Introduction to Environmental Health

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Section A

Objectives and Definitions
Course Learning Objectives

- Define the major types, sources, and environmental distribution of environmental agents
- Describe how these agents interact with biological systems, and describe the mechanisms by which they exert adverse effects
- Predict the nature of the agent’s adverse effects from its physical, chemical, or infectious properties, and how that may influence environmental or public health
Course Learning Objectives

- Describe and use models for prediction of the magnitude of adverse effects in biological systems
- Identify significant gaps in the current knowledge base concerning health effects of environmental agents, and areas of uncertainty in the risk-assessment process
- Describe current legislation and regulation regarding environmental issues
Definitions: Environment

- The circumstances, objects, or conditions by which one is surrounded
- The complex of climatic, edaphic (soil-based), and biotic factors that act upon an organism or an ecologic community
Public Health Definition of “The Environment”

- All that which is external to the individual host. [It] can be divided into physical, biological, social, and cultural factors, any or all of which can influence health status in populations.

Definitions: Health

- The condition of being sound in body, mind, or spirit
- A flourishing condition or well-being—not just the absence of disease
A state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity

— WHO. (1948).
Definitions: Disease

- Trouble or a condition of the living animal or plant body or one of its parts that impairs the performance of a vital function
Definitions: Safe

- **Free** from harm or risk
- **Secure** from threat of danger, harm, or loss
- **Zero** risk
Definitions: Risk

- Possibility of loss or injury, peril
- The chance of loss; the degree of probability of such loss
What Is Environmental Health Sciences?

- NIEHS charter: “The study of those factors in the environment that affect human health”
  - Factors (“pollutants” or “toxicants”) in air, water, soil, or food
  - Transferred to humans by inhalation, ingestion, or absorption
  - Production of adverse health effects
Contributors to the “Environment”

- Chemical
  - Air pollutants, toxic wastes, pesticides, VOCs
- Biologic
  - Disease organisms present in food and water
  - Insect and animal allergens
- Physical
  - Noise, ionizing and non-ionizing radiation
- Socioeconomic
  - Access to safe and sufficient health care
Environmental health comprises those aspects of human health, including quality of life, that are determined by physical, biological, social, and psychosocial factors in the environment. It also refers to the theory and practice of assessing, correcting, controlling, and preventing those factors in the environment that can potentially affect adversely the health of present and future generations.
Facets of Environmental Health

- Environmental epidemiology
  - Associations between exposure to environmental agents and subsequent development of disease
- Environmental toxicology
  - Causal mechanisms between exposure and subsequent development of disease
- Environmental engineering
  - Factors that govern and reduce exposure
- Preventive medicine
  - Factors that govern and reduce disease development
- Law
  - Development of appropriate legislation to protect public health
Section B

Environmental Health Issues
Do you think that environmental issues are among the top three public health issues in this country?
What criteria do you use to identify an important public health issue?
Traditional Public Health Approach

1. Define the problem
2. Identify and characterize the parameters governing the problem
3. Design appropriate PH interventions
4. Implement and evaluate the interventions
Another Possible Approach

1. Define the health parameters of importance
2. Identify the problems most impacting the health parameters
3. Identify and characterize the parameters governing the problem
4. Design appropriate PH interventions
5. Implement and evaluate the interventions
Measure of Disease Burden and NIH Funding


<table>
<thead>
<tr>
<th>Measure (Year Assessed)</th>
<th>Units</th>
<th>Correlation Coefficient (r)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence (1990)</td>
<td>No. of new cases per year</td>
<td>-0.05</td>
<td>0.82</td>
</tr>
<tr>
<td>Prevalence (1990)</td>
<td>No. of existing cases</td>
<td>0.25</td>
<td>0.23</td>
</tr>
<tr>
<td>Hospital days (1994)</td>
<td>Days in acute care hospitals</td>
<td>0.24</td>
<td>0.21</td>
</tr>
<tr>
<td>Mortality (1994)</td>
<td>Deaths per year</td>
<td>0.40</td>
<td>0.03</td>
</tr>
<tr>
<td>Years of life lost (1994)</td>
<td>Years</td>
<td>0.42</td>
<td>0.02</td>
</tr>
<tr>
<td>Disability-adjusted life-years (1990)*</td>
<td>Years</td>
<td>0.62</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

*Loss of one year of healthy life to disease

Source: Adapted from (1999). NEJM, 340, 1181
Disability-Adjusted Life-Years and NIH Funding

- Relationship between NIH disease-specific research funding and disability-adjusted life-years

Source: Adapted from (1999). NEJM, 340, 1181.
Should You Care about EHS?

- Acute environmental catastrophes (high-level exposures)
- Chronic (low-level) exposures
- Indirect effects of global environmental changes
The Wake-up Calls: Environmental Catastrophes

- Minamata disease (1953–1961)
  - Methyl mercury poisoning
- Seveso, Italy (1976)
  - Leak of toxic gas (TCDD)
- Bhopal (1984)
  - 16.5 tons of toxic pesticide released
The Wake-up Calls: Environmental Catastrophes

- Chernobyl (1986)
  - Nuclear reactor accident
- Milwaukee incident (1993)
  - Cryptosporidium in drinking water
# Major Air Pollution Episodes

<table>
<thead>
<tr>
<th>Date</th>
<th>Place</th>
<th>Xs Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec. 1882</td>
<td>London, England</td>
<td>1,000</td>
</tr>
<tr>
<td>Dec. 1930</td>
<td>Meuse Valley, Belgium</td>
<td>63</td>
</tr>
<tr>
<td>Oct. 1948</td>
<td>Donora, Penn.</td>
<td>20</td>
</tr>
<tr>
<td>Dec. 1952</td>
<td>London, England</td>
<td>4,000</td>
</tr>
<tr>
<td>Dec. 1962</td>
<td>Osaka, Japan</td>
<td>60</td>
</tr>
<tr>
<td>Jan. 1963</td>
<td>New York City</td>
<td>200–405</td>
</tr>
<tr>
<td>Nov. 1983</td>
<td>New York City</td>
<td>250</td>
</tr>
</tbody>
</table>

*Excess deaths refers to the additional number of fatalities counted above the number expected under otherwise normal conditions.*
The London “Killer” Smog of 1952

Source: Adapted from Turco, R. P.
Roughly 70,000 different synthetic chemicals are on the global market; many others are emitted as by-products of their production, use, or disposal.

Production of synthetic organic chemicals (e.g., dyes, plastics, solvents) has increased from less than 0.15 billion kilograms (1935) to more than 150 billion kilograms (1995).
World Production of Synthetic Organic Chemicals

Data from Mitchell, J.D.
Substance-specific toxicity and health information (NRC/NAS, 1984)

HHE = health hazard evaluation; meds = medications; pests = pesticides; food = food additives; cosm = cosmetics; chem = commercial chemicals
Why Don’t We Know More about These Chemicals?

- Number of chemicals (1984—NRC/NAS)
  - Pesticides: 3,350
  - Drugs: 1,815
  - Cosmetics: 3,410
  - Food additives: 8,627
Why Don’t We Know More about These Chemicals?

- Chemicals in commerce (1984)
  - >1 million lbs/yr 12,860
  - <1 million lbs/yr 13,911
  - Production unknown 21,752
Why Don’t We Know More about These Chemicals?

- Each year ~1,000 new chemicals come on line
- It costs ~ $ 2 million to do a cancer toxicology screen on each chemical (NTP guidelines)
- The cancer toxicology screen takes ~2 years
Routes of Exposure

- Routes of exposure through gaseous, liquid, and solid media

Adapted from Moeller, D.W.
Pollutant Source Pathways

- Pollutant Source
  - Air Concentration → Inhalation
  - Water Concentration → Fish Concentration → Breast Milk → Human Receptor
  - Soil Concentration → Soil Ingestion → Root Uptake → Cattle & Poultry Concentration
  - Plant Concentration → Plant Consumption

Adapted from Derelanko, M. J.
### Environmental Pathways for Selected Toxic Agents

<table>
<thead>
<tr>
<th>Agent</th>
<th>Disease</th>
<th>Source</th>
<th>Pathway</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>L. pneumophila</em></td>
<td>Legionnaire’s disease</td>
<td>Soil, cooling towers</td>
<td>Air, building ventilation systems</td>
</tr>
<tr>
<td><em>Salmonella</em></td>
<td>Acute diarrhea</td>
<td>Human or animal feces</td>
<td>Water, meat, eggs</td>
</tr>
<tr>
<td>Dioxin</td>
<td>Chloracne, soft tissue tumors</td>
<td>Herbicides, paper mills, incinerators</td>
<td>Air, water, food</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Nervous system tox.</td>
<td>Agriculture</td>
<td>Food, water</td>
</tr>
<tr>
<td>Asbestos</td>
<td>Asbestosis, lung cancer</td>
<td>Insulation, auto brakes</td>
<td>Air, water</td>
</tr>
</tbody>
</table>
Agents and Vectors

- Agents
  - Chemical, biological, and physical
- Vectors
  - Water, air, soil, and food
- Routes of entry
  - Inhalation, ingestion, absorption
The Toxicological Paradigm

Exposure

Internal dose

Biologically effective dose

Early biologic effects

Altered structure and function

Clinical disease

Effect modifiers
- Diet
- Habits
- Health
- Medication
- Co-exposure

Susceptibility
- Genetic factors
The Toxicological Paradigm

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Effect modifiers
Diet
Habits
Health
Medication
Co-exposure
Severity of Adverse Health Effects

- Death
- Significant disease
- Manifest dysfunction
- Clinical nuisance effects
- Sub-clinical chronic alterations
- Acute reversible (functional) effects

Population exposed
Health Effects

- Adverse vs. beneficial
- Acute vs. delayed onset
- Clinical vs. subclinical manifestations
- Transient (reversible) vs. chronic (irreversible)
Examples of Manifestations

- Lung disease
- Reproductive effects
- Teratogenic effects
- Neurologic effects
- Immunosuppression and hypersensitivity
- Cancer
“Genetics loads the gun, but environment pulls the trigger.”
— Judith Stern
UC Davis
Vulnerable Groups

- Low socioeconomic status
- Women
- Children
- Elderly
- Ethnic minorities
- Disabled
- Indigenous peoples
- All of whom are often more vulnerable because of—
  - Genetics
  - They are not empowered to change their environment
Section C

Problem Solving
<table>
<thead>
<tr>
<th>Problem-Solving Paradigm: Six Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Define the problem</td>
</tr>
<tr>
<td>2. Measure its magnitude</td>
</tr>
<tr>
<td>3. Understand key determinants</td>
</tr>
<tr>
<td>4. Develop intervention/prevention strategies</td>
</tr>
<tr>
<td>5. Set policy/priorities</td>
</tr>
<tr>
<td>6. Implement and evaluate</td>
</tr>
</tbody>
</table>

- Risk assessment
- Risk management
Selecting Priorities

- **Risk assessment**
  - The determination of the probability that an adverse effect will result from a defined exposure
    1. Hazard identification
    2. Exposure assessment
    3. Dose-response assessment
    4. Risk characterization
  - Pure “science” activities
Selecting Interventions

- **Risk management**
  - The process of weighing policy alternatives and selecting the most appropriate regulatory actions based on the results of risk assessment and social, economic, and political concerns
Commonplace Risks Calculated

- Commonplace risks calculated as number of deaths per 100,000 per year

<table>
<thead>
<tr>
<th>Activity or Exposure</th>
<th>Risk/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorcycling</td>
<td>2,000</td>
</tr>
<tr>
<td>Smoking (all causes)</td>
<td>1,000</td>
</tr>
<tr>
<td>Hand gliding</td>
<td>80</td>
</tr>
<tr>
<td>Driving</td>
<td>24</td>
</tr>
<tr>
<td>Fires</td>
<td>2.8</td>
</tr>
<tr>
<td>4 TBS peanut butter per day (aflatoxin)</td>
<td>0.8</td>
</tr>
<tr>
<td>Being struck by lightning</td>
<td>0.05</td>
</tr>
<tr>
<td>Being hit by a meteor</td>
<td>0.000006</td>
</tr>
</tbody>
</table>
Major Environmental Legislation

Number of Laws

The Cost of Cleanup

- The closer we get to the goal of zero emissions of a pollutant, the more costly it becomes to eliminate each unit of pollution.
The Cost of Cleanup

Reason

- First control method is usually the most effective and easiest to implement, and produces the largest benefit at the lowest cost
- Continued progress requires using more and more expensive methods that remove smaller amounts of pollutant
- At some point, costs outweigh benefits
The Law of Diminishing Returns

Cost of Emission Controls ($ Million)

Pollutant Emissions

High Pollution

Low Pollution
Societal Determinants

- Human *needs* and *wants* drive choices that produce environmental impacts which, in turn, may result in adverse health consequences.
Societal Determinants Flowchart

- Human Needs
  - Human Wants
    - Choice of Technology
      - Intentionality

- Human & Biologic Consequences
  - Exposure to Materials or Energy
    - Release of Materials or Energy

- Annual mortality
- Annual morbidity
- Transgenerational
- Nonhuman mort/morb
- Ecologic Effects

- Populations at risk
- Delay of consequences

- Spatial extent
- Concentration
- Persistence
- Recurrence
Factors

- Factors influencing environmental health problems and solutions
  - Objective (technical/scientific)
  - Subjective (non-scientific)
Examples of Technical/Scientific ("Objective") Factors

- Sources of agents
- Measurement of environmental change
- Toxicological process
- Biological susceptibility
- Engineering approaches
- Human needs
Examples of Non-Scientific (“Subjective”) Factors

- Human wants
- Religious beliefs (“world view”; e.g., humankind vs. other species and the planet)
- Political systems
- Economic systems
- Societal values
- Population dichotomies (e.g., rich vs. poor; developed vs. developing countries)
Basic Requirements for a Healthy Environment

- Clean air
- Safe and sufficient water
- Safe and adequate food
- Safe and peaceful settlements
- Stable global environment

Source: Yassi et al. (2001). UNEP.
Improving Human Health and Environment: 3 Models

Clinical Intervention Model

Public Health Intervention Model
Improving Human Health and Environment: 3 Models

Environmental Stewardship Model

Source: Adapted from Moeller, D. W.
**Key Points**

- EHS is the study of those factors in the environment that affect human health.
- These factors represent chemical, biological, or physical agents contained in air, water, soil, or food, and are transported to humans via inhalation, ingestion, or skin absorption.
- Adverse health effects may be acute or delayed in onset, clinical or subclinical, and reversible or irreversible.
Key Points

- Environmental health sciences includes
  - Environmental epidemiology and toxicology as the basis of environmental health risk assessment
  - Environmental engineering and regulation/risk communication as the basis of environmental health risk management