Chapter 2

Environmental Epidemiology
Learning Objectives

By the end of this chapter the reader will be able to:

• Define the term *environmental epidemiology*

• Describe three major historical events in environmental epidemiology

• Provide examples of epidemiologic tools used in environmental health

• Identify types of associations found between environmental hazards and health outcomes

• List study designs used in environmental epidemiology
What is Environmental Epidemiology?

- The study of diseases and health conditions (occurring in the population) that are linked to environmental factors.
- These exposures usually are involuntary.
Epidemiology’s Contributions to Environmental Health

• Concern with populations
• Use of observational data
• Methodology for study designs
• Descriptive and analytic studies
Concern with Populations

- Environmental epidemiology studies a population in relation to morbidity and mortality.
  - Example: Is lung cancer mortality higher in areas with higher concentrations of “smokestack” industries?
Use of Observational Data

• Epidemiology is primarily an observational science that takes advantage of naturally occurring situations in order to study the occurrence of disease.
Methodology for Study Designs

- Characteristic study designs used frequently in environmental epidemiology:
  - Cross-sectional
  - Ecologic
  - Case-Control
  - Cohort
Two Classes of Epidemiologic Studies

• Descriptive
  – Depiction of the occurrence of disease in populations according to classification by person, place, and time variables.

• Analytic
  – Examines causal (etiologic) hypotheses regarding the association between exposures and health conditions.
Measures of Disease Frequency

- Prevalence
- Point prevalence
- Incidence
- Incidence rate
- Case fatality rate
Prevalence

- Refers to the number of existing cases of a disease, health condition, or deaths in a population at some designated time
Point Prevalence

• Refers to all cases of a disease, health condition, or deaths that exist at a particular point in time relative to a specific population from which the cases are derived.
Formula for Point Prevalence

\[
\text{Point Prevalence} = \frac{\text{Number of persons ill}}{\text{Total number in the group}\times \text{time}}
\]

at a point in
Incidence

• The occurrence of new disease or mortality within a defined period of observation (e.g., week, month, year, or other time period) in a specific population.
Formula for Incidence Rate

Incidence Rate = \frac{\text{Number of new cases over a time period}}{\text{Total population at risk}} \times \text{multiplier (e.g., 100,000)}
Case Fatality Rate (CFR)

• Provides a measure of the lethality of a disease.
Case Fatality Rate (CFR) (continued)

\[
CFR (\%) = \frac{\text{Number of deaths due to disease} \ "X"}{\text{Number of cases of disease} \ "X"} \times 100 \quad \text{during a time period}
\]
Major Historical Figure: Sir Percival Pott (1714-1788)

- A London surgeon thought to be the first individual to describe an environmental cause of cancer.
- Chimney sweeps had high incidence of scrotal cancer due to contact with soot.
Major Historical Figure: John Snow

- An English anesthesiologist who linked a cholera outbreak in London to contaminated water from the Thames River in the mid-1800s.
- Snow employed a “natural experiment,” a methodology used currently in studies of environmental health problems.
Study Designs Used in Environmental Epidemiology

- Experimental
- Case Series
- Cross-Sectional
- Ecologic
- Case-Control
- Cohort
Odds Ratio (OR)

• A measure of association for case-control studies.

• Exposure-odds ratio:
  – Refers to “… the ratio of odds in favor of exposure among the cases [A/C] to the odds in favor of exposure among the non-cases [the controls, B/D].”
## Odds Ratio Table

**TABLE 2-2** Table for a Case-Control Study

<table>
<thead>
<tr>
<th>Disease Status—Outcome of Interest</th>
<th>Yes (Cases)</th>
<th>No (Controls)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>No</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Total</td>
<td>A + C</td>
<td>B + D</td>
</tr>
</tbody>
</table>

**Exposure Status**
- Yes
- No

Total
- A + C
- B + D
Odds Ratio Equation

\[
OR = \frac{A}{C} \div \frac{B}{B} = \frac{AD}{BC}
\]

Note that an OR >1 (when statistically significant) suggests a positive association between exposure and disease or health outcome.
Relative Risk (RR)

- The ratio of the incidence rate of a disease or health outcome in an exposed group to the incidence rate of the disease or condition in a non-exposed group.
## TABLE 2-3  Table for a Cohort Study

<table>
<thead>
<tr>
<th>Exposure Status</th>
<th>Disease Status</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td></td>
<td>A</td>
<td>B</td>
<td>A+B</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td>C</td>
<td>D</td>
<td>C+D</td>
</tr>
</tbody>
</table>
RR Equation

\[
RR = \frac{\frac{A}{A + B}}{\frac{C}{C + D}}
\]

Notes:
When an association is statistically significant:
RR > 1 indicates that the risk of disease is greater in the exposed group than in the nonexposed group.
RR < 1 indicates possible protective effect.
Study Endpoints

- Self-reported symptom rates
- Physiologic or clinical examinations
- Mortality
Figure 2-5 The epidemiologic triangle.

What is the Epidemiologic Triangle?

- Used for describing the causality of infectious diseases
- Provides a framework for organizing the causality of other types of environmental problems
Environment in the “Triangle”

• The term *environment* is defined as the domain in which disease-causing agents may exist, survive, or originate; it consists of “All that which is external to the individual human host.”
Host in the “Triangle”

• A host is “a person or other living animal, including birds and arthropods, that affords subsistence or lodgment to an infectious agent under natural conditions.”
Agent in the “Triangle”

• **Agent** refers to “A factor, such as a microorganism, chemical substance, or form of radiation, whose presence, excessive presence, or (in deficiency diseases) relative absence is essential for the occurrence of a disease.”
Causality

• Certain criteria need to be taken into account in the assessment of a causal association between an agent factor (A) and a disease (B).
Hill’s Criteria of Causality

• Strength
• Consistency
• Specificity
• Temporality

• Biological gradient
• Plausibility
• Coherence
Bias in Environmental Epidemiologic Studies

• Definition of bias
• The healthy worker effect
• Confounding
Definition of Bias

“Systematic deviation of results or inferences from the truth. Processes leading to such deviation. An error in the conception and design of a study—or in the collection, analysis, interpretation, reporting, publication, or review of data—leading to results or conclusions that are systematically (as opposed to randomly) different from the truth.”

Healthy Worker Effect

• Refers to the observation that employed populations tend to have a lower mortality experience than the general population.

• The healthy worker effect could introduce selection bias into occupational mortality studies.
Confounding

- Denotes “… the distortion of a measure of the effect of an exposure on an outcome due to the association of the exposure with other factors that influence the occurrence of the outcome.”

Limitations of Epidemiologic Studies

- Long latency periods
- Low incidence and prevalence
- Difficulties in exposure assessment
- Nonspecific effects