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RISK COMMUNICATION:

UNCERTAINTIES AND THE NUMBERS GAME

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INTRODUCTION

The science of risk assessment seeks to characterize the potential risk in situations that may pose hazards to human health or the environment. However, the conclusions reached by the scientists and engineers who perform risk assessments are not an end in themselves. These conclusions are passed on to the involved companies, government agencies such as the U.S. Environmental Protection Agency, legislators, and the public. All the interested parties must then decide what to do with the information at hand. Risk communication is a type of technical communication that involves some unique challenges. This paper first defines the relationships between risk assessment, risk management, and risk communication and then explores two issues in risk communication: addressing uncertainty and putting the risk numbers into perspective.

DEFINITIONS

Three relevant terms must be defined: *risk assessment, risk management,* and *risk communication.* The order of these tasks is not sequential, and, ideally, much overlapping occurs among them.

Risk assessment is defined by the National Academy of Sciences as the characterization of the potential adverse health effects of human exposures to environmental hazards. This type of assessment describes the potential adverse health effects after evaluating the results of epidemiologic, clinical, toxicologic, and environmental research; extrapolates from those results to predict the type of health effects in humans under particular conditions of exposure and estimate their extent; identifies the populations who will be exposed; and summarizes the overall magnitude of the public health problem. A risk assessment also characterizes the uncertainties inherent in inferring risk (Paustenbach 1989).

Risk management, also as defined by the National Academy of Sciences, is the process of evaluating alternative regulatory actions and selecting among them. In performing risk management, regulatory agencies should consider political, social, economic, and engineering information along with risk-related information to choose the best regulatory response to a potential chronic health hazard. This process by definition requires the use of value judgments about the acceptability of risk and the reasonableness of the costs (Paustenbach 1989).

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The "bad" (or politically incorrect) definition of *risk communication* is the presentation to the public of facts, determined by scientists and engineers, and policies, developed by the government. Usually inherent in this conception is the assumption that the audience is not too bright and full of unfounded fears and suspicions about the topic. Moreover, the purpose of such communication is primarily to convince the public that the foregone conclusions are the best possible solutions.

The "good" definition of *risk communication* is "an interactive process of exchange of information and opinion among individuals, groups, and institutions. It involves multiple messages about the nature of risk as well as other messages, not strictly about risk, that express concerns, opinions, or reactions to risk messages or to legal and institutional arrangements for risk management" (National Research Council 1989). In stark contrast to the "bad" definition, this assumes that people have valuable knowledge and concerns regarding the risk, although their information and opinions may be different from those of the "experts" from science, industry, and government. Also, the good definition of risk communication assumes it is a process whose outcome is not predetermined; it is not simply a presentation of the "facts."

Entire books can, and have, been written about risk communication. This topic can involve many issues, such as audience assessment, media coverage, community outrage, trust, public meetings, and ethical concerns. However, this report is limited to two specific aspects of risk communication: how uncertainty in the risk assessment process is discussed and how the risk numbers are put into perspective for the audience. Some means of addressing each aspect are presented, and examples are analyzed.

ADDRESSING UNCERTAINTY

Risk assessment, by its very definition, has many inherent uncertainties. Although it embodies scientific facts and principles, it is not pure science; moreover, even science is never 100% certain. Some of the uncertainties in a risk assessment stem from the underlying studies that provide standards for predicting risk. For example, laboratory studies subject animals to extremely high doses of chemicals and then extrapolate the results to realistic doses for humans. This practice contains two major areas of uncertainty. First, just because a high dose produces a negative health effect does not necessarily indicate that smaller doses will result in a proportionately smaller negative effect. Second, even toxicologists do not all agree that the responses of laboratory animals can be assumed to be the same as those of humans (Kraus et al. 1991).

Another source of uncertainty in risk assessment is the judgments that must be made by the scientists and engineers conducting the assessment. Because assessments are predicting possible outcomes, and then predicting how likely each outcome is, many assumptions underlie the conclusions. By using different models and assumptions about particular situations, the risk assessors might come to different conclusions. Moreover, the risk managers who use the information from risk assessments are making value judgments about what is more important and how much cost is justified for particular answers.

Because risk assessment is an evolving field, the data available to risk assessors are always being tested, added to, and evaluated. In addition, some important information is still not known, so risk assessors are trying to complete the puzzle when some of the pieces are missing. For example, the actual costs and benefits of particular technologies and approaches have yet to be tested, so decisions must often be made without truly knowing how they will work in practice.

These examples illustrate only a few of the inherent uncertainties in risk assessment and management. Having established that these uncertainties exist, we should address how they are presented in risk communication. Although no professionals in the field would deny that uncertainty exists, their opinions and practices about explaining uncertainty to the public are not so unanimous.

Some officials may try to sound more sure than they are because they want the public to believe the conclusions being presented. This practice "makes them vulnerable to charges of inaccuracy, at best, or 'cover up' at worst" (Chess 1990). Although it is natural to try to sound confident when attempting to persuade, this tendency feeds into the "bad" definition of risk communication (that is, to persuade rather than to inform and discuss). Likewise, not acknowledging uncertainty up front can put a company or an agency in the position of being defensive when inevitable questions about uncertainty are raised by the media or by the public, and being defensive "implies that you have something to be defensive about" (Hance et al. 1991).

One argument for not explaining uncertainty contends that risk assessment is a very complex, sophisticated process. If assessors try to explain, for example, that different methods can be used to extrapolate the information from animal studies, some lay members of the public might simply conclude that the assessors do not know what they are doing. Some assessors — rather than presenting such scientific debates, which can confuse the public and jeopardize their credibility — avoid the subject altogether (Sheridan 1990). Others agree, arguing that admitting uncertainty only gives the public more ammunition with which to attack the assessment and the assessors (Hance et al. 1991).

This position is at best naive and at worst completely destructive for anyone trying to communicate risk to the public. The "public" comprises many intelligent, analytical adults who take the issues of potentially hazardous chemicals in their food or releases by industries in their neighborhood very seriously. If a risk communicator (scientist, engineer, agency representative, or media relations person) assumes that the public has no previous knowledge about risk, he is certainly underestimating his audience. By not acknowledging uncertainty, the risk communicator insults the ability of the public to understand subtleties and make educated decisions.

Moreover, questions about these areas of uncertainty will arise, and the audience is more likely to be receptive to the answers if offered by the risk communicators rather than having to be dragged out of them. Also, by being clear about what is certain and what is not, the risk communicator can dispel the public's concern that the risk assessment is all fiction. An honest and straightforward presentation about uncertainty will help to further a sense of trust among the public, which is one of the most important factors in successful communication.

Discussions of uncertainty are often included in documents that present the results of risk assessments. These discussions can help to explain the methodology used to arrive at the conclusions. A good example (slightly altered from the original; source is not relevant) of how one aspect of uncertainty can be presented follows:

> The uncertainty associated with each input or computational source could be estimated, and the resultant uncertainty in each set of calculations could be predicted. Thus, one could propagate the uncertainties from one set of calculations to the next and estimate the uncertainty in the final, or absolute, result. However, conducting such a full-scale quantitative uncertainty analysis is often impractical and sometimes impossible. Instead, the risk analysis is designed to ensure — through uniform and judicious selection of scenarios, models, and input parameters — that relative comparisons of risk among the various alternatives are meaningful. In the transportation risk assessment, this objective is accomplished by uniformly applying input parameters and assumptions to all alternatives. Therefore, although considerable uncertainty is inherent in the absolute magnitude of the transportation risk for each alternative, much less uncertainty is associated with the relative differences among the alternatives.

This paragraph makes an important point that underlies the risk assessment process. The assessment is designed to compare the relative risk among the different alternatives being considered and not to project the exact outcome of any single action. By articulating this in a risk communication document, the author can help the reader better understand the framework within which the risks are being considered by the risk assessors and managers.

Newspaper articles are an example of one way in which the public is informed about potential health risks. This type of information is then used by the public to understand more direct communication from the experts who, for example, write environmental impact statements. Last year, the *Chicago Tribune* published an article about the health risks of herbicides in drinking water (Francis 1994). This article, although fairly short, is a good overview of a complex issue:

> Three weeks after an environmental group reported that herbicides are common in Midwestern drinking water, the EPA has called for a thorough examination of the chemicals to determine if they are too risky to use.
>
> By calling for a review of the herbicides and linking them to breast cancer, the EPA lands itself in the middle of an old but unresolved debate: How much risk is too much when it comes to cancer?
>
> The evidence is there, scientists agree. Three widely applied herbicides — atrazine, cyanazine, and simazine — increase the rate of breast cancer in some rats during laboratory testing. And most researchers agree that a carcinogen for rats is probably a carcinogen for humans.
>
> But when it comes to calculating and judging relative risk, consensus falls apart.
>
> "A carcinogen is a carcinogen," said Marvin Legator, director of the University of Texas at Galveston's Division of Environmental Toxicology. "Where we really have a problem is trying to put a number on it."
>
> The numbers reported by the Environmental Working Group in October are big. The activist group, which focuses on chemical contaminants in food and water, reported that 10.2 million people in the Midwest drink water containing two to four herbicides, and by drinking the water 3.5 million people in 120 communities are running a risk of getting cancer 10 to 100 times greater than some federal benchmarks allow.
>
> Legator said such numbers are at best complex guesses and often "totally inaccurate."
>
> To arrive at cancer risk factors, researchers test varying doses of a chemical on animals, often rats.

Looking at the likelihood of cancer cases at doses ranging from massive to imperceptible, analysts adjust the numbers to represent the incidence of tumor growth for the doses a human would encounter.

"If we are forced to extrapolate from animals to people, we come up with . . . underestimates or overestimates," Legator said. "God created risk assessors to make astrologers look good."

Legator said it is very difficult to trace human cancers to one cause. In laboratories, chemicals are tested in animals one at a time.

"If you are exposed to a carcinogen, regardless of how small, it's an incremental effect," he said, and each factor — from pesticides to genes to diet — contributes to each individual's chances of getting cancer.

"[Triazines might be] a contributing factor, but it's only one . . . . In humans it's [also] our genetic makeup, it's also our lifestyle that determines whether we get cancer," Legator said.

But Richard Wiles, vice president of the Environmental Working Group, said risk assessments are useful to determine just how toxic carcinogens are.

He said that regardless of the methods used, the federal government has set certain standards for food — standards that he said are more stringent than those for drinking water.

"Apply the standards that you have," Wiles said.

David Baker, director of the Water Quality Laboratory at Ohio's Heidelberg College, has another problem with the risks: They add up to what he called a "negligible" increase in cancer.

Even accepting the environmental organization's methods, which Baker said he doesn't, the herbicides would lead to between two and four more cases of cancer a year over 70 years, depending on whether you account for just those 120 communities or for the entire region.

"If you had four additional cancers in Chicago in a year, it would not be noticed," Baker said. "I think the risks are negligible."

Wiles countered, however, that by translating the number of additional annual cases into the more common "lifetime" figure over 70 years, these herbicides alone would give about 200 people cancer.

"We don't believe in negligible risks," Wiles said.

"We think three people getting cancer a year is three too many, and that's not necessary. There's no need to put people's health at risk for a surplus food supply."

This article introduces several key uncertainties in the debate about use of chemical herbicides, and, more generally, risk assessments for carcinogenicity. It raises questions about the validity of animal toxicity testing and extrapolating from high to low doses, and it advises readers to view one carcinogen in the context of all of the factors that affect a person's likelihood to get cancer. The journalist has interviewed people with divergent perspectives: Baker, who considers the risks to be negligible, and Wiles, who doesn't "believe in negligible risks." Moreover, the issue is framed within the relevant, broader question faced by us as a society: "How much risk is too much?" By posing this question near the beginning of the article, the author invites the reader to join in the debate along with government agencies, scientists, and activist groups.

The issue raised about "negligible" risk is worth further discussion. In communicating about risk, we need to be sensitive to word choices. In this context, the use of the word "negligible" can cause an emotional reaction from people who perceive that the potential loss of life can never be considered negligible. This term has become common in risk assessment, however, and may not be avoidable. The word "negligible" must be clearly defined in any risk communication, and the possible consequences of using this word should be considered.

Risk communicators in government and industry often criticize the way the media portray subjects about risk and risk assessment; however, the roles of the news media and risk communicators are different (Klaidman 1990). Risk communicators seek to inform and educate the public about the risks being assessed by their companies or agencies; the desired result is a viable solution that is scientifically appropriate, economically feasible, and socially acceptable. Journalists, on the other hand, seek to present stories of interest and topical relevance to the public. They are less concerned with giving their audience an in-depth, well-rounded perspective and more concerned with what is newsworthy. They focus on events rather than issues.

Instead of seeing the media as an enemy in their efforts to educate the public, risk assessors and risk communicators should try to be available to journalists to ensure that the information presented is correct. Risk communicators can also learn from journalists; the questions journalists ask are often the types of questions that the public wants answered about uncertainty and other aspects of the risk. Instead of criticizing the journalists' lack of focus on appropriate issues, risk communicators should consider addressing these questions themselves (Bruening 1990).

This discussion acknowledges some of the uncertainties inherent in risk assessment. In some cases, further research and implementation will eliminate the uncertainty; however, risk assessment will always involve some judgments on the part of the risk assessors and risk managers. After considering some of the reasons that risk communication has not always explained, or at least acknowledged, these uncertainties, it seems clear that the benefits of addressing uncertainty outweigh the negative consequences from not addressing it.

PUTTING RISK NUMBERS INTO PERSPECTIVE

One of the most challenging aspects of risk assessment to communicate is the magnitude of risk. Even for an intelligent adult, it is difficult to comprehend what an incremental risk of 1×10^{-6} means. Risk communicators have attempted to present this information in a variety of ways, some of which are more successful than others.

A complicating factor in this issue is its emotional aspect: these numbers represent people. Even though the numbers are not "real" (that is, a risk of 1×10^{-6} does not mean that for every million people in the exposed population, one person will definitely die from cancer because of exposure), it is impossible to deny their relationship to the actual lives of actual people. Any attempt to completely do so will only incense the audience because of the attempt to "depersonalize" the hazards.

One way that risk communicators have tried to put the risk numbers into perspective is by ranking the risks of various common activities with the risks of more potentially "dangerous" activities such as living near a nuclear power plant. This approach can really backfire with audiences, because such comparisons can be perceived as being highly manipulative. Several criticisms can be made of risk rankings that compare activities like "remaining single," "commuting to work by car," and "living near a nuclear power plant." First, this method is like comparing apples with oranges; some of the activities listed in such rankings have absolutely nothing to do with each other. Second, such mismatched lists compare activities that individuals can choose to engage in or avoid (like smoking) with situations that will be imposed upon them (like the siting of a nuclear waste facility).

Finally, these comparisons imply that if an individual is willing to accept a larger risk from a voluntary activity, then he should be willing to accept a comparatively smaller risk that the experts consider to be insignificant. That implication is neither logical nor acceptable to most people and is likely to make a reader angry, thereby considerably decreasing the chance that he will continue to read the risk communication with an open mind. Also, comparable risks from a known factor and an unknown factor are not necessarily equally acceptable to the public (National Research Council 1989). Although such risk comparisons usually backfire if the purpose is to reassure people, they can help alert people to an imminent danger (Hance et al. 1991).

Some valuable suggestions for putting risk numbers into perspective have been compiled in *Improving Dialogue with Communities: A Short Guide for Government Risk Communication* (Chess et al. 1991). This guide suggests comparing similar situations or substances, as in the following examples: comparing the same risk at two different times, comparing with state or federal standards for risks, comparing different estimates of the same risk (comparing the government estimate with that of industry or environmental groups), and comparing risks in different communities with each other or with national averages. In general, it is preferable to discuss a risk in several different ways to help the reader better understand the numbers; different readers may find different examples helpful.

A good example of risk characterization that puts the numbers into an understandable perspective can be found in the *Feasibility Study for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (U.S. Department of Energy 1992):

> Potential carcinogenic risks from radiological and chemical exposures were estimated for the human health assessment in terms of the increased probability that an exposed individual could develop cancer over the course of a lifetime. The U.S. Environmental Protection Agency has identified a range of 1×10^{-6} to 1×10^{-4} — or 1 in 1 million to 1 in 10,000 — for the incremental risk associated with an National Priorities List site (EPA 1990). This range is referred to as the target range in this discussion, and it provides a point of reference for the site-specific risks presented in the baseline assessment and feasibility study. For comparison, about one in three Americans will develop cancer from all sources, and it is estimated that 60% of cancers are fatal (American Cancer Society 1992). These estimates translate to a cancer risk of about 2×10^{-1}, or 1 in 5. The individual lifetime risk of fatal cancer associated with background radiation, primarily from naturally occurring radon, is estimated to be about 1×10^{-2}, or 1 in 100 (EPA 1989).

Several approaches used in this paragraph are worth noting. First, the authors present the risk range that the U.S. Environmental Protection Agency has developed for sites like the one being studied. That approach allows the readers to put the risk numbers that will be discussed into a regulatory perspective. Next, the authors compare that range with the American Cancer Society's estimates for how many Americans will develop cancer in their lifetimes. The risk of receiving cancer from background radiation further helps the reader to put the risk numbers into an understandable context. The writing in this example is clear and accessible without being overly simplistic or needlessly filled with technical jargon.

Another good example of how the risk of contracting cancer can be explained follows:

> Persons exposed to a carcinogen have a risk of contracting cancer, but there is no certainty that they will. For example, not everybody who smokes cigarettes gets cancer. The derivation of a risk-based dose therefore requires identifying a risk level that policymakers are willing to accept. The risk range that the EPA most often assumes in deriving "safe levels" for carcinogens is from 10^{-4} to 10^{-6}; that is, a risk that 1 person in from 10,000 to 1 million people will contract cancer.

This discussion raises several valuable points. First, it explains that the risk numbers do not directly translate into actual people who will die from cancer. Also, it makes the point that policymakers (not scientists) decide what an acceptable risk level is. This reference to policymakers can remind the reader that risk assessment and risk management are complex processes that are not performed in isolation by a single group.

In trying to explain a new or unfamiliar concept, we often use comparisons with something that is more familiar. Although this tool can be helpful in learning, comparisons in risk communication must be used with care. An inappropriate comparison can be worse than no comparison at all if it makes the reader unreceptive to the information being presented. However, despite the potential problems, the well-reasoned use of applicable comparisons will continue to be a valuable aspect of risk communication. And over time, the comparisons that risk communicators use should become more appropriate to the topics and more accessible to the audiences.

CONCLUSIONS

Just as the science of risk assessment is relatively young, the art of risk communication also has much growing up to do. The communication of uncertainty and risk numbers will continue to improve as risk communicators learn more about what methods are effective. Two valuable lessons have already been learned: (1) the uncertainties inherent in risk assessment must be addressed in risk communication and (2) if risk numbers are to be effectively compared, the risks themselves must be comparable (that is, related in a direct and understandable way).

Risk assessors and risk managers need to consider these, and other, aspects of risk communication when they are preparing their assessments and presenting them to the public. Good science alone does not guarantee good risk communication. Further, good risk communication does not guarantee that the public will accept the conclusions arrived at by the risk assessors and risk managers (National Research Council 1989). Instead, risk assessors, managers, and communicators would do well to accept the "good" definition of risk communication and see it as a dialogue among all interested parties.

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