Precautionary Assessment: Getting Out of the Risk Assessment Box

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November 12 2006

Introduction

"We should remember that risk assessment data can be like the captured spy: If you torture it long enough, it will tell you anything you want to know."
William Ruckelshaus (1st administrator of U.S. EPA) 1984.

Our children have a right to an environment that allows them to reach and maintain their full potential and we have a duty to provide it. One tool used to exercise this responsibility is risk assessment, which evaluates the potential exposures and hazardous of chemicals or activities. In the best cases we evaluate the risks and take precautionary measures such as requiring the use of seat belts in cars. In other situations, despite knowledge of risk, we have allowed promotion of hazardous behavior such as the use of tobacco products.

Despite a layer of quantitative analysis and rationality, risk assessment is an expression of our values and ethical decision making; it is a blunt tool for a complex problem. The over whelming advantage of classical quantitative risk assessment is that it is mathematically definable producing a number and is simple. The corresponding disadvantage is that it is simple minded. Some might conclude that the current risk assessment approach is both arbitrary and capricious in its attempt to characterize the uncertainty that surrounds hazard and exposure assessment process. Among many deficiencies, the classical risk assessment approach fails to address community and environmental justice issues.

The goal of precautionary assessment (PA) is to move beyond risk assessment and allow communities and individual to incorporate their knowledge, values and ethics into a more comprehensive evaluation of a hazardous condition. Precautionary assessment combines the philosophy and ethics of the precautionary principle[1 2] with the standard scientific evaluation of the hazard and exposure. PA is built upon a belief that we have the knowledge and also a duty to prevent disease and promote human and environmental health. The risk assessment of toxic agents must change if we are to prevent adverse

health effects and truly protect the potential of our children and indeed the children of all species.

Principles of Risk Assessment

"What is food to one man may be fierce poison to others."
Lucretius (c. 99 B.C.–c. 55 B.C.)

In it simplest form risk is defined as function of an agent's hazard and your possible exposure. This is often written as: Risk = Hazard X Exposure. A major missing part of this formulation of risk is individual sensitivity. For example, for most people there is no risk from exposure to peanuts but for some an allergic response to peanuts can be deadly. Hazard is derived from the classical dose / response relation usually with the adage that the dose makes the poison. Again, the response is dependent on the sensitivity or susceptibility of the individual. The dose / response relationship is usually defined from research studies with animals or assessing the consequences of human exposure. A major challenge is determine what is the most sensitive response endpoint.

Quantitative Risk Assessment (QRA) developed during the 1960-1970s primarily to provide a numerical means to evaluate the likelihood of developing cancer. QRA was formally defined as: "Process of estimating association between an exposure to a chemical or physical agent and the incidence of some adverse outcome."[3] This methodology was eventually expanded to non-cancer endpoints such as developmental effects of hazardous agents. A primary goal of QRA was to numerically address the inherent uncertainty of the risk assessment process.

Risk assessment is often characterized as a four step process. 1) Hazard identification – using structure activity relationship, cell culture, animal studies or human studies to characterize the hazard. 2) Exposure assessment – evaluates the type and means of exposure as well who or what might be exposed. 3) Dose / response assessment – determines appropriate end points or response and mathematically characterize the dose / response relationship, which usually means extrapolation to the lowest doses that might produce a response. 4) Risk characterization – brings all this information together to characterize the risk.

The Four Elements of Standard Risk Assessment
1. Hazard Identification 2. Exposure Assessment 3. Dose-Response Assessment 4. Risk Characterization

The risk assessment process can seem to be arbitrary and capricious with application of various safety factors, which usually means divide the dose by 10, to account for uncertainty. For example if there is animal data but no human data, the dose that produced no effect in animals would be divided by 10. Other incidences that one might use the divide by 10 rule would extrapolating from adults to children, absence of a no

effect dose, or only short term studies and no long term studies. Of course some would argue that 10 is to much and only a safety factor of three or two is sufficient which greatly changes the risk assessment. The end point of the classic risk assessment is a reference dose (RfD) or the amount that the most sensitive individual can consume daily over a life time.

The inadequacies of classical risk assessment have been recognized by others (see below), while some agencies have sought to address the more glaring deficiencies. The World Health Organization The International Programme on Chemical Safety (IPCS) developed an Integrated Risk Assessment that emphasizes a multimedia and ecological assessment[4]. The U.S. Environmental Protection Agencies - National Center for Environmental Assessment (NCEA) – is also investigating ways to expand risk to be more inclusive[5]. However, neither of these approaches explicitly addresses community and societal issues.

Risk Assessment – example Mercury

"For then she bare a son, of many shifts, blandly cunning, a robber, a cattle driver, a bringer of dreams, a watcher by night, a thief at the gates, one who was soon to show forth wonderful deeds among the deathless gods..."
Description of the birth of the Greek God Mercury

Mercury is a fascinating compound, incredibly versatile, changeable from a metallic form to an organic form and we now know is very hazardous particularly to the developing organism. There are no doubts that mercury bioaccumulates in fish and is a well established neurotoxicant at low levels of exposure[6]. Risk assessment tries to determine if there is safe level of exposure particularly for the most vulnerable such as women of child bearing age and children. When developing a risk assessment on mercury exposure, one starting point is a non-human primate study that found adverse effects at a dose of 25 µg/kg. The first step is to divide by 10 to establish a no effect dose (2.5 µg/kg), then divide by 10 to extrapolate from animals to humans (0.25 µg/kg), and finally divide by 10 to account for sensitive populations such as children to arrive at reference dose of 0.025 µg/kg. Discussion is often focused on this last divide by 10 and if it is truly needed to protect children. There is also human exposure and response data so a human risk assessment can be compared to animal assessment. The endpoint in the human studies was delayed on set of walking in infants exposed to mercury in utero. The maternal hair concentration ranged from 10-20 ppm (parts per million). The hair levels are then extrapolated to blood mercury levels of 40-80 ppb (parts per billion), which is then extrapolated to an estimated consumption of 0.645 µg/kg to achieve the estimated blood level. To protect children a safety factor of 10 is applied to yield a reference dose of 0.06 µg/kg. The reference doses from a risk assessment using animal and human data are fairly close. The EPA established a reference dose of 0.1 µg/kg-day based an analysis of available data of the effects of mercury on humans and animals. The FDA continues to hold 1 ppm (1 mg/kg) is an acceptable concentration of mercury in canned tuna. Clearly there is room for many disagreements and interpretations of a risk assessment of

mercury. The risk assessment numbers for mercury have profound policy implications and have formed the basis for numerous fish consumption advisories cross the United States, as well influencing state efforts to control coal fired power plant emissions of mercury.

Summary of Mercury Risk Assessment

Animal Data	Human Data
25 µg/kg – dose of effects in monkeys	10-20 ppm Hg in maternal hair
2.5 µg/kg – /10 to extrapolate to no effect	40-80 ppb – extrapolate to maternal blood
0.25 µg/kg – /10 to extrapolate to humans	0.645 µg/kg – extrapolate to dose
0.025 µg/kg – /10 for most sensitive individuals - children	0.06 µg/kg - /10 for most sensitive individuals - children

Weaknesses / Limitations of Risk Assessment

"Doubt is our product since it is the best means of competing with the 'body of fact' that exists in the mind of the general public."
1969 an executive at Brown & Williamson
owned by R. J. Reynolds Tobacco Company

Risk assessment has a number of serious weaknesses that make it appear arbitrary and capricious, which in turn reduces its value in establishing a consensus toward improved public health[7 8]. One of the biggest problems is that QRA as been come exceedingly complex procedures demanding experts in toxicology and risk assessment. This expert driven approach makes it difficult for community members to participate and is hence undemocratic. Risk assessment is supposed to be done on the most sensitive health effect or end point. However, the most sensitive health effect may not be known or there may be very little data on this health effect. Exposure information may also be incomplete or vary greatly among different groups of people. For example, high fish consumer will be exposed to more mercury than the occasional fish consumer. Once the endpoint is selected a dose / response relation must be derived. There are several different methods for extrapolating from higher to low doses and determining a dose where there is no health effect. Some compounds, such as lead, appear to have no safe level of exposure. We are also exposed to multiple chemicals which are now well documented in biomonitoring studies[9]. Most animal studies and risk assessment focus on evaluating the risk on only one chemical exposure at a time which is clearly problematic[10]. Human studies also struggle to account for exposure to multiple chemicals and approaches need to be developed[11].

Weaknesses of Risk Assessment
• Complex – expert driven – undemocratic • Lack of community involvement • Lack of adequate data • Most sensitive endpoint

- Low dose extrapolation
- Exposure information
- Multiple chemical exposures
- Individual sensitivity
- Narrow perspective – lack of community social and ethical

Precautionary Assessment

"Everything's got a moral, if you can only find it"
Lewis Carroll in Alice's Adventures in Wonderland

The goal of precautionary assessment (PA) is to move beyond risk assessment and allow communities and individual to incorporate their knowledge, values and ethics into a more comprehensive evaluation of a hazardous condition. The PA combines the philosophy and ethics of the precautionary principle with the standard scientific evaluation of the exposure and hazards. Precautionary assessment contains three basic elements: a) community and social issues, b) exposure issues, and c) hazard and toxicity issues. Each element is broken down into a series of questions that are scored numerically and summed to produce a summary score for each element. A lack of knowledge usually is indicated by applying the highest score. The PA is designed to help place the knowledge available within the context of the community. In contrast to the traditional risk assessment, the PA is a more comprehensive approach to evaluating the human and environmental health risks. Overall, the PA, by building upon the foundation of the precautionary principle, is a more reasonable, rational, and responsible approach to evaluating environmental and human health risks of chemicals[12].

The PA can be used by community members as a substitute for the standard risk assessment. The PA can be contrasted with a more standard risk assessment and officials or proponents of an activity can be asked to respond to the community's assessment of the situation.

The PA is a work in progress. Your comments and feedback are welcome. The elements of the PA are summarizes below, followed by more detailed examination and scoring for each element. Similar to the standard quantitative risk assessment, the PA produce a summary number for each element; the higher the score, the greater the concern. One approach for using the PA is for community members meet to develop a PA scores and then with proponents of an activity to determine if a conscience score can be reached. A spreadsheet with categories is available at www.asmalldoseof.org.[13]

Summary of precautionary assessment categories.

Community / Social Issues	Exposure Issues	Hazard / Toxicity
G = Goal N = Need	E = Exposure M = Multiple exposures	H = Hazard IS = Individual Sensitivity

F = Future Generations D = Democratic, community based process A = Alternatives	Ch = Children exposed CP = Consumer products O = Occupational exposure F = Food exposure	EC = Ecological hazard UC = Uncertainty V = Volume P = Persistent B=Bioaccumulate

Community and Social Issues

The community and social issues category allows community members to assess the impact of the agent or proposed action on their community. The fundamental question is does the action support a healthy and sustainable community. The goal of this section is to focus attention on the impact of the proposed action on the community.

Initial	Parameter	Score	Comment
	Community / Social Issues		Evaluate effects on the community and related social issues.
G	G=Goal	1-3	1-a lot, 2-some, 3-little. Does this move forward the goal of human and environmental health?
N	N=Need	1-3	1-a lot, 2-some, 3-little or not sure. Ask the question: Is it necessary? Do we really need this? What are the benefits?
F	F=Future Generations	1-3	1-little, 2-some, 3-high impact. Is there a potential impact on future generations of humans and other species?
D	D=Democratic, community based process	1-3	1-a lot of community involvement and consultation, 2-some, 3-little. Was the community consulted early and often in the process? Was the process democratic and inclusive.
A	A=Alternatives	1-3	1-alternatives were carefully considered, 2-some consideration, 3-no consideration. Where alternatives considered?
	Total	5-15	5-good, supportive of health and community 15-poor, not supportive of health or community

Exposure Issues

Exposure is a central element in evaluating risk. Assessment of exposure issues is critical but it must be expanded beyond just the evaluation of one agent or one source of

exposure. For example, are there multiple chemical exposures or are children likely to be exposed? Manufactures are generally not required to identify ingredients in consumer products or even pesticides. The goal of assessing exposure is to evaluate not only the amount but also our knowledge of the sources of exposure. Lack of knowledge or greater uncertainty will result in a higher score.

	Exposure Issues		Evaluate potential exposure issues.
E	E=Exposure	0-3	0-none, 1-little, 2-some, 3-high. Do we have control over the exposure?
M	M=Multiple exposures	0-3	0-none, 1-little, 2-some, 3-high. Is there exposure to other chemicals with similar hazard?
Ch	Ch=Children exposed	0,3,5	0-none, 3-little, 5-some or high or don't know. Children are often more vulnerable. Are children being exposed.
CP	CP=Consumer products	0-3	0-not in consumer products, 1-little, 2-some, 3- a lot or do not know. Is this compound in consumer products?
O	O=Occupational exposure	0-3	0-no occupational exposure, 1-little, 2-some, 3- a lot or do not know. Is there occupational exposure?
F	F=Food exposure	0-3	0-not in food supply, 1-little, 2-some, 3- a lot or do not know. Is the compound present in the food supply.
	Total	0-20	0-no exposure, no problems 20-significant exposure, serious concern

Hazard / Toxicity Issues

Hazard and toxicity issues are closely aligned with the standard toxicity or hazard assessment of an chemical or activity. An important aspect of a potential hazard is related to its persistence and bioaccumulation. This section focuses on the available science to establish a knowledge base about the hazards of an agent. Lack of knowledge or uncertainty results in higher score.

	Hazard / Toxicity		Evaluate potential hazards.
H	H=Hazard	1,5,10	1-low, 5-some, 10-high. Follow classical hazard evaluation, pick endpoint, exam relevant quality studies (cancer, reproductive, neurotoxicity, irreversible)
IS	IS=Individual Sensitivity	1-3	1-little 2-some, 3-a lot. Determine if any individuals are more sensitive than health adult such as the very young or old.

EC	EC=Ecological hazard	1-3	1-little 2-some, 3-a lot. Is it a hazard to other species or the environment?
V	V=Volume	1-5	how much is produced (1=research only, 2=<1000 lbs, 3=<10,000, 4=<100,000, 5=>100,000 or do not know)
P	P=Persistent	1-3	1-little persistence 2-some, 3-a lot of persistence or do not know. Is the compound persistent in the environment?
B	B=Bioaccumulate	1-3	1-little 2-some, 3-a lot. Does it bioaccumulative in humans or animals or move up the food chain?
UC	UC=Uncertainty	1-3	1-little 2-some, 3-a lot. How certain is the information?
	Total	7-30	7-low hazard 30-significant hazards or unknowns, serious concern

As an example, lead scores are detailed below and as expected lead scores poorly in call categories. Lead is a well know neurotoxicant and would predictably score very high. Currently the Centers for Disease Control and Prevention (CDC) has established a blood lead action level of 10 µg/dL for the start of intervention, which given current scientific and community information is unacceptably high[14]. A precautionary assessment is a further argument for lowering the blood lead action level.

Lead example
• Community / Social Issues - 12/15 • Exposure Issues – 16/20 • Hazard / Toxicity – 27/30

Conclusions

"When an activity raises threats of harm to human health or the environment, precautionary measures should be take even if some cause and effect relationships are not fully established scientifically."
Wingspread Conference, 1998.[15]

We have a right to an environment in which we can reach and maintain our potential.[16] PA is an approach to evaluating the scientific, safety, community, ethical, and social issues related to a chemical or procedure. It is tool to assist community members in developing a quantitative assessment of hazard and exposure issues combined with social and ethical standards that honor the community. An important goal of PA is to place the risk evaluation in the context of the community. A PA is designed to provoke discussion, point out uncertainties, and generate knowledge about the situation as well as challenge the conventional risk assessment approach.

While quantitative risk assessment is a powerful tool for summarizing the hazards and exposure associated with individual agents, it has a number of limitations that are often under emphasized. Precautionary assessment is a community based tool to be used as an alternative to or in conjunction with traditional risk assessment. Ideally the PA will build a foundation of community knowledge, empower community action, and prevent adverse health effects while promoting human and environmental health.

Ultimately, risk assessment is a blend of science, judgment, ethics, and policy. PA incorporates the science, social, and ethical aspects of hazard and exposure assessment while acknowledging the uncertainty and policy requirements with the goal of empowering community members.

"Environmental health is state that ensures that all living things have the best opportunity to reach and maintain their full genetic potential."
Steven G. Gilbert, 1999

References

[1] Meyers, N. K., and Rafensperger, C., eds. (2006). Precautionary tools for reshaping environmental policy. The MIT Press, Cambridge.

[2] Gilbert, S.G. Public Health and the Precautionary Principle. Northwest Public Health. Spring / Summer 2005. p 4. (http://healthlinks.washington.edu/nwcphp/nph/s2005/).

[3] National Research Council, Risk Assessment in the Federal Government: Managing the Process. National Academy Press, Washington, DC, 1983

[4] World Health Organization - The International Programme on Chemical Safety (IPCS) – Integrated Risk Assessment
http://www.who.int/ipcs/methods/risk_assessment/en/index.html

[5] U.S. Environmental Protection Agencies - National Center for Environmental Assessment (NCEA) –
http://cfpub.epa.gov/ncea/cfm/nceariskassess.cfm?ActType=RiskAssess

[6] Gilbert, S.G., and Grant-Webster, K.S. Neurobehavioral effects of developmental methylmercury exposure. Env. Health Persep. 103(Suppl 6), 135-142, 1995.

[7] Anonymous. Getting Beyond Risk Assessment. Rachel's Democracy & Health News #846. March 16, 2006. (access:
http://www.precaution.org/lib/06/alternatives_to_qra.060316.htm)

[8] Kriebel, D., Tickner, J., Epstein, P., Lemons, J., Levins, R., Loechler, E. L., Quinn, M., Rudel, R., Schettler, T., and Stoto, M. (2001). The precautionary principle in environmental science. Environ Health Perspect 109, 871-6.

[9] Pollution in People: A Study of Toxic Chemicals in Washingtonians. A Toxic-Free Legacy Coalition Report. Released May 2006. report available at: http://www.pollutioninpeople.org/

[10] Cory-Slechta, D. A. (2005). Studying toxicants as single chemicals: does this strategy adequately identify neurotoxic risk? Neurotoxicology 26, 491-510.

[11] Rice, D. C. (2005). Assessing the effects of environmental toxicant exposure in developmental epidemiological studies: issues for risk assessment. Neurotoxicology 26, 483-9.

[12] Gilbert, S.G. Precautionary Principle: Reasonable, Rational, and Responsible. Rachel's Precaution Reporter #17. "Foresight and Precaution, in the News and in the World". Wednesday, December 21, 2005. http://www.precaution.org/lib/05/ht051221.htm (Environmental Research Foundation http://rachel.org/).

[13] Gilbert, S.G. (2004) A Small Dose of Toxicology. CRC Press. Risk Assessment - http://www.asmalldoseof.org/toxicology/risk_assessment.php

[14] Gilbert, S.G. and Weiss, B. A Rationale for Lowering the Blood Lead Action Level From 10 to 2 µg/dL. Neurotoxicology Vol 27/5, September 2006, pp 693-701. http://dx.doi.org/10.1016/j.neuro.2006.06.008

[15] Raffensperger, C., & Tickner, J. (Eds.). (1999). Protecting Public Health & the Environment - Implementing the Precautionary Principle. Washington, DC: Island Press.

[16] Gilbert, S. G. (2005). Ethical, Legal, and Social Issues: Our Children's Future. Neurotoxicology 26, 521-530.