Background Information for Educators

THE RISKS AROUND US

Risks are all around us. We face them if we eat too many—or not enough—fatty foods, drive a car, ride a bicycle, or invest money in the stock market. In an effort to reduce the adverse consequences of risks, we constantly make ***risk assessments*** and decisions. For example, before starting the car, an individual may consider the risks involved in driving and, consequently, may decide to wear a seat belt.

Not all risks are personal. In fact, many of the risks we face are societal and require government regulation. For example, pesticide use is regulated under the Federal Insecticide, Fungicide, and Rodenticide Act, and air quality is regulated under the Clean Air Act. Managing risks at both the personal and societal levels requires careful consideration of the tradeoffs between the costs and benefits of reducing that risk, as well as the potential for creating new risks.

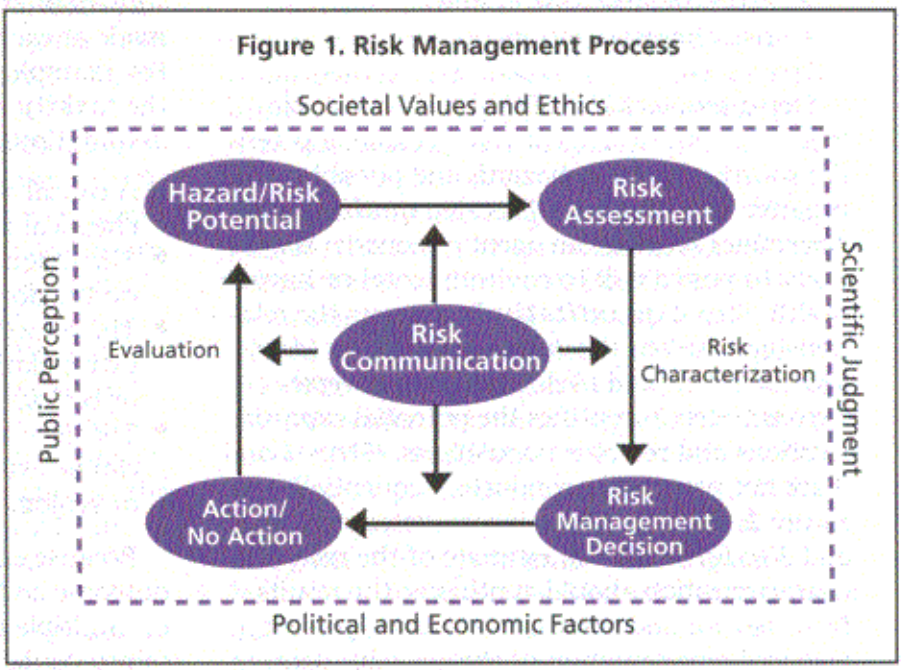
WHAT IS RISK?

Risk is the ***probability*** (or likelihood) that a harmful consequence will occur as a result of an action and is a function of ***hazard*** and ***exposure.*** In other words, for risk to occur, there must be both a source of risk (hazard) and an exposure to the hazard. The study of risk looks at the probability of a harmful consequence occurring from exposure to a hazard. Probability is usually expressed as a fraction, ranging between 0.0 and 1.0. For example, the estimated risk of developing cancer from exposure to a certain ***carcinogen*** might be expressed as 0.000001, or 1 chance in 1 million (also written as 10^{-6}). A probability of 1.0 indicates absolute certainty that exposure to a hazard will have an adverse consequence, and a probability of 0.0 indicates absolute certainty that no adverse consequence will occur. Of course, there is no such thing as a zero-risk estimate because there is always some degree of ***uncertainty***. (In this context, uncertainty is used to describe the possibility that an error was made in the probability calculation.)

STUDYING RISK

Risk professionals attempt to mitigate risks to public health, safety, and the environment through the synthesis of risk assessment, risk management, and risk communication (see Figure 1). Risk assessment and risk management entail generating estimates, making judgments, and taking actions. Risk communication involves the exchange of information among experts, professionals, and the general public. Activity 1 "What Is Risk?" introduces students to the study of risk.

Figure 1. Risk Management Process



NOTE:

The above figure is one way to visualize the risk management process. Addressing risk involves a cycle of steps beginning with the identification of a potential hazard. Subsequent processes include risk assessment, risk management, and the decision to implement a policy, take voluntary action, or do nothing. Each step is influenced by scientific judgment, societal values and ethics, economic factors, political climate, and the public's perception of risk. In addition, the successful communication of risk is important throughout the process.

RISK ASSESSMENT

Risk assessment is the process by which one attempts to evaluate and predict the likelihood and extent of harm (in quantitative and qualitative terms) that may result from a health or safety hazard. In 1983, the National Research Council issued a report, *Risk Assessment in the Federal Government: Managing the Process,* which outlines a four-step risk assessment process. This procedure was originally geared toward the assessment of carcinogenic chemicals. It has since been adapted by the U.S. Environmental Protection Agency for ecological risk assessment (U.S. EPA 1991, C). The four steps include

1. hazard identification,
2. dose/response assessment,
3. exposure assessment, and
4. risk characterization.

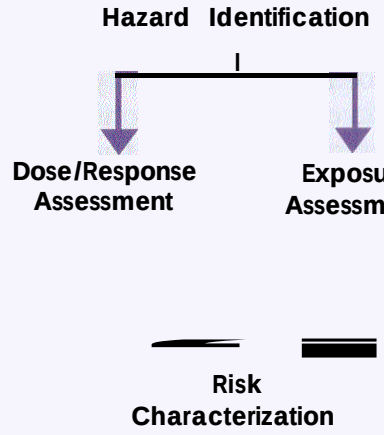
Step 1 involves identifying a chemical, biological, or physical agent that presents a potential source of risk, or hazard, and possible negative consequences. This step ***qualitatively*** determines whether an agent of concern is likely to pose a risk to environmental or human health. Step 2 ***quantitatively*** assesses the relationship between the degree of exposure *(dose)* and the extent and likelihood of an adverse response. Step 3 identifies the potential exposure locations and receptor populations. (Steps 2 and 3 are not necessarily conducted sequentially; see Figure 2.) Finally, step 4 incorporates steps 1, 2, and 3 to formulate an estimate of the risk. Risk characterization should synthesize the results from hazard and exposure estimates, present a balanced representation of the available data, and identify key assumptions and areas of uncertainty (IETC 1996, C). This step is critical because it is the link between the risk assessment and risk management processes (National Research Council 1983, C).

Although risk assessment models aim to define a given risk as accurately as possible, there is always an element of uncertainty in the final risk characterization. Uncertainty arises because risk assessments are often based on limited information. In addition, the information available is influenced by the accuracy and precision of measurements and by the natural ***variability*** of systems and populations, all of which are potential and actual sources of error. Assumptions, therefore, are made at each step of the assessment process. For example, when animals are used to test for the toxicity of a chemical, the following assumptions are usually made:

-) A causal relationship exists between the chemical and the response.
-) The magnitude of the response depends on the dose.
- b The response in the test animal can be extrapolated to a response in a human or ecological receptor.
-) The dose administered to the test animal can be extrapolated to a dose for a human or ecological receptor (Klaassen 1996, A).

Because each assumption influences the final outcome and because most estimates are based on multiple assumptions, the level of uncertainty could potentially span several orders of magnitude. To effectively communicate the risk estimate, risk analysts must explicitly state all the assumptions and uncertainties contained in the study.

Figure 2. Risk Assessment Process



RISK ASSESSMENT TOOLS AND TECHNIQUES

Analysts who perform risk assessments use various statistical tools and modeling techniques to arrive at a quantitative or qualitative representation of a risk. Statistical tools include **sampling** procedures, the **Monte Carlo method,** and descriptive statistics. Modeling

techniques include event trees and ***fault*** trees, ***incidence rates*** and ***prevalence rates,*** and ***dose/response curves.*** In ecological risk assessments, predicted effects estimated through modeling can be verified through ecological field surveys, toxicity tests, and biological monitoring. Activity 3, "Chances Are ... Understanding Probability and Risk," provides more information on statistical tools while Activity 4, "Risk Assessment: Tools of the Trade," provides more information on modeling techniques.

DESCRIBING RISK

In human health risk assessment, the most common description used to characterize a risk is ***excess individual*** risk-the increased probability that anyone will experience an adverse effect from exposure to a hazard. For example, the annual risk that any individual in the United States will die from an automobile accident is estimated as 2 in 10,000, or 2 x 10^{-4}. Another way to characterize risk is to present the ***societal*** risk-the number of cases expected to occur in a population over a given time. For example, approximately 40,000 deaths are expected to occur by motor vehicle accidents each year in the United States. Risks are also described in relative terms, such as the risk of developing lung cancer among people who smoke compared to people who don't smoke. In addition, risks may be described in terms of a reduction of life expectancy. For example, the estimated reduction of life expectancy from being 15 percent overweight is 2 years.

Risk estimates alone, however, do not answer the question of whether a public risk requires mitigation. Rather, the combination of the estimate, societal values, risk reduction options, and available resources will contribute to the management decision.

RISK MANAGEMENT

Risk ***management*** is the process of identifying, evaluating, selecting, and implementing actions to reduce risk to human health and to ecosystems (Presidential/Congressional Commission on Risk Assessment and Risk Management 1998a, E). The process involves incorporating the data obtained from risk assessments and the social, ethical, cultural, economic, and political values of the time. Therefore, a risk management decision is not based exclusively on scientific information nor are the decisions value free. Managing risk also involves comparing options: acting or not acting, reducing some risks while increasing others, using alternative methods and technologies for risk reduction, and making tradeoffs.

Risk management decisions are complex because they are almost always based on incomplete, insufficient, or inconclusive data. In addition, the decisions will most likely have significant impacts on human and environmental health, environmental regulations, and industry and consumer costs.

Three methods that are commonly used to help make a risk management decision are ***comparative risk*** assessment, ***cost/benefit analysis,*** and ***cost-effectiveness analysis.*** ***Risk*** managers are often faced with multiple risks that require attention. Because the resources for managing those risks are usually limited, the risk manager must decide where the resources will be most effectively spent. Comparing risks, usually in the form of a ranked list, can help to distinguish the top priorities. This technique is called comparative *risk* assessment. It involves organizing the stakeholders, making a list of environmental problems, collecting information about the risks the problems pose, ranking the list, and using the rankings to guide planning and budgeting strategies (Presidential/Congressional Commission on Risk Assessment and Risk Management 1998b, E).

NOTE:

Comparing risks for priority setting is different from comparing risks for risk communication purposes, as discussed below.

In the most general terms, a cost/benefit *analysis* involves assigning a monetary value to the costs and benefits of a risk management option. This process reduces all effects to a common measure so that they can be compared. While this analysis is useful for organizing the issues, it is sometimes difficult to identify and

articulate the different costs and benefits of a risk reduction option. It is also difficult to assign a dollar value to items that are not usually thought of in monetary terms. Applying a cost/benefit analysis can, therefore, be a complex and controversial process.

GET TO KNOW THE FACTS

- Who published or presented the information?
- Who conducted the risk assessment study?
- Who funded the research?
- Is a range of uncertainty given in the research results?
- Are all sides of the issue addressed?

Performing a cost *effectiveness* analysis is another way to organize the issues for the decision-making process. In this approach, a predetermined objective, such as a 30 percent reduction in air pollution from a facility, is established. Holding this figure constant, the risk manager looks for the most efficient way to achieve this goal. Each alternative is given a cost estimate and the method that minimizes the total costs to society is identified.

It is important to keep in mind that these analytical tools are used as an aid in the management process and that other factors, such as personal values, politics, and public relations, also influence the final management decision.

RISK COMMUNICATION

Although risk managers are likely to obtain the bulk of their information from a risk analyst, the general public is most often informed through the media (television news reports, newspaper articles, radio programs or pamphlets), town meetings, or word of mouth. Each method is a form of risk communication.

In general, ***risk communication*** refers to the exchange of information to inform citizens, organizations, corporations, industry, the media, and other public and special interest groups about sources of risk and possible solutions. Making risk communication an interactive process is a growing priority because it allows citizens to take part in the decision-making process by voicing their concerns, asking questions, and making suggestions

Risk communication should be an open, multidirectional process.

In addition to raising awareness, the communication of risk information is intended to motivate people to take preventive or protective action (Fiorino 1995, A; Eblen and Eblen 1994, A). For example, when the death toll from drunk driving accidents is publicized, one of the intentions is to persuade people not to drive while under the influence of alcohol.

The way in which risks are communicated influences people's perception of risk. Therefore, students should learn to view risk information with a critical eye. Having students ask questions such as those presented on this page, encourages them to think for themselves before they react to media coverage of a potential risk. Finding the answers to those questions may reveal inconsistencies in the data, may raise other questions, or may strengthen the credibility of the source. Activity 5, "Communicating Risk," provides more information on effective risk communication.

RISK PERCEPTION

The field of ***risk perception*** examines people's attitudes toward risk, their levels of acceptance, and their behavior in response to their perceptions. Our perceptions of risk depend on how risk information is communicated and what we believe (or know) about the risk. The way we think about a risk is often based on our values and on psychological, socioeconomic, and cultural factors.

As risks are communicated, we tend to place them in certain categories. Which categories we put them in depends on how the risks are perceived and how we respond to the information. For example, risks that are categorized as involuntary (such as water pollutants), unknown or unfamiliar (such as nuclear power), catastrophic (such as a large earthquake), or acute (such as exposure to a toxin) usually elicit a

great degree of concern or dread. Conversely, people seem to be more accepting of, or apathetic about, risks that they believe are voluntary (such as suntanning), familiar (such as smoking), common (such as driving), or necessary (such as a vaccination).

Additional factors that influence risk perception are the image of the institution that is managing the risk, the public's perception of fairness with respect to a risk, and the number of people reportedly exposed to the hazard. By understanding how risks are likely to be perceived, we can understand how people will behave when faced with a potential risk. This is important when deciding how to effectively communicate and manage risk. Activity 2, "Things Aren't Always What They Seem," focuses on risk perception.

ETHICS

Ethics provide a framework for viewing events and actions as either *right* or *wrong*. For issues such as human rights and public safety, many people share the same general code of ethics. For other issues, such as environmental protection, people's notion of what is and is not ethically acceptable is more varied. For example, some may question the morality of depleting nonrenewable resources. Others may not consider the unrestricted use of nonrenewable resources to he a moral issue. Because different people follow different ethical codes, it is useful to consider ethics when communicating risk information, developing risk assessment studies, and making decisions about societal risks.

Involving ethics in the discussion of risk will help students to consider whether or not actions taken to reduce a risk, or actions taken that pose a risk, are "fair." The environmental justice movement promotes the fair treatment of people of all i-aces, cultures, and incomes with respect to developing, implementing, and enforcing environmental laws, regulations, programs, and policies. Fair treatment means that no racial, ethnic, or socioeconomic group should carry a disproportionate share of the negative environmental or health consequences that result from the operation of industrial, municipal, or commercial enterprises, or from the execution of federal, state, local, or tribal programs and policies.

Teaching students about the nature of risks, risk assessments, and risk management will help create an awareness and an understanding of the risks they face in their own environment. It will also stimulate students' critical thinking and help them to make informed decisions about risk.