Environmental Hazards and Human Health

Chapter 17
Core 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

- 25 Million deaths, so far; alter country’s age structure
Lesions That Are a Sign of Kaposi’s Sarcoma
Global Outlook: Worldwide, AIDS Is the Leading Cause of Death for Ages 15–49
Fig. 17-2, p. 438

The diagram illustrates the age distribution of the population with and without AIDS. The x-axis represents the population in thousands, while the y-axis shows the age groups. The colors red and yellow represent individuals with AIDS and without AIDS, respectively. The age groups are as follows:

- 0–4
- 5–9
- 10–14
- 15–19
- 20–24
- 25–29
- 30–34
- 35–39
- 40–44
- 45–49
- 50–54
- 55–59
- 60–64
- 65–69
- 70–74
- 75–79
- 80–84
- 85–89
- 90–94
- 95–99
- 100+
Concept 17-1  People face health hazards from biological, chemical, physical, and cultural factors, and from the lifestyle choices they make.
Risks Are Usually Expressed as Probabilities

- Risk
- Probability and possibility
- Risk Assessment
- Risk Management
Science: Risk Assessment and Risk Management

**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?
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

- Five major types of hazards
  - Biological: pathogens
  - Chemical
  - Physical
  - Cultural
  - Lifestyle choices
Concept 17-2  In terms of death rates, the most serious infectious diseases are flu, AIDS, diarrheal diseases, malaria, and tuberculosis; most of these deaths occur in developing countries.
Some Diseases Can Spread from One Person to Another (1)

- Nontransmissible disease
- Infectious disease
- Transmissible disease (contagious or communicable disease)
Some Diseases Can Spread from One Person to Another (2)

- Since 1950, death from infectious diseases have declined due to
  - Better health care
  - Antibiotics
  - Vaccines

- Disability-adjusted life years (DALYs)
<table>
<thead>
<tr>
<th>Major Causes of Death</th>
<th>World</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cardiovascular disease</strong></td>
<td>30%</td>
<td>39%</td>
</tr>
<tr>
<td><strong>Infectious diseases</strong></td>
<td>30%</td>
<td>7%</td>
</tr>
<tr>
<td><strong>Cancers</strong></td>
<td>17%</td>
<td>23%</td>
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Cardiovascular disease

- World: 30%
- United States: 39%

Infectious diseases

- World: 30%
- United States: 7%

Cancers

- World: 17%
- United States: 23%
Infectious Diseases Are Still Major Health Threats

- Infectious diseases spread through
  - Air
  - Water
  - Food
  - Body fluids

- **Epidemics** and **pandemics**

- Resistance of bacteria and insects
Science: Pathways for Infectious Diseases in Humans

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

Other humans

Humans

Fetus and babies
Pets | Livestock | Wild animals | Insects | Food | Water | Air
--- | --- | --- | --- | --- | --- | ---
Fetus and babies

Other humans | Humans
--- | ---

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Fig. 17-5, p. 441
The World’s Seven Deadliest Infectious Diseases Kill 12.5 Million People

<table>
<thead>
<tr>
<th>Disease (type of agent)</th>
<th>Deaths per year</th>
</tr>
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<tbody>
<tr>
<td>Pneumonia and flu (bacteria and viruses)</td>
<td>3.2 million</td>
</tr>
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Science Focus: Genetic Resistance to Antibiotics Is Increasing (1)

- Bacteria: rapid reproduction, easily spread
- Over use of antibiotics
- Over use of pesticides
Science Focus: Genetic Resistance to Antibiotics Is Increasing (2)

- **Methicillin-resistant *Staphylococcus aureus* (MRSA)**
  - Resistant to most antibiotics
  - Symptoms of MRSA
  - How will it be controlled?
Case Study: The Growing Global Threat from Tuberculosis

- 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
Some Viral Diseases Kill Large Numbers of People (1)

- Influenza or flu virus
  - #1 Killer
  - Transmission

- HIV
  - #2 Killer
  - Antiviral drugs
Some Viral Diseases Kill Large Numbers of People (2)

- Global strategy to slow down the spread of HIV
  - Reduce the number of new infections
  - Concentrate on those most likely to spread HIV
  - Free testing
  - Education for prevention
  - Provide free or low-cost drugs
  - Research
Some Viral Diseases Kill Large Numbers of People (3)

- Hepatitis B virus (HBV)
  - #3 Killer
  - Mode of transmission

- Viruses that move form animals to humans
  - West Nile virus
  - Severe acute respiratory syndrome (SARS)

- Reduce chances of infection: Wash your hands
Tracking the Spread of Infectious Diseases to Humans from Other Animals

- **Ecological medicine**

- Human practices that encourage the spread of diseases from animals to humans

- Emerging infections
  - HIV
  - SARS
  - West Nile virus
  - Lyme virus
Case Study: Malaria—Death by Parasite-Carrying Mosquitoes (1)

- Malaria
  - Caused by *Plasmodium* sp. carried by *Anopheles* mosquitoes
  - Spread
  - Symptoms
  - Malarial cycle
Case Study: Malaria—Death by Parasite-Carrying Mosquitoes (2)

- Malaria on the rise since 1970
  - Drug resistant *Plasmodium*
  - Insecticide resistant mosquitoes
  - Effect of global warming
  - AIDS patients particularly vulnerable

- Prevention of spread and current research
Global Outlook: Distribution of Malaria
A Boy in Brazil’s Amazon Sleeps Under an Insecticide-Treated Mosquito Net
We Can Reduce the Incidence of Infectious Diseases

- Good news
  - Vaccinations on the rise
  - Oral rehydration therapy

- Bad news
  - More money needed for medical research in developing countries
Solutions: Infectious Diseases, Ways to Prevent or Reduce Their Occurrence

- Increase research on tropical diseases and vaccines
- Reduce poverty
- Decrease malnutrition
- Improve drinking water quality
- Reduce unnecessary use of antibiotics
- Educate people to take all of an antibiotic prescription
- Reduce antibiotic use to promote livestock growth
- Require careful hand washing by all medical personnel
- Immunize children against major viral diseases
- Provide oral rehydration for diarrhea victims
- Conduct global campaign to reduce HIV/AIDS
Infectious Diseases

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Animation: HIV replication
Animation: Life cycle of plasmodium
ABC Video: AIDS conference in Brazil

Peter Piot
Executive Director, UNAIDS
ABC Video: Germs in Pakistan
ABC Video: Polio scare
ABC Video: The problem with pork
Concept 17-3 There is growing concern about chemicals that can cause birth defects and cancers and disrupt the human immune, nervous, and endocrine systems.
Some Chemicals Can Cause Cancers, Mutations, and Birth Defects

- **Toxic chemicals**
  - Carcinogens
  - Mutagens
  - Teratogens
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
  - Biomagnification
  - Food chains and webs

- Banned, but found everywhere
Potential Pathways on Which Toxic Chemicals Move Through the Environment
Some natural and synthetic chemicals in the environment can weaken and harm
- Immune system
- Nervous system
- Endocrine system
Some Chemicals May Affect Our Immune, Nervous, and Endocrine Systems (2)

- Hormonally active agents (HAAs)
  - Gender benders
  - Thyroid disrupters
  - Toxic chemicals

- Phthalates

- Effects on the endocrine system

- Cancer
Science Focus: Mercury’s Toxic Effects (1)

- Hg: teratogen and potent **neurotoxin**
  - Once airborne, persistent and not degradable
  - 1/3 from natural sources
  - 2/3 from human activities
  - Enters the food chain: biomagnification
Science Focus: Mercury’s Toxic Effects (2)

- 2007: Hg hotspots identified

- How are humans exposed?
  - Inhalation: vaporized Hg or particulates of inorganic salts
  - Eating fish with high levels of methylmercury

- Effects of Hg on humans

- Who is most at risk?
Science: Cycling of Mercury in Aquatic Environments
WINDS
Hg and SO₂

Precipitation

WINDS
Hg²⁺ and acids

Human sources
Coal-burning plant
Incinerator

Elemental mercury vapor (Hg)

Photochemical oxidation

Inorganic mercury and acids (Hg²⁺)

Inorganic mercury and acids (Hg²⁺)

Runoff of Hg²⁺ and acids

Large fish
Small fish
Biomagnification in food chain
Zooplankton
Phytoplankton

Elemental mercury liquid (Hg)

Settles out

Oxidation

Inorganic mercury (Hg²⁺)

Organic mercury (CH₃Hg⁺)

Settles out

Bacteria and acids

Bacteria

Settles out

SEDIMENT

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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 such as wind, solar cells, and hydrogen
- Convert coal to liquid or gaseous fuel
- Phase out use of mercury in batteries, TVs, compact fluorescent lightbulbs, and all other products unless they are recycled

**Control**
- Sharply reduce mercury emissions from coal-burning plants and incinerators
- Tax each unit of mercury emitted by coal-burning plants and incinerators
- Collect and recycle mercury-containing electric switches, relays, and dry-cell batteries
- Require labels on all products containing mercury
SOLVEDS

Mercury Pollution

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Fig. 17-B, p. 451
Hormones and Hormones Mimics or Blockers

Normal Hormone Process

Hormone Mimic

Hormone Blocker

© Brocks/Cole, Cengage Learning
Hormone
Receptor
Cell

Normal Hormone Process

Estrogen-like chemical

Hormone Mimic

Antiandrogen chemical

Hormone Blocker

Fig. 17-12, p. 452
Hormone

Estrogen-like chemical

Antiandrogen chemical

Receptor

Cell

Normal Hormone Process

Hormone Mimic

Hormone Blocker

Stepped Art
Science Focus: Bisphenol A

- Estrogen mimic
- Found in many common products
- Laboratory findings
- Effects on human health
- Should it be banned?
17-4 How Can We Evaluate and Deal with Chemical Hazards?

- **Concept 17-4A** Scientists use live laboratory animals, non-animal tests, case reports of poisonings, and epidemiological studies to estimate the toxicity of chemicals, but these methods have limitations.

- **Concept 17-4B** Many health scientists call for much greater emphasis on pollution prevention to reduce our exposure to potentially harmful candidates.
Many Factors Determine the Harmful Health Effects of a Chemical (1)

- Toxicology

- Toxicity dependent on
  - Dose
  - Age
  - Genetic makeup
  - Multiple chemical sensitivity (MCS)
  - Solubility and persistence of the chemical
  - Biomagnification
Many Factors Determine the Harmful Health Effects of a Chemical (2)

- **Response**
  - Acute effect
  - Chronic effect
Science: Estimating Human Exposure to Chemicals and Measuring Their Effects
Water pollutant levels
Soil/dust levels
Air pollutant levels

Food pesticide levels
Nutritional health
Overall health
Lifestyle
Personal habits
Genetic predisposition
Scientific measurements and modeling

Lung, intestine, and skin absorption rates
Metabolism
Accumulation
Excretion

Predicted level of toxicant in people

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Case Study: Protecting Children from Toxic Chemicals

- Analysis of umbilical cord blood: significance

- Infants and children more susceptible to the toxic effects of chemicals than adults
  - Eat, drink water, and breathe more per unit of body weight than adults
  - Put their fingers in their mouths
  - Less well-developed immune systems and body detoxification processes
Scientists Use Live Lab Animals and Nonanimal Tests to Estimate Toxicity (1)

- **Dose-response curve: median lethal dose (LD50)**
  - Nonthreshold dose-response model
  - Threshold dose-response model

- Can the data be extrapolated to humans?
Scientists Use Live Lab Animals and Nonanimal Tests to Estimate Toxicity (2)

- 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?
Hypothetical Dose-Response Curve Showing Determination of the LD50
Fig. 17-14, p. 455

Percentage of population killed by a given dose

Dose (hypothetical units)

LD50

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# Toxicity Ratings and Average Lethal Doses for Humans

## Table 17-1

<table>
<thead>
<tr>
<th>Toxicity Rating</th>
<th>LD50 (milligrams per kilogram of body weight)*</th>
<th>Average Lethal Dose**</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supertoxic</td>
<td>Less than 5</td>
<td>Less than 7 drops</td>
<td>Nerve gases, botulism toxin, mushroom toxin, dioxin (TCDD)</td>
</tr>
<tr>
<td>Extremely toxic</td>
<td>5–50</td>
<td>7 drops to 1 teaspoon</td>
<td>Potassium cyanide, heroin, atropine, parathion, nicotine</td>
</tr>
<tr>
<td>Very Toxic</td>
<td>50–500</td>
<td>1 teaspoon to 1 ounce</td>
<td>Mercury salts, morphine, codeine</td>
</tr>
<tr>
<td>Moderately toxic</td>
<td>500–5,000</td>
<td>1 ounce to 1 pint</td>
<td>Lead salts, DDT, sodium hydroxide, sodium fluoride, sulfuric acid, caffeine, carbon tetrachloride</td>
</tr>
<tr>
<td>Slightly toxic</td>
<td>5,000–15,000</td>
<td>1 pint to 1 quart</td>
<td>Ethyl alcohol, Lysol, soaps</td>
</tr>
<tr>
<td>Essentially nontoxic</td>
<td>15,000 or greater</td>
<td>More than 1 quart</td>
<td>Water, glycerin, table sugar</td>
</tr>
</tbody>
</table>

*Dosage that kills 50% of individuals exposed.

**Amounts of substances in liquid form at room temperature that are lethal when given to a 70-kilogram (150-pound) human.
Science: Two Types of Dose-Response Curves

No threshold

Threshold

Nonlinear dose-response

Linear dose-response

Effect

Dose

Effect

Dose

Threshold level
Nonlinear dose-response

Linear dose-response

Effect

Dose

No threshold

Threshold

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Fig. 17-15, p. 456
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
  - Can you link the result with the chemical?
  - Can not be used for new hazards
Are Trace Levels of Toxic Chemicals Harmful?

- We do not know

- Are the dangers increasing or are the tests just more sensitive?
Some Potentially Harmful Chemicals Found in Most Homes

- **Nail polish**: Perfluorochemicals and phthalates
- **Perfume**: Phthalates
- **Hairspray**: Phthalates
- **Food**: Some food contains bisphenol-A
- **Milk**: Fat contains dioxins and flame retardants
- **Frying pan**: Nonstick coating contains perfluorochemicals
- **Tile floor**: Contains perfluorochemicals, phthalates, and pesticides
- **Fruit**: Imported fruit may contain pesticides banned in the U.S.
- **Water bottle**: Can contain bisphenol-A
- **Clothing**: Can contain perfluorochemicals
- **Baby bottle**: Can contain bisphenol-A
- **Mattress**: Flame retardants in stuffing
- **Carpet**: Padding and carpet fibers contain flame retardants, perfluorochemicals, and pesticides
- **TV**: Wiring and plastic casing contain flame retardants
- **Sofa**: Foam padding contains flame retardants and perfluorochemicals
- **Toys**: Vinyl toys contain phthalates
- **Tennis shoes**: Can contain phthalates
Vinyl toys contain phthalates. Imported fruit may contain pesticides banned in the U.S. Some stuffed animals made overseas contain flame retardants and/or pesticides. Perfluorochemicals and phthalates may be used in shampoo to add shine. Perfluorochemicals can be found in nail polish to add shine. Mattress, bedding, and baby bottle can contain bisphenol-A. Mattress, bedding, toys, and baby bottle may contain flame retardants. Some food contains bisphenol-A. Fat contains dioxins and flame retardants. Nonstick coating contains perfluorochemicals. Foam padding and plastic casing contain flame retardants and perfluorochemicals. Flame retardants in stuffing may be found in mattresses. Padding and carpet fibers contain flame retardants, perfluorochemicals, and pesticides. TV wiring and plastic casing may contain flame retardants. Computer flame retardant coatings of plastic casing and wiring may be found. Imported fruit may contain phthalates. Perfluorochemicals can be found in shoe soles. Hairspray and nail polish can contain phthalates.
Why Do We Know So Little about the Harmful Effects of Chemicals?

- Severe limitations estimating toxicity levels and risks
- Acceptable levels vary between 1/100 and 1/1000 of the estimated harmful levels
Pollution Prevention and the Precautionary Principle

- Those introducing a new chemical or new technology would have 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 (POPs)
1974: Ozone layer being depleted by chlorofluorocarbons (CFCs)

1992: International agreement to phase out CFCs and other ozone-destroying chemicals

Ray Turner: citrus-based solvents to clean circuit boards
17-5 How Do We Perceive Risks and How Can We Avoid the Worst of Them?

- **Concept 17-5** We can reduce the major risks we face if we become informed, think critically about risks, and make careful choices.
The Greatest Health Risks Come from Poverty, Gender, and Lifestyle Choices

- **Risk analysis**

  - Greatest health risks
    - Poverty
    - Gender
    - Lifestyle choices
## Comparative Risk Analysis: Most Serious Ecological and Health Problems

### High-Risk Health Problems
- Indoor air pollution
- Outdoor air pollution
- Worker exposure to industrial or farm chemicals
- Pollutants in drinking water
- Pesticide residues on food
- Toxic chemicals in consumer products

### High-Risk Ecological Problems
- Global climate change
- Stratospheric ozone depletion
- Wildlife habitat alteration and destruction
- Species extinction and loss of biodiversity

### Medium-Risk Ecological Problems
- Acid deposition
- Pesticides
- Airborne toxic chemicals
- Toxic chemicals, nutrients, and sediment in surface waters

### Low-Risk Ecological Problems
- Oil spills
- Groundwater pollution
- Radioactive isotopes
- Acid runoff to surface waters
- Thermal pollution

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Global Outlook: Number of Deaths per Year in the World from Various Causes

<table>
<thead>
<tr>
<th>Cause of death</th>
<th>Annual deaths</th>
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<tbody>
<tr>
<td>Poverty/malnutrition/disease cycle</td>
<td>11 million (150)</td>
</tr>
<tr>
<td>Tobacco</td>
<td>5.4 million (74)</td>
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<td>Pneumonia and flu</td>
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<td>Automobile accidents</td>
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Comparison of Risks People Face in Terms of Shorter Average Life Span

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<th>Shortens average life span in the United States by</th>
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<tr>
<td>Poverty</td>
<td>7–10 years</td>
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<tr>
<td>Born male</td>
<td>7.5 years</td>
</tr>
<tr>
<td>Smoking</td>
<td>6–10 years</td>
</tr>
<tr>
<td>Overweight (35%)</td>
<td>6 years</td>
</tr>
<tr>
<td>Unmarried</td>
<td>5 years</td>
</tr>
<tr>
<td>Overweight (15%)</td>
<td>2 years</td>
</tr>
<tr>
<td>Spouse smoking</td>
<td>1 year</td>
</tr>
<tr>
<td>Driving</td>
<td>7 months</td>
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<td>Air pollution</td>
<td>5 months</td>
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<tr>
<td>Pesticides</td>
<td>1 month</td>
</tr>
<tr>
<td>Fire</td>
<td>1 month</td>
</tr>
<tr>
<td>Natural radiation</td>
<td>8 days</td>
</tr>
<tr>
<td>Medical X rays</td>
<td>5 days</td>
</tr>
<tr>
<td>Oral contraceptives</td>
<td>5 days</td>
</tr>
<tr>
<td>Toxic waste</td>
<td>4 days</td>
</tr>
<tr>
<td>Flying</td>
<td>1 day</td>
</tr>
<tr>
<td>Hurricanes, tornadoes</td>
<td>1 day</td>
</tr>
<tr>
<td>Living lifetime near nuclear plant</td>
<td>10 hours</td>
</tr>
</tbody>
</table>
Case Study: Death from Smoking (1)

- Most preventable major cause of suffering and premature death

- Nicotine: additive

- Effects of **passive smoking** (secondhand smoke)
Case Study: Death from Smoking (2)

- How to reduce smoking
  - Taxes
  - Ban
  - Classify and regulate nicotine
  - Education
## Annual Deaths in the U.S. from Tobacco Use and Other Causes in 2004

<table>
<thead>
<tr>
<th>Cause of Death</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobacco use</td>
<td>442,000</td>
</tr>
<tr>
<td>Accidents</td>
<td>101,500 (43,450 auto)</td>
</tr>
<tr>
<td>Alcohol use</td>
<td>85,000</td>
</tr>
<tr>
<td>Infectious diseases</td>
<td>75,000 (17,000 from AIDS)</td>
</tr>
<tr>
<td>Pollutants/toxins</td>
<td>55,000</td>
</tr>
<tr>
<td>Suicides</td>
<td>30,600</td>
</tr>
<tr>
<td>Homicides</td>
<td>20,622</td>
</tr>
<tr>
<td>Illegal drug use</td>
<td>17,000</td>
</tr>
</tbody>
</table>
Cause of Death  

- Tobacco use: 442,000 deaths
- Accidents: 101,500 deaths (43,450 auto)
- Alcohol use: 85,000 deaths
- Infectious diseases: 75,000 deaths (17,000 from AIDS)
- Pollutants/toxins: 55,000 deaths
- Suicides: 30,600 deaths
- Homicides: 20,622 deaths
- Illegal drug use: 17,000 deaths

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Estimating Risks from Technologies Is Not Easy

- System reliability = Technological reliability × Human reliability

- To err is human
Most People Do Not Know How to Evaluate Risks

- Fear
- Degree of control
- Whether a risk is catastrophic
- Optimism bias
- Unfair distribution of risks
Several Principles Can Help Us to Evaluate and Reduce Risk

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