Technical Topics:

Assessing Health Risks From Nuclear Facilities: Epidemiology and Risk Assessment

The Issue

Residents of communities near nuclear facilities around the world have questioned the safety of living close to such large sources of radiation. The public near these facilities has shown particular interest in whether rates of diseases in their communities are higher than average and whether any increases in disease rates are related to radiation exposure. Attention is usually focused on cancer rates near nuclear facilities, since, in many different scientific studies, radiation has been shown to cause cancer.

Answers to such questions come from two types of studies: epidemiologic analysis and risk assessment. An epidemiologic study focuses on disease rates computed for specific communities, while risk assessment centers on evidence of radiation and/or chemical exposure to residents. Both techniques are useful in answering questions about health risk, although both have certain limitations.

Many think that an epidemiologic study is the best way to determine the health hazards posed by environmental exposures. Under favorable conditions, this is probably true. Unfortunately, conditions for epidemiologic analysis are rarely favorable. Some major problems faced by epidemiologists include:

- Finding all persons who may have been exposed,
- Designing a study with enough cases to analyze using statistical techniques and
- Estimating toxic exposures for all individuals in a study.

Estimating exposures (the amounts of contaminants people received) is usually the most difficult problem to overcome. Scientists who are assessing risks at nuclear facilities in the United States have tried to overcome this problem by conducting dose reconstruction studies like the

Technical Topics: This series of papers explains the research design, methods and terminology used in the State of Colorado's health studies related to the Rocky Flats Plant. For information about this ongoing research to identify past contaminant releases from the plant and assess potential health risks, call the Colorado Department of Health at (303) 692-2640 or 692-2652.

COLORADO DEPARTMENT OF HEALTH

Meanings of Terms

Dose Reconstruction: Research and analysis of historical data and information regarding contaminant releases from a facility and calculation of doses, or amounts of contaminants received by an exposed population group. This information is used to assess the risks of potential health effects related to past exposure to contaminants.

Epidemiology: The study of specific health effects or diseases and their distribution in a population group; the determination of potential causes of the observed health effects.

Risk Assessment: A study process involving identification of a source of toxic substances, evaluation of conditions under which a population group could have been exposed, analysis of the toxicity of the specific substances and calculation of increased risks of adverse health effects related to the exposure.

Statistical Analysis: Collection, organization and interpretation of data and the application of mathematical techniques to identify trends or characteristics in a population or study sample group.

one being directed by the Colorado Department of Health on Rocky Flats. Dose reconstruction provides information to estimate past contaminant releases and potential public exposures, which in turn can be used to determine the feasibility of epidemiologic studies.

Epidemiologic Studies

An epidemiologic study identifies the types and frequencies of specific diseases in a population group. For example, a cancer study involves collecting data on the number of residents who have developed different types of cancer. Data on diagnosed cancers (termed cancer incidence) are available for analysis in some communities with nuclear facilities. The Colorado Central Cancer Registry, for instance, is compiling data on cancers statewide to allow for the accurate comparison of incidence in the Rocky Flats Plant area with other regions of Colorado.

Just because disease rates can be computed for areas near nuclear facilities does not mean they can be used to show whether or not the facility was responsible for causing disease. Scientists require fairly stringent evidence for such conclusions. In short, cancer rates must be high enough to satisfy criteria for statistical analysis, and must be clearly related to exposure to radiation or other hazardous substances that came from the nuclear facility.

What kinds of epidemiologic studies could be used to assess cancer risks from Rocky Flats? First, an exposed population would need to be defined, for example, people who lived during a specified time period in a location affected by contaminant releases from the plant. Records of cancer incidence or cancer deaths (mortality) in this population would then have to be collected and categorized by different measures of exposure to radiation and chemicals from the

plant. The disease rates would then be examined statistically to see if they are related to the magnitude of exposure.

Two studies of cancer incidence in communities near Rocky Flats were published in the 1980s. The studies reached opposite conclusions about the relation between cancer incidence and estimates of plutonium concentrations around the plant. A problem with both studies is the small number of measurements of plutonium in soil that were used to determine exposure from Rocky Flats. It is not clear that those measurements accurately reflected the cumulative history of plutonium releases from the plant.

Another type of epidemiologic study involves identifying cases of cancer and a control group of persons without cancer and determining whether the estimates of radiation and chemical exposure are different between the two groups. This design is called a "case control" study and has not often been used in studying public exposures to nuclear facilities. This is because data for exposure to radiation from nuclear facilities are usually not available in the detail necessary to make estimates of exposures for individual cases and control subjects.

An important question raised by concerned citizens is the extent to which they were exposed to plutonium from Rocky Flats. With detailed information about the distribution of plutonium contamination from Rocky Flats operations, scientists can identify members of the public who were most likely to have been exposed.

Sensitive techniques recently developed for measuring plutonium in urine can then be used to see if concentrations are higher in a group of people who were exposed compared with a control group of those judged to be unexposed. These techniques are not widely available, however, and cannot be used to assess exposures to other substances which do not stay in the body as long as plutonium.

Risk Assessment

Risk assessment involves analyzing a source of contamination, assessing the toxicity or potential effects on humans and estimating the potential exposures in a population. With detailed information on releases to the environment and estimated exposures – such as data from the State's dose reconstruction study at Rocky Flats – scientists can predict the types and frequencies of diseases that would be expected from such exposures.

Risk assessment can be performed for any time period of interest – past, present or future. In epidemiologic studies of cancer, however, exposure to cancer-causing materials generally occurs many years before the disease appears. This is called cancer latency. For example, depending on the dose received, it can take anywhere from a few years to 30 years for radiation exposure to cause cancer that can be detected in humans.

Latency makes it difficult in an epidemiologic study to draw conclusions about the relation between exposure and disease. In a risk assessment, on the other hand, exposure data are used to predict the potential risks or chances of specific health effects under specific circumstances.

There are four basic steps in a risk assessment:

1) Identifying the source of toxic substances and the human population potentially exposed;
2) Estimating the extent of exposure for that population;
3) Identifying estimates of risk per unit of exposure based on the scientific literature; and
4) Computing the range of risks for the exposures of interest.

Data from a risk assessment for a particular site can be interpreted by comparing them with guidelines for risk developed by a variety of scientific, regulatory and public interest groups. Risk estimates for a particular nuclear facility can also be compared with data from similar exposures at other sites.

The problems and technical limitations of risk assessments include lack of adequate exposure data, uncertainty in estimates of risk per unit exposure and difficulty in explaining the complex sets of mathematical equations used to compute risk. In addition, some argue that risk estimates are subject to bias in the selection of the factors used in the complex mathematical calculations.

These problems can be solved, in part, by carefully reconstructing residents' historical exposures to contaminants and by including independent review and public oversight in the dose reconstruction and risk estimation process.

Combining Risk Assessment and Epidemiology

Both risk assessment and epidemiology can be useful in certain situations. Since both techniques require data from dose reconstruction, it makes sense to reconstruct doses and estimate risks first. Data from a risk assessment can then be used to identify those risks that could be unacceptably high or that might warrant further study.

Risk assessment data can also be used to determine the feasibility of an epidemiologic study and to plan a study that will produce scientifically valid results. Specifically, epidemiologists can determine which groups of people and which diseases are appropriate to study, and whether a study can include enough exposed people to produce results that can be analyzed with statistical techniques.

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