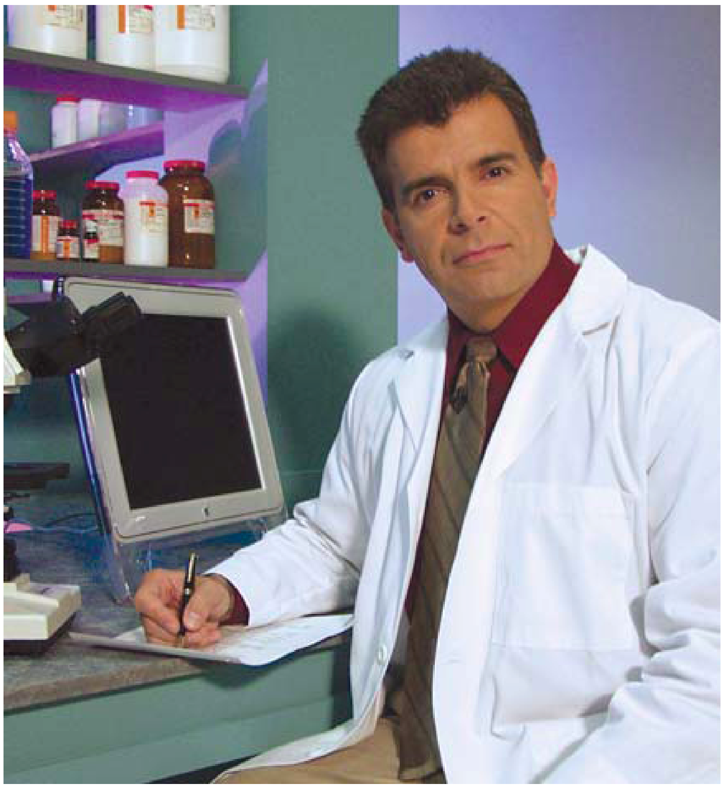
Exposure and Contamination

Factors Affecting the Toxicology of Chemical, Biological, and Radiological Agents



This training is intended for emergency responders and medical personnel who may be involved with a chemical, biological, or radiological event. It describes the concepts of exposure and contamination, exposure pathways, surface deposition, toxicity measures, secondary contamination, dose and dosage, concentration time integrals (Cts), acute and chronic exposures, and Acute Exposure Guideline Levels (AEGLs). The video also describes some of the health effects that result from a biological or radiological exposure.

STUDENT GUIDE

Exposure and Contamination: Factors Affecting the Toxicology of Chemical, Biological, and Radiological Agents
Student Guide

Prepared for the
Chemical Stockpile Emergency Preparedness Program
Department of Homeland Security
Federal Emergency Management Agency

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Acronyms

ADME	absorption, distribution, metabolism, and excretion
AEGL	Acute Exposure Level Guideline
AELs	Airborne Exposure Levels
ASTSDR	Agency for Toxic Substances and Disease Registry
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
CSEPP	Chemical Stockpile Emergency Preparedness Program
Ct	concentration time integral or concentration times time (often followed by number representing the % of population affected)
DDT	dichlorodiphenyltrichloroethane (insecticide banned in 1974)
ECt	effective concentration times time
ER	emergency room
GB	nerve agent (sarin)
GI	gastrointestinal
ICt	incapacitating concentration times time
IDLH	Immediately Dangerous to Life and Health
HD	mustard agent
H_2O	water
LCt	lethal concentration
LD	lethal dose; number of organisms expected to kill a certain % of the exposed population
LD_{50}	amount of agent sufficient to kill 50% of exposed population
Mg-min/m^3	milligram–minutes per cubic meter
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PEL	Permissible Exposure Level
PPE	personal protective equipment
VX	nerve agent

Forward

This video in VHS and DVD ROM formats was designed for the Chemical Stockpile Preparedness Program (CSEPP) to enable first receivers, both medical and emergency responders, as well as others who present risk information, to understand the basic toxicology and health measures associated with exposure and contamination from chemical, biological, and radiological agents. The topics covered in the modules can be viewed sequentially or separately depending on the needs of the audience or student. In addition, there are selected references and documents in pdf format that can be accessed by a computer with DVD ROM capabilities. These include:

- Information on AEGLs for chemical agents,
- Textbook of Military Medicine, Medical Aspects of Chemical and Biological Warfare,
- Medical Management of Biological Casualties, 5th Edition
- Medical Management of Chemical Casualties, 3rd Edition
- Medical Management of Radiological Casualties, 2nd Edition
- OSHA January, 2005, Recommendations to First Receivers,
- Technical reports on the toxicology of chemical agents,
- Sections of CFR 1910-120
- Managing Hazardous Material Incidents, ATSDR's planning guide for first responders and hospitals, and the
- Standardized Medical Training Course for CSEPP.

The target audience includes those emergency and pre-hospital personnel who require additional knowledge on measures affecting the toxicology of chemical, biological, and radiological substances and the consequent health effects on victims who are exposed to and contaminated with those substances. This audience includes those qualified to perform emergency medical treatment, such as emergency medical technicians, paramedics, ambulance operators, nurses, and others who may have to describe or explain the factors affecting exposure and contamination to patients or the public when an event involving warfare agents occurs.

The objectives of the video are to present an overview of the basic measures related to the toxicology of chemical, biological, and radiological agents and their consequent health effects. Included are:

- Characteristics that make chemicals hazardous,
- How chemicals are dispersed,
- Measures in exposure and contamination,
- How exposure results or doesn't occur from contamination,
- Exposure pathways,
- Secondary contamination,
- Persistence and deposition,
- Toxicity,
- Dose and dosage,
- Concentration time integral (Ct),
- Lethal concentration times time (LCt),
- Acute Exposure Guideline Levels (AEGLs),

• How radiological and biological agents are similar or different from chemical agents, and
• Vulnerability factors specific to an individual.

It is important that factors associated with exposure and potential contamination are understood so individuals can take appropriate protective actions when potential or actual exposure occurs. Equally important is that emergency responders, planners, and public information specialists understand the issues clearly and can communicate the facts to individuals at risk.

Acknowledgements

A number of organizations and individuals contributed their time and resources to make this presentation possible. We would like to thank the following organizations for their valuable contributions. In alphabetical order, these are:

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Pueblo, CO

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Knoxville, TN

Module One - Introduction

Narrator:
Recognize any of these situations? The world we live and work in can cause us severe distress at times. Often we forget that most everything we encounter consists of chemicals, or mixtures of chemicals. To maintain health a person must inhale, ingest, or otherwise absorb sufficient quantities of chemicals - including the familiar H2O - water. But too much of a chemical substance - even water - taken into the body intentionally or accidentally - can be harmful.

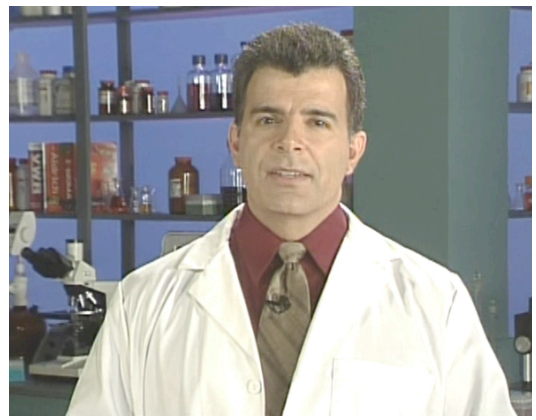
This presentation will explain the consequences of being exposed to or contaminated by a hazardous chemical substance, and what you can do to prevent becoming hurt or sick. It will also discuss what happens to a person exposed to biological agents or radiation.

Although we need to constantly breathe oxygen, with every breath we also inhale nitrogen, and carbon dioxide, as well as combustion products from engine exhausts and energy production, and possibly chemical vapors from industrial sources or more commonly, consumer products in our homes and workplaces.

Even foods we commonly eat have non-nutritional products such as spices, colorants, and preservatives added to them. And individuals apply make-up, lotions, and hair care products - all chemical mixtures - liberally to their skin and hair. The wide range of routine exposures to hundreds of chemicals may not benefit a person but overall is not harmful to most healthy individuals.

Then there are fires, explosions, and spills of toxic chemicals that may disperse hazardous vapors, aerosols or particles into the environment. What we will discuss in this presentation are potentially highly harmful exposures that usually result in immediate or not greatly delayed effects.

Notes



In this presentation you will learn:
• the characteristics that make some chemicals hazardous to human health,
• how chemicals are dispersed into the environment,
• measures related to exposure, including concentration, timing, and length of exposure,
• how exposure results (or doesn't occur) from contaminants,
• exposure pathways, including dermal, inhalation, ingestion and ocular pathways, and
• about secondary contamination.

Objectives
• Characteristics that make chemicals hazardous
• How chemicals are dispersed
• Measures in exposure and contamination
• How exposure results or doesn't occur from contamination
• Exposure pathways
• Secondary contamination

And you will also learn:
• what happens to contaminants when they adhere to or are deposited on surfaces,
• the differences between high, versus low, toxicity and between dose and dosage,
• what is meant by concentration time integral or Ct, peak concentration, and lethal concentration times time or LCt,
• how Acute Exposure Guideline Levels (known as AEGLs) are used in emergency response,
• how radiological and biological hazards are similar or different from chemical agents, and
• how other factors, such as an individual's general health and age, contribute to an individual's vulnerability to harm from exposure or contamination from a hazard.

Objectives
• Persistence and deposition
• Toxicity
• Dose and dosage
• Concentration time integral (Ct)
• Lethal concentration times time (LCt)
• Acute Exposure Guideline Levels (AEGLs)
• How radiological and biological agents are similar or different from chemical agents
• Vulnerability factors

The dictionary describes exposure as coming into contact with some environmental condition or social influence that has an effect, either beneficial or harmful.

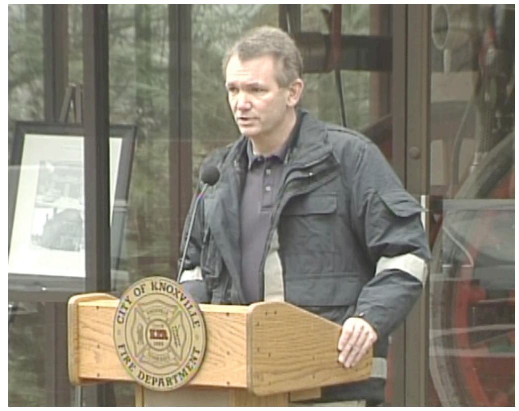
Some substances in the environment - called contaminants - have the ability to make something unclean, corrupt, infected or polluted through contact or association.

Toxicologists refer to contamination as occurring when contaminants are externally deposited on surfaces - such as structures, skin, clothing, hair or vegetation. The process whereby the contaminant is taken into the body and absorbed is referred to as uptake by toxicologists.

Medical personnel often use the verb contaminate to describe infection - such as "bacteria contaminated the wound."

The act of physically removing or neutralizing the contaminating substance to render it harmless is referred to as decontamination.

It is important that factors associated with exposure and potential contamination are understood so individuals can take appropriate protective actions when potential or actual exposure occurs. Equally important is that emergency responders, planners, and public information specialists understand the issues clearly and can communicate the facts to individuals at risk.



Module 2
Exposure and Contamination Pathways

Female Firefighter:
Do all exposures result in contamination?

Narrator:
Not all exposures necessarily result in contamination. For example, if a truck overturns in a field and liquid leaks out, a person walking up to the truck can be exposed by breathing in vapors but not be externally contaminated. Should that person make contact with the liquid - such as dipping a finger into the spilled liquid, then that individual is contaminated and also receives a skin exposure.

If liquid only gets on the person's shoes and clothing, only contamination occurs. The contaminant - the liquid from the truck in this example - may or may not harm the individual.

Contamination does not necessarily result in exposure. Contamination means having a substance get on one's clothing, shoes, hair, exposed skin or eyes. An actual exposure only occurs when skin or eyes are contaminated, in which case the chemical may be absorbed into the body.

To understand exposure one must first examine how chemical substances move from the environment into the body and how scientists determine the percentage that results in uptake into the body and potentially generates 'health effects'.

Substances are found in various forms and the chemical and physical properties will characterize their potential for harm. First responders to a liquid spill will often check the vapor density and specific gravity to determine if they are dealing with a

Note: Vapor density is defined as the density of gas compared to air, which has an arbitrary value of one. If a gas has a vapor density of less than one it will generally rise in still air and dissipate. If the vapor density is greater than one the gas will generally sink in still air. This concept is potential vapor hazard.

Some chemicals used safely in one form are less safe in another form when they vaporize or aerosolize in the air. An example is chlorine. Most everyone knows that chlorine in bleach is a disinfectant. As long as liquid chlorine is in a container or the chlorine molecules released as vapor remain at low concentrations, there are likely no health effects. But if highly concentrated chlorine vapor is released - especially in a closed environment, it can be extremely dangerous to individuals.

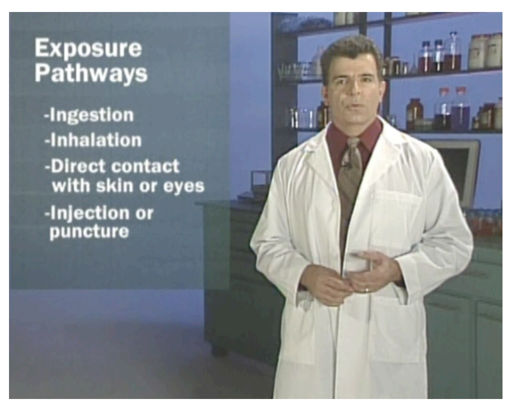
Under certain circumstances - an explosion, fire, or when intentionally heated, liquids may change into an aerosol or vapor form. Think of aerosols as fine solid or liquid particles - or droplets -suspended in air, such as smoke or fog.

A vapor is the gaseous state of fluids that may exist as liquids under normal circumstances. For example, steam is water vapor. Vapors are sometimes visible as mist, clouds, or fumes, or can be invisible. Vapors may form from an evaporating pool of liquid - such as a gasoline puddle.

How an individual takes a substance into the body is called the "exposure pathway." Substances directly enter the body through:

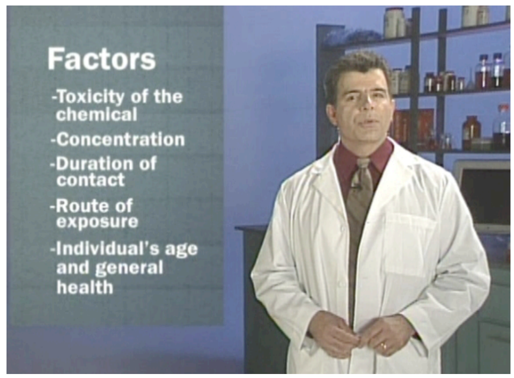
• eating or swallowing (termed ingestion),
• inhalation (or breathing),
• direct contact with the skin or eyes, and,
• by injection or puncture.

important for responders because it will indicate where the gas or vapors can generally be expected to be located at hazmat releases.
Specific gravity is defined as the density of a chemical compared to the density of water. If the specific density is less than one, the chemical will float on water; if less than one it will sink. In either case, it is important to consider the solubility of the chemical concurrently with specific gravity.



Female EMT:
Does the exposure pathway affect the risk of injury?

Narrator:
For each route of exposure, and potential contamination by a chemical, the risk of injury depends on several factors. These include:
• the toxicity of the chemical involved,
• the amount and/or concentration of the chemical,
• the duration of the contact,
• the route of exposure, and
• the individual's age and general health.



Sometimes exposure occurs only once. Or there could be several exposures over a lengthy period of time, even lasting a lifetime.

Exposures are called acute if they last only briefly - minutes or hours. You could briefly be exposed to a harmful chemical by drinking a glass of contaminated water.

Acute exposure and contamination – brief duration

Chronic exposures have a lengthy duration - weeks, months or even years. For example, a person could have a chronic exposure from arsenic from drinking water everyday from a contaminated source.

Chronic exposure and contamination – lengthy duration

Another important factor - which is common to all exposures - is an individual's own susceptibility or vulnerability - especially when a person's health status is a problem at the time of exposure.

Factors

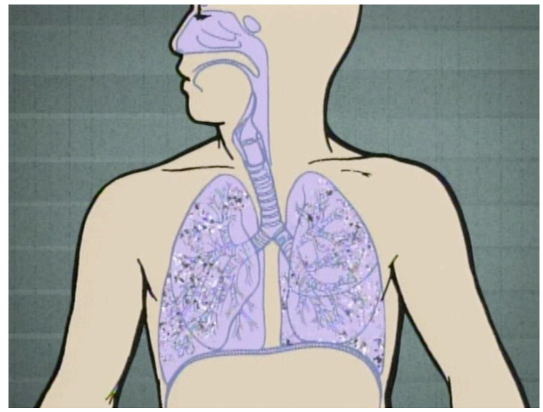
Health effects that occur several days, weeks or even years after exposure to certain chemicals are called latent. The period between exposure and the appearance of symptoms is called a latent period. One example of a very long latent period is the time

Latent health effects

between exposure to a cancer-causing dose of radioactivity and the appearance of a tumor.

Some chemicals can accumulate in the body over time and result in cumulative health effects.
Sometimes this is caused by exposure to and absorption of certain chemicals in the workplace or in the environment over long periods of time. Asbestos or coal particles can lodge in the lungs and cause disease in individuals who are frequently exposed to them at work.

Cumulative health effects



Some health effects increase by successive small doses resulting in cumulative poisoning - such as may occur to agricultural workers exposed daily to certain pesticides. That's why the Occupational Safety and Health Administration - or OSHA - has set Permissible Exposure Levels, or PELs, to protect individuals in the workplace. PELs are the measurable levels of chemicals that an individual can safely be exposed to over certain periods of time.

Cumulative poisoning

PELs - Permissible Exposure Levels

Secondary exposure can occur when a person is exposed to a contaminant already on another person or object. Usually this occurs by inhalation of the off-gassing of a chemical or by direct contact with the residual chemical. Storing contaminated gear that wasn't properly cleaned in a closed space - such as a locker or dirty clothes bin - allows the off-gassing vapors to accumulate and potentially contaminate again. An example of 'contact exposure' to a residual contaminant is an individual having a skin reaction to the oily material remaining on a pet's fur after washing a pet that rolled in poison ivy.

Secondary Exposure

Nurse:
I've heard some ERs have been closed because of secondary contamination.

Narrator:
Some ERs have been forced to close for hours because healthcare providers were sickened by fumes from contaminated clothing on patients. Medical personnel need to be careful when treating patients exposed to toxic substances because residual contamination on clothing and hair, or chemicals in

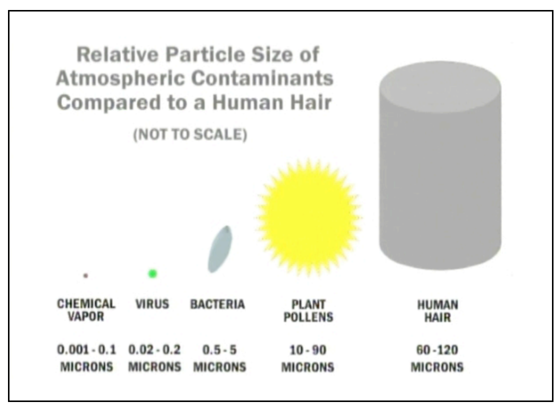
patient's exhaled air or internal organs may be a source of secondary exposure. Secondary contamination may go unnoticed until someone becomes ill.

Although the potentially contaminated clothing and personal belongings of a decontaminated patient are generally bagged before entering an ER, there have been documented reports of individuals retrieving personal items such as cell phones, wallets, belts and other contaminated items from the bags - placing everyone in the vicinity at potential risk of secondary exposure and cross-contaminating the waiting room. Anything leather readily absorbs chemicals.

Inhalation is the most common route of exposure to chemical aerosols and vapors. Heated liquids and solids can be inhaled when they change into gases, vapors, or aerosols, or become associated with fumes and dust. Inhaled gases and vapors easily reach the lungs. However, inhaled particles are deposited in different parts of the respiratory tract, depending on their size.

Inhalation
- Vapors
- Fine mists
- Aerosols
- Fumes
- Dusts
- Particles

Large particles - larger than 10 microns - are rapidly deposited in the upper respiratory tract and are cleared into the digestive tract. Smaller particles -especially particles under 4 microns - maybe inhaled into the deep lungs where they remain for long periods of time. This diagram illustrates how small a micron is compared to a human hair and how the size of the particle affects its entrance into the body.



Some inhaled toxic chemicals - such as chlorine and chemical agents - are very reactive and will exert their toxic effect on the lungs upon contact. Other toxic chemicals may be absorbed from the lungs into the circulatory system and transported to various organs where they may exert a toxic effect.

How easily the chemical dissolves in water or oils also affects the extent of absorption and the degree and type of toxicity. Highly water-soluble gases and vapors are generally deposited - and create irritation - in the upper airways. Less water-soluble chemicals can be inhaled more deeply and may produce delayed effects in the lower airways. Highly fat-soluble chemicals can travel to the deep lung areas and cause very rapid effects due to their rapid absorption.

Ingestion

Individuals can ingest contaminated substances as well. Although we tend to think mainly of kids ingesting toxic substances by eating dirty items, playing in - or even eating - contaminated soil or dust, adults can ingest contaminated substances as well. Mass poisoning via food occurred in Japan in 1968 when rice oil contaminated with PCB's was used for cooking.

Note: PCBs = polychlorinated biphenyl

Direct contact

Toxic substances can come into direct contact with the eyes or skin from exposure to hazardous vapors or aerosols, liquids or solids on surfaces, in the air, or in water. Although the skin acts as a protective barrier to most substances, some chemicals can penetrate easily.

Injection

And chemicals can be directly injected into the body. Individuals who suffer severe reactions to wasp stings know how quickly the body can react to an injection.

Puncture

An individual can be accidentally contaminated if an object punctures the skin - such as a rusty nail or tack contaminated with bacteria.

Being exposed to a substance doesn't mean you will automatically become sick. The body's first reaction is protective - to get rid of the substance. And there has to be enough of the substance remaining in your body to cause a reaction. For example, coughing or sneezing may expel many inhaled particles from your body. Likewise, vomiting can be induced to decrease absorption of a toxicant from the GI tract. Decontamination - removing clothing, washing the exposed skin and hair with plenty of soap and water and flushing the eyes with clear water - eliminates most of the substances on the skin and eyes.

If the substances are mildly to moderately toxic and little is absorbed into the bloodstream, few health effects may be seen. On the other hand, if the substance is very toxic and easily absorbed, just a very small but highly concentrated amount in a very short period of time can cause great harm. Even a drop of VX nerve agent so tiny that it will fit between the columns of the memorial on the back of the Lincoln penny can be fatal.

Module 3
Dose and Dosage

Notes

Male firefighter:
How are dose and dosage measured? Do they mean the same thing?

Narrator:
The term "dose" describes the actual amount of any compound - drug, or chemical or biological agent - that is absorbed by the body. The medical definition of "dose" is slightly different. Physicians think of dose as the actual quantity taken into body - such as the measured amount of medication or the number of pills - at one time or at stated intervals. This is because medications are tailored to be well-absorbed.

Dose - Amount absorbed by the body

You may also see the term LD_{50} when talking about dose. LD_{50} - which stands for lethal dose 50% - is the amount of a toxic agent (such as a poison, virus, or radiation) that is sufficient to kill 50% of the exposed population.

LD_{50} - The amount of toxic agent (as a poison, virus, or radiation) that is sufficient to kill 50% of a population of animals usually within a certain time.

Dosage is measured as the ratio of the chemical substance to body weight or to body surface area that is expected to cause a specific effect. The metric system is used for more scientific measurement. Scientists generally use the metric system because it is a decimal system that can be conveniently multiplied and divided by factors of 10.

Dosage - Ratio of chemical substance to body weight or body surface area that causes an effect.

For example - a kilo means one thousand so a kilogram equals 1000 grams. 'Milli' means one one-thousandth - so one milligram equals one one-thousandth of a gram and 1000 milligrams equals one gram. Most individuals are familiar with medication doses expressed in milligrams - such as the 325 milligram aspirin tablet. Today's analytic instruments can now monitor effects at much lower levels - such as by one millionth of a gram - called a microgram -

Metric System
Kilogram = 1000 grams
Milligram = 1/1000 gram
1000 milligrams = 1 gram
Microgram = one millionth of a gram
Nanogram = one billionth of a gram

Narrator:

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Metric System
Kilogram = 1000 grams
Milligram = 1/1000 gram
1000 milligrams = 1 gram
Microgram = one millionth of a gram
Nanogram = one billionth of a gram

Dosage is expressed as milligrams of substance per kilogram of body weight. Milligrams are used to measure medicine weight, kilograms to measure body weight. A kilogram is about 2.2 pounds. So two individuals who have different weights would have to receive different doses of medicine to achieve the same effect.

Dosage - milligram/kilogram = mg/kg

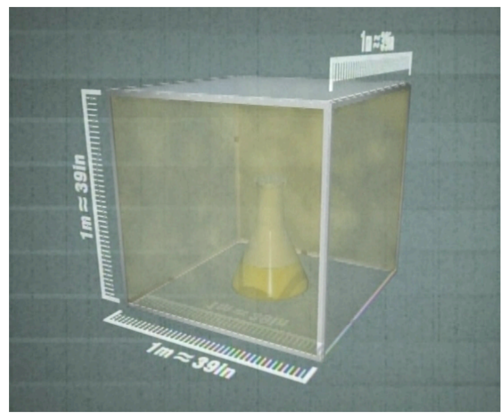
1 kilogram = 2.2 pounds

Male firefighter:
What about being exposed to a toxic cloud? Does thee concentration of hazardous material also affect its toxicity?

Narrator:
Good point. Dose also applies to the inhalation route, but the mass of substance per-unit volume in the air is usually referred to as concentration.

The standard unit used to measure volume of air is a cubic meter. Picture a cubic meter of air as a box measuring one meter by one meter by one meter. A meter equals 39 inches - slightly longer than a yard. If a certain number of molecules or droplets are dispersed in the box it would look like this. Now if the molecules were packed in tighter or there were more bottles opened in the box the concentration of molecules would increase.

Cubic meter = m^3



Notice that the air in the box becomes very concentrated with molecules over time. Air concentrations of chemical agent vapors or aerosols are expressed in milligrams per cubic meter. If we distribute a single bottle with one milligram of molecules in vapor, or aerosol form, in the box - we then have 1 milligram per cubic meter.

$1 mg/m^3$ = 1 milligram per cubic meter

Time is also an important factor when considering exposure and absorption. Ct is concentration multiplied by time (usually in minutes) - the official term is "concentration time integral." It's easy to remember Ct as "concentration times time." Ct is also called 'cumulative exposure' as it describes the amount of chemical that accumulates over time.

Time
Ct = concentration time integral or
concentration times time

Ct = cumulative exposure

For example, if a person is exposed to a substance for 3 minutes, and in minute one the concentration is 1 milligram per cubic meter, in minute 2 the concentration is 2 milligrams per cubic meter, and in minute 3 the concentration is 1 milligram per cubic meter, then the concentration time integral would be 4 milligram - minutes per cubic meter.

Minute one = 1 mg/m^3
Minute two = 2 mg/m^3
Minute three = 1 mg/m^3
4 milligram-minutes per cubic meter or
4 $mg\text{-}min/m^3$

Male Doctor:
I know what LC stands for - but what do the letters "E" and "I" stand for?

Narrator:
Ct is often preceded by the letter E, I or L. ECt is "Effective concentration multiplied by time." ECt is the estimated Ct that produces minimal threshold effects in a specified percentage of exposed individuals. For nerve agents the minimal threshold effects can include runny nose, and/or pinpoint pupils, also called miosis.

ECt = effective concentration x time

ECt → minimal effects

ICt is Incapacitating Concentration times time. ICt is the estimated Ct that incapacitates a specified percentage of exposed individuals. Incapacitation means a person may not be able to leave a scene or drive a car. Remember that incapacitation can include mental health effects - such as confusion - and doesn't necessarily mean just physical symptoms such as muscle weakness.

ICt = incapacitating concentration x time

ICt → incapacitating effects

LCt is Lethal Concentration times time. LCt is the estimated Ct that is lethal to a specified percentage of exposed individuals within a certain exposure time.

LCt = Lethal concentration times time
LCt → lethal effects

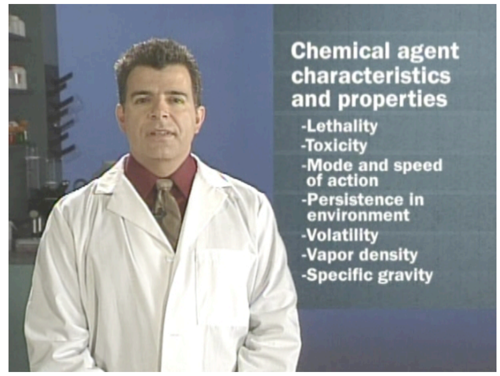
Ct is often followed by a number that represents the percent of the population that is affected. LCt_{50} means the lethal concentration times time that would be expected to kill 50 percent of the exposed population. The exposure to the chemical warfare agent vapor GB that is estimated to be lethal to one percent of the exposed population is 10 milligram -minutes per cubic meter of air and it's written as LCt_1 = 10 milligram-minutes per cubic meter. This means that a concentration of 10 milligrams per cubic meter of air would be lethal to one percent of the population in one minute. If the exposure were for a shorter time, the concentration - or dose - is not expected to be lethal.

LCt_{50} = Lethal concentration times time
Expected to kill 50% of exposed population

GB (Sarin)
LCt_1 = 10 milligram-minutes per cubic meter or
LCt_1 = 10 mg-min/m^3

Every chemical has a unique set of characteristics and properties. When discussing hazardous chemical substances, the most important factors to know are the:

- lethality;
- toxicity,
- mode and speed of action,
- persistence in the environment,
- volatility;
- vapor density, and
- specific gravity.

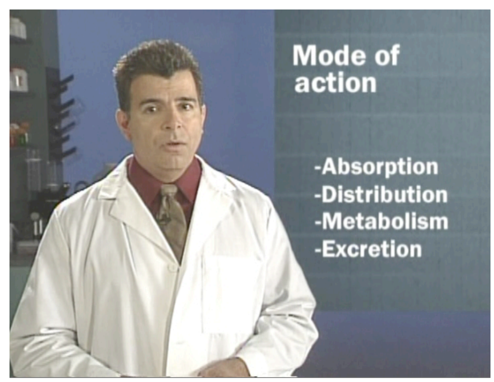


Lethality

A chemical is considered lethal if it has capacity to kill. At lower doses, it may produce incapacitation, non-lethal effects, or no effects. Some benign chemicals can be lethal in high concentrations. Non-lethal chemical agents - such as riot control agents - are generally intended to incapacitate a person - but at high doses may injure or kill as well.

Mode of action

There are other factors that influence toxicity. The mechanism by which a chemical works to affect the body is called the mode of action. For example, most individuals know that insecticides kill insects but the way in which those chemicals work is a mystery to most of us. To understand the insecticide's mode of action, scientists study how the insecticide is absorbed- that is how it enters the body and is distributed through the insect's system, then how it is metabolized and finally how -or if- it is excreted.



ADME

- Absorption
- Distribution
- Metabolism
- Excretion

Scientists use the acronym ADME - absorption, distribution, metabolism and excretion - to describe the process. These processes determine the level of the substance in the body's tissues and length of stay. These, together with the mechanism of action, determine the effects on the body. The traditional insecticides affect the nervous system but they can affect other important insect biological systems - such as the production of energy, growth of cuticle, the endocrine system, or the water balance.

Speed of action

Speed of action refers to time between actual exposure and onset of effects. Some chemical agents are fast acting while others are slower - such as mustard agents - while the effect of some agents will depend on how the person is exposed. Some agents can act fast but only have observable effects later. These are called latent effects. A tiny drop of liquid nerve agent on the skin can be lethal within minutes but minimal effects from mild exposure to nerve agent vapor can be delayed for up to 18 hours.

Latent effects

And concentration and accumulation of a chemical can alter the number and kind of health effects. For some chemical agents there is a level above which further symptoms will not increase, called the 'toxic load'.

Toxicity is the degree to which something is poisonous. It is expressed as the quantity or dose of chemical substance that can produce a given effect in the body. Toxicity is measured in various ways. For example: LD_{50} is the lethal dose by exposure routes - other than inhalation - that is expected to kill 50 percent of the exposed population. The lower the number for the lethal dose, the more toxic the substance. And an oral lethal dose will usually differ from a lethal skin dose for the same chemical.

Toxicity - Quantity or dose that can produce a given effect in the body

LD_{50} = Lethal dose expected to kill 50% of exposed population

The amount of chemicals in your body at any time - the body burden - depends on the body's ability to detoxify and discharge substances. After absorption, chemicals enter the blood system and are distributed through the body, eventually reaching the many organs and systems of the body.
In most cases chemicals undergo chemical changes as they reach body tissues - changes known as metabolism. The liver and kidneys are the primary organs where chemicals are changed or metabolized, in preparation for excretion.

Body Burden
- Metabolism
- Excretion

The body disposes of the chemicals through the urine or feces or in exhaled air. The combined effects of these processes will determine the concentration of a particular chemical in the tissues and organs and how long a chemical stays there. And the chemical form, concentration, and length of time in the tissues will determine the nature and form of the injury or the systemic effect produced in the body.

Female Medic:
How long can a chemical remain toxic in the environment? I've heard of people finding old bombs containing chemical agent.

Narrator:
Usually chemicals in containers stay about the same as when they were loaded into the container. How long chemicals that are released into the environment keep their toxic properties, that's the issue. Scientists refer to the result of degradation as the fate of a chemical.

Fate of chemical

How long a chemical agent keeps its toxic properties on surfaces depends on the chemical's form - liquid, aerosol or vapor - as well as its stability. Stability is the chemical's ability to remain unbroken or undegraded by water or sunlight, or by some other biological process, such as uptake into plant root systems, or by microbial metabolism.

Persistence describes how long chemicals retain their characteristics when released into the environment. When chemicals in the form of liquid droplets, or aerosols, fall out of a cloud onto vegetation, structures, or individuals, it is called "wet deposition."

Persistence

Wet deposition

Dry deposition

When a cloud of vapor containing the gas molecules or mist - fine droplets - comes into contact with an object, some molecules of the chemical are deposited onto objects - but not in liquid or droplet form. This is called "dry deposition" and is not nearly as toxic as wet deposition - although it could be a source of contamination for humans and animals. For example, in March of 1968,the nerve agent VX was sprayed from aircraft at Dugway Proving Ground in Utah. A weather front carried the agent off-site to Skull Valley where it was deposited on native forage plants. Approximately 6,300 sheep grazing there were made ill and of those, 4,500 died.

Chemical agents vary in persistence. Some chemical agents - such as the nerve agent GB - evaporate readily and do not persist on vegetation or other surfaces. Sulfur Mustard, a blister agent, is an oily and very persistent substance that solidifies at about 57 degrees Fahrenheit. It is not water-soluble, so pockets of uncontained sulfur mustard agent can remain toxic for hours to days on soil or in water. However, mustard in containers can remain active for many years. In the late 1970's French authorities reported that children were severely injured when a World War One mustard agent munition exploded near them.

Module 4
Acute Exposure Guideline Levels
AEGLs

Male EMT:
What does AEGL stand for?

Narrator:
AEGL stands for Acute Exposure Guideline Level. An AEGL indicates the concentration of a chemical in air, above which, specific categories of health effects could begin to occur in an unprotected civilian population.

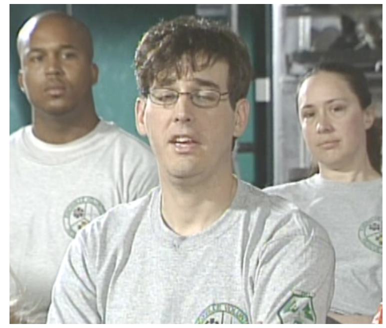
AEGLs are expressed as the concentration of a chemical an individual is exposed to over a given period of time. They represent threshold exposure limits for the general public and are applicable to one-time emergency exposure periods ranging from 10 minutes to 8 hours.

AEGLs are used by federal and state agencies to help develop emergency preparedness plans and to put priorities on emergency response actions if hazardous chemicals were released during an accident or a terrorist attack.

Unlike other toxicity values for emergency response, AEGLs are established for multiple exposure durations and effects levels. When appropriate, AEGL values are developed for five exposure periods -10 minutes, 30 minutes, 1 hour, 4 hours, and 8 hours - and are distinguished by varying degrees of severity of toxic effects.

AEGLs include three chemical-specific effect levels for specified time durations that describe the general range of toxic effects caused by a chemical. Airborne concentrations below the AEGL-1 value represent exposure levels that can produce mild and

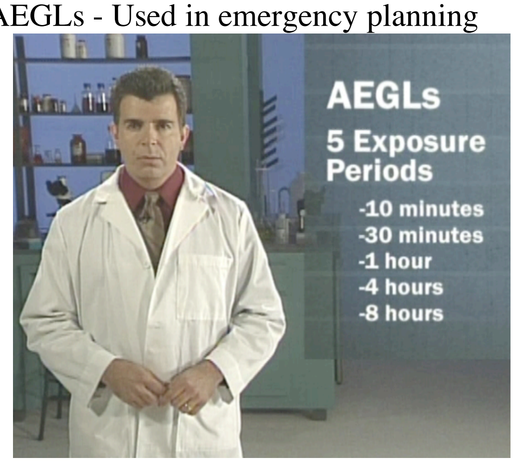
Notes



AEGL = Acute Exposure Guideline Level

Note: EPA defines the three AEGLs as follows:
AEGL-1 is the airborne concentration (expressed as parts per million or milligrams per cubic meter of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.
AEGL-2 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
AEGL-3 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death."
http://wwwepa.gov/oppt/aegl/define.htm

AEGLs - Used in emergency planning



progressively increasing effects that are transient and not disabling. With increasing airborne concentrations above each AEGL, there is a progressive increase in the likelihood of occurrence, and severity of chemical-specific effects, described for each corresponding AEGL.

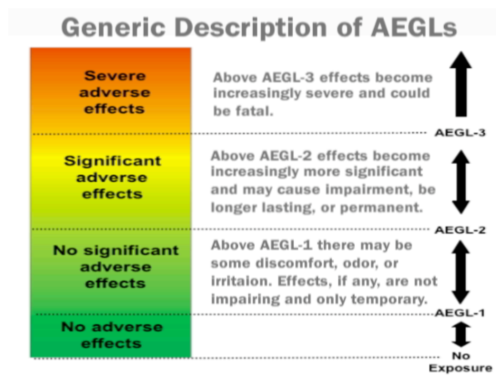
The AEGL 1 value is considered by the National Advisory Committee convened by the EPA and the National Research Council to be the lowest observed effect level that could be experienced without danger to the public - and that includes vulnerable populations such as the elderly and children. For concentration levels above AEGL 1 but below AEGL 2 there may be some discomfort, odor, irritation; but effects, if any, are not impairing and only temporary. For concentrations less than AEGL 3 but above concentration levels of AEGL 2, effects become more significant and may impair ability to escape, be long lasting, or permanent. For concentrations greater than AEGL 3 there is a potential for increasingly severe effects and possible death without treatment.

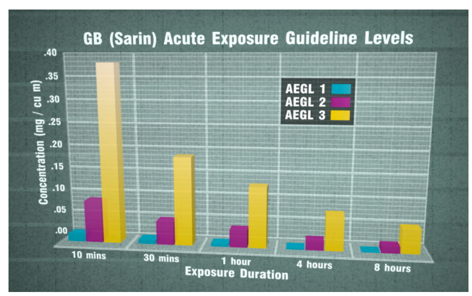
Let's look at GB. Note that as the time period increases the value of the concentration gets lower. With longer exposure times it takes a lower concentration of the agent over time to produce a similar health effect as a short exposure with a higher concentration.

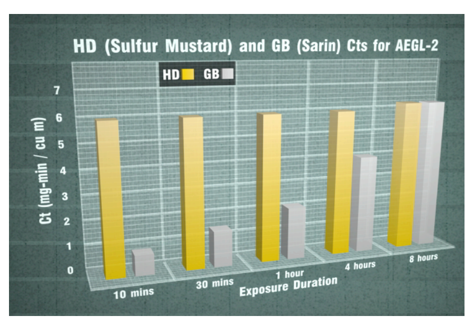
If we look at cumulative exposure or total amount, the 'Concentration times time' - or Ct, we see that as exposure time increases, it takes more of the GB to produce a given effect than it does at shorter exposure durations. This shows that the 'concentration times time' relationship is a constant. In addition, the body is detoxifying the nerve agent over time.

Next, consider 'HD'. Like GB, the AEGLs decrease, as length of exposure increases. However, the cumulative exposure curves remain fairly constant over time, because the time-scaling relationship for HD differs exponentially from that of GB.

Three Concentration Levels







The Centers for Disease Control and Prevention has published Airborne Exposure Limits (AELs) in the Federal Register for interim exposure limits for HD for workers and the general population. Exposures for these AELs range from 15 minutes to 8 hours (for the worker population), and is 12 hours for the general population. The CDC also recommends a 30 minute Immediately Dangerous to Life and Health concentration.

Module 5
Biological Agents

Male Firefighter:
How does exposure and health effects from biological agents compare to chemical agents?

Narrator:
Biological organisms and agents consist of:

- viruses,
- bacteria,
- fungi,
- protozoa,
- toxins, and
- mycotoxins.

Bacteria, viruses and toxins could all be used as biological warfare agents, so these are all discussed here. Like chemical agents, certain characteristics make biological organisms less effective as threats - such as being easily destroyed by sunlight or heat.

Biological agents include very small organisms - called microorganisms - that cause diseases (smallpox for example), but they are usually not lethal with early and appropriate treatment. And not all biological agents are infectious - that is, an individual will not get sick if in contact with a person who was sickened with a non-infectious agent such as ricin.

Viruses are the simplest form of microorganisms and are made up of genetic material surrounded by a coat of protein. Viruses require a live host - such as a plant, insect, bacterium, animal, or human - to reproduce.

Bacteria are single celled microorganisms that can live independently and reproduce outside a host. The spore form of bacillus anthracis, or anthrax, can remain viable for years in soil or water.

Notes

Biological Agent
- Viruses
- Bacteria
- Fungi
- Protozoa
- Toxins
- Mycotoxins

Biological Agents
- Viruses
- Bacteria
- Toxins

Note: **Viruses** are made up of genetic material surrounded by a coat of protein that need a live host to replicate.
Bacteria are single-celled organisms that can live independently and reproduce outside the host.
Fungi are saprophytic and parasitic spore-producing lower plants that lack chlorophyll and include molds, rusts, mildews, smuts, mushrooms, and yeasts.
Protozoa are minute protoplasmic acellular or unicellular animals which are represented in almost every kind of habitat, some of which can be serious parasites of humans and domestic animals.
Mycotoxins are poisonous substances produced by a fungus and especially a mold.
Toxins are non-living by-products of living organisms. US law states that the term 'toxin' means the toxic material of plants, animals, micro-organisms, viruses, fungi, or infectious substances, or a recombinant molecule, whatever its origin or method of production, including:
(A) any poisonous substance or biological product that may be engineered as a result of biotechnology

Toxins are the non-living chemical by-products of living organisms - the toxin, ricin, is a by-product of crushing the castor bean plant for its economically valuable castor oil product.

Bacteria produce disease by invading body tissues, producing an inflammatory reaction, or by manufacturing toxins poisonous to cells (and sometimes both). Many diseases caused by bacteria can be treated successfully with antibiotics or vaccines.

Viruses attack specific cells and use the cell's own energy and protein synthesizing capabilities to reproduce. This brings about changes in the host cell resulting in disease and death. Few viruses can be treated with drugs, but vaccination, when available, is an effective preventive measure.

Biologic toxins are non-living, poisonous chemical compounds produced by living organisms. Some toxins are up to one thousand times more lethal than chemical agents, but unlike chemicals, are not typically volatile, nor do they pass through intact skin. Most toxins are not prone to person-to-person transmission, nor are they very persistent when released. With the exception of ricin, preparing an effective quantity of a biological toxin as a terrorist weapon requires sophisticated laboratory equipment.

Biological agents work quite differently from chemical agents. For one, the effects from biological agents might not be evident for a few days, and second, there are various treatments and interventions for diseases.

Biological agents have been used in warfare for hundreds of years. In 14th Century Europe, plague-infected corpses were catapulted into walled towns during sieges. The organisms were effective at killing indiscriminately, because of the confined space and close quarters shared by the victims.

produced by a living organism; or
(B) any poisonous isomer or biological product, homolog, or derivative of such a substance.
(Source: United States Code; Title 18, Crimes and Criminal Procedure; Chapter 10, Biological Weapons; Section 18, Definitions; may be cited as the 'Biological Weapons Anti-Terrorist Act of 1989')
There is a broad range of substances known as toxins. Some of the bacterial toxins, such as botulinum toxin, require large-scale industrial microbiology methods to produce. In the middle range are the snake poisons, insect venoms, plant alkaloids and products of chemical synthesis, such as ricin. At the other end of the range are the small molecules, found in plants such as hydrogen cyanide. It occurs in some 400 varieties of plants, in certain animals, and is synthesized by at least one bacterium.
(Source: World Health Organization. Annex 2: Toxins. p. 214-216)

There are four different ways biological agents create effects:
• through infection by multiplication of organisms,
• by irritation of membranes,
• by killing cells, and
• by causing allergic reactions.

Biological agents create effects
• Infection
• Irritation of membranes
• Toxicity (killing of cells)
• Allergic reactions

Exposure and absorption pathways are similar to chemical agents although inhalation is the most common for biological agents. Few biological agents can penetrate the skin, nor are they volatile. However, they can be dispersed as aerosols to cause inhalation exposure or be introduced into food or water supplies. For example, in 1984, items on a salad bar where intentionally contaminated with salmonella bacteria by cult members in Oregon. Patrons that ate the salads consequently experienced 'food poisoning'.

The problem is that biological agents may not be visible and detection is difficult without expensive equipment, so the first evidence of an attack may occur several days later with the disease outbreak. The point of distribution of the release may not be important if the disease is highly infectious, as individuals visit many places during a single day - sometimes crossing states or international boundaries.

An infectious dose is the number of organisms needed to cause an effect in the body. An infectious dose can be as low as one organism, but others may take a million or more organisms. For example, it takes only 10 to 50 tularemia organisms to cause the disease, but the disease is not usually lethal. An infectious dose for inhalational anthrax varies widely, but is usually fatal without treatment.

LD refers to the number of organisms that likely cause death in a certain percentage of the population. LD_1 is the amount expected to kill 1% of the population exposed to an agent. During the anthrax incidents in the fall of 2001, it was widely reported by the national media that a person needed to inhale 8,000 to 10,000 spores in order to contract inhalational anthrax. The impression given was that this was a threshold dose that needed to be met or exceeded to be at risk. On the other hand, the

LD - Lethal Dose
LD_1= Amount expected to kill 1% of the population exposed to an agent

LD_{50} = Amount expected to kill 50% of population exposed to agent scientific literature suggests this number of spores is the LD_{50}, or amount of agent required to cause lethality to 50% of the population exposed to this level of anthrax.

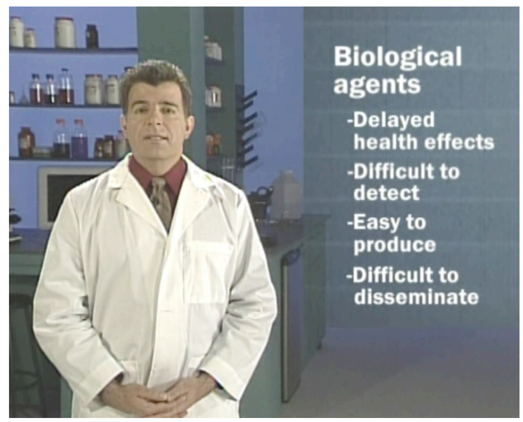
In investigating actual deaths from an anthrax release in the former Soviet Union, it was estimated that the LD_2, or number of spores to kill 2% of the exposed population, was 9 spores. The scientific community has taken the position that there is no threshold dose below which infection cannot occur, and that theoretically a single spore could result in disease, although this is highly unlikely.

Biological agents differ from chemical and nuclear or explosive weapons for several reasons. The organisms can reproduce after being disseminated, causing delayed health effects and infection, days after exposure and absorption. They're hard to detect and trace - there's usually no smell or physical sensation to the body when present. Most are easy to produce - it's the processing and dissemination that's difficult because the organisms generally have to be under 5 microns in diameter to be inhaled deep into the lungs.

Although inhalation is the most common exposure route for most biological agents, toxins can be ingested from eating contaminated food or even injected directly into the bloodstream. For example, a Bulgarian exile living in London was assassinated in 1978 by being shot with a tiny pellet of ricin, from an air gun concealed in an umbrella with a hollow tip.

Scientists refer to the time between exposure to the biological agent and the appearance of symptoms as the incubation period. The incubation period is determined by several factors:
• infectious dose,
• virulence (the disease-producing capacity of the organism) or it's infectiousness;
• how the agent enters the body (the exposure route),
• how fast the bacteria or virus can reproduce itself to overcome the body's defenses or produce the toxins within the cells,
• the host body's own immune defenses, and

LD_2 = Amount expected to kill 2% of the population exposed to agent
LD - Theoretically there is no threshold dose below which infection can not occur.



Incubation period:
• Infectious dose
• Virulence
• Exposure route
• Speed of replication
• Host body's immune defenses
• Antimicrobial resistance or antibiotic care after exposure

• antimicrobial or antiviral resistance or antibiotic care after exposure.

A zoonotic disease is one that can be communicable from animals to humans under natural conditions. Sometimes this occurs through a vector or intermediate host. Bubonic plague is transmitted by infected fleas moving from infected rodents to other animals or humans. Researchers believe the West Nile virus is spread when a mosquito bites an infected bird and then bites a person.

Note: **zoo·no·sis** (noun) is defined as a disease communicable from animals to humans under natural conditions such as the West Nile virus which is transmitted by mosquitoes and causes an illness that ranges from mild to severe. West Nile virus is a type of organism called a "flavivirus" and is similar to many other mosquito-borne viruses. Researchers believe the virus is spread when a mosquito bites an infected bird and then bites a person. West Nile virus was first identified in 1937 in the West Nile region of Uganda, in eastern Africa. It was first identified in the US in the summer of 1999 causing 62 cases of encephalitis and 7 deaths. Since 1999 the virus has spread throughout the US and has been identified in 42 states. Although many people are bitten by mosquitoes carrying the West Nile virus, most do not know they've been exposed. Few people develop severe disease or even notice any symptoms at all. Data from the outbreak in Queens, NY, suggests that although 2.6% of the population was infected, only 1 in 5 infected people developed a mild illness, and only 1 in 150 infected people developed brain inflammation (meningitis or encephalitis).
(Source: http://www.medtermscom)

Module 6
Radiation Exposure and Contamination

Female Firefighter:
Does radiation cause health effects in the body similar to chemical or biological agents?

Narrator:
Radiation is energy that comes from a source and travels through matter or space. Radiation is divided into two categories: ionizing; and non-ionizing - such as visible light, microwaves, lasers, radio waves, and heat.

Ionizing radiation has enough energy to remove an electron from an atom, creating an ion. Everyone is exposed daily to both ionizing and non-ionizing radiation. Natural sources of ionizing radiation include cosmic rays from the sun and stars, radon gas from the earth's crust, rocks and soils, and radioactive materials within the body itself. Sources of human produced background radiation include medical X-rays or other medical diagnostic and therapeutic procedures as well as tobacco products and weapons testing fall-out.

Radiation that produces charged particles - called ions - is called ionizing radiation. There are four main types of ionizing radiation:

- alpha particles,
- beta particles,
- X-rays or gamma rays, and
- neutrons.

Notes

Radiation
- Ionizing
- Non-Ionizing
  - Visible light
  - Microwaves
  - Lasers
  - Radio waves
  - Heat

Ionizing Radiation
- Alpha particles
- Beta particles
- X-rays, gamma rays
- Neutrons

Male Firefighter:
Is radiation always hazardous?

Narrator:
It depends on the type of radiation, the dose, and the route of exposure. Radiation doses can be received either as external radiation such as cosmic rays or medical X-rays, or as internal radiation from absorption of radioactive elements into the body, as in nuclear medicine procedures or strontium-90 absorption from fall-out.

X-rays
Gamma rays
Neutrons
• Highly penetrating

Some types of radiation such as X-rays, gamma rays, and neutrons are highly penetrating. That means they can pass through air, clothing and even the body. They may hit a few cells and interact with them. The ions created in these interactions produce forms of oxygen that are highly reactive chemically, and can damage the cells. Usually the cell repairs such damage, but sometimes (especially during cell division) the repair may be incorrect or faulty. Alpha particles are non-penetrating - they only travel an inch or two in the air and cannot penetrate the skin but they are hazardous if ingested or inhaled. Alpha particles emitted from a source within the body have sufficient energy to do much damage.

Alpha particles - Non-penetrating

Beta particles are slightly more penetrating - they can travel a few yards and in sufficient quantities might cause skin damage. Beta-emitting materials create internal hazards if ingested or inhaled and can cause significant damage if long-lived beta-emitters are incorporated into tissues such as bone. A unit of radiation dose is called a rem. A rem is a measure of radiation dose based on the amount of energy absorbed in a mass of tissue. Because it is a rather large quantity, radiation dose is often expressed in units of millirem instead.

Beta particles - Slightly more penetrating

Note: rem stands for r(oentgen) e(quivalent in) m(an)
roentgen = unit of dose of ionizing radiation, e.g. X-rays or gamma rays. Wilhelm Conrad Röntgen was the first scientist to observe and record X-rays, first finding them on November 8, 1895. After some considerable investigation, he named the new rays "X" to indicate they were unknown. (http://imagine.gsfc.nasa.gov/docs)

On average, an individual in the US receives a

Rem
1 rem = 1000 millirem

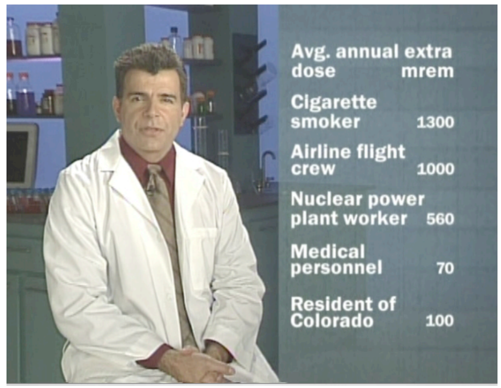
background dose of radiation of about a third of a rem per year. Most of this comes from naturally occurring radon gas. Human-made sources contribute about 60 millirem for a non-smoker, for a total average background radiation dose of 360 millirem. Scientists can't detect any harmful effects at these doses.

1 mrem = 1/1000 or 0.001 rem

Average annual background radiation dose

Natural	300 mrem
Human-made	60 mrem
Total	360 mrem/year

Some individuals may get higher doses because of their lifestyle, occupation, or where they live. Cigarette smokers, for example, receive an average annual additional dose of 1300 millirem, Airline flight crews receive 1000 millirem, nuclear plant workers receive 560 millirem, and medical personnel receive an extra 70 millirem annually. Just living at a higher altitude - as in Denver - increases the annual dose by 100 millirem due to increased cosmic ray exposure.



(Source: NCRP 1987. *Ionizing Radiation Exposure of the Population of the United States*, NCRP Report No. 93, National Council on Radiation Protection and Measurements, Washington, D.C.)

Female EMT:
What is the difference between radiation and contamination?

Narrator:
There's a common misconception that things exposed to radiation become contaminated or radioactive. This is not true. Food is irradiated to preserve it but it does not become radioactive. Irradiation is not the same as becoming radioactive or contaminated.

Irradiation
Contamination
Radioactive

Contamination occurs when material containing radioactive atoms is deposited on skin, clothing, grass, or any place where it is not wanted. And radioactive contamination can be spread. A person contaminated with radioactive materials will be irradiated until the source is removed - either washed off if external, or

Note: Radionuclide is a radioactive nuclide. Nuclide is a term used to categorize different forms of atoms very specifically. Each nuclide has a unique set of characteristics:

- number of protons
- number of neutrons
- energy state.

flushed out of the body in urine and feces if internal. The source will also be removed by radioactive decay; the short-lived radionuclide iodine-131 has a half-life of 8 days.

A high radiation dose from a single exposure can cause various degrees of radiation sickness or poisoning and even death. Signs and symptoms may not be seen for days or weeks with moderate exposure. Either very low acute doses or low doses over long periods - that is, chronic exposure, can cause cancer, premature aging, or genetic effects which are passed onto on future generations.

Radiation sickness signs and symptoms usually begin with nausea, vomiting, and diarrhea, and progress to anemia, skin burns, fatigue, dehydration, hair loss, bleeding and bruising, and reduced blood cell counts. The symptoms occur in a predictable sequence. And the greater the radiation dose, the more rapid the onset of symptoms.

The severity of illness depends on:
• the dose,
• the dose rate,
• the type and amount of radiation, and
• duration of exposure.
The effects also depend in part on whether the person receives whole-body exposure, or if not, what body areas are exposed.

The best indicators of the severity are:
• the time from exposure to the start of signs and symptoms,
• the severity of symptoms, and
• the severity of changes in white blood cells at 48 hours after exposure.
There is no cure, but supportive therapy can be helpful.

Female Medic:
What radiation threats should we be concerned with?

Narrator:
There are several types of radiation threats. Terrorists might use a dirty bomb - where a conventional

If any of these change, the atom becomes a different nuclide. Approximately 3,700 nuclides have been identified. Most of them are radionuclides, meaning they are unstable and undergo radioactive decay. Most people encounter only the few that are used routinely for medical, military, or commercial purposes. (http://www.epa.gov/radiation/radionuclides/)

Acute high exposure

Chronic exposure
• Cancer
• Premature aging
• Genetic effects

Radiation sickness signs and symptoms
• Nausea and vomiting
• Diarrhea
• Anemia
• Skin reddening and burns
• Fatigue and weakness
• Dehydration
• Hair loss
• Bleeding and bruising
• Reduced blood cell counts

Severity of illness
• Dose
• Dose rate
• Type and amount of radiation
• Duration of exposure

Severity of exposure and contamination shown by:
• Time to start of symptoms
• Severity of symptoms
• Severity of white blood cell changes

Dirty bomb
High intensity sources

explosive device is coupled with radioactive material that spreads contamination when detonated. Then there could be high intensity external sources, or a nuclear facility could be sabotaged, or there could be a nuclear blast detonation.

Nuclear facility incident
Nuclear weapon blast

The consequences of each of these threats differ in terms of:

• the types of radiation that would result,
• the doses that individuals would likely experience, and
• the ensuing health effects.

Types of radiation
Doses
Ensuing health effects

The main ways to protect yourself are through time, distance, and shielding. This means to:

• minimize the duration or time of exposure,
• maximize the distance from the source of radiation, and
• have as much shielding as possible between yourself and the source of radiation.

Protection
• Minimize time
• Maximize distance
• Increase shielding

The lower floors of thick concrete-walled buildings could offer good protection from radiation from nuclear fall-out from a nuclear blast. Walking a short distance from the scene of a dirty bomb could provide significant protection since 'dose rate' drops dramatically with distance from the source.

To protect from inhaling or ingesting substances causing internal radiation exposure, you may shelter in place, use a mask to reduce or eliminate inhalation of radioactive particles, avoid contact with radioactive particles, and avoid eating contaminated food and drink.

Protection against inhalation or ingestion of radioactive particles:
• Shelter-in-place
• Use a mask
• Avoid contact with radioactive particles
• Avoid eating contaminated food and drink

There are no reliable antidotes once radioactive particles are in the body but there are some chemicals that help cleanse the body of specific radioactive materials. If exposure and absorption have occurred, medical treatment with chelating agents may be used to bind the radioactive elements and enhance their flushing from the body.

Note: Chelating agent is a substance whose molecules can form several coordinate bonds to a single metal ion. Chelation therapy is treatment with a chelating agent to enhance the elimination or reduce the toxicity of a metal ion.

Potassium iodide tablets may be taken within 2 to 4 hours after an event such as a containment breach at a nuclear power plant or from a nuclear weapon blast in which radioactive iodine is released. The dose is the same for adults and children. The tablets block the uptake of radioactive iodine by the thyroid gland. However, they are effective only against radioactive iodine isotopes, and are not protective for any other radioisotopes.

Module 7
Review

Narrator:
Let's review. The main points for this training have been:

- factors in exposure and contamination,
- understanding the characteristics that make chemicals hazardous,
- exposure pathways or routes,
- secondary contamination and off-gassing,
- vulnerability factors, such as age and general health status,
- persistence and deposition,
- toxicity;
- dose and dosage,
- concentration time integral or Ct,
- peak concentration,
- lethal concentration times time or LCt, and
- Acute Exposure Guideline Levels (AEGLs).

Then we reviewed biological agents, how they work and affect health, and the constraints in using biological organisms as warfare agents. The last section discussed radiation exposure and health effects and the protection offered by time, distance and shielding.

Today's world is very different from that of our grandparents. What was taken for granted - that all industrial processes and technologies were beneficial - has changed. Many of the hazards we see today were not even dreamed of a hundred years ago. What you need to understand is what happens when a person is potentially exposed and what you can do to prevent or eliminate contamination, exposure, and absorption, and the consequent health effects.

Notes

Review
- Factors in exposure and contamination
- Understanding the characteristics that make chemicals hazardous
- Exposure pathways or routes
- Secondary contamination and off-gassing
- Vulnerability factors
- Persistence and deposition
- Toxicity
- Dose and dosage,
- Concentration time integral or Ct
- Peak concentration,
- Lethal concentration times time or LCt,
- Acute Exposure Guideline Levels (AEGLs)
- Biological agents
- Constraints in using biological organisms as warfare agents
- Radiation exposure and health effects
- Protection offered by time, distance, and shielding

You now know what to ask about when scientists and officials provide explanations and how they make the calculations to define exposure and absorption. The best way you can protect yourself and your community is through knowledge, being prepared, and taking steps to prevent unnecessary contamination and exposure.

CITED REFERENCES

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