Ch. 17 - Risk, Toxicology and Human Health

The Big Killer

There are about 1.1 billion smokers in the world.

The World Health Organization estimates that each year tobacco contributes to the premature death of at least 3 million people.

A 1998 report estimated that more than 500,000 people in Europe and 750,000 people in China die from smoking-related disease every year.

The overwhelming consensus in the scientific community is that nicotine inhaled in tobacco smoke is highly addictive.

Only 1 in 10 people who try to quit smoking succeed.

U.S. Government agencies and independent economists estimate that the country's 48 million smokers cost the United States up to 100 billion a year in medical bills, increased insurance costs, disability, and lost earnings and productivity because of illness. A $2-4 tax on tobacco products would help pay a much greater share of the health, economic, and social costs associated with their smoking: a user-pays approach.

Reducing the death toll from cigarettes

1) Banning all cigarette advertising
2) Forbidding the sale of cigarettes to anyone under 21
3) Banning all cigarette vending machines
4) Classifying nicotine as an addictive and dangerous drug
5) Eliminating all federal subsidies and tax breaks to U.S. tobacco farmers and companies
6) Using cigarette tax income to finance a massive anti-tobacco campaign

Risks and Hazards

Risk is the possibility of suffering harm from a hazard that can cause injury, disease, economic loss, or environmental damage.

Risk is expressed in terms of probability: a mathematical statement about how likely it is that some event or effect will occur.

The probability of a risk is expressed as a fraction ranging from 0 to 1.0.

Risk assessment involves using data, hypotheses, and models to estimate the probability of harm to human health, to society, or to the environment that may result from exposure to specific hazards.

Major types of Hazards

Cultural hazards such as unsafe working conditions.

Chemical hazards from harmful chemicals (such as, in the air).

Physical hazards (such as, noise, fire, and tornadoes).

Biological hazards from pathogens, bacteria, and pollen.

Toxicology

The study of the adverse effects of chemicals on health is called toxicology.

Toxicity is a measure of how harmful a substance is.

The amount of potentially harmful a substance that a person had ingested, inhaled, or absorbed through the skin is called the **dose** and the amount of the resulting type and amount of damage to the health is called the **response**. (Dose-Response Curves)

An **acute effec**t is an immediate or rapid harmful reaction to an exposure: it can range from a rash to death.

A **chronic effect** is a permanent or long-lasting consequence of exposure to a harmful substance.

Bioaccumulation is an increase in the concentration of a chemical in specific organs or tissues at a level higher than would normally be expected.

The levels of some toxins in the environment can also be magnified as they pass through food chains and webs by a process called **biomagnification**.

Dose and especially response can also depend on whether and how a chemical interacts with other chemicals (e.g., asbestos and cigarette smoking).

What is a Poison?

Legal definition: a poison is a chemical that has an LD_{50} of 50 milligrams or less per kilogram of body weight.

An LD_{50} is the median lethal dose, or amount of a chemical received in one dose that kills exactly 50% of the animals in a test population within a 14-day period.

How do Scientists Determine Toxicity?

Three methods used to determine the level at which a substance poses a threat:

1) case reports - about people suffering from some adverse health effect or death after exposure to a chemical

2) laboratory investigations - usually on test animals, to determine toxicity, residence time, what parts of the body are affected, and how the harm takes place.

3) epidemiology - which involves studies of populations of humans exposed to certain chemicals or diseases.

Dose-response curve - which shows the effects of various doses on a group of test organisms. (see Miller, p.440)

linear dose-response model - any dose of a toxic chemical or ionizing radiation has a certain risk of causing harm (no threshold).

threshold dose-response model - there is a threshold dose below which no detectable harmful effects occur, presumably because the body can repair the damage caused by low doses of some substances.

Some scientists challenge the validity of extrapolating data from test animals to humans because human physiology and metabolism are often different from those of test animals.

Another approach to testing toxicity and identifying the agents causing diseases is epidemiology. Epidemiology is the study of the patterns of disease or toxicity to find out why some people get sick and other do not.

Chemical Hazards

Toxic chemicals are generally defined as substances that are fatal to over 50% of test animals at given concentrations (LD_{50}).

Hazardous chemicals cause harm by

1) being flammable or explosive

2) irritating or damaging the skin or lungs

3) interfering with or preventing oxygen uptake and distribution

4) inducing allergic reactions of the immune system

Mutagens - are agents, such as chemicals and radiation, that cause mutations, or changes in the DNA molecules found in the cells.

Teratogens - are chemicals, radiation, or viruses that cause birth defects while the human embryo is growing and developing during pregnancy, especially during the first 3 months (first trimester).

Carcinogens - are chemicals, radiation, or viruses that cause or promote the growth of malignant tumor, in which certain cells multiply uncontrollably.

In the U.S. the incidence of all new cancers increased by 54% between 1950 and 1992, and the death rate for all cancers increased by 9.6%.

According to the World Health Organization, environmental and lifestyle factors play a key role in causing or promoting 80% of all cancers.

How Can Chemicals Harm the Immune, Nervous, and Endocrine Systems?

The immune system consists of:

1) antibodies- which identify alien invaders in your blood stream and mark them for other immune cells to attack.

2) Cellular defenses- such as killer T-cells, which seek out and kill cells that have been invaded.

The human nervous system is also being threatened by synthetic chemicals in the environment.

Do Hormone Disrupters Threaten the Health of Wildlife and Humans?

Hormone mimics - are estrogen-like chemicals that disrupt the endocrine system by being able to attach to estrogen receptor molecules.

Hormone blockers - disrupt the endocrine system by preventing natural hormones (such as androgens) from attaching to their receptors.

Pollutants can now act as thyroid disruptors and cause growth, weight, brain, and behavioral disorders.

So far, 51 chemicals, many of them widely used, have been shown to act at extremely low levels as hormone disruptors in wildlife, laboratory animals, and some populations of humans.

Why Do We Know So Little About Harmful Effects of Chemicals?

The U.S. National Academy of Sciences estimates that only about 10% of the nearly 100,000 chemicals in commercial use have been thoroughly screened for toxicity and only 2% have been adequately tested to determine whether they are carcinogens, teratogens, or mutagens.

Each year we introduce into the marketplace about 1,000 new chemicals about whose potentially harmful effects we have little knowledge.

The difficulty and expense of getting information about the harmful effects of chemicals is one reason an increasing number of environmentalists and health officials are pushing for much greater emphasis on pollution prevention.

Physical Hazards: Earthquakes, Volcanic Eruptions, and Ionizing Radiation.

Earthquakes.

Volcanoes.

Ionizing radiation, a form of electromagnetic radiation, has enough energy to damage body tissues.

> Ionizing radiation can cause harm by penetrating a human cell, knocking loose one or more electrons from a cellular chemical, and thus altering molecules needed for normal cellular functioning.

Ionizing radiation can damage cells in two ways: 1) genetic damage or 2) somatic damage.

Is Nonionizing Electromagnetic Radiation Harmful?

Electromagnetic fields are low-energy, nonionizing forms of electromagnetic radiation given off when an electric current passes through a wire or a motor.

Since the 1960s there has been growing public concern and controversy over the possibility that EMFs could have harmful effects on humans (e.g., cell phones).

Numerous epidemiological studies have suggested that prolonged exposure to EMFs could lead to increased risk from some cancers, miscarriages, birth defects, and Alzheimer's disease.

Biological Hazards

What are Nontransmissible Diseases?

Diseases not caused by living organisms and that do not spread from one person to another.

What Are Transmissible Diseases?

A transmissible disease is caused by a living organism and can spread from one person to another.

In developing countries, infectious diseases accounted for about 44% of the deaths, compared to only 5% in developed countries (in 1997).

About 80% of all illnesses in developing countries are caused by waterborne diseases , mainly from unsafe drinking water.

However, ebola, HIV and other new emerging diseases, which have been rising for at least two decades and are likely to increase in the near future, should not be ignored.

What Factors Can Affect the Spread of Transmissible Diseases?

Outbreaks of infectious diseases often occur because of a change in the physical, social, or biological environment of disease reservoirs, carrier vectors, or hosts.

In 1998, scientists warned that increased outbreaks of many tropical infectious diseases in developing countries are related to **reducing biodiversity** by destroying forests and wiping out other species that help control disease vectors.

Climate can also affect the spread of infectious diseases.

Natural disasters such as floods, landslides, and hurricanes can also spread disease-causing organisms.

Are We Losing the War Against Infectious Bacteria?

There is growing and alarming evidence that we may be losing our war against infectious bacterial diseases because bacteria are among Earth's ultimate survivors. Microbes that cause disease are constantly and rapidly mutating and evolving in ways that allow them to escape human control.

Through natural selection, a single mutant can pass such traits on to most of its offspring, which can amount to 16,777,216 in only 24 hours.

Bacteria can become genetically resistant to antibiotics that they have been exposed to.

How Rapidly are Viral Diseases Spreading?

Health officials worry about the emergence of new viral diseases, they recognize that the greatest viral health threat to humans is the emergence of new, very virulent strains of influenza.

Flu viruses move through the air and are highly contagious.

In 1918-19, a flu epidemic infected more than half the world's population and killed 20-30 million people. These massive epidemics are called pandemics. Case Study: Malaria, a Protozoal disease

According to a 1993 World Bank report, among infectious diseases malaria is a serious global health problem second only to tuberculosis.

Currently, an estimated 300-500 million people are infected with malaria parasites worldwide, and at least 110 million new cases occur each year.

Malaria is caused by four species of protozoa of the **genus Plasmodium**.

The malaria cycle repeats itself until immunity develops, treatment is given, or the victim dies.

What are the major diseases in developed countries?

A country makes an epidemiological transition:

First phase - characterized by extremely high death rates.

Second phase - epidemic peaks become less frequent and the crude death rate from infectious diseases drops.

Third phase - in which the death rate levels off and the leading causes of death are from nontransmissible diseases associated with aging.

Fourth phase - degenerative diseases associated with aging continue to cause more deaths.

Fifth phase - might be the emergence of new infectious diseases which will cause death rates to rise.

How can we reduce infectious and other diseases

Increasing research on tropical diseases

Mounting a global campaign to reduce overcrowding, unsafe drinking water, poor sanitation, inadequate health care system, and poverty.

Increase funding for monitoring, diagnosing and responding to disease outbreaks

Using extreme caution in instituting strategies to battle disease causing organisms.

Not using as many antibiotics.

Educating the public, establishing and enforcing much more rigorous anti-infection programs.

Not selling antibiotics without a presecription

Reducing the use of pesticides

Increase funding for development of vaccines to prevent infections by bacteria and viruses

Emphasizing preventative health care

Risk Analysis?

Risk analysis involves identifying hazards and evaluating their associated risks, ranking risks, determining options and making decisions about reducing or eliminating risks, and informing decision makers and the public about risks.

Risk assessment involves determining the types of hazards involved, estimating the probability that each hazard will occur, and estimating how many people are likely to be exposed to it and how many suffer serious harm.

Comparative risk analysis summarizing the greatest ecological and health risks identified by a panel of scientists and the public.

What are the Greatest Risks people face?

In terms of reduced life span from malnutrition, exposure to disease-causing organisms, and dangerous chemicals, and lack of basic health care, the greatest risk by far is poverty.

After the health risks associated with poverty, the greatest risks of premature death are mostly the result of voluntary choices people make about their lifestyles.

How can we estimate risks for Technological Systems

The more complex a technological system and the more people needed to design and run it, the more difficult it is to estimate the risks.

System reliability % = Technology reliability x Human reliability x 100

What are the limitations of Risk assessment and Risk benefit analysis?

Risk assessment is a young science that has many built-in uncertainties and limitations.

Some see risk analysis as a useful and much needed tool, and others see it as a way to justify premeditated murder in the name of profit.

How should risks be managed?

Risk management includes the administrative, political, and economic actions taken to decide whether and how to reduce a particular societal risk to a certain level and at what cost.

How well do we perceive risks?

People are not really prepared for risks but they become terrified of dying in a plane crash or being shot.

The concept of people's risks is not the same concept that the environment around them has and they must begin to realize this.