Environmental Science, 15e

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14

Environmental Hazards and Human Health

Core Case Study: Mercury's Toxic Effects

- Mercury, a toxic metal, is naturally released into the air from volcanoes, soil, and rocks
  - Also used to separate gold from the ore
- Mercury moves through food webs
  - Humans are exposed to it by eating fish and breathing air with mercury particles
- How big a health hazard is mercury in your community?

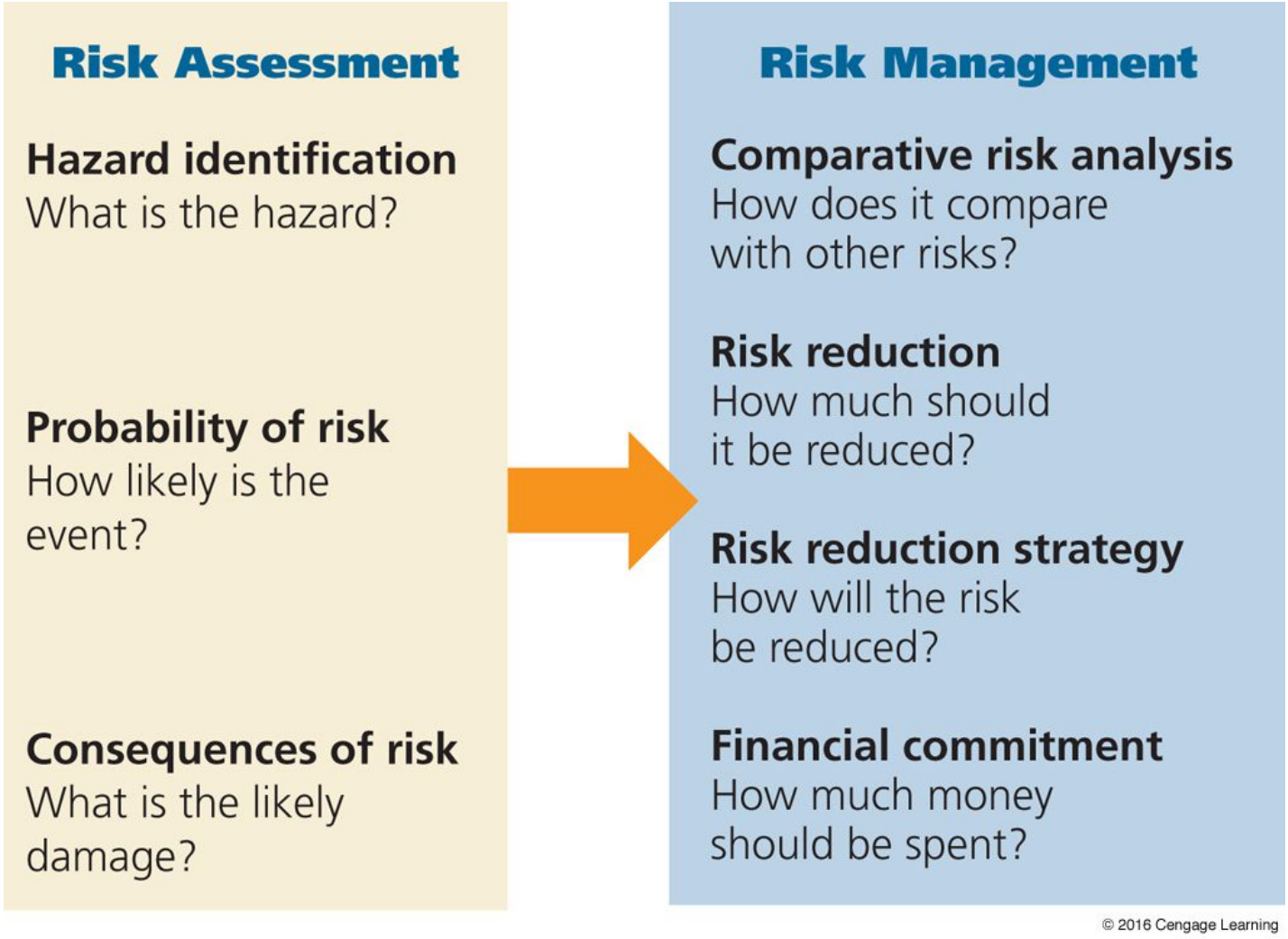
14.1 What Major Health Hazards Do We Face?

- Humans make life-style choices that result in health risks from biological, chemical, physical, and cultural factors

We Face Many Types of Hazards

- Risk: probability of one's health being harmed by a hazard that can cause injury, disease, or death
  - Risk can also cause economic loss/damage
- Risk assessment: use of statistics to estimate harm from a hazard
- Risk management: decisions whether and how to reduce hazards – and at what cost

Risk Assessment and Risk Management



Types of Hazards

- Biological hazards (pathogens or organisms causing disease)
- Chemical hazards (in air, water, soil, food, and manufactured products)
- Natural hazards (fire, earthquakes)
- Cultural hazards (poor working conditions, poverty)
- Lifestyle choices (smoking, poor food choices)

14.2 What Types of Biological Hazards Do We Face?

- Infectious diseases (bacteria, viruses, parasites) that invade the body
  - Transmissible – passed from one person to another
  - Nontransmissible – cause is not from passage between living organisms
- Epidemic: outbreak of infectious disease
  - Pandemic: global outbreak of infectious disease

Viral Diseases Kill Large Numbers of People

- Antibiotics are not effective against viruses, so viruses can be deadly
  - Transmitted by airborne particles
- Examples:
  - HIV and hepatitis B virus – transmitted by unsafe sex; sharing needles
  - Avian flu – transmitted to humans from animals, especially from birds

Ecological Medicine

- Ecological medicine: studies the infectious disease connections between animals and humans
- Humans spread these diseases by:
  - Clearing and fragmenting forests for cities
  - Hunting wild game for food (bushmeat—may contain HIV)
  - Illegal international trade in wild species
  - Industrialized meat production (*E. coli*)

Reducing Infectious Diseases

- Between 1970 and 2010, deaths from infectious diseases dropped world-wide from 35% to 15%
  - Scientists think this is because children were immunized against infectious diseases
  - Implement measure to prevent or reduce the incidence of infectious disease: oral rehydration therapy – reduces deaths from dehydration

Solutions: Infectious Diseases

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

14.3 What Types of Chemical Hazards Do We Face?

- Many chemicals in the environment can be hazardous to humans and can cause cancer, birth defects, and disrupt the immune, nervous, and endocrine systems

Some Chemicals Can Cause Cancers, Mutations, and Birth Defects

- Toxic chemical: substance that causes temporary/permanent harm or death
  - Carcinogens: certain viruses, some types of radiation, and chemicals that cause cancer
  - Mutagens: chemicals or forms of radiation that cause or increase genetic mutations
  - Teratogens: chemicals that harm or cause birth defects – genetic changes passed on to the next generation

Some Chemicals Can Affect Important Human Body Systems

- Long-term exposure to some chemicals in the environment can disrupt/weaken human body systems, especially the immune, nervous, and endocrine systems
  - Immune system: produces antibodies to protect from disease and harmful substances
  - Neurotoxins: substances that harm the nervous system, which can cause:
    - Behavioral changes, learning disabilities, attention-deficit disorder, paralysis, and death

Some Chemicals Affect the Human Endocrine System

- Endocrine system: hormones released through a complex network of glands
  - Regulates/controls, growth, sexual reproduction, learning ability, and behavior
- Hormones have a molecular shape and can attach to cell walls – called receptors
  - Some pesticides and synthetic chemicals (called hormone activation agents) have similar shapes and can replace hormones (hormone mimics, hormone blockers)

More Effects On the Endocrine System

- Some chemicals contain antibacterial ingredients that can reduce the effectiveness of antibiotics
  - Thyroid disrupters: cause growth, weight, brain and behavioral disorders
  - Plastics with phthalates cause cancer, sexual irregularities, kidney/liver damage
- These endocrine system disruptions can lead to other health problems

What Can You Do? Exposure to Hormone Disruptors

14.4 How Can We Evaluate Chemical Hazards?

- Scientists use several evaluation tools to estimate toxicity of chemicals, but they have limitations
  - Experiments with live laboratory animals
  - Case reports of poisoning
  - Epidemiological studies
- The solution to these health problems is to reduce chemical environmental pollution

Many Factors Determine the Harmful Health Effects of Chemicals

- Toxicity: a measure of the ability of a substance to cause injury, illness or death
  - Synthetic/natural chemicals can be harmful if ingested or inhaled in large enough quantities
- What level of chemical exposure causes harm?
  - Dose: the quantity of a harmful chemical that has been ingested, inhaled, or absorbed through the skin

More Harmful Health Effects

- Effects depend on age -- younger children are more susceptible to health effects – can be 10-100x that of adults
- Toxicity can depend on the genetic makeup of the person and their ability to resist toxic effects
  - Multiple chemical sensitivity
  - How well the body's systems are functioning

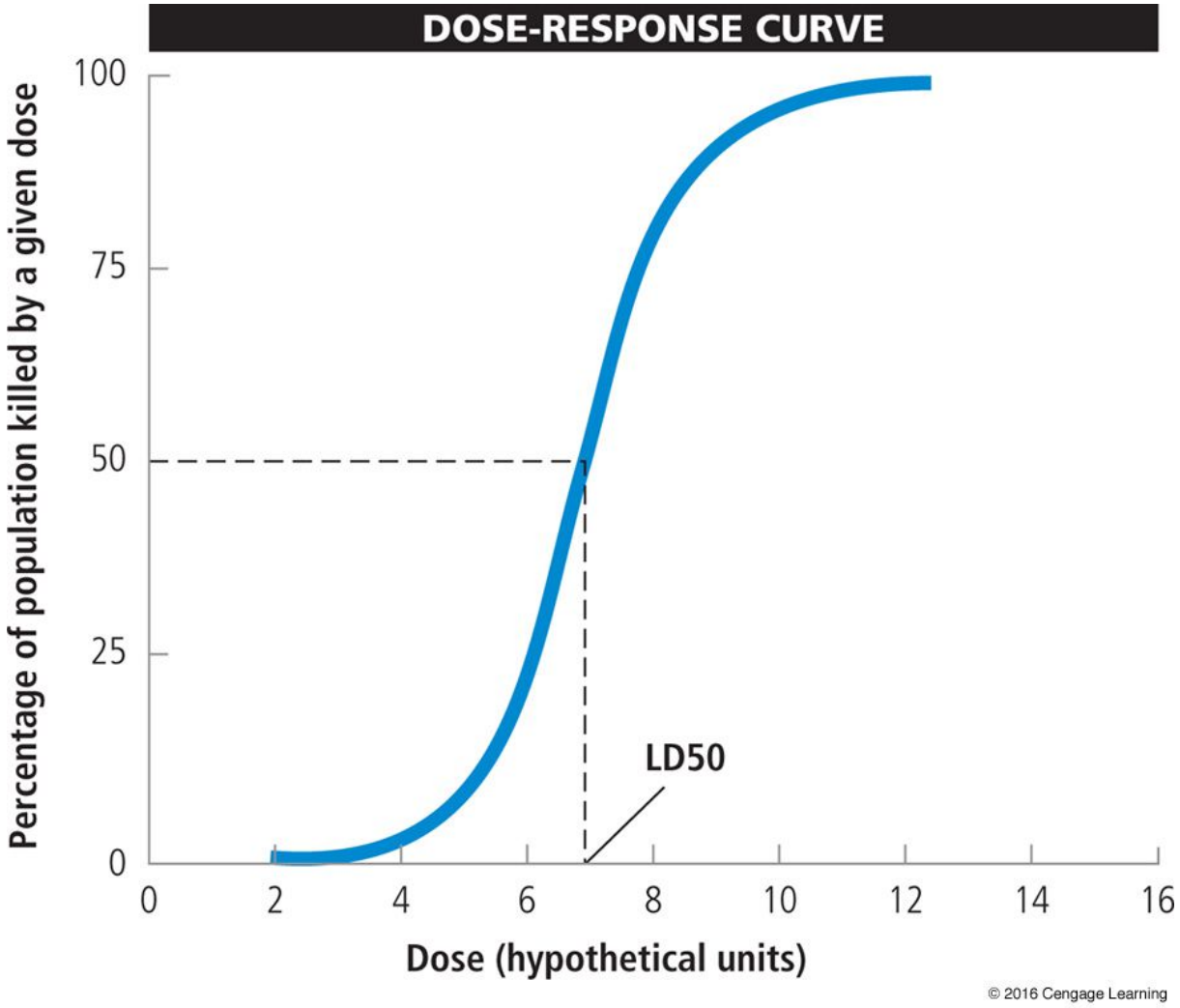
Variables That Influence the Extent of Harmful Human Health Effects

- Solubility: water-soluble toxins get into water supplies, as well as the aqueous solutions that surround our body cells
  - In the body, these dissolved chemicals can penetrate the cell membranes
- Persistence: the chemical's ability to resist being broken down into other substances
  - PCBs and DDTs break down slowly and remain in the body longer

Scientists Use Live Laboratory Animals For Toxicity Testing

- Live laboratory tests are the best way to determine chemical toxicity
  - Rats and mice used because their systems are similar to humans
  - Tests can run 2-5 years -- with 100s-1000s of animals and cost as much as $2 million per chemical tested
- A dose-response curve: a plot that shows the lethal dose of the chemical

Hypothetical Dose-Response Curve



Chemicals Vary Widely In Their Toxicity

- Results show chemicals can be toxic, even causing death with a single, low dose
  - Other chemicals would require such large doses that it would be almost impossible to ingest that amount
- Scientists question testing
  - Some say humans differ from animals
  - Others say problem is that humans are exposed to a variety of chemicals with multiple interactions

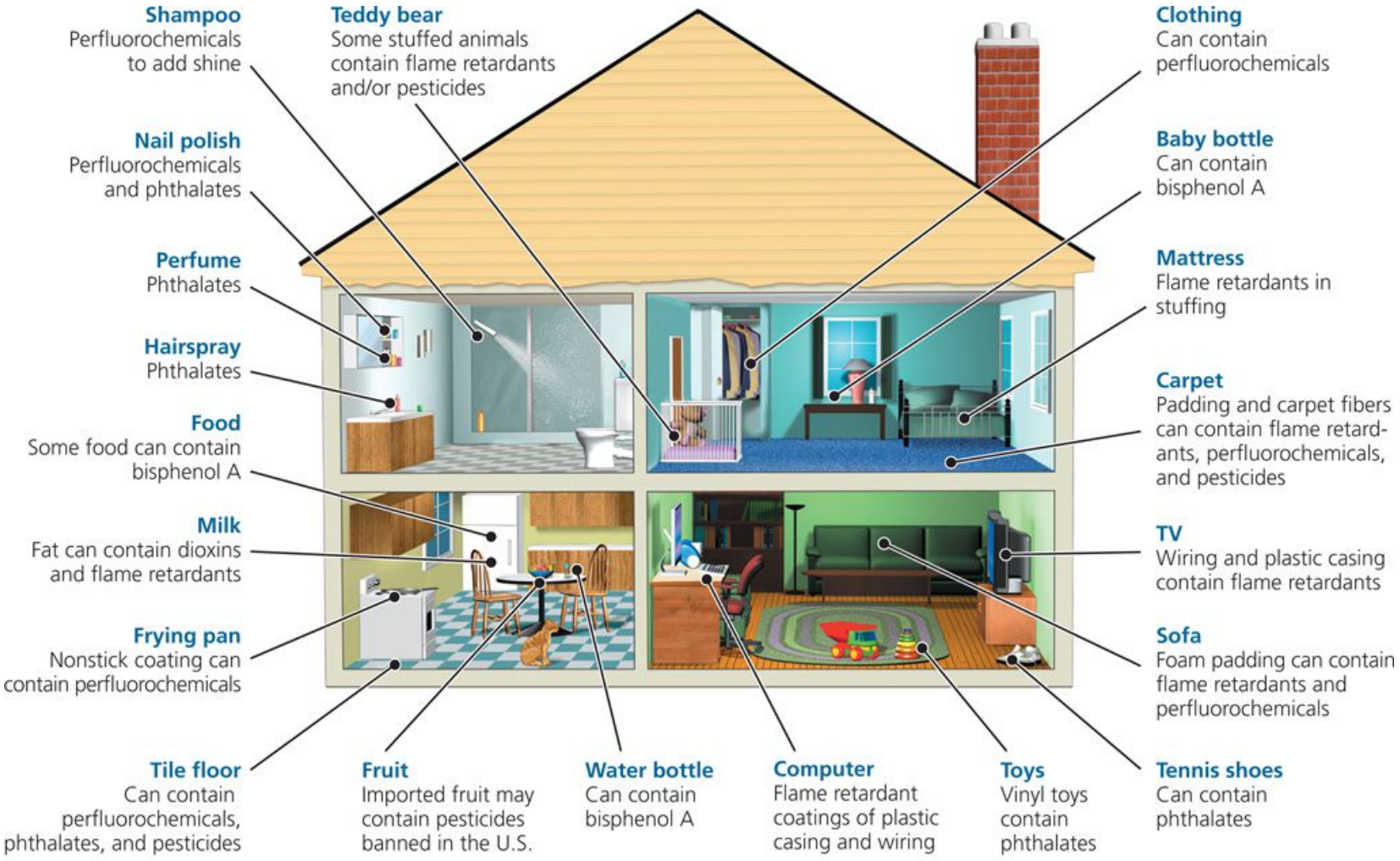
Estimating Harmful Effects of Chemicals

- Case reports from doctors can be used to study people experiencing adverse effects
  - As a result of accidents, deliberate poisonings, and other events
  - Difficult to determine the exact dosages of chemicals received or the health of the person
- Epidemiological studies
  - Compares the health of people exposed to a particular chemical with a control group

Factors Limiting Use of Epidemiological Studies

- Too few people have been exposed to high enough dosages to see differences
- Studies are done over many years
- Isolating the effects of a single chemical is difficult because people are exposed to many chemicals during their lifetime
- Studies cannot be used on new hazards from technologies or chemicals not yet experienced

Potentially Harmful Chemicals Found in Homes



Compiled by the authors using data from U.S. Environmental Protection Agency, Centers for Disease Control and Prevention, and New York State Department of Health.

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

- "Toxicologists know a great deal about a few chemicals, a little about many, and next to nothing about most" – all testing methods have serious limitations
- Only 10% of registered synthetic chemicals have been tested for toxicity
- Governments do not monitor 99.5% of chemicals used in manufacturing and this is higher in less-developed countries

How Far Should We Go in Using Pollution Prevention and Precautionary Principle?

- Pollution prevention: do not use or release chemicals into the environment that we know or suspect can cause harm
  - Find substitutes and recycle chemicals in a closed system
- Precautionary principle: take action now to reduce suspected consequences, rather than wait for scientific results to show conclusive effects

The Precautionary Principle

- Controversy over the extent of implementation
  - Those in favor: to introduce a new chemical, a company must cover the cost of testing to determine safety before it is used
    - Remove harmful chemicals from the market
  - Those against: impossible to monitor – only 200 of the more than 85,000 chemicals registered have been tested – and testing would be too costly

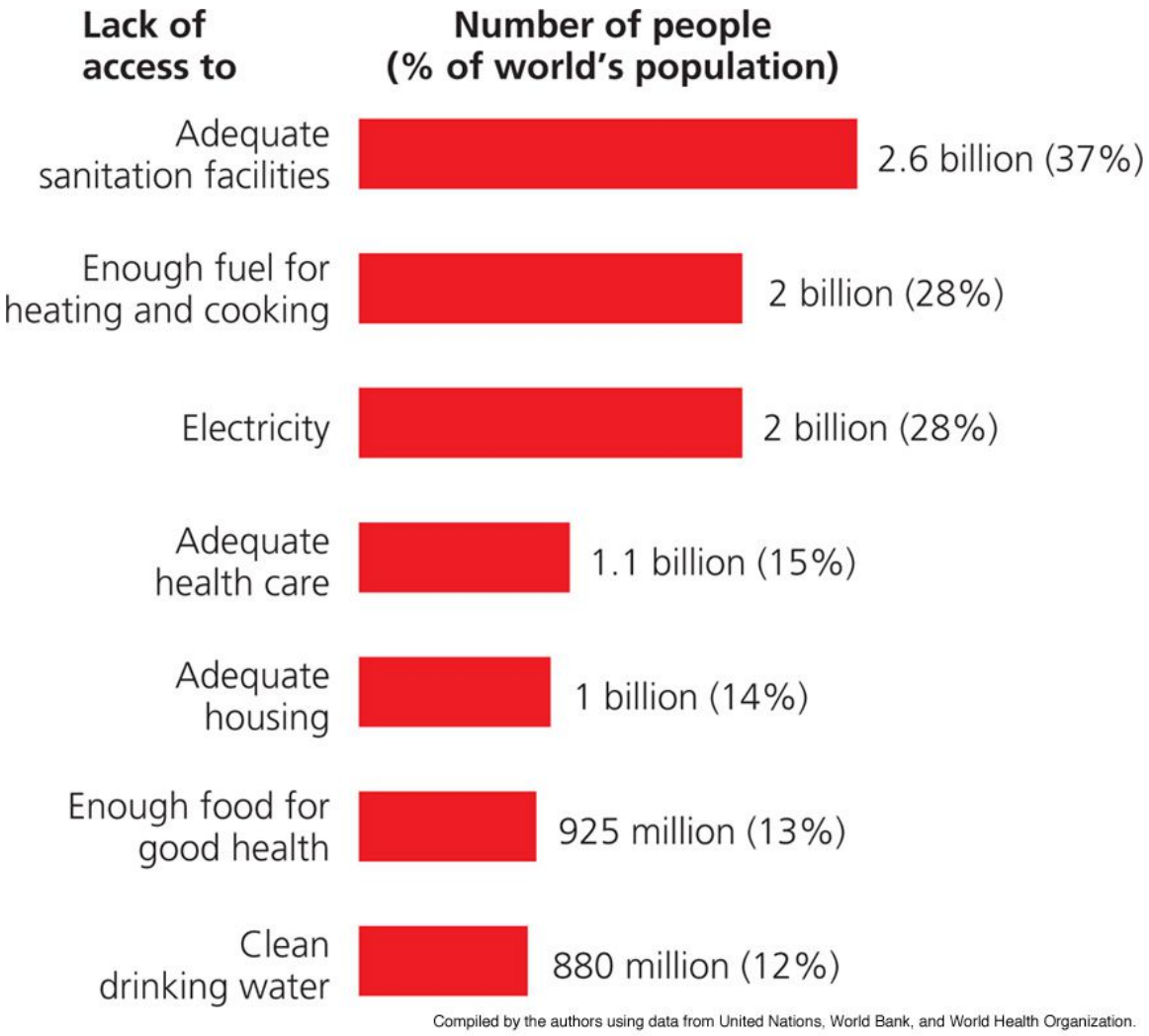
14.5 How Do We Perceive Risks and How Can We Avoid the Worst of Them?

- Perceiving risks requires:
  - Becoming informed
  - Thinking critically
  - Making careful choices

The Greatest Health Risks Come from Poverty, Gender, and Lifestyle Choices

- Risk analysis: risk assessment, comparative risk analysis, and risk management
- Poverty is the greatest health risk – malnutrition and increased susceptibility to non-fatal/fatal infectious diseases
  - Four greatest risks: living in poverty, being born male, smoking, and being obese
  - Premature death affected by related choices

Harmful Effects of Living in Poverty



Compiled by the authors using data from United Nations, World Bank, and World Health Organization.

Estimating Risks from Technologies Is Not Easy

- Reliability of a system is the probability that the system will complete a task without failing:
  - System reliability (%) = Technology Reliability (%) x Human Reliability (%)
  - High technology reliability can be achieved, but human reliability is impossible to predict
- In technology reliability, computer programs can be flawed by human design

Certain Principles Can Help Us Evaluate and Reduce Risks

- People are not good at evaluating the relative risks of activities
- Factors that cause people to see technology as risky:
  - Fear and degree of control we have in a situation
  - Whether a risk is catastrophic
  - Optimism bias (optimistic no matter what)
  - Instant gratification

Most People Do a Poor Job of Evaluating Risks

- Compare risks – “Is it safe?” and “How risky is it compared to other risks?”
- Determine how much risk you are willing to accept
- Evaluate the actual risk involved – take care in reviewing media reports
- Concentrate on evaluating and carefully making important lifestyle choices – “Do I have control over this?”

Additional Case Study: VOC Free Paint

- Until recently interior/exterior house paint contained volatile organic compounds (VOCs)
  - These toxic substances gave off fumes that lasted days/months even after the paint was totally dry
  - The fumes have harmful health effects including respiratory problems, headaches, loss of coordination, birth defects, and the liver, kidneys and central nervous system

Additional Case Study: VOC Free Paint (cont'd.)

- As health risks became known, paint companies developed have low/non-VOC paint with the same necessary attributes:
  - Scrubbability, adherence of paint to the wall, one coat coverage, etc.
- How does VOC free paint support the principle of chemical sustainability?
- Why is VOC paint still sold?
- Would you use VOC free paint?

VOC Free Paint and the Three Big Ideas

- VOC paint exposes humans to chemicals that can disrupt the immune, nervous and endocrine systems
- VOC free paint prevents pollution bypassing the problems associated with evaluating harmful chemicals
- With the manufacturer's information readily available, informed decisions can be made that reduce health risks