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Pesticides, Adverse Effects

ICD-10 X48

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A pesticide is any substance used to prevent, destroy, repel, or mitigate insects, rodents, nematodes, fungi, weeds, or other organisms considered pests. Plant growth regulators, defoliants, desiccants, and insect repellents are also among the many substances regulated as pesticides. Pesticides are ubiquitous, being used in homes, schools, workplaces, and communities. Pesticides play an important pest management role in most conventional and organic agricultural operations worldwide. The widespread dissemination of pesticides, however, creates potential for related illness and injury, especially among pesticide handlers and agricultural workers.

Formulated pesticide products consist of active ingredients (those chemical compounds that have pesticidal action) and inert ingredients (chemicals such as soaps, adjuvants, and carriers having no pesticidal action, but nevertheless possibly being harmful to humans). The chemical components of some pesticide materials cause poisoning by interfering with biochemical and physiological functions. The nature and extent of injury depends on (a) the hazards of the inert components, (b) the toxicity of active ingredients, and (c) the dose. Some pesticide compounds are very toxic and cause poisoning at low doses; ingesting a few drops of these has the potential to cause severe illness or even death. Other pesticide compounds are so mildly toxic that large quantities of the active ingredient must enter the body before signs of illness or injury can be detected. Exposure to certain chemicals used as pesticides correlates to specific chronic disorders, although it is difficult to accurately predict what effects can result from long-term repeated exposures to most types of pesticidal chemicals.

There are several ways workers are exposed to pesticides, most commonly when they mix or apply them or when they enter, or perform work in, treated areas soon after pesticide application. People also may be exposed if they work near areas where pesticides are used, eat contaminated produce, or touch recently treated foliage, livestock or poultry, stored products, clothing,

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or furnishings. Spills or accidents may result in high levels of exposure. Sometimes the circumstances of exposure reveal the approximate amount absorbed. For example, exposure to drift from a spray application that has been properly diluted for field application is not likely to convey a large dose, unless exposure has been prolonged. In contrast, spills of concentrated material onto the skin or clothing may well represent a large dose of pesticide, unless the pesticide is promptly and properly removed.

In some cases, poisoning or injury may result from a single exposure to a specific pesticide. In other cases, symptoms do not occur until a person has been exposed repeatedly to small doses of a single compound or combination of materials over a period of time. Individuals commonly vary in their reaction to a pesticide exposure dose. Some people may exhibit no noticeable effect to a dose that causes severe illness in others. A person's age, body size, and health status often influence response to a given dose; thus, infants and young children are normally affected by smaller doses than are adults. In addition, women often are affected by lower doses than men.

Usually the most harmful levels of pesticide exposure result from occupational accidents. Workers in the agricultural industry have the highest number of pesticide-related accidents, most occurring during mixing or application, when workers handle concentrated pesticides.

Spills, explosions, or similar accidents during manufacturing and packaging of pesticide products have the potential to seriously injure plant employees and people living or working nearby. Persons involved in transporting pesticides risk possible illness and injury if pesticide containers rupture and spill their contents or are involved in a fire. Pesticide spills during transport also endanger the public.

The type and severity of pesticide poisoning depends on the toxicity and mode of action of the pesticide, the amount absorbed (dose), and the speed of absorption, metabolism, and excretion. Severity of poisoning may sometimes be reduced by prompt decontamination and medical treatment. Very small doses usually produce no symptoms. Depending on the toxicity of the pesticide, larger doses may cause severe illnesses. Effects of exposure may be localized, such as irritation of the skin, eyes, nose, or throat, or generalized, when pesticides are absorbed. Pesticides may adversely affect several organ systems concurrently.

Symptoms vary among classes of pesticides and among pesticides within a class. Presence and severity of symptoms are usually proportional to dose. Common symptoms include rashes, headaches, and irritation of the eyes, nose, and throat, all of which symptoms may resolve within a short period of time and are often difficult to distinguish from similar symptoms produced by allergies and respiratory infections. Other more-specific symptoms, which might indicate exposure to certain classes of pesticides, include blurred vision, dizziness, excessive sweating, weakness, nausea and vomiting, abdominal pain, diarrhea, extreme thirst, and blistered skin. Serious poisoning may also lead to apprehension, restlessness, anxiety, unusual behavior, shaking, convulsions, or unconsciousness. Certain individuals exhibit allergic reactions when exposed to some types of pesticides; the substance causing the reaction may be the pesticide or one of the ingredients in the pesticide formulation. Symptoms often include breathing difficulties, sneezing, eye watering and itching, rashes, apprehension, and general discomfort.

Most pesticide poisoning is reversible, although irreversible damage can occur and result in a chronic illness, disability, and/or death.

Occurrence

Surveillance for adverse health effects due to pesticide exposure tends to focus on acute effects, and is not generally designed to identify chronic health effects. There are few population-based pesticide surveillance programs, and little data on the completeness or representativeness of those that exist. The California Pesticide Illness Surveillance Program, operated by the California Environmental Protection Agency, is one major source of information about pesticide effects on human health. In the decade from 1993 through 2002, it collected 12,275 case reports of pesticide illnesses. These were classified as definitely (21%), probably (47%), or possibly (32%) related to pesticide exposure based on investigation by county agricultural commissioners. Of the 12,275 cases, 82% resulted from exposures during work, and 41% from exposure to pesticides used for agricultural purposes. Field worker exposures constituted 17% of the total, with 56% due to residue, 41% to drift, and 3% to other or unknown causes.

Causes

Table 1 lists many occupations in which pesticide exposure may occur. Although workers who apply, mix, and/or load pesticides are most at risk, farm field workers, tractor drivers, and irrigators may receive injurious exposures if they are not protected from pesticide residues. The establishment of restricted-entry intervals following application of highly toxic or otherwise hazardous pesticides has been an important step in reducing farm worker injury. Techniques, such as reducing drift and applying pesticide spray when workers are not present in adjacent fields, are other regulatory controls designed to reduce potential for exposure of workers in nearby areas.

Workers who perform maintenance or repair on pesticide application or handling equipment may come in contact with pesticide residues on that equipment. Oil-soluble pesticides are a major concern because they accumulate more in grease deposits and on oily surfaces and may be difficult to remove. Employees in packing sheds and food processing plants may unknowingly be exposed to contaminated produce or soil-borne residues, especially when persistent pesticides have been used during crop production. The activities of greenhouse and nursery workers often expose them to treated foliage due to the density of plants and the narrow aisles. Greenhouses have limited ventila-

Table 1. Occupations in Which There May Be Risks of Pesticide Exposure

agricultural field workers
agricultural irrigators
agricultural pesticide applicators
agronomists
aquatic area workers
building maintenance workers
crop duster maintenance workers
emergency responders
entomologists
farmers and farm workers
field scouts
firefighters
flaggers
forestry workers
formulators of pesticide products
fumigators
golf course workers
greenhouse, nursery, mushroom house workers
hazardous waste workers
institutional maintenance crews
interior plantscapers
landscapers
livestock handlers
maintenance gardeners
manufacturers of active ingredients
marina workers
medical personnel
mixers and loaders of pesticides
park and campground workers
pest management consultants
pesticide application equipment maintenance workers
pesticide applicators
plant pathologists
produce packing-house workers
public health pest control workers
recreational area workers
research chemists
right-of-way workers
rodent control specialists
sewer line workers
storage and warehouse workers
structural pest control operators
transporters of pesticides
treaters of contaminated workers
veterinarians
weed specialists
wood treatment workers

tion, increasing the potential for respiratory, dermal, and ocular exposures. Similar conditions exist for pest-control operators working in enclosed areas of buildings, homes, warehouses, factories, and offices. Residues remaining after fumigation of buildings and other work areas are a source of possible exposure to people if they enter these areas too soon after application. Fabrics, furniture, and carpeting are sometimes treated to prolong useful life by protecting them from insect damage or reducing the build-up of fungi or bacteria, and, in some instances, may subject people to low levels of exposure. Livestock and pets treated with pesticides may be a low-level source of exposure if people work in close contact with recently treated animals. Lawns, shrubs, and other parts of residential, industrial, and public landscape that have been treated for pests sometimes can be sources of pesticide exposure.

Certain types of pesticides, such as some chlorinated hydrocarbons, persist in the environment for as long as 50 to 100 years or more. Other pesticides, organophosphates for example, break down rapidly (within a few hours to several weeks or months) under normal environmental conditions. The persistence of a pesticide is often referred to as its half-life-the measure of how long it takes for the material to be reduced to half of the amount originally applied. Besides the chemical nature of the pesticide, there are other factors that influence persistence. The types of adjuvants in a pesticide formulation affect persistence. Pesticides dissolved in oils or petroleum solvents may volatilize more slowly than water-soluble materials, and therefore persist longer. The pH of the water used for mixing pesticides affects the speed of degradation. In addition, the pH of plant or animal tissues may have a similar influence. High temperatures and humidity cause chemical changes in some compounds, accelerating breakdown. Sunlight produces photochemical reactions that decompose many pesticides.

Pesticides enter the body via skin or eye absorption, ingestion, or inhalation. Dermal contact is the most frequent route of entry. Pesticides on the skin may cause a mild dermatitis or more severe skin injury. The ability of a pesticide to be absorbed dermally depends on chemical characteristics of the pesticide and its formulation components. Pesticides that are more soluble in oil or petroleum solvents penetrate the dermis more easily than those that are more soluble in water. In addition to injury to ocular tissues, the eyes provide another route for pesticide absorption. Ingestion may occur by accidentally drinking a pesticide (usually because it has been improperly stored in a beverage or food container), by accidentally splashing liquids or dusts into the mouth during mixing or application, or by eating foods or drinking beverages that have become contaminated during pesticide handling. Intentional ingestion during suicide attempts also accounts for many illnesses and deaths in some countries. Smoking while handling pesticides may also increase the potential for ingestion. In the lungs, some types of pesticides are quickly absorbed and transported to other sites. Certain chemicals used as pesticides or adjuvants in a pesticide formulation directly damage lung tissue.

Prevention

Pre-Market Testing and Registration: Federal law requires that before selling or distributing a pesticide in the United States, a person or company must obtain a registration of this product from the EPA. Before registering a new pesticide or new use for a previously registered pesticide, the EPA must ensure that the pesticide, when used according to label directions, can be used with reasonable certainty of no harm to human health and without posing unreasonable risks to the environment. To make such determinations, the EPA requires more than 100 scientific studies and tests from applicants. Where pesticides may be used on food or feed crops, the EPA also sets tolerances (maximum pesticide residue levels) for the amount of the pesticide that can legally remain in or on foods.

Most states conduct a review of each label of pesticides sold in order to ensure that they comply with federal labeling requirements and any additional state restrictions of use. States may require the registration of pesticides and inert ingredients that are exempt from the requirements of federal registration.

The EPA is reregistering existing pesticide products in order to ensure that older pesticides meet current safety standards. Changes in the way a pesticide is used may be necessary to protect consumers, workers, or the environment.

Surveillance and Biological Monitoring: Medical surveillance of pesticide-exposed workers includes several components common to proper risk management in the workplace. There is a need for both broad-based efforts to reduce exposure and prevent disease, as well as focused efforts to monitor those workers at the highest risk. Each surveillance system has different strengths and weaknesses, and may be appropriate in different situations.

Some recent efforts have focused on individual susceptibility to the adverse effects of pesticide exposure. For example, individual differences in "toxifying" and "detoxifying" metabolic rates for alkylating and arylating pesticides may explain inter-individual susceptibility to their adverse effects. However, such individual susceptibility information is not well understood and generally has no known role in the development and management of risk among individuals with possible pesticide exposure.

Medical surveillance programs can be offered at the population level or the individual level. At the population level, monitoring of pesticide illnesses provides data on overall rate of acute pesticide illnesses, indicates possible localized epidemics, and identifies risk factors for acute illnesses in the population being monitored. Such surveillance can be performed at the national, state, county, or any other level for which data are collected. The most well-known example is the reporting requirement for pesticide illnesses in California. This system has been used to identify individual cases or clusters of pesticide illness for evaluation, to monitor the overall number and distribution of pesticide illnesses in the state, and to investigate risk factors for acute pesticide illnesses. Using a surveillance system as a case-finding database, one can also evaluate short- and long-term health outcomes of individuals.

Surveillance of pesticide illnesses at the national level has also been successfully achieved. For example, three national registers (of occupational accident and disease reports, hospitalizations, and deaths) were analyzed in Costa Rica in order to characterize pesticides associated with the highest risk of poisoning and population characteristics associated with increased occupational poisonings. A surveillance system in Malaysia identified the most common pesticides associated with poisonings in that country. An epidemic of acute pesticide poisonings was identified in Nicaragua by use of a ministry of health surveillance system for detecting pesticide poisonings.

Medical surveillance for pesticide illness at the individual level can be used with various data sources to detect probable cases. Surveillance may also be conducted by measurement of biological markers of exposure to pesticides. Such markers may detect either pesticide metabolites or the effects of pesticide exposure.

The Sentinel Event Notification System for Occupational Risks (SENSOR), sponsored by NIOSH, uses targeted sources of information to recognize and report selected occupational disorders to a state surveillance center. This system is a cooperative federal-state effort designed to develop local capability for preventing selected occupational disorders. It has been used to monitor various occupational diseases, including pesticide poisoning. Other surveillance can be conducted through use of other databases of mortality, hospital discharge, and poison control center data.

Recent advances have improved the ability to estimate long-term, chemical-specific pesticide exposures in epidemiologic studies. Detailed questionnaires can be used to collect intensity-related exposure information, such as maintenance or repair of mixing and application equipment, work practices, and personal hygiene. While such methods are useful for epidemiologic studies of chronic effects from pesticide exposure, they are not appropriate for surveillance of acute pesticide illness.

Exposure assessment for pesticides may be conducted on environmental samples or by measurement of the pesticide or its metabolites in body tissues (biologic monitoring). Biologic markers exist for several pesticides and pesticide metabolites. Biologic monitoring measures the actual dose absorbed by any route, thus reflecting actual exposure conditions, work practices, and use of personal protective equipment. In some instances, biologic markers may reflect both occupational and nonoccupational exposures. Methods for biologic monitoring of pesticides have been reviewed, reflecting biologic exposure indices for several classes of pesticides, including phenoxyacids, quaternary ammonium compounds, coumarin rodenticides, synthetic pyrethroids, organochlorine pesticides, and chlortriazines.

One advantage of biologic monitoring of pesticides or their metabolites is that exposures can be measured at very low concentrations, reflecting exposure not known to be associated with adverse health effects. For example, urinary alkylphosphates reflect exposure to organophosphate pesticides (OPs) and can be measured to evaluate acute effects of OP exposure. Paraquat can be measured at extremely low concentrations in the urine, reflecting exposures not known to be associated with adverse acute effects. Exposure to high concentrations of paraquat results in respiratory toxicity, and urinary monitoring may be useful to identify workplace factors associated with paraquat exposure so they can be minimized. Biologic markers of pesticide exposure are useful for epidemiologic studies, but have significant limitations for medical surveillance programs, the major one being the short half-life of most currently used pesticides (usually 1 to 2 days). The cost of these assays also limits their use for routine surveillance.

The most well-established biologic marker for monitoring OP exposure is blood cholinesterase. Cholinesterases hydrolyze esters of choline; for example, acetylcholinesterase hydrolyzes the neurotransmitter acetylcholine. Acetylcholinesterase is an extremely useful biomarker for evaluation of acute illness possibly due to cholinesterase-inhibiting pesticides. It has also been used for monitoring exposure to a broad range of OPs and carbamate pesticides. Monitoring of blood cholinesterase is required in California for workers using OPs and carbamates. Recently-developed automated kits for cholinesterase measurement are not recommended for routine use without standardization against a laboratory standard. Because of poor correlation of cholinesterase assays among commercial laboratories, there is a need for better standardization of assay methods.

There are several components of surveillance programs for workers exposed to OPs or carbamates, including: (1) identification of high-risk populations requiring surveillance, (such as mixers, loaders, applicators, flaggers, and others who directly handle pesticides); (2) baseline cholinesterase determination (red cell cholinesterase is the preferable measurement, although problems with standardization of this assay persist); (3) periodic surveillance (the repeat testing interval is variable, and may depend on the type of system used and the duration of pesticide application); and (4) criteria for medical removal from work (although exact criteria are difficult to establish because of variability in blood cholinesterase measurements, depressions of 15% to 30% from baseline should be medically evaluated).

Appropriate Diagnosis and Treatment: Recognition of acute pesticide poisoning and prompt treatment, essential elements in the prevention of serious adverse effects, are particularly important because many symptoms of mild acute pesticide poisoning are nonspecific and may be misdiagnosed as other health problems, such as systemic viral illness, gastroenteritis, or asthma. It is important to consider possible pesticide poisoning in any individual with an altered state of consciousness or with findings that suggest OP poisoning. A history of working with pesticides should increase suspicion of this diagnosis, but pesticide poisoning can also occur from nonoccupational exposures.

The signs and symptoms of acute pesticide poisoning due to OPs and/or carbamates are sometimes remembered by the mnemonic MUDDLES (miosis, urination, defecation, diaphoresis, lacrimation, excitation, and salivation). OPs and carbamates inhibit acetylcholinesterase at nerve endings, resulting in an accumulation of acetylcholine. Severe OP poisoning must be distinguished from an acute cerebrovascular accident and, especially in agricultural workers, heat stroke, heat exhaustion, and infection. Clinical manifestations reflect the organ systems where acetylcholine is the neurotransmitter (Table 2). Severity of the symptoms may reflect dose; pre-existing medical conditions, such as asthma, and localized effects.

Treatment of possible OP poisoning should never be delayed pending results of blood cholinesterase testing. If the clinical diagnosis of OP poisoning is suspected, samples should be drawn for laboratory analysis and a test dose of atropine administered. The required dose of atropine depends on the severity of the poisoning. Other considerations in treatment include: (1) decontamination, including bathing of skin and gastric lavage, as appropriate; (2) increasing doses of atropine every 15 minutes to reverse the muscarinic effects; (3) pralidoxime chloride (2-PAM), only for OP poisoning; and (4) clearance of secretions, artificial ventilation, oxygenation, and other supportive measures, as clinically indicated. More complete descriptions of the recognition and management of pesticide poisonings can be found in a book available free of charge

Table 2. Signs and Symptoms of Acute Organophosphate Poisoning

System	Receptor Type	Organ	Sign or Symptom
Parasympathetic	Muscarinic	Eye, iris, and ciliary muscles	Miosis
Sympathetic		Glands: lacrimal, salivary, respiratory, gastrointestinal, sweat	Tearing, salivation, bronchorrhea, pulmonary secretion, nausea, vomiting, diarrhea, frequent urination, perspiration
		Heart: sinus node, AV node	Bradycardia, arrhythmias, heart block
		Smooth muscle: bronchial, gastrointestinal	Bronchoconstriction, cramps, vomiting, diarrhea
		Bladder	Frequent urination, incontinence
Neuromuscular	Nicotinic	Skeletal muscle	Fasciculation, cramps, followed by weakness, loss of reflexes and paralysis
Central nervous system		Brain	Headache, dizziness, malaise, confusion, convulsions, and, as a late effect, loss of consciousness

from the EPA (see Further Reading) and in standard medical texts on diagnosis and treatment.

There are many other pesticides, used for control of diverse pests ranging from insects to weeds to rodents (Table 3). Acute health effects vary with many factors, including dose, route, duration of exposure, and chemical structure. Adverse health effects for specific agents should be ascertained from more detailed reference texts.

Protecting People through Pesticide-Use Decisions: Often several pesticides can be used for control of the same weed, insect, pathogen, nematode, or vertebrate pest in a particular situation. One of the ways that employers can reduce hazards to employees is to avoid or reduce the use of specific pesticides, and when needed, select the least hazardous materials for the pest control situation. Integrated pest management (IPM) is a method of controlling pests that reduces pesticide use and therefore reduces human health and environmental concerns. IPM uses life history information and extensive monitoring to understand a pest and its potential for causing economic damage. Control is achieved through multiple approaches including prevention, cultural practices, exclusion, natural enemies, host resistance, and limited pesticide applications. The goal is to achieve long-term suppression of target pests with minimal impact on nontarget organisms and the environment. Selecting a pesticide that is effective and that does not present hazards to people can be a difficult task. In order to make decisions, pest managers often gather information about pesticide choices from pesticide labels, county agents, consultants, university publications, and other sources. Factors such as cost, hazards to users, label-imposed plant-back restrictions (restrictions that limit the type of commodity that can be grown in an area for a designated period of time after a certain pesticide has been used), persistence characteristics, ease of use, ability of the pesticide to combine with other materials, its effects on natural enemies and beneficial insects, and required restricted-entry intervals and harvest limitations all have an influence on which pesticide a pest manager chooses.

Each pesticide has a toxicity category rating that suggests the relative hazard of the pesticide to people, animals, and plants in the environment. The signal words "danger," "warning," or "caution" printed on product labels reference the hazard categories. Hazards are modified by such factors as formulation type (for example, microencapsulated formulations are safer for applicators to use than wettable powders), persistence in the environment, and amount of pesticide used.

Regulation: Registration of pesticide products and establishment and enforcement of regulations for transporting, handling, applying, and disposing of these products play important roles in preventing harmful exposures. Regulation of pesticides does not focus solely on assessing toxicity, but also on managing risk by controlling exposure. State and federal pesticide regulatory programs focus not on eliminating all pesticides, but on protecting people and the environment from harmful exposures. If a pesticide product cannot be used

Categories of Pesticides and Associated Acute Adverse Health Effects*

Use	Examples	Major Acute Adverse Health Effects
Insecticide	Azinphos-methyl, chlorpyrifos, tribufos (DEF), demeton, diazinon, dichlorvos, dimethoate, ethyl 2,4-dichlorophenyl thionobenzene phosphorate (EPBP), famphur, fenthion, malathion, mevinphos, parathion, phenthoate, phosalone, tetraethyl pyrophosphate, trichlorfon	Salivation, incontinence, convulsions, sweating, diarrhea, meiosis, rhinorrhea, bronchorrhea, pulmonary edema (see Table 2)
Insecticide	Aldicarb, bendiocarb, carbaryl, carbofuran, dioxacarb, isoprocarb, methiocarb, methomyl, pirimicarb, propoxur, thiodicarb	Symptoms are similar to those for organophosphates.
Insecticide	Aldrin, benzene hexachloride, chlordane, chlordecone, DDT, dicofol, dieldrin, endosulfan, endrin, heptachlor, hexachlorobenzene, lindane, methoxychlor, mirex, toxaphene	Hyperesthesias, paresthesias, headache, dizziness, nausea, vomiting, mental confusion, convulsions, respiratory depression.
Varies with agent	azadirachtin, nicotine, pyrethrum, rotenone	Varies with agent.
Herbicide	2,4-D (2,4-dichlorophenoxyacetic acid); 2,4-DP (2,4-dichlorophenoxy propionic acid); 2,4-DB (2,4-dichlorophenoxy butanic acid); 2,4,5-T (2,4,5-trichlorphenoxyacetic acid); MCPA (4-chloro-2-methylphenoxy acedtic acid); MCPB (4-chloro-2-methylphenoxy butanoic acid); MCPP (2-methyl-4-chlorophenoxy propionic acid); 2-methyl-3,6-dichlorobenzoic acid	Skin, mucous membrane and respiratory irritation, vomiting, diarrhea, headache, confusion.
Herbicide	Paraquat, diquat	Vomiting, dysphagia, oropharyngitis, restlessness, jaundice, cyanosis, hemoptysis.
Pesticide	Arsenic acid, arsenic trioxide, cacodylic acid, copper arsenite, lead arsenate, methane arsonic acid, sodium arsenate, zinc arsenate	Garlic odor, vomiting, abdominal pain, bloody-watery stools, headache, dizziness, drowsiness, confusion, muscle weakness and spasms, convulsions, hematuria, cardiac arrhythmia, jaundice.
Fungicide	Substituted benzenes (chloroneb, chlorothalonil, dicloran); thiocarbamates (metam-sodium, thiram, ziram); EBDC compounds (mancozeb, maneb, nabam, zineb); thiophthalimides (captafol, captan, folpet); copper compounds; organomercury; organotin; cadmium compounds	Variable with agent. Dermatitis, mucous membrane irritation common. Systemic toxicity with ingestion.
Multiple organisms	Halocarbons, hydrocarbons, nitrogen compounds, oxides and aldehydes, phosphorus and sulfur compounds	Varies with agent. Highly toxic. Irritants, CNS and respiratory effects common.
Rodenticides	Coumachlor, warfarin, chlorophacinone, diphacinone	Nosebleed, hematuria, melena, ecchymoses.

e health effects depend on many factors, including dose, route, and duration of exposure.

safely, then its use will be banned; however, the initial step is to impose strict controls on the use.

Regulatory provisions include requiring pesticide manufacturers to submit studies that document the potential health and environmental effects of their products; regulatory scientists then evaluate these data to ensure that the chemicals can be used safely. Risks are mitigated by imposing restricted-entry intervals of varying length for treated areas and harvest limitations on specific crops. Depending on the hazards of the specific product, the regulatory agencies may also require handlers to wear certain types of personal protective equipment, such as chemical-resistant gloves and footwear, eye protection, respiratory protection, and full-body protection.

Engineering Controls: In order to reduce the risks associated with handling and applying pesticides, engineering controls can be used that help to reduce or practically eliminate exposure to these toxic chemicals. Certain types of packaging of pesticide products, such as pre-weighed water-soluble bags, reduce the risk of exposure to workers mixing powdered pesticides; these bags dissolve in a spray tank, thereby removing the need for a worker to open large containers and measure specific quantities to put into the tank.

Closed transfer systems allow accurate and safe measuring of pesticides being put into a spray tank; concentrated liquid pesticides are moved from original shipping containers to a sprayer mixing tank with minimal or no worker contact and without the need to pour these materials into measuring vessels. Pesticide injection systems allow pesticides to be mixed directly with water in the sprayer plumbing system, usually at the sprayer pump or manifold, rather than in the water tank of the sprayer; only clean water is held in the sprayer tank, reducing spill and leak hazards and eliminating interior tank cleaning. Liquid pesticide containers that have been drained still contain amounts of concentrated pesticides; container rinse systems provide a way to thoroughly wash the inside of these containers and transfer the rinse water into the spray tank. Enclosed cabs installed on tractors protect operators from exposure to pesticides. Some types block spray droplets and mists while providing the operator with a comfortable air-conditioned environment. Certain types of enclosed cabs are acceptable for respiratory protection since their air-conditioning systems are equipped with multiple-stage filters that include a pre-filter, a high efficiency particulate air (HEPA) filter, and an activated carbon filter.

Training and Education: Most workplace exposures to pesticides result from carelessness, accidents, or failure to follow instructions. Reducing exposures and pesticide-related illnesses among workers who handle pesticides or who work in areas where pesticides have been applied requires training on proper and safe handling methods. It also involves educating workers on how to avoid contact with pesticide residues on treated surfaces and contaminated equipment. Workers should be instructed on proper emergency decontamination procedures as well as routine washing during and after work activities.

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Pigment Disorders

ICD-10 L80-L81

Michael E. Bigby

Pigment disorders can be identified by lightening or darkening of the skin. Hypopigmented or hyperpigmented macules often occur in areas of previous dermatitis or trauma to the skin or following exposure to certain chemicals.

Occurrence

Post-inflammatory hyperpigmentation and hypopigmentation are the most common pigment disorders. Any dermatitis or trauma to the skin, such as thermal or chemical burns, may lead to an increase or decrease in pigmentation in that area. Heavily pigmented individuals have postinflammatory pigment abnormalities most notably, and these abnormalities are slower to resolve. (See Contact Dermatitis for data on incidence rates for occupational skin diseases.)

Causes

Monobenzyl ether of hydroquinone, an antioxidant used in rubber manufacturing, was the first chemical implicated in inducing work-related loss of pigment (chemical leukoderma). Certain phenolic compounds used as antioxidants or germicidal disinfectants also produce pigment loss. Hypopigmented macules that are not in sites of direct contact may also occur after exposure to these chemicals. Hyperpigmentation can also be caused by exposure to aerosols of metallic silver, mercury compounds, and arsenic.

Pathophysiology

Chemically induced leukoderma occurs because the chemical either blocks the synthesis of melanin (the pigment responsible for skin color) or, in