayed effects are often the result of different mechanisms and are not related to the substance’s level of acute toxicity.

People who use pesticides routinely should have regular medical checkups to determine if they are experiencing any ill effects from pesticide use. Regular monitoring of blood cholinesterase levels can determine if certain insecticides are affecting an individual before symptoms appear.

Early recognition of pesticide poisoning symptoms is the key to preventing further injury. The label often provides important information on first aid procedures for the particular pesticide product. Make sure a copy of the label is readily available whenever you are using pesticides. Take the label to a medical professional if a poisoning incident occurs.

Review Questions

CHAPTER 5: PESTICIDE HAZARDS AND FIRST AID

Write the answers to the following questions, and then check your answers with those in Appendix A.

- The capacity of a pesticide to cause short-term (acute) or long-term (chronic) injury is referred to as its:
 - Toxicity.
 - Exposure.
 - Hazard.
- Which statement about harmful effects of pesticides is *false*?
 - The most common form of pesticide injury is by inhalation.
 - Asthma-like symptoms may be caused by allergies to pesticides.
 - Many herbicides and fungicides cause dermatitis (skin reactions).
- Which signal word is associated with very low oral LD_{50} values?
 - DANGER-POISON.
 - WARNING.
 - CAUTION.
- Which statement about pesticide toxicity is *true*?
 - A pesticide with an oral LD_{50} of 5 mg/kg is more toxic than a pesticide with an LD_{50} of 250 mg/kg.
 - Manufacturers are not required to include chronic toxicity warning statements on product labels.
 - The signal word on the product label indicates how likely the product is to cause both acute and chronic toxic effects.
- For which class(es) of pesticides might cholinesterase monitoring be appropriate?
 - Organophosphate and carbamate insecticides.
 - Pyrethroids.
 - Phenoxy herbicides, such as 2,4-D.
- Which statement about what happens to pesticides inside the body is *true*?
 - Most pesticides used today are stored in our body fat.
 - The kidneys filter pesticides from the blood into the urine.
 - Most chemical breakdown of toxic substances takes place wherever the pesticide is first absorbed.
- Which statement about pesticide exposure routes is *true*?
 - Studies show that about 97% of all body exposure to pesticides during a spraying operation is by inhalation.
 - Eating, drinking, or smoking without first washing your hands after handling pesticides is likely to transfer the product to your mouth.
 - The palms and forearms absorb pesticides more quickly than the scalp, ear canal, and forehead.
- Which statement about first aid response for pesticide exposure to the eye is *false*?
 - You should hold the eye open and immediately begin gently washing it.
 - You should drip water directly into the eye.
 - You should flush under the eyelid with water to remove debris.

continued 

9. What is the first thing you should do to help a victim of inhalation exposure?
- A. Get the victim to fresh air.
 - B. Administer artificial respiration.
 - C. Have the victim lie down and loosen clothing.
10. Which statement about heat stress is *true*?
- A. Wearing extra PPE prevents heat stress.
 - B. Constricted pupils is a symptom of heatstroke.
 - C. Lack of sweat is a symptom of heatstroke.