

Unit 6

Risk, Exposure, and Health

Background

Introduction

Research indicates that each of us is exposed to a diverse and dynamic mixture of environmental hazards as a routine part of our lives. The effective management of human exposure to a variety of chemicals and biological agents present in various sectors of society has indeed become a very important public health policy issue. Using a risk assessment paradigm presents a systematic way to develop appropriate strategies in hazard identification, response assessment, exposure assessment, and risk characterization. Risk assessment generally serves as a tool that can be used to organize, structure, and compile scientific information in order to help identify existing hazardous situations or problems, anticipate potential problems, establish priorities, and provide a basis for regulatory controls and corrective actions.

Essential Questions

How do we know what contaminants are in our environment and how do they affect us?

What is risk assessment and how does it lead to an estimate of overall risk to the general population or target population?

What are the criteria for citing causal relationships between environmental threats and illness?

How and when do we communicate risk information to the public? Should the public be involved in the decision-making process?

Content

Soil, air, and water are ubiquitous. As more and more toxic chemicals find their way into these common mediums, concerns about environmental degradation become concerns about human health. Unit 6 points out that although single exposure to an environmental toxin is frequently studied, we must also look at the more common situation of differential exposure to mixtures of environmental agents, including biological, chemical, and physical stressors, which can further contribute to increased vulnerability of human populations and ecological systems.

Scientists study the relationship of exposure to health risk and risk management through a process called risk analysis. The Unit 6 text explains how risk analysis leads scientists through three basic phases: risk assessment, risk management, and risk communication. The unit concludes with a discussion of “risk perception.”

The Unit 6 video presents two epidemiologic studies on environmentally induced health risks that demonstrate risk assessment, management, and communication to the public. Howard Hu and David Bellinger (Harvard School of Public Health) have followed the effects of children’s exposure to metals from abandoned zinc mines in Tar Creek, Oklahoma. In 1983 the site was listed on the National Priorities List, making it one of the first Superfund Sites. This

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study focuses on aberrant neurodevelopmental problems as a result of differing degrees of exposure to the toxic mine tailings. The second case study takes viewers out of the rural setting and to an urban environment. Robin Whyatt, Columbia School of Public Health, is researching pesticide exposure (in utero and post-birth) in the inner city populations of New York City. Robin is studying the links to birth defects from indoor pesticide use. The goal of both case studies is to reinforce the need for improved assessment of exposure and better understanding of the biological mechanisms that determine toxicological interactions of single toxins or among mixture constituents.

Learning Goals

During this session you will have an opportunity to build understandings of the following.

- a. Knowledge
 - i. We are surrounded by both natural and man-made toxic substances; education on responsible care is the key to a healthy, productive environment.
 - ii. The definition of “risk” is the probability of experiencing a hazard.
 - iii. The degree of hazardous outcomes from chemical exposure depends on the toxicity of the substance, dose received, and the length of the exposure.
- b. Skills
 - i. To recognize science as an experimental process
 - ii. To be aware of the importance of proper evaluation of scientific results and to realize that not all scientific results are conclusive.
 - iii. To understand the importance of the exchange of information between the scientific community and the public
- c. Dispositions
 - i. Our economy has been built on a technological base. Technological processes produce chemicals that, if not managed carefully, can damage our entire ecosystem.
 - ii. We need to develop an awareness of society’s attempts to minimize risks of exposure from toxic substances through education, research, regulation of some industries for occupational and environmental health, and establishment of standards for food, air, and water quality.

Key Concepts

Case-control study	Partition
Cohort study	Precautionary Principle
Contingent valuation	Reference concentration
Delivered dose	Reference dose
Endocrine disrupter	Risk analysis
Epidemiology	Risk assessment
Hedonic valuation	Risk communication
No Observable Adverse Effects Level	

FACILITATOR: These concepts correspond roughly to the sections of the unit. There are a number of other concepts that could be included. It is best to start with the author’s major ideas and then ask for input from the study group for other concepts they would include.

Background

Misconceptions about Risk, Exposure, and Health

Much controversy exists about the effects and risks that natural and synthetic pollutants have on the human population. Below is a list of some common misconceptions about risk and exposure to human health.

Many people believe that because adults are more mobile and work outside of their home for most of the day, they are more at risk for environmental exposures than children. But, in fact, children are more exposed to environmental threats. Children eat proportionately more food, drink more fluids, breathe more air, and play outside more than adults. This means that children may breathe in or ingest more pollutants per pound of body weight. For example, children absorb and retain a larger percentage of ingested lead than adults, which increases the toxic effects of the lead.

A common misconception is that lead poisoning is NOT a significant problem in the United States. However, despite a 94 percent decline in blood lead levels since 1976, caused principally by the removal of lead from gasoline, significant numbers of preschool children in the United States still have elevated blood lead levels (10 micrograms per deciliter or above) and suffer from lead toxicity. These children are at risk because they tend to live in poor quality housing, and many are of immigrant families that are not aware of the dangers of lead-based paint.

The scientifically unsound claim that the results of toxicity testing in animals have little relevance to human health is another important misconception. This claim is contradicted by the fact that every known human carcinogen has been shown to cause cancer in animal species. It is further supported by the close genetic similarity that has recently been demonstrated between humans and other species.

Another incorrect belief is that genetic inheritance and not air pollution is responsible for adolescent rates and degree of asthma attacks. Ambient air pollutants, especially ground-level ozone and fine particulates of automotive origin, appear to be important triggers of asthma. Asthma frequency declines when levels of these pollutants drop. Indoor air pollution, including insect dust, mites, molds, and environmental tobacco smoke is an additional trigger.

Finally, an everyday misconception is that if a product is on the shelf, it is safe. When we purchase a product, most of us assume that it has been tested and declared safe for the intended purpose. Many chemicals in products have not been tested or approved by any regulatory authority for their impacts on human health.

Getting Ready (45 minutes)

Activity One: Assessing Prior Knowledge, Questions, and Related Experiences

Each person in the group should have 3 index cards. On the first card, participants should name a specific environmental hazard (biological, physical, or chemical) and describe its use or function and its health risk. On the second card, participants should write one question they have about environmental contaminants that pose a risk to human health. Finally, on the third card, they should describe a direct experience they have had with exposure to and/or health concern with contaminants in the environment. For example an individual might write:

Getting Ready

Methyl tertiary-butyl ether (MTBE), an additive to make gasoline burn cleaner and reduce emissions, causes cancer.

Is the toxicity of synthetic chemicals different from that of natural chemicals?

I feel bad that I live in a 200 year old farm house and there is still some lead based paint under the old paint.

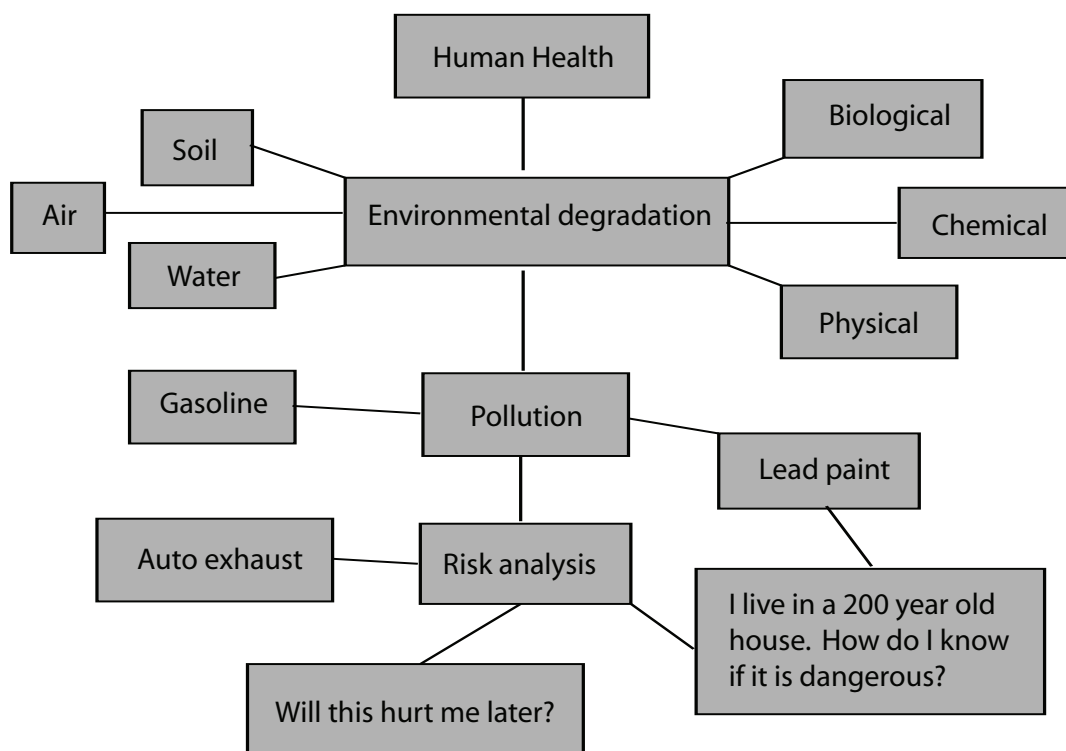


Figure 6.1 An example of a study groups' idea collection, with major subjects identified and the addition of the major focus ideas of the video. This activity links individual pre-existing knowledge with that of other members of the group and the unit content.

Activity Two: Current Events & Editorial Cartoons

Participants will share an article that they have found that relates to the week's topic. All members of the group will share their headlines for the articles. The leader should ask a few people to summarize their articles and ask for comments from others with related articles. As the group discusses the articles, a participant should record key concepts and make a list. (Participants may choose to bring in a cartoon or an editorial related to the week's topic instead of an article.)

Getting Ready

Activity Three: Who Gets the Vaccine?

FACILITATOR: The study group will need access to at least one computer that can access the Internet.

In this exercise the participants will play the role of CDC epidemiologists and they must use the Interactive Lab: Disease (www.learner.org/channel/courses/envsci/interactives/disease) to help them decide "Who Gets the Vaccine."

Scenario Part 1

There is an immediate and dire situation occurring in two very different locations in the State of Alaska. It has come to the attention of the CDC in Atlanta that two towns are experiencing an outbreak of the Smoolichen Disease. Neither population has ever been exposed to this quite virulent disease. The only effective vaccine is a counter virus vaccine and specifically a slow counter virus and there are only 200 individual vaccine doses available at this time. The job of the CDC epidemiologist is to determine a course of action; let the disease run its course without using the vaccine or administer the vaccine to the population that will benefit the most..

PARTICIPANTS: Discuss the imaginary scenario up to this point and the proposed solution.

Scenario Part 2

The first outbreak has occurred in Shishmaref, which is located on a small barrier island off the coast of Alaska and is home to 600 Eskimos. These people live in small isolated groups around the island. They subsist through their fishing and harvesting from the sea. The degree of interaction between family groups is considered medium. The second outbreak has occurred in Point Lay, Alaska, population 213 people. About 85 percent of the population is American Indian. Point Lay is a very close knit community with high interaction from all parts of the community. Most of the population is either government workers or military personnel.

PARTICIPANTS: Run the Interactive Lab: Disease simulator for both populations in the virgin mode (tableau drop down menu). Do five to ten runs and then calculate the averages of both deaths and sick days per capita. Then run each population with a counter vaccine, C-slow virus. (The Smoolichen disease is similar in its etiology to the Red Death disease.) Again, all runs should be repeated five to ten times and averages calculated.

Using the data results and outcomes of the simulation, choose a course of action. The first option is to not give the vaccine to either group. The second option is to choose one of the two groups. The third is to give it to both groups. Be prepared to explain and defend your choice.

Video (45 minutes)

Activity Four: Watch the Video (30 minutes)

As you watch the video, think about the following focus questions.

1. What has happened in Pitcher, Oklahoma, to make it the largest Superfund site in the United States?
2. What are chat piles and how do they affect Tar Creek?
3. The people in the town of Pitcher have experienced high exposure to the lead in the mine tailing. How does exposure to lead lead to neurological problems?
4. Why were the children the primary targets for Howard Hu's study of exposure to metal from abandoned zinc and lead mines?
5. Hu's study also looks at the effects of multiple mixes of toxic metal exposure on people. What are the problems of doing exposure and risk assessments when more than one toxin is involved at the same time?
6. Robin Whyatt is researching links to birth defects from indoor pesticide use in New York City. What does she believe to be a common misconception about pesticides?
7. What are biomarkers and what biomarker(s) did Whyatt use in her pesticide exposure study? Did Hu use any biomarkers?
8. What did the public learn from both Hu's and Whyatt's exposure studies?

Activity Five: Discuss the Video (15 minutes)

Discuss the following questions about the video.

1. Summarize Howard Hu's study of children's exposures to metals from the abandoned Tar Creek mines. How will these results benefit you?
2. The unit text in Section D, Using Epidemiology in Risk Assessment, presented A.B. Hill's nine criteria for citing causal relationships. Using the nine criteria, determine if Hu's and Whyatt's study results satisfy all criteria in assessing the relationship between environmental threats and illnesses.
3. Do you see a need for any risk assessment and management assessments in your particular environment, such as work, school, home, fitness center, mall, restaurant, recreation area, etc.?
4. How do we discover what contaminants are in our environment and how do we know what impact they will have on us?

FACILITATOR: Refer back to the misconception section and Activity One: Assessing Prior Knowledge. Has the video contributed to the participants' new understanding of concepts? Are there any changes the participants would make about the arrangement of their cards from Activity One?

Going Further (60 minutes)

Activity Six: Toxic Dosage: Hazard or Not?

The hazard of chemicals in the environment is one that can be exaggerated or misinterpreted. Because we are exposed to many chemicals, both naturally occurring and synthetically produced, it makes sense to understand when to worry and when not to worry. The problem arises when people do not know the dose of a chemical required to cause an adverse effect. In many cases, people assume that any exposure to a chemical that can cause harm is harmful. In order for citizens to make good choices in their life styles, an understanding of dose and exposure is important.

To illustrate the above misconception, the American Council on Science and Health publishes a Holiday Dinner Menu each year. This menu is analyzed to determine exposure to natural chemicals known to cause adverse effects in rats. For example, people consume natural chemicals such as ethyl benzene in their coffee, hydrogen peroxide in their tomatoes, and furan in their sweet potatoes.

The bread in Thanksgiving stuffing contains furfural, a chemical that can cause cancer in rats when they are fed high doses of it. How many slices of bread would an average middle school student have to eat to consume an amount of furfural equal to the amount that increased the risk of cancer in rodents?

The facts

- White bread contains 167 micrograms of furfural/slice,
 - The carcinogenic dose for rats is 197 milligrams per kilogram of body weight per day, fed every day of its life.
 - A typical middle school student weighs 110 pounds (50 kilograms).
1. Calculate how many slices of bread a student would need to consume to reach a toxic dose. (Solution can be found after Unit 6: Between Sessions.)
 2. Calculate how many slices of bread you would have to consume to reach a toxic dose.
 3. What are some ways we can teach the public the differences between toxic and non-toxic dosages?

Activity Seven: Return to Essential Questions

The facilitator should draw the attention of the participants back to the essential questions posed in the Background Section of this unit guide. Discuss how the participants' ideas may have changed in regard to the questions. Discuss the most logical and complete answers to the questions.

Activity Eight: Discuss Classroom Supplementary Activities

If the participants in the study group are teachers, the facilitator should draw the participants' attention to supplementary classroom activities located at the end of this guide. Discuss how teachers would implement these activities in their classrooms and how they would relate them to the topics in this unit.

Between Sessions

Next Week's Topic Overview

Read Unit 7 before the next session. In Unit 7, the emphasis is on the major environmental impact of agriculture and habitat loss associated with the expansion of lands devoted to human consumption of food and fiber. Environmental effects of this land conversion include: ecosystem stability (fragmentation of natural systems) and biodiversity loss.

Read for Next Session

For the next session be sure to read the Unit 7 Professional Development Guide background section. Consider the essential questions as you read the text. The misconceptions section will give you some insight into what misunderstandings people may have about agriculture. Consider discussing the topic with your friends or students and discussing common misconceptions.

Current Events

Bring in a current event article or cartoon related to agriculture.

Solution to Activity 6: *The carcinogenic dose for a student is $197,000 \text{ micrograms} \times 50 \text{ kilograms} = 9,850,000 \text{ micrograms per day}$. If each slice has 167 micrograms of furfural, then she would need to eat 58,982 slices of bread to reach a toxic dose.*

Supplementary Classroom Activity 1

Hazardous Substance Exposure and Treatment Simulation

Objective

Students will be able to perform research on the exposure pathways, health effects, and treatment of patients exposed to hazardous substances.

Students will be able to work with a group to develop a script, action, and props for a simulated treatment of a patient or patients exposed to a hazardous substance.

Setting

Preview and show clips from any number of TV medical/hospital dramas of a treatment scenario, preferably one dealing with hazardous materials exposure.

Procedure

TV medical programs can be believable if people do enough research into the situation they are trying to create. Writers for these hospital dramas have access to real medical professionals as advisors. They also research their topics before trying to film them for an audience.

Supplementary Classroom Activity 1

Your task is to develop a scene—a mock response to a hazardous substance exposure event. The event must focus on the exposure itself, the health impacts of the exposure, and the medical treatment following the exposure.

The purpose of this exercise is to educate you and your classmates about the pathway, health effects, and treatment of a hazardous substance exposure. Your task is to develop a script and act it out in front of the class, or film it on location and show the tape to the class. The scene will deal with an exposure of a patient or patients to a hazardous substance, the patient's symptoms and health impacts as a result of the exposure, treatment, and prognosis for recovery.

Your cast of characters should include one or more patients, witnesses if appropriate, and medical professionals (doctors, nurses, paramedics, and ER staff). Your set, location, and costumes are up to you. You are required to hand in a complete script along with your performance. Remember that the goal is to educate your audience about the implications of exposure to the hazardous substance you choose.

Supplementary Classroom Activity 2

Develop a Fact Sheet

Materials

Access to computers, the computer lab, the library, and the Internet

Examples of Fact Sheets

Various art supplies (markers, colored pencils, construction paper, glue, tape, and scissors)

Copies of rubric

Objectives

Students will design a fact sheet intended to educate the public about the harmful health effects of hazardous substances.

Students will conduct research to support the information included in their fact sheet.

Procedure

List as many hazardous substances as you can. Pick one and write what you know about it. How does it affect human health? How did you learn about the health effects of this substance?

Discussion

Invite student to share answers.

Develop a consensus among the students by discussing what a hazardous substance is (a substance that could be harmful to people who come into contact with it).

Discuss the ways students have learned about hazardous substances.

Supplementary Classroom Activity 2

Show an example of a fact sheet. Have students seen one of these before? (Most likely they have in the form of anti-smoking or drug pamphlets.) Inform students that the purpose of a fact sheet is to inform the public about health issues and hazardous substances.

The students' task is to choose a hazardous substance and develop a fact sheet for it. Fact sheets should contain the following:

- Title
- An explanation of what the hazardous substance is
- An explanation of what happens when the substance enters the environment
- Description of how humans can be exposed
- Description of the health effects of the hazardous substance
- How to avoid exposure
- What to do if you are exposed
- Summary
- A section of references people can access for more information

Students are required to hand in a set of references to document the sources of their information.

Formatting

Traditionally, fact sheets are no longer than one page, filled front and back. Fact sheets can have simple or elaborate formats, as long as they effectively convey their message. The rationale behind a one-page document is that many people will not take the time to read a multi page document. Also, it is much easier to distribute a single page fact sheet to the public than multi-page documents. Provide examples of fact sheets for the students. Include a variety of formats (simple, columns, two and three fold pamphlets).

Evaluation

- Students will be required to peer review each other's fact sheets prior to handing them in, using the rubric.
- Rubrics should be used to evaluate the fact sheets. Students may develop their own or develop one in conjunction with the class, or use the rubric provided by the teacher.
- Encourage students to use the rubrics to assess their own work as they develop the fact sheets. You may want to practice using the rubric by allowing students to score sample fact sheets, matching their scores against yours.
- Students may be allowed class time to research and construct their fact sheets, or you may require that they work on their own, or both.

Closure

You may wish to have the students share their fact sheets, or even require them to present them in class. After evaluating the fact sheets, hang them in the hall, the library, the office, the nurse's office, or any place where they might be appropriate. You may even wish to submit them to your local health district for evaluation.