Observations on Work Force and Training Needs for Assessing Environmental Health Risks

ROGER L. DeROOS, MPH, PhD
PRISCILLA N. ANDERSON, MS
NORBERT J. BERBERICH, PhD
BETTY MAUGANS
GILBERT S. OMENN, MD, PhD
P. G. RENTOS, PhD

Dr. DeRoos is Associate Professor, Department of Environmental Health, School of Public Health and Community Medicine, University of Washington. Ms. Anderson is a toxicologist with Ecology and Environmental, Inc. Dr. Berberich is the Curriculum Development Branch Chief with the National Institute for Occupational Safety and Health, Centers for Disease Control, Public Health Service. Ms. Maugans is Executive Secretary of the Conference of State Health and Environmental Managers. Dr. Omenn is Professor and Dean, School of Public Health and Community Medicine, University of Washington. Dr. Rentos is Training Grant Program Officer, National Institute for Occupational Safety and Health.

This report is based in part on research supported by the National Institute for Occupational Safety and Health under procurement orders 83-2934 and 83-2919, and by the Health Resources and Services Administration, Public Health Service, under contract HRSA 84-244(P). The American Public Health Association and the Conference of State Health and Environmental Managers assisted the project.

Tearsheet requests to Dr. Roger L. DeRoos, Associate Professor, Environmental Health, School of Public Health and Community Medicine (SC-37), University of Washington, Seattle, WA 98195.

Synopsis

The continuing discoveries of hazardous waste sites have stimulated environmental health risk assessment efforts in State and local environmental health agencies. Elements of risk assessment are defined, showing how risk assessment interfaces with risk management. Environmental health risk assessment involves work components (tasks, activities, and technologies), the worker (position, classification, and occupation), and work organization (purpose, outputs, and objectives). Information from six State agencies was used to describe current State government experiences with environmental health risk assessment.

Education and risk assessment are described, particularly as they relate to schools of public health and the role of continuing education for the public health work force.

QUALITATIVE and quantitative assessments of public health risks from environmental exposures have been carried out for decades in the occupational areas of radiation safety, industrial hygiene, and food safety, and for at least the past 15 years in development of community standards for levels of chemicals in water and air.

The discovery of numerous hazardous waste sites and the advent of the Superfund have encouraged State and local agencies to undertake environmental risk assessment activities in the pursuit of protective and remedial measures on behalf of the communities surrounding abandoned waste sites and workers involved in site assessment and corrective actions.

During the 1980s, an increasing amount of information became available on research and experience with environmental health risk assessment methodology. The National Governors Association issued its State Integrated Toxics Management Series (*1,2*). Payne and Brough noted the use of risk assessment in town planning and development in England (*3*). Newly enacted worker and community right-to-know laws particularly directed attention to worker and community risks associated with hazardous waste sites (*4,5*) and more generally to risks of chemicals.

Developments in environmental health risk assessment have been closely related to development of another specialty, environmental epidemiology. Lapham and Castle's (*6*) survey of State agencies showed that the need to apply epidemiologic techniques to environmentally related diseases is recognized. The Association of State and Territorial Health Officials (*7,8*) has demonstrated the importance of environmental epidemiology studies in State agencies.

State and local agencies are experiencing a lack of workers trained in risk assessment and problems in training new people, existing personnel, and those transitioning into this area. This challenge may be understood better through a description of the knowledge and skills needed by persons working on environmental risk assessment tasks, and

the information on the mix of specialties required by State environmental health agencies.

Elements of Risk Assessment

Risk assessment systematically identifies and characterizes human health hazards from various environmental exposure to chemicals. The Department of Health and Human Services (*9*) has provided a philosophy of risk which is related to exposure to toxic substances and has defined important terms (see box).

The elements of risk assessment and risk management are outlined in figure 1 (*10*). Hazard identification depends upon scientific results from epidemiologic investigations and toxicological studies, and increasingly, *in vitro* screening test systems. The first step is to ascertain if a given chemical has the capacity, often at very high doses, to cause cancers, mutations, birth defects, or organ-specific damage. If so, it is necessary to investigate the dose-response relationship, the real-life exposure levels in various settings, and the differing susceptibility of identifiable subgroups in the population (*10–14*). Such information permits qualitative and quantitative characterization of the health effects and a quantitative extrapolation along the dose-response curve in estimating the likelihood of the described effect at various levels of exposure, as the effect is experienced by specific groups of workers, children, or other population groups.

As emphasized in the National Research Council report (*10*), the guidelines for interpretation of the data from epidemiologic and toxicologic studies reflect value-laden policy judgments. These include whether or not to count "benign" tumors, choosing a model for extrapolation to low dose, and weighing conflicting results from different studies of the same chemical. The current policy of regulatory agencies and many independent scientists is to rely on linear, or multistage linearized extrapolation, so that no dose except zero is associated with a zero-risk estimate.

Risk assessment can be useful in evaluating the options for risk management and, subsequently, in evaluating the impact of risk reduction actions. However, technological, social, economic, and political factors may be as, or more, important in the decisions of regulators, manufacturers, environmental and consumer groups, and health agencies. The risk assessment process should draw upon the best available evidence about the effects of the chemical and the levels of human exposure. The interpretation of that evidence should not be biased by prejudgments about what should be done about the problem.

State and local agencies often require risk assessment inputs for decisions regarding specific environmental problems. Federal agencies are more likely to be involved in using risk assessment for standard-setting and in support of the epidemiologic and toxicologic studies for obtaining primary data. However, many State and local agencies have issued guidelines for toxics in air, water pollutants, and waste disposal sites. Useful sources of information, especially in emergency

Philosophy of Risk

People have always lived with risk, presently live with risk, and will continue to live with risk. Some degree of risk of adverse health effects from toxic substances is inevitable, as a consequence of exposure to both naturally occurring and man-made toxicants. The public should be made aware of the nature of risk. Public health risks that are not acceptable should be reduced or eliminated when feasible. Means to accomplish this goal should not pose additional significant risks.

Risk is the possibility of an adverse health effect as a result of exposure to a hazardous substance.

Risk assessment is the use of available information to evaluate and estimate exposure to a substance and its consequent adverse health effects. Risk assessment consists of three elements:

Hazard identification is the qualitative evaluation of the adverse health effects of a substance in animals or humans.

Exposure assessment is the evaluation of the types (routes and media), magnitudes, time, and duration of actual or anticipated exposures and doses, when these are known, and the number of persons who are likely to be exposed.

Dose-response assessment is the process of estimating the probable incidence of an adverse health effect to humans under various conditions of exposure and describing the uncertainties involved.

Risk management is the process of integrating risk-assessment results with engineering data and social, economic, and political concerns. Alternatives are weighed to select the most appropriate public health action that will lead to reduction or elimination of the identified risk. Appropriate actions may range from public education to interdiction (*9*).

SOURCE: Reference 9.

Figure 1. Elements of risk assessment and management

Risk assessment:
Hazard identification (does the agent cause the adverse effect?)
Dose response assessment (what is the relationship between dose and incidence in humans?)
Exposure assessment (what exposures are currently experienced or anticipated under different conditions?)

Agency decisions and actions

Risk characterization:
What is the estimated incidence of the adverse effect in a given population?

Risk management:
Development of regulatory options along with evaluation of public health, economic, social, and political consequences of regulatory options

NOTE: Agency decisions and actions pertain primarily to risk characterization and risk management.
SOURCE: Adapted from reference *10*.

responses, are the International Agency for Research on Cancer, the National Toxicology Program, the Environmental Protection Agency, and the National Institute for Occupational Safety and Health. Other sources provide information about chemicals classified as definite, probable, or unlikely causes of cancers or other adverse health effects (*15–18*).

The framework outlined in this paper of the identification, characterization, and reduction of risks from environmental chemicals is a useful organizational approach. The approach lacks the crucial element of how a chemical becomes a matter of public concern. Sometimes that occurs through systematic testing by the National Toxicology Program of chemicals known to be produced and used in large amounts, or known to be structurally related to other hazardous chemicals. More often, questions arise, generally at the local level, about potential health risks from chemicals detected in water, food, air, or waste sites, and about potential environmental explanations for observed health problems in clusters of patients.

In practice, preliminary remedial actions may be necessary to prevent serious adverse health impacts even before an adequate risk assessment can be obtained or performed. Nevertheless, it is wise to insist on an orderly and rigorous review of the available evidence before risk management decisions generate such controversy that actions are delayed and agencies undermine their own credibility for the future (*19*).

Examining the Work

The work of environmental risk assessment differs, depending upon the role and expertise of the individual and the type of employing organization. In the Federal Government, risk assessment is often directed at standard setting and consists of special studies of the health hazards of a variety of materials and processes. However, in State and local agencies, efforts are more often directed at remedial or emergency situations.

A successful risk assessment program at the State or local level includes interagency coordination and cooperation, well-established procedures, maintenance of a network of outside technical assistance, well-organized data management activities, and skillful handling of direct communications with the affected public.

Risk Assessment Manpower

At the State and local levels, possibly more often than at the Federal level, risk assessment and management activities are mixed. The conduct of any single risk assessment generally requires the application of knowledge and skills from several persons, among them at least one with a general understanding of the process in order to integrate the contributions of others. Such specialties as epidemiology, toxicology, industrial hygiene, engineering, statistics, mathematics, clinical medicine, and others are often involved (*20*). One person may have knowledge and skills in one or more of these fields, and the key is to assemble a team to provide reasonably comprehensive coverage of a variety of knowledge and skill areas.

Figure 2 elaborates on manpower and training questions using terms defined by a report of the American Public Health Association (*21*). APHA proposed an "approach to personnel classification that would characterize the workforce according to three major dimensions (work organization, work, worker) . . . ." The first step is to define risk assessment—the task, the activities, and the technologies (the work). This leads to better understanding of the skills and knowledge of people who contribute to risk assessment (the worker). Finally, there is the milieu in which those talents are brought together to solve risk assessment problems (the work organization) (box). Elements of risk assessment are further defined in figure 1.

To illustrate the application of this framework, consider the example of an environmental health risk assessment of organic chemical contamination of a water supply by a hazardous waste site. The chemicals contaminate ground water, the source of drinking water for a major metropolitan area. There is no readily available standard for this

organic contaminant on which to base a decision concerning the safety of the water.

To make an environmental health risk assessment, the work probably involves geologic and hydrogeologic investigation of the site, sampling and analysis of water, and evaluation of the acute or chronic toxicology, or both, of the contaminants in the water. Epidemiologic assessment of disease patterns in the community, or at least an assessment of available data, may be needed.

The information must be integrated to characterize the risk to the community realistically (box, risk characterization). In this assessment, some, but not necessarily all, of the technologies of toxicology, epidemiology, statistics, hydrology, geology, and analytical chemistry may be required. Activities include directing, sampling, and analyzing (both laboratory and statistical). Several different types of workers, including physicians, engineers, geologists, chemists, and hydrologists, may be involved. Some may be classified as scientists or epidemiologists, with titles such as chronic disease epidemiologist, analytical chemist, public health geologist, and environmental scientist.

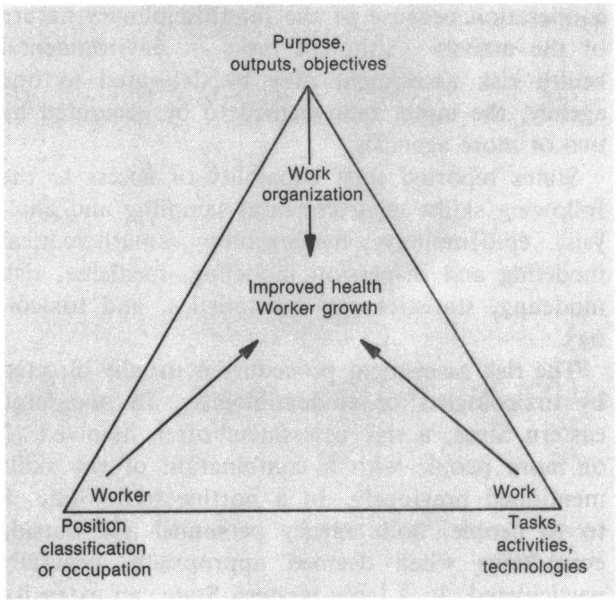
The objective is to provide an estimate or estimates, of risk which can be related to rational alternative actions and remedial measures to deal with the problem and to protect the public health of the people in the community. At this point the process begins to focus on remedial measures, which are part of risk management (figure 1, risk management). The application could be for an individual site, or a more general approach to solve a community-wide problem, such as the development of regulatory options.

Although the example is hypothetical, the conditions are representative of local and State government settings, based upon the several sources of information examined. Risk assessment and risk management may merge, with some of the same persons participating in both. However, decision making in risk management often must be expanded into the public and political arenas.

State Government Experiences

A survey to define the skills and knowledge of those involved in environmental health risk assessment has been conducted by the Conference of State Health and Environmental Managers. In the survey the States were asked who was involved in environmental health risk assessment relating to hazardous waste. This elicited information primarily about organizational structures of public agencies dealing with hazardous waste site safety for workers and communities. Followup telephone inquiries to six States provided additional information, including a considerable amount of written material. The six States were selected on the basis of geographic distribution and population density. Telephone inquiries identified persons involved in environmental risk assessment including those involved with hazardous waste situations.

Figure 2. Locus and definition of "job" concept



SOURCE: Reference (21)

More than one respondent stated that the only competency now lacking in the work force was a basic knowledge of risk assessment methodologies. They emphasized the importance of understanding assumptions made during the risk assessment process and how those assumptions affect the precision of the numbers generated. Respondents in two States indicated a need for more interdisciplinary training. For example, a person with a PhD in epidemiology might need more formal training in toxicology and a familiarity with environmental sampling and monitoring methodology. Other needs expressed were an understanding of the legal aspects of environmental issues and the ability to relate to the news media.

Respondents in two States said that they lacked sufficient funds to attract well-qualified persons into government positions to perform environmental risk assessments. One said they lacked a toxicologist for that reason.

States' organizational structures for dealing with community risk assessment show variation. Those

States providing information relied on interagency cooperation because of the interdisciplinary nature of the activity. Although tasks of environmental health risk assessment may be delegated to one agency, the input data seemed to be generated by two or more agencies.

States reported staff capability or access to the following skills: environmental sampling and analysis, epidemology, hydrogeology, mathematical modeling and dispersion modeling, medicine, risk modeling, statistics and biostatistics, and toxicology.

The risk assessment procedure is usually directed by toxicologists or epidemiologists. In one large eastern State, a risk assessment often involved 12 or more people with a combination of the skills mentioned previously. In a northwestern State, 8 to 10 people, both agency personnel and outside consultants when deemed appropriate, generally participated. In a large western State, an extensive environmental risk assessment program received its primary impetus from epidemiologists. In a large industrialized midwestern State, the departments of natural resources and public health cooperatively conducted environmental health risk assessments. The natural resources agency had nine aquatic and six terrestrial toxicologists and the health department had one toxicologist responsible for risk assessment.

The program in a sparsely populated southwestern State is based in an epidemiology section within the environmental agency. In another State similar in population density and location, the process is led by a person who was originally trained in infectious disease epidemiology, but who refers to his current field of practice as "environmental epidemiology." This environmental epidemiologist considers this discipline to be a cross between the two traditional spheres of infectious disease and chronic disease epidemiology.

Lapham and Castle (*6*) reported on a survey of State environmental epidemiology programs. Their definition of environmental epidemiology is similar to chronic disease epidemiology: a field "separate from communicable disease epidemiology" devoted to environmentally related diseases. They found that the most common problems investigated were indoor air pollution, exposures to toxic or hazardous substances and pesticides and that all State health agencies had conducted "investigations that could be considered environmental epidemiology." Further, they indicated that most of these programs were directed by physicians; comparatively few toxicologists participated.

From our inquiries made to State agencies, we observed that epidemiologists conducting environmental health risk assessments often functioned in a somewhat broader context than the more traditional view of epidemiology. For instance, one State which bases its program in the Epidemiological Studies Section actually employed sociologists, biochemists, toxicologists, environmentalists, physicians, and statisticians in addition to epidemiologists.

It would appear that a purely epidemiologic response to most situations requiring environmental health risk assessments may be somewhat narrow. Often epidemiologic data are not available for specific environmental problems. The population at risk may be too small, or there may not be sufficient time to conduct a full scale epidemiologic investigation. Respondents in one of the larger States confirmed this observation, stating that it is almost impossible to use data from disease registries for environmental risk assessment because the population exposed in a specific incident is usually too small for meaningful conclusions based upon epidemiologic analyses. Although it is important to incorporate epidemiology into the risk assessment process, it is as important to understand the limitations of epidemiologic studies and data.

Because of the nature of the process, risk assessment should include application of the skills of people with toxicological training, in addition to incorporating the participation of people with other skills, such as the air quality measurement capabilities of the industrial hygienist. Those States with well-developed risk assessment capabilities generally do include persons with these additional skills. However, in the area of hazardous waste management, in which risk assessment should be a fundamental element, the CSHEM data indicates a significant lack of toxicologic input. This may either result from a lack of trained personnel or inadequate coordination of resources available in State agencies.

Education and Risk Assessment

A study by the Rand Corporation (*21*) indicates that risk assessment courses are offered in many fields, including nuclear engineering, health and safety, civil engineering, business administration, insurance, and law. However, the term may have different meanings in each discipline. Course listings from the schools of public health accredited by the Council on Education for Public Health

were reviewed to determine the availability of courses in risk assessment methodology and environmental epidemiology. Of the 18 schools which provided sufficient information in their catalogs, 6 had courses in environmental risk assessment, and 9 had courses or programs in environmental epidemiology. Although this finding might give some indication that, in the future, risk assessment skills will become more commonplace in the public health trained work force, at this juncture not enough is known about specific course content and numbers of students enrolled to predict accurately the impact of this training. This could be one of several possible questions for followup studies. Future studies could also solicit information about training provided by other graduate and undergraduate programs.

Because States have difficulty in attracting well-qualified persons with the competencies needed for environmental health risk assessments, an attractive option is to provide retraining opportunities so that staff members can move into positions from other areas of public health and become prepared to participate as full or part-time risk assessment team members. Strong candidates for retraining often come from units of the agency with responsibilities in epidemiology, industrial hygiene, laboratory, engineering, and toxicology. Short courses and continuing education classes will enable people to acquire competency in risk assessment. It is important that risk assessment education stress an understanding of the assumptions and limitations involved in the process. As schools of public health and other academic units which train the future employees of health and environmental agencies incorporate into their academic programs basic skills in environmental risk assessment, the emphasis in continuing education courses can shift to the polishing of skills and application of new technologies.

Summary

The knowledge and skills needed to analyze environmental health risks, and the educational preparation of those involved, were reviewed, with particular reference to State agencies. Information was derived from literature sources, interviews with those conducting risk assessments, and a survey of catalogs from schools of public health. Data were categorized according to job locus and definitions as proposed in an earlier health manpower study.

State risk assessment programs include a core

Summary of Risk Assessment Descriptors

Work organization objectives

Standard setting
Planning remedial measures
Interpreting remedial measures to the public
Dealing with private consultants

Work tasks and activities

Surveys of environmental parameters
Epidemiologic studies
Visual surveys
Response to citizen complaints
Collection and analysis of epidemiologic, toxicological, and physical data
Estimation of risks associated with various alternative remedial measures
Geological and hydrogeological investigations
Sampling and analysis of water, air, groundwater, fish, or soil
Integration and analysis of data (risk assessment)
Detection and reporting of problems which may require risk assessment
Collection of data in cooperation with another agency
Air dispersion modeling
Chemical analysis of physical properties of contaminant
Communication

Work knowledges and skills

Toxicology
Epidemiology (environmental epidemiology)
Hydrology
Geology
Analytical chemistry
Environmental sampling and analysis
Medicine
Engineering
Mathematical modeling and dispersion modeling
Risk modeling
Statistics and biostatistics
Biochemistry
Sociology
Computer programming
Organic chemistry
Demography (exposure patterns)
Physics
Bacteriology
Electronic data management
Nursing
Industrial hygiene

SOURCE: Reference 21.

team of professionals with expertise in toxicology, epidemiology, industrial hygiene, medicine, biostatistics, chemistry, and hydrogeology; interagency coordination and cooperation; maintenance of a network of outside technical assistance; well organized data management; and skillful handling of communication with the public.

Some States require additional personnel trained in risk assessment methodology and related skills. Training for the core disciplines is generally available. However, there is a lack of training in basic risk assessment methodology. This training should stress an understanding of the assumptions and limitations involved in the process. In-depth training should be provided for persons who provide technical leadership of risk management teams. An overview of the risk assessment process should be provided for team participants from other disciplines. Continuing education is an important part of the response to this training need. However, it is not clear at this time if sufficient training is available or if there are the resources to support this training within the already strained budgets of government agencies.

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