17

Environmental Hazards and Human Health
Core Case Study: Mercury’s Toxic Effects

- All mercury compounds are toxic
- One third in the atmosphere comes from natural sources
  - Human activities provide the rest
- Two main human exposures
  - Fish contaminated with mercury
  - Inhalation of vaporized mercury
- Greatest risk is brain damage
Fish from these waters contain mercury and may be harmful to eat especially for women and children.
17-1 What Major Health Hazards Do We Face?

• We face health hazards from biological, chemical, physical, and cultural factors, and from the lifestyle choices we make.
Risks Are Usually Expressed as Probabilities

• Risk
  – Probability of suffering harm from a hazard
  – Expressed as ratio or percentage

• Risk assessment
  – Using statistical methods to estimate harm

• Risk management
  – Deciding whether and how to reduce a particular risk
Risk Assessment

- Hazard identification: What is the hazard?
- Probability of risk: How likely is the event?
- Consequences of risk: What is the likely damage?

Risk Management

- Comparative risk analysis: How does it compare with other risks?
- Risk reduction: How much should it be reduced?
- Risk reduction strategy: How will the risk be reduced?
- Financial commitment: How much money should be spent?
We Face Many Types of Hazards

• Biological
  – Pathogen – an organism that causes disease in other organisms

• Chemical
  – Harmful chemicals

• Natural
  – Fire, earthquakes, volcanoes, etc.
We Face Many Types of Hazards (cont’d.)

- Cultural
  - Unsafe working conditions, poverty, etc.
- Lifestyle choices
  - Smoking, drinking too much alcohol, etc.
17-2 What Types of Biological Hazards Do We Face?

- The most serious biological hazards we face are infectious diseases such as flu, AIDS, tuberculosis, diarrheal diseases, and malaria
Some Diseases Can Spread from One Person to Another

- **Infectious disease**
  - Pathogen invades the body and multiplies
  - Viruses, bacteria, parasites

- **Transmissible disease**
  - Contagious or communicable disease
  - Infectious disease transmitted between people
• Nontransmissible disease
  – Not caused by living organisms
  – Heart disease, most cancers, diabetes

• Epidemic
  – Large-scale outbreak of an infectious disease
  – Pandemic – global
Humans

- Pets
- Livestock
- Wild animals
- Insects
- Food
- Water
- Air

Humans

- Other humans
- Fetus and babies

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Disease (type of agent) | Deaths per year
---|---
Pneumonia and flu (bacteria and viruses) | 3.2 million
HIV/AIDS (virus) | 2.1 million
Diarrheal diseases (bacteria and viruses) | 1.9 million
Tuberculosis (bacteria) | 1.7 million
Malaria (protozoa) | 1 million
Hepatitis B (virus) | 1 million
Measles (virus) | 800,000
Many people have latent TB
  – 1.4 million deaths each year, primarily in less-developed countries

Why is tuberculosis on the rise?
  – Not enough screening and control programs
  – Genetic resistance to a majority of effective antibiotics
  – Person-to-person contact has increased
  – AIDS individuals are very susceptible to TB
Estimated TB incidence rate (per 100,000 population)

- 1 – 24
- 25 – 49
- 50 – 99
- 100 – 299
- ≥ 300
- 0 or No Estimate

(Compiled by the authors using data from the World Health Organization and the U.S. Centers for Disease Control and Prevention.)

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Fig. 17-6, p. 446
Viral Diseases and Parasites Kill Large Numbers of People

- Influenza or flu virus
  - Kills the most worldwide
- HIV
  - Infects about 2.5 million people yearly
- Hepatitis B virus (HBV)
- Emergent diseases – West Nile virus
• Viruses that move form animals to humans
  – West Nile virus
  – The new field of ecological medicine

• Reduce chances of infection
  – Wash your hands
  – Avoid touching your face
  – Avoid sick people
Case Study: The Global HIV/AIDS Epidemic

- Acquired immune deficiency syndrome (AIDS)
  - Caused by human immunodeficiency virus (HIV)
  - Many secondary infections
- No vaccine to prevent or cure AIDS
- Expensive drugs – live longer
Case Study: The Global HIV/AIDS Epidemic (cont’d.)

• 30 million deaths between 1981-2012
  – Kills about 1.7 million people yearly

• Most prevalent in sub-Saharan Africa
  – Life expectancy dropped from 62 to 47
  – Alters age structure of population
Case Study: Malaria – The Spread of a Deadly Parasite

- Malaria
  - Caused by parasite carried by certain mosquitoes
  - Tropical and subtropical regions
  - Spread
    - Uninfected mosquito bites infected person, later bites an uninfected person

- Climate change – expected to spread malaria
• Malaria is on the rise since 1970
  – Drug-resistant *Plasmodium*
  – Insecticide resistant mosquitoes
  – Clearing of tropical forests
  – AIDS patients particularly vulnerable

• What is the focus of current malaria research?
We Can Reduce the Incidence of Infectious Diseases

• Good news
  – Percentage of worldwide deaths resulting from infectious diseases
    • Dropped from 35% to 15% from 1970 to 2008
  – Vaccinations on the rise
  – Oral rehydration therapy

• Bad news
  – More money needed for medical research in developing countries
Solutions

Infectious Diseases

- Increase research on tropical diseases and vaccines
- Reduce poverty and malnutrition
- Improve drinking water quality
- Reduce unnecessary use of antibiotics
-Sharply reduce use of antibiotics on livestock
-Immunize children against major viral diseases
- Provide oral rehydration for diarrhea victims
- Conduct global campaign to reduce HIV/AIDS
There is growing concern about chemicals in the environment that can cause cancers and birth defects, and disrupt the human immune, nervous, and endocrine systems.
Some Chemicals Can Cause Cancers, Mutations, and Birth Defects

- Toxic chemicals
  - Carcinogens
    - Chemicals, types of radiation, or certain viruses that cause or promote cancer
  - Mutagens
    - Chemicals or radiation that cause mutations or increase their frequency
  - Teratogens
    - Chemicals that cause harm or birth defects to a fetus or embryo
Case Study: PCBs Are Everywhere – A Legacy from the Past

• Class of chlorine-containing compounds
  – Very stable
  – Nonflammable
  – Break down slowly in the environment
  – Travel long distances in the air
  – Fat soluble
  – Ends up in food chains and webs
• Banned, but found everywhere
Atmosphere

Crops

Vegetation

Surface water

Humans

Animals

Vegetation

Surface water

Groundwater

Fish

Water table

Rock

Soil

Groundwater

Water table

Rock
Some natural and synthetic chemicals in the environment can weaken and harm:

– Immune system
  • Some chemicals weaken the immune system

– Nervous system
  • Neurotoxins – PCBs, arsenic, lead, some pesticides

– Example – Methylmercury
  • What are the effects of mercury poisoning?
## Solutions

### Mercury Pollution

#### Prevention
- Phase out waste incineration
- Remove mercury from coal before it is burned
- Switch from coal to natural gas and renewable energy resources

#### Control
- Sharply reduce mercury emissions from coal-burning plants and incinerators
- Label all products containing mercury
- Collect and recycle batteries and other products containing mercury

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Some Chemicals Affect the Human Endocrine System

• Endocrine system
  – Glands that release hormones that regulate bodily systems and control sexual reproduction, growth, development, learning, behavior

• Hormonally active agents have similar shapes and bind to hormone receptors
  – Hormone mimics
  – Hormone blockers
Hormone Estrogen-like chemical Antiandrogen chemical

**Receptor**

**Cell**

**Normal Hormone Process**

**Hormone Mimic**

**Hormone Blocker**
What Can You Do?

Exposure to Hormone Disrupters

- Eat certified organic produce and meats
- Avoid processed, prepackaged, and canned foods
- Use glass and ceramic cookware
- Store food and drinks in glass containers
- Use only natural cleaning and personal care products
- Use natural fabric shower curtains, not vinyl
- Avoid artificial air fresheners, fabric softeners, and dryer sheets
- Use only glass baby bottles and BPA-free, phthalate-free sipping cups, pacifiers, and toys
Scientists use live laboratory animals, case reports of poisonings, and epidemiological studies to estimate the toxicity of chemicals, but these methods have limitations.

Many health scientists call for much greater emphasis on pollution prevention to reduce our exposure to potentially harmful chemicals.
Many Factors Determine the Harmful Health Effects of Chemicals

- Toxicology – study of harmful effects
  - Dose
  - Age
  - Genetic makeup
  - Multiple chemical sensitivity (MCS)
  - Solubility
  - Persistence
  - Biomagnification
Many Factors Determine the Harmful Health Effects of Chemicals (cont’d.)

• Response
  – Acute effect – immediate or rapid
  – Chronic effect – permanent or long-lasting
Fig. 17.16, p. 459

- Water pollutant levels
- Air pollutant levels
- Soil/dust levels
- Food pesticide levels
- Nutritional health
- Overall health
- Lifestyle
- Personal habits
- Genetic predisposition
- Lung, intestine, and skin absorption rates
- Metabolism
- Accumulation
- Excretion

Scientific measurements and modeling

Predicted level of toxicant in people


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Case Study: Protecting Children from Toxic Chemicals

• Analysis of umbilical cord blood
  – 180 chemicals found that cause cancers in humans or animals

• Infants and children more susceptible
  – Less well-developed immune systems and body detoxification processes

• Fetal exposure may increase risk of autism, asthma, learning disorders
Scientists Use Live Lab Animals and Non-animal Tests to Estimate Toxicity

- Mice and rats
  - Systems are similar to humans
  - Small, and reproduce rapidly
- Dose-response curve – median lethal dose (LD50)
  - Nonthreshold dose-response model
  - Threshold dose-response model
Scientists Use Live Lab Animals and Non-animal Tests to Estimate Toxicity (cont’d.)

- More humane methods using animals
  - Replace animals with other models
    - Computer simulations
    - Tissue culture and individual animal cells
    - Chicken egg membranes
- What are the effects of mixtures of potentially toxic chemicals?
Percentage of population killed by a given dose

Dose (hypothetical units)

LD50
**Nonlinear dose-response**

- **Effect** vs. **Dose**
  - Nonthreshold

**Linear dose-response**

- **Effect** vs. **Dose**
  - Nonthreshold

**Threshold**

- **Effect** vs. **Dose**
  - Threshold level
There Are Other Ways to Estimate the Harmful Effects of Chemicals

- Case reports and epidemiological studies
- Limitations of epidemiological studies
  - Too few people tested
  - Length of time
  - Result linked to chemical
  - Cannot be used for new hazards
Are Trace Levels of Toxic Chemicals Harmful?

- Insufficient data for most chemicals
- We are all exposed to toxic chemicals
  - Trace amounts
- Difference between increasing dangers and better testing
Asbestos
Source: Pipe insulation, vinyl ceiling and floor tiles
Threat: Lung disease, lung cancer

Carbon monoxide
Source: Faulty furnaces, unvented gas stoves and kerosene heaters, woodstoves
Threat: Headaches, drowsiness, irregular heartbeat, death

Tetrachloroethylene
Source: Dry-cleaning fluid fumes on clothes
Threat: Nerve disorders, damage to liver and kidneys, possible cancer

Formaldehyde
Source: Furniture stuffing, paneling, particleboard, foam insulation
Threat: Irritation of eyes, throat, skin, and lungs; nausea; dizziness

Styrene
Source: Carpets, plastic products
Threat: Kidney and liver damage

Benzo-α-pyrene
Source: Tobacco smoke, woodstoves
Threat: Lung cancer

Tobacco smoke
Source: Cigarettes
Threat: Lung cancer, respiratory ailments, heart disease

Stepped Art
Fig. 17-19, p. 462
Why Do We Know So Little about the Harmful Effects of Chemicals?

• There are severe limitations in estimating toxicity levels and risks
• Only 2% of 100,000 chemicals have been adequately tested
• 99.5% of chemicals used in the United States are not supervised by government
• Precautionary principle
  – Those introducing a new chemical or new technology need to follow new strategies
    • A new product is considered harmful until it can be proved to be safe
    • Existing chemicals and technologies that appear to cause significant harm must be removed

• 2000 – global treaty to ban or phase out the dirty dozen persistent organic pollutants (POPs)
Case Study: Pollution Prevention Pays

• The 3M Company
  – 1975 to 2008, prevented more than 1.5 million tons of pollutants from reaching the environment
  – Employee reward program
• We can reduce the major risks we face by becoming informed, thinking critically about risks, and making careful choices
The Greatest Health Risks Come from Poverty, Gender, and Lifestyle Choices

• Poverty
  – Greatest health risk by far
  – Malnutrition, increased infectious disease, unsafe drinking water

• Gender
  – Being born male

• Lifestyle choices
  – Overeating, smoking, etc.
<table>
<thead>
<tr>
<th>Cause of death</th>
<th>Annual deaths</th>
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</thead>
<tbody>
<tr>
<td>Poverty/malnutrition/disease cycle</td>
<td>11 million</td>
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<tr>
<td>Tobacco</td>
<td>6.0 million</td>
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<tr>
<td>Pneumonia and flu</td>
<td>3.2 million</td>
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<tr>
<td>Air pollution</td>
<td>3.2 million</td>
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<tr>
<td>HIV/AIDS</td>
<td>1.7 million</td>
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<tr>
<td>Diarrhea</td>
<td>1.6 million</td>
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<tr>
<td>Tuberculosis</td>
<td>1.4 million</td>
</tr>
<tr>
<td>Automobile accidents</td>
<td>1.2 million</td>
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<tr>
<td>Work-related injury and disease</td>
<td>1.1 million</td>
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<tr>
<td>Malaria</td>
<td>1.0 million</td>
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<tr>
<td>Hepatitis B</td>
<td>655,000</td>
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<tr>
<td>Measles</td>
<td>139,000</td>
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</table>

(Compiled by the authors using data from World Health Organization, Environmental Protection Agency, and U.S. Centers for Disease Control and Prevention.)

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Lack of access to

<table>
<thead>
<tr>
<th></th>
<th>Number of people (% of world’s population)</th>
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<tbody>
<tr>
<td>Adequate sanitation facilities</td>
<td>2.6 billion (37%)</td>
</tr>
<tr>
<td>Enough fuel for heating and cooking</td>
<td>2 billion (28%)</td>
</tr>
<tr>
<td>Electricity</td>
<td>2 billion (28%)</td>
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<tr>
<td>Adequate health care</td>
<td>1.1 billion (15%)</td>
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<tr>
<td>Adequate housing</td>
<td>1 billion (14%)</td>
</tr>
<tr>
<td>Enough food for good health</td>
<td>925 million (13%)</td>
</tr>
<tr>
<td>Clean drinking water</td>
<td>880 million (12%)</td>
</tr>
</tbody>
</table>

(Compiled by the authors using data from United Nations, World Bank, and World Health Organization.)
Case Study: Death from Smoking

• Most preventable major cause of suffering and premature death
  – Killed 100 million people during the 20th century
  – Could be linked to increased dementia and Alzheimer’s disease
• Nicotine – additive
• What are the effects of passive smoking (secondhand smoke)?
Case Study: Death from Smoking (cont’d.)

• How to reduce smoking
  – Taxes
  – Classify and regulate nicotine
  – Bans on smoking in public places
  – Education
Estimating Risks from Technologies Is Not Easy

- Reliability
  - System reliability (%) = Technological reliability (%) \times Human reliability (%)

- Human reliability is much lower than technological reliability
  - Much harder to predict
Most People Do a Poor Job of Evaluating Risks

• Five factors can cause misjudgments in risk:
  – Fear
  – Degree of control
  – Whether a risk is catastrophic or chronic
  – Optimism bias
  – Instant gratification
Certain Principles Can Help Us Evaluate and Reduce Risk

- Compare risks
- Determine how much you are willing to accept
- Evaluate the actual risk involved
- Concentrate on evaluating and carefully making important lifestyle choices
Three Big Ideas

• We face significant hazards from:
  – Infectious diseases
    • Flu, AIDS, tuberculosis, diarrheal diseases, and malaria
  – Exposure to chemicals that can:
    • Cause cancers and birth defects,
    • Disrupt the human immune, nervous, and endocrine systems
• Because of the difficulty of evaluating the harm caused by exposure to chemicals, many health scientists call for much greater emphasis on pollution prevention.

• By becoming informed, thinking critically about risks, and making careful choices, we can reduce the major risks we face.
Tying It All Together: Mercury’s Toxic Effects and Sustainability

• Mercury is highly toxic
• We can reduce some threats
  – Shift to renewable sources of energy
  – Cutting resource use and wastes
  – Mimic biodiversity
    • Use diverse strategies for solving environmental and health problems