

Testimony of Barbara D. Beck, Ph.D., DABT
Regarding "Discussion Draft of H.R. ____, a Bill that would Revise
the Consumer Product Safety Improvement Act"

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Executive Summary

The lead limits stipulated by the Consumer Product Safety Improvement Act (CPSIA) of 2008 have forced many manufacturers to stop selling certain products, because the products contain components exceeding the current 300 ppm total lead standard of the Act. The difficulty with this approach to regulating lead in products is that it does not consider the *actual* exposure of children to lead. This is because the presence of lead in a product, as reflected by the concentration of lead, does not necessarily mean that there will be a significant exposure to lead. If the exposure to lead is very small, there will not be any health effects. Unfortunately, the present version of the CPSIA does not support consideration of exposure. Risk-based analyses that take into consideration age of child, exposure frequency and duration, exposure route, and dose represent a scientifically supportable approach to determine exclusions from the lead standard. In 2009, I recommended at a Congressional Briefing that that such risk-based analysis be allowed under the auspices of the Act. The "Discussion Draft H.R.____," dated March 29, 2011, proposed by the Subcommittee on Commerce, Manufacturing, and Trade to amend the Act, suggests just such an approach. Although details need to be worked out with respect to the testing method and specific criteria (*e.g.*, allowable lead exposure limits), conceptually the proposal, by focusing on *actual* exposure of young children to lead from a product, rather than concentration of lead in the product, represents an improvement over the present version of the CPSIA, while remaining health protective.

1 Introduction

Good morning and thank you for this opportunity to testify regarding the CPSIA and the need for a risk-based approach for lead in children's products. I am Barbara D. Beck, Ph.D., diplomate of the American Board of Toxicology (DABT), and fellow of the Academy of Toxicological Sciences. For 24 years I have been a toxicologist and Principal with Gradient, a firm specializing in human health exposure and risk assessment, and located in Cambridge, Massachusetts. Prior to Gradient, I held positions at the Harvard School of Public Health, US EPA Region I, and Tufts University School of Medicine. I am past president of the Academy of Toxicologists, and have been a DABT for 20 years.

Over my 30+ year career in toxicology and public health, I have worked extensively on projects involving lead. More than 20 years ago, while at US EPA Region I, I developed the first target action level for lead in soil. During my tenure at Gradient, I have worked for the private and the public sector on many projects involving lead exposure, toxicology and risk. These projects have included refinery and mining sites, children's toys, consumer products, and automotive vehicles. I was also significantly involved in providing regulatory comment for the lead National Air Quality Standard (NAAQS). On April 1, 2009, I testified at the CPSIA Rally and Congressional Briefing regarding lead and the CPSIA.

I would also like to emphasize that I am presenting my testimony this morning on my own behalf as an independent scientist. I am not being compensated for my travel expenses or any of the time I have spent preparing for today's testimony. In addition, I am not representing myself under any Federal contract or grant.

2 Consumer Product Safety Improvement Act (CPSIA) of 2008

The Consumer Product Safety Improvement Act (CPSIA) of 2008 stipulates that, as of August 14, 2009, children's products that contain more than 300 ppm (mg/kg) lead may no longer be sold in the United States (US Congress, 2008). The limit will be reduced to 100 ppm on August 14, 2011, unless the Commission determines that this lower limit is not technically feasible. Based on the current language, while manufacturers may petition for exclusion from these standards, exclusions are allowed only if the manufacturers can demonstrate that no lead can be absorbed by children.

The scientific community understands that, based on multiple lead-related recalls occurring in 2007, Congress was motivated to write the Act to be protective of our children's health, and, in the case of lead, to eliminate lead risk to children. However, there have been untoward consequences of the Act, as some manufacturers and businesses have suspended sales of their existing inventory. The act has been particularly burdensome for manufacturers of steel, copper, and aluminum alloys, as components made from these materials typically contain fairly high concentrations lead. The end result is that certain individual components in the products exceed the current lead standard – even though exposure to lead in those components is, because of the nature of the way children come into such components, unlikely, and would not result in health effects. Thus, the Subcommittee on Commerce, Manufacturing, and Trade has responded with a proposed bill that would amend the CPSIA to allow for a risk-based approach, that is protective of public health, and to relieve the burden to manufacturers.

As I explained during my testimony at the Congressional Briefing in 2009, a risk-based approach focuses on *actual* exposure and the health significance of that exposure. Such an approach can be extremely effective in protecting a child's health. Consider, for example, how average blood lead levels in children have been reduced by nearly 10-fold, from 15 µg/dL in 1976 to 1.5 µg/dL in 2007-2008 (CDC,

2011), an important public health success story. This was accomplished by focusing on *important* sources of lead exposure (*i.e.*, sources that had a significant impact on blood lead levels), specifically lead in air (from leaded gasoline), in food (primarily from lead solder in cans), and in paint, to the general population of children. Indeed, risk-based approaches are widely used and considered appropriate in other sectors, for example, in human health risk assessment for lead in soil performed for Superfund sites (US EPA, 1997).

3 Lead Standards and Permissible Intake

Regulatory agencies develop standards to prevent harmful health effects. In general, the agencies purposely over-estimate exposures to and the toxicity of chemicals in order to be certain that human health is protected. This means that standards have a margin of safety (*i.e.*, the permissible dose of a chemical is well below the dose that causes harmful health effects). This provides confidence that regulatory limits will be sufficiently protective for all individuals, even those who might especially sensitive to the chemicals of interest. In the case of lead, children are typically considered to be more susceptible than adults.

A permissible level of lead in a toy or another children's product must be based on an understanding of how lead is released from a toy, the amount of lead potentially ingested by a child, and the quantitative impact of that ingested lead on blood lead. Lead that cannot be released from a toy or other product because the lead is in an inaccessible location or bound in a matrix would not constitute a risk potential because the lead would not be ingested by the child. Thus, to be meaningful, a standard should be linked to the amount of lead released from the toy. A standard based on soluble lead [*e.g.*, the 90 ppm standard specified for soluble lead in ASTM F963-07e1 (ASTM, 2007)] would, in general, be

preferable to a standard based on total lead (unless a robust relationship between total lead and soluble lead has been determined).

Thus, a standard could be developed by setting a target blood lead increment and then calculating the amount of lead released from a toy or other product that would result in an impact at or below the target blood lead increment. Conceptually, health-based limits for lead in other media, such as air, water, or soil, have been developed in this manner, using exposure parameters specific to that medium (see, for example, CPSC, 1977; US EPA, 2001, 2002).

4 Proposed Change to the CPSIA: *De Minimis* Exemption

The new bill proposed by the Subcommittee on Manufacturing, Trade, and Commerce proposes a *de minimis* exemption for lead released from children's products, specifically stating that:

The limits established under subsection (a) shall not apply to any component part of a children's product if, under reasonably foreseeable conditions of use and abuse, it is unlikely that a child who is exposed to the product would ingest more than a *de minimis* amount of lead. (Subcommittee on Manufacturing, Trade, and Commerce, 2011)

In terms of implementation, the proposed amendments state:

The Commission shall, by regulation, establish a methodology for estimating the amount of lead a child would likely ingest from exposure to a component part. Such methodology shall distinguish, at a minimum, between parts that can be placed in the mouth and parts that cannot be placed in the mouth. (Subcommittee on Manufacturing, Trade, and Commerce, 2011)

Moreover, until such methodology is defined by the US Consumer Product Safety Commission (CPSC):

[A] manufacturer may use any reasonable methodology to estimate the amount of lead a child would ingest from exposure to a component part. (Subcommittee on Manufacturing, Trade, and Commerce, 2011)

Although details on implementation (*e.g.*, testing method and definition of the *de minimis* lead exposure limit) need to be worked out, the proposal focuses on *actual* exposure of young children to lead from a product, and considers the impact of that exposure in terms of health. This is an important improvement over the present version of the CPSIA.

The following sections provide scientific support for the use of a risk-based approach, including a hypothetical example that describes an approach to assist in the definition of a *de minimis* level. The sections also contain information on application of such a risk-based approach to children's products, including a discussion of possible extraction methods for product testing and the use of blood lead modeling.

5 Consideration of Exposure: Risk-Based Approach

The mere presence of lead in a children's product or component does not mean that there is an exposure hazard to a child. Moreover, a component with a high concentration of lead does not necessarily mean that a child will subsequently be exposed to a high concentration of lead. Several exposure factors, described below, must be considered to determine whether the lead in a particular product constitutes a health risk to a child contacting that product.

5.1 Dose Response

The most fundamental concept in toxicology is the dose-response relationship, commonly summarized as "the dose makes the poison" (Eaton and Gilbert, 2008). All substances show a dose-response relationship. For example, small amounts of salt may be consumed without adverse effects, but ingestion of much larger quantities can result in adverse effects, such as elevated blood pressure (Braunwald *et al.*, 2001, p. 1415). As another example, at the recommended dose of two tablets,

aspirin yields pain relief from headaches or other minor aches, and even lower doses can be used to prevent and manage cardiovascular disease. However, taking more than the recommended dose can lead to increasing levels of toxicity, including death (Roberts and Morrow, 2001). Similarly, lead exhibits a dose-response relationship, with the likelihood and nature of effects being greater with increasing dose, typically expressed as blood lead levels.

5.2 Exposure Duration and Frequency

The dose of a chemical is affected by a number of factors. For example, how long and how often someone comes into contact with a chemical will affect the dose. In the case of a children's consumer product, it is important to know whether the child comes into contact with the product every day, or only occasionally. It is also important to know how many hours or minutes of each day a child contacts the product. For example, daily or infrequent contact with the product may be possible. With less time of contact, exposure will generally be less. One-time acute exposure (*i.e.*, accidental ingestion) is also possible; appropriate science-based assessments are available to account for such potential acute exposure, if that is a plausible exposure scenario.

5.3 Exposure Route

The manner in which a person comes into contact with the chemical (for example, through the skin *versus* taking the chemical in through the mouth) is also important. The chemical also must be accessible to the child in order for an exposure to occur. While some chemicals can be taken in through the skin, others are not taken in through the skin very well, if at all. In the case of children's products, a young child might possibly chip or bite paint off a painted product, or, if the paint is loose, take paint off by sucking on the children's product. If the paint contains lead, these activities could result in some lead taken into the body through the mouth; this is termed "ingestion." Because lead is not taken up through

the skin, just handling the children's product will not result in a dose of lead. Another possible exposure scenario is surface-to-hand transfer and subsequent transfer from hand to mouth. Considerations for this scenario include the surface area of the hand/fingers touching a component, the transfer of lead to the hand/fingers, the frequency and duration of the contact, the transfer of lead from hand/fingers to mouth, and subsequent intake of the lead into the body. Methods are available to quantify the transfer of metals, such as lead, from components to hands *via* use of wipe tests (see, for example, Dubé *et al.*, 2004).

5.4 Lead Intake *versus* Uptake

Intake is generally expressed as the amount of a chemical at the skin, lungs, gastro-intestinal tract that is available for absorption. Intake, while necessary to yield a "dose," is not equivalent to absorbed dose (uptake), the amount of a chemical absorbed into the blood stream. Lead intake (particularly from children's products) is primarily through ingestion (*e.g.*, through direct mouthing of a children's product or through hand-to-mouth contact).

How much lead a child actually absorbs, after lead is ingested, is an important consideration in a risk-based approach. Bioavailability (*i.e.*, the fraction of ingested lead that is solubilized in the gastro-intestinal tract) determines the amount of lead that can be absorbed into the body (uptake). Bioavailability should be considered when evaluating exposure using a risk-based approach. The bioavailability of lead in the digestive tract depends on the physical (*i.e.*, particle size) and chemical form of lead, and can vary by more than 10-fold. This is clearly an important determinant of the amount of lead uptake into the body.

5.5 Blood Lead Modeling

In order to evaluate the impact of lead exposure to the body, the amount of lead absorbed must be converted to a blood lead value. Models such as the *Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children* (US EPA, 1994), or the O'Flaherty model (1997) are widely accepted risk-based approaches that have been used in a number of circumstances to quantify the impact of lead uptake on blood lead. These models can be and have been applied in risk-based approaches to evaluate the impact on blood lead of different types of exposures of lead, from soil, air and products.

5.6 Consideration of Age of Child

The Act considers products manufactured for children up to age 12. However, it is important to note that there is a significant difference between a 2- to 3-year-old toddler and a 12-year-old, and how they will interact with a children's product. The 2- to 3-year-old will have much more frequent hand-to-mouth contact than the 12-year-old and will contact products in a different manner than a 12-year-old (US EPA, 2006; RIVM, 2008). The 2- to 3-year-old absorbs more ingested lead and is more susceptible to the developmental effects of lead than older children (US EPA, 2006; O'Flaherty, 1998). Recognition of the important behavioral and physiological differences between the young child and older children would represent a significant improvement in the CPSIA. Although the proposed amendment does not specify the age group under consideration, it appears to be reducing the target group to younger children (*versus* as old as 12 years).

6 Appropriate Extraction Methods

The new amendment is written in such a way that approaches beyond the testing procedures defined in ASTM Method F963-7e1 (ASTM, 2007) toy safety standard might be considered appropriate

for evaluating lead exposure. The use of extraction methods is one accepted approach to evaluating exposure of lead and other constituents from products. Some of the methods evaluate chemicals leaching in acidic solutions that mimic gastric fluid [*i.e.*, the solubility extraction procedures in ASTM Method F963-7e1 (ASTM, 2007)]. As another example, CPSC recently released an updated 24-hour acid extraction test procedure to address acute exposure and mimic accidental ingestion of metal jewelry; the method was designed to evaluate cadmium leaching from swallowable small parts (CPSC, 2011). These methods, while appropriate for the scenario where a small part is likely to be swallowed whole, would potentially overestimate exposure in certain cases, such as mouthing or sucking scenarios. However, protocols have also been developed and used to assess chemical leaching in saliva. For example, CPSC developed a method to assess migration of diisononyl phthalate (DINP) from polyvinyl chloride (PVC) children's products (CPSC, 1998), a method that has also been adapted by CPSC to assess lead leaching from objects due to contact with saliva. This method involves shaking the sample for 6 hours in a simulated saliva solution at a neutral pH of approximately 7.2 and at a temperature of 37°C. A similar method was adapted and used by Duke University to evaluate lead leaching from brass ball point pen tips (Baker, 2009). CPSC has used a saline extraction method to evaluate cadmium leaching from metal jewelry during a mouthing scenario (CPSC, 2010). Depending on the nature of the product and how young children interact with that product, a saline extraction method would be more appropriate than an acid extraction method in a number of cases.

7 Use of Blood Lead Modeling in Developing Permissible Lead Limits

Blood-lead modeling is an important tool used to calculate the impact of exposure on blood lead. It has been used to set permissible limits for lead in other media, such as air, water, and soil (for example, US EPA, 2008, 1988, 1998, respectively). Various blood lead targets may be considered for determination of the *de minimis* amount of lead extracted from a product. For example, in developing the

National Ambient Air Quality Standard for Lead, US EPA used a 1-2 µg/dL increment in blood lead as the target to establish a permissible air lead limit (US EPA, 2008). In the case of lead in soil, US EPA (1998) focuses on a modeled distribution of blood lead for a hypothetical child. Another consideration is whether the modeled impact of the extractable lead could have a detectable incremental impact on blood lead.¹

While the proposed amendment does not define a *de minimis* daily intake of lead, I provide here a hypothetical example using a value of 1 µg/day intake of lead, every day for a 2- to 3-year-old. Using blood modeling, specifically US EPA's IEUBK model, this amount of ingested lead would result in a mean blood lead change of 3.0 µg/dL to 3.1 µg/dL. As presented graphically below, such an increment would be negligible.²

Specifically, Figure 1 compares the blood lead impact based on a 1 µg/day intake of lead. In this example, I assumed that a 2- to 3-year-old child would take in this amount of lead in a soluble form, every day for two years.³ Alternate assumptions may, depending upon the product and the plausible ways in which a child might interact with that product, also be appropriate. In this calculation, it can be seen that the contribution of lead from 1 µg is indiscernible as the blood level remains the same.

¹ It should be emphasized that my description of these approaches is meant to be illustrative. I am not proposing a specific increment to blood lead as a target under the CPSIA, but rather describe approaches whereby a permissible limit may be developed.

² An impact of approximately 2 µg/dL or less of a lead release would not be reliably and routinely detectable in an individual child. For example, in a study by Chandramouli *et al.* (2009), the majority of quality control results were within a range of +/- 2 µg/dL. These findings are generally consistent with recommendations from the US Centers for Disease Control that, for investigative actions, laboratories set their internal quality control limits to +/-2 µg/dL or ±10%, whichever is greater (Parsons and Chisolm, 1997).

³ I do not provide these exposure assumptions as ones that ought to be used under amendments to the CPSIA, but to illustrate a process.

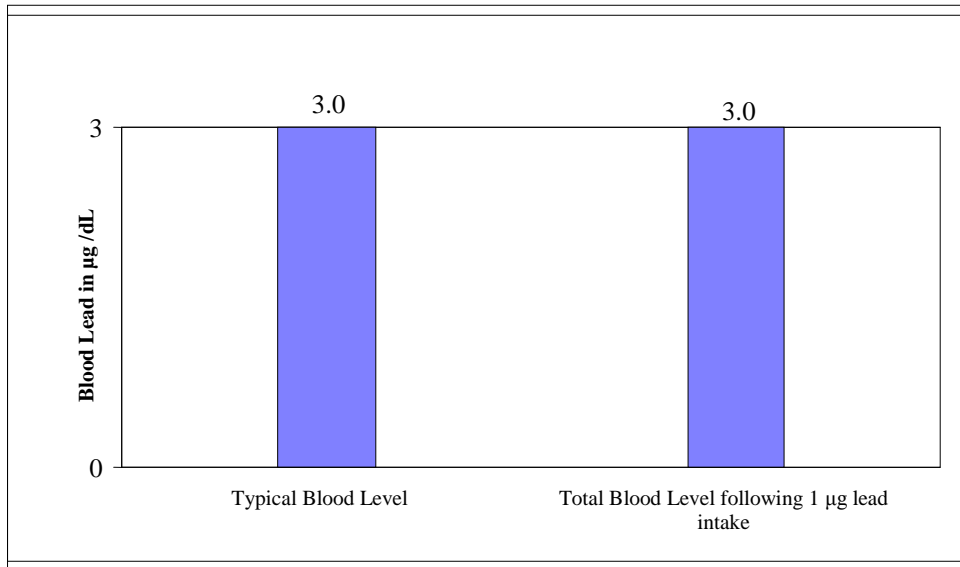


Figure 1. Comparison of Blood Lead Levels in µg/dL Before and After a 1 µg Intake by a 2- to 3-Year-Old Child

8 Recommendation

In conclusion, in order to appropriately evaluate exposure to lead in children's products, I recommend use of a risk-based approach that incorporates methods such as saliva extraction and blood lead modeling. This approach would reasonably mimic exposure scenarios relevant for a young child, while also emphasizing prevention of significant increases to blood lead. While many details remain to be worked out, I urge Congress and CPSC to seriously consider the new bill proposed by the Subcommittee on Manufacturing, Trade, and Commerce, which would amend the CPSIA to allow a health-protective risk-based approach.

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Appendix A

Curriculum Vitae

Barbara D. Beck, Ph.D., DABT, FATS, ERT



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Areas of Expertise

Risk assessment, exposure assessment, toxicology, metals, inhaled pollutants, soil contaminants, historical knowledge of toxicology.

Education & Certifications

Ph.D., Molecular Biology and Microbiology, Tufts University, 1976.

A.B., Biology, Bryn Mawr College, 1968.

Diplomate of the American Board of Toxicology, 1988; recertified 1994, 1999, 2004, 2009.

Fellow, Academy of Toxicological Sciences, 2002 to Present.

EU-registered toxicologist (ERT) *via* membership in the UK Register of Toxicologists, 2004; recertified 2007, 2009.

President, Academy of Toxicological Sciences, July 1, 2009 to June 30, 2010.

Professional Experience

1987 – Present GRADIENT, Cambridge, MA

Principal. Environmental consulting practice includes evaluation of chemical toxicity, health risk assessment for cancer and non-cancer endpoints, review of animal toxicology studies, and multi-media assessment of exposure to environmental chemicals. Special emphasis on metals and inhaled chemicals.

1985 – Present HARVARD SCHOOL OF PUBLIC HEALTH, Boston, MA
Visiting Scientist in Toxicology.

1985 – 1987 REGION I ENVIRONMENTAL PROTECTION AGENCY, Boston, MA
Regional Expert in Toxicology and Supervisory Scientist, Air Toxics Staff. Performed risk assessments for toxic air pollutants. General staff responsibilities included air impacts at waste sites, state air toxic programs, and US EPA radiation programs.

1979 – 1985 HARVARD SCHOOL OF PUBLIC HEALTH, Cambridge, MA
Research Associate in Environmental Science and Physiology and Fellow in Interdisciplinary Programs in Health. Developed short-term animal bioassay for pulmonary toxicants. Editor and author of monograph on variations in susceptibility to inhaled pollutants for both cancer and non-cancer endpoints.

1978 – 1979 TUFTS UNIVERSITY SCHOOL OF MEDICINE, Boston, MA
Instructor in Protein Chemistry. Isolated phagocytosis inhibiting factor from immunoglobulin of individuals with inherited susceptibility to bacterial infections.

1977 – 1978 HARVARD UNIVERSITY, Cambridge, MA
Postdoctoral Fellow in Biology. Researched novel properties of bacterial protein elongation factor, EF-Tu, relevant to possible role as a structural protein.

1975 – 1976 UNIVERSITY OF MASSACHUSETTS MEDICAL SCHOOL, Worcester, MA
Postdoctoral Fellow in Microbiology. Isolated and analyzed messenger RNA from slime molds.
Initiated project on elongation factor, EF-Tu.

1968 – 1969 TUFTS UNIVERSITY SCHOOL OF MEDICINE, Boston, MA
Research Assistant in Molecular Biology and Microbiology. Performed genetic and biochemical
studies on bacterial lipopolysaccharide.

Professional Activities

- Past President, Academy of Toxicological Sciences, June, 2010-June 20, 2011.
- President of the Academy of Toxicological Sciences, July 2009-June, 2010.
- Member of the National Research Council's Committee on the Future Operations for Management in the Nation's Subsurface Remediation Effort, November 2009-March 31, 2012.
- Visiting Scientist, Molecular and Integrative Physiological Sciences Program, Department of Environmental Health, Harvard School of Public Health, October 2008-Present.
- Member of Massachusetts Department of Public Health Advisory Committee, 2007.
- Member of Executive Committee of International Hormesis Society, 2006-Present.
- Councilor, Metals Specialty Section, Society of Toxicology, 2006-2007.
- Member of Board of Directors, Academy of Toxicological Sciences, 2005-Present.
- Member of Scientific Advisory Committee to the Manganese Health Research Program, 2004-Present.
- Peer Review Committee, US EPA National Health and Environmental Effects Research Laboratory, Experimental Toxicology Division, 2003.
- CIIT Science Advisory Committee, 2002-2004.
- Program Committee, Society of Toxicology, 2001-2005.
- American Chemistry Council Risk Assessment Methods Technical Implementation Panel, 1998-2001.
- International Life Sciences Institute Steering Committee on Cumulative Risk Assessment, 1998.
- American Water Works Association Research Foundation Peer Review Panel on Arsenic, 1997-1998.
- Membership Committee, Society of Toxicology, 1997-2000.
- Continuing Education Committee, Society of Toxicology, 1996-1997.
- Risk Assessment Task Force, Society of Toxicology, 1996 to 2000; chair 1999-2000.
- Advisory Committee to Public Health Program, Florida A & M University, 1996-2002.
- Chair of Session on Ecological and Human Health Protocols at GRI meeting on Environmentally Acceptable Endpoints in Soil, Arlington, VA, 1995.
- Session Chair, International Conference on Arsenic, San Diego, CA, 1995.
- Watertown, MA, Board of Health, 1995 - Present; chair, 2003.
- Rapporteur 1994. US EPA Meeting on Risk Assessment for Chemical Mixtures, Research Triangle Park, NC.
- Program Committee, Society of Toxicology, 1993 - 1996.
- Member of Arsenic Task Force, Society for Environmental Geochemistry and Health, 1993-1995.
- Work Group on Arsenic, Society for Environmental Geochemistry and Health, 1993.
- President, Society of Toxicology, Risk Assessment Specialty Section, 1994-1995.
- Vice President, Society of Toxicology, Risk Assessment Specialty Section, 1993-1994.
- President, Northeast Chapter of the Society of Toxicology, 1992-1993.
- Review Committee, US EPA Workshop on the Methodology for Deriving National Ambient Water Quality Criteria for the Protection of Human Health, 1992.
- Consultant to SAB Committee on Hazardous Air Pollutants, 1991.
- Member of Advisory Committee to US EPA on Metal Bioavailability, 1990.

- Member of Advisory Committee to Harvard Center for Risk Analysis, 1990-1993.
- Member of Committee on Public Communications, Society of Toxicology, 1990-1992.
- Councilor of Inhalation Specialty Section, Society of Toxicology, 1990-1992.
- Member of Technical Committee of Council for Health and Environmental Safety of Soils (CHESS), 1988-1990.
- President, Northeast Chapter of the Society for Risk Analysis, 1987-1988.
- US EPA Risk Assessment Forum, 1986-1987.
- Maine Science Advisory Panel, 1986-1990.
- Air Toxics Committee of Northeast States for Coordinated Air Use Management, 1985-1987.
- Rhode Island Air Toxics Advisory Committee, 1986-1987.
- Massachusetts Visibility/Public Health Index Peer Review Team, 1986.
- Massachusetts Air Toxics Guidelines Review Committee, 1985-1988.
- Peer Review Committee, US EPA Inhalation RfD Document, 1987.

Professional Affiliations

American Thoracic Society • Society of Toxicology • Northeast Chapter of the Society of Toxicology • Society for Risk Analysis • New England Chapter of the Society for Risk Analysis • American Association for the Advancement of Science • Society of Environmental Geochemistry and Health • International Society of Exposure Analysis • Academy of Toxicological Sciences

Projects

Law Firm: Provided expert support regarding health significance of releases to air from an oil refinery during upset conditions.

Law Firm: Evaluation of potential human health risks for metals, including arsenic, barium, lead and zinc, at a site used for manufacture of drilling muds.

Law Firm: Evaluation of potential risks from manganese into air and soil near manufacturing facility.

Engineering Company: Exposure to hexavalent chromium in outdoor air and soil. Evaluated toxicological causation and need for medical monitoring.

Health Canada: Peer review of exposure components of pilot program *Screening Assessment Document* for ethylbenzene. Peer review of toxicological analysis of aniline.

Perchlorate Study Group: Comments on scientific validity of US EPA RfD for perchlorate.

Gas Utility Companies: Analysis of exposures to and toxicological effects of elemental mercury in air.

Multiple Industrial Clients: Analysis of historical state of knowledge of asbestos exposure, toxicology, and risks.

Law Firm: Litigation support for lead- and arsenic-contaminated site in western US, including critique of risk assessments and assistance in design and interpretation of epidemiological study.

Industrial Client: Litigation support in multiple cases involving effects of lead on different health endpoints, including neurocognitive changes and behavioral effects in children.

Chemical Manufacturer: Analysis of toxicity of PCE and review of state risk assessments at dry cleaning sites.

Law Firm: Evaluation of risks associated with CCA-treated wood. Development of studies for CCA-treated wood.

Law Firm: Evaluation of health effects of ozone, including consideration of epidemiological, chamber, and animal studies.

Utility company: Evaluation of exposures and risks of coal fly ash.

Law Firm: Evaluation of potential short-term and long-term human health risks from metals including zinc and organics (including mineral oils) from possible medical exposures.

Environmental Engineering Company: Human health and ecological risk assessment for PAHs, dioxins, and other compounds at a former chemical R&D facility, including development and oversight of sampling.

EPRI: Synthesis report of arsenic research studies. Toxicological analysis of methylmercury and lead; development of research plan.

US EPA, Office of Research and Development: Development of toxicity data base for inhalation exposure to the Hazardous Air Pollutants listed under the 1990 Clean Air Act Amendments.

Law Firm: Risk communication and evaluation of toxicological causation for range of organic and inorganic compounds at landfill site. Also evaluated potential cancer cluster.

Law Firm: Analysis of exposures and risks of elemental mercury, including use of biomonitoring data.

Pesticide Registrant: Evaluation of carcinogenic mode-of-action and EU classification of a biocide.

Utility Research Organization: Analysis of toxicity of methylmercury and lead, and potential for interactions.

Trade Association: Evaluation of releases of lead into drinking water and potential health risks.

Wood Preservative Science Council: Evaluation of US EPA Stochastic Human Exposure Dose Simulation model.

Electronics Manufacturer: Risk communication to plant employees regarding exposures to TCE and DCE in groundwater.

Consumer Product Manufacturer: Evaluation of toxicity of hydrogen sulfide and risk communication on hydrogen sulfide at community meetings.

Consulting Company: Evaluation of health significance of metal exposures, especially iron, at historic mine site in New England.

New Mexico Environment Dept.: Risk assessment for metals at copper mining and smelting site.

Non-Governmental Organization: Evaluation of regulatory approaches regarding environmental releases of mercury.

Law Firm: Review of historic toxicological knowledge of PCBs for a case involving two manufacturing sites.

Law Firm: Exposure and risk assessment for vinyl chloride, ethylene dichloride, other solvents, and mercury at on-going chemical manufacturer.

Chemical Manufacturers Association: Review of US EPA land disposal regulations Phase IV. Review of ozone risk assessment in US EPA ozone staff paper.

Multinational Manufacturer: Risk assessment and risk communication for perchloroethylene in drinking water at operating facility in Asia.

Law Firm: Evaluation of risks and regulatory decisions associated with trichloroethylene in drinking water at site in southeastern US.

American Petroleum Institute: Role of risk assessment and potential cost savings in Superfund remedy selection process.

Law Firm: Evaluation of elemental mercury exposure in residences.

Pesticide Manufacturer: Evaluation of toxicity and environmental migration of organo-arsenicals. Probabilistic margin-of-exposure analysis for inorganic arsenic.

Law Firm: Evaluation of association between multiple pesticides and a birth defect. Multi-pathway dose reconstruction.

Utility Company: Risk assessment and risk communication support for TRI emissions from coal-fired power plants.

Industrial Client: Participation in advisory panel regarding health effects of inhaled and ingested hexavalent chromium.

Law Firm: Evaluation of medical monitoring claim in case involving exposure to arsenic, nickel, and antimony.

Law Firm: Evaluation of possible air exposures and health studies at former phosphorous manufacturer in Florida.

Law Firm: Toxicological evaluation of oil residuals on medical implants.

International Chemical Manufacturer: Evaluation of cancer classification systems and setting of occupational exposure limits in European countries and organizations.

Boston Medical Center: Coordination of study of potential effects of perchlorate in humans.

Zinc Corporation of America: Risk assessment using both environmental and epidemiological data for lead and cadmium in soil at a Superfund site.

Major Canadian Mining Company: Evaluation of arsenic exposure at mining/milling site using biological monitoring, risk assessment for arsenic, and communication with the public and regulatory agencies.

Law Firm: Evaluation of toxicological effects from acute exposures to ammonia.

Law Firm Representing Utility Company: Prepared report regarding historic knowledge of toxicity of simple and complex cyanides, and of oxide box waste materials at former MGP sites. Prepared risk assessment for site.

Law Firm: Evaluation of toxicology of mineral spirits.

US Dept. of Justice: Development of sampling plan and risk assessment for spray drift exposure to pesticides.

US Dept. of Navy: Risk assessment for volatiles released from waste water treatment plant.

Law Firm: Assessment of toxicity and risks of MTBE.

Law Firm Representing Smelter Owner: Evaluated health protectiveness of state cleanup levels for arsenic, lead, and cadmium in soil in class action case.

Law Firm Representing Municipality and Port Authority: Prepared risk assessment for proposed development at former MGP site, evaluating future exposures to construction workers and residents. Developed risk-based remedial targets.

Major Mining Company: Reviewed historical toxicological knowledge of lead.

Law Firms Representing Multiple PRPs at Site Involving Groundwater: Evaluation of historical uses, and standards and criteria for trichloroethylene.

Chemical Manufacturer: Development of risk screening process for evaluating potential hazards at international sites as part of property transfer.

Major Consumer Product Manufacturer: Development and application of adult blood lead model to predict blood lead levels from discontinuous exposures to lead released from a consumer product.

Engineering Firm: Evaluation of methodologies and assumptions used by US EPA and other investigators to estimate risks from polychlorinated biphenyls in soils and sediments, with particular emphasis on dermal absorption.

Health Effects Institute: Assessment of literature on carcinogenicity of inhaled diesel exhaust particulates, especially using urine mutagenicity. Review of literature on toxicity of carbon monoxide and effects on individuals with angina.

Massachusetts Attorney General: Expert witness testimony on the use of risk assessment for the siting of an energy facility.

Chemical Manufacturer: Review of toxicity of barium compounds in cost allocation project.

Lead Industries Association: Critique of HUD cost benefit analysis on apartment deleading.

Engineering Company: Risk assessment for lead, asbestos, PCBs, and other chemicals in soil and water at former brake lining manufacturing facility.

Law Firm: Risk support at multiple MGP sites, including evaluation of potential risks from VOCs in groundwater and evaluation of potential risks to workers from PAHs in soil.

Battery Manufacturing Company: Development and oversight on sample collection and analysis program for lead exposure, evaluation of existing blood lead and tooth lead data, and application of blood lead model.

Oil & Gas Company: Risk assessment support for several major mining-related Superfund sites in the western US. Evaluation of toxicology, epidemiology, and bioavailability of metals, including lead, arsenic, and cadmium.

International Lead Zinc Research and Organization: Development of probabilistic blood lead model.

Chemical Manufacturer: Toxicology assessment for organo-tin compounds.

Marine Shale Processors: Risk assessment of lead, other inorganics and organic compounds in aggregate produced by hazardous waste recycling. Evaluation of risks of air emissions during incineration process.

American Red Cross: Review of toxicity of new blood bag plasticizer and assessment of potential risks to blood product recipients.

Remedial Trust Representing Consortium of PRPs: Evaluation of university and agency research plans involving groundwater modeling and remedial approaches at former manufacturing site. Evaluation of biomonitoring approaches for metals. Evaluation of arsenic risk assessment for site.

Coalition for Clean Air Act Implementation: Evaluation of technical issues, including use of composite scores, in 112(g), trading of hazardous air pollutants. Quantification of uncertainty in the composite source.

Law Firm: Review of toxicology of atmospheric sulfuric acid.

Canadian Mining Company: Arsenic risk assessment at tailings site. Risk assessment for multiple metals associated with tailings release at mine in Southeast Asia.

American Chemistry Council: Evaluation of epidemiological studies used in ozone NAAQS.

Law Firm: Litigation support case involving alleged residential exposure to municipal landfill chemicals.

Mining/Smelting Company: Evaluation of multipathway risks associated with slag use. Critique of US EPA Hazardous Waste Identification Rule.

Oil & Gas Company: Preparation of technical comments on toxicological evaluation and risk assessment used for listing of lead by Cal EPA as toxic air pollutant.

Consortium of Massachusetts Utility Companies: Review of toxicological knowledge of chemicals at MGP sites over time for Massachusetts generic rate setting case.

Law Firm: Evaluation of non-cancer risks from alkylphenols in groundwater at a wood tar site, based on structure activity relationships. Evaluation of risks from polycyclic aromatic hydrocarbons.

US EPA Region I: Compilation and review of air toxics monitoring studies in Region I with respect to adequacy in reflecting human exposure and in identifying relevant sources from a risk perspective.

Engineering Firm: Risk assessment for volatile chemicals possibly entering a building due to site remediation.

Pharmaceutical Company: Critique of *Federal Register* notice on delisting of incinerator ash from RCRA regulations. Reviewed applicability of model to dioxin-contaminated ash.

Petroleum Company: Risk assessment for volatile compounds, polycyclic aromatic hydrocarbons, and metals in air, soil, and water associated with former refinery operations and with natural gas and petroleum formations.

American Lung Association of Maine: Technical advice on health effects of criteria and non-criteria air pollutants. Review of regulatory packages.

Northeast States for Coordinated Air Use Management: Technical assistance in organizing conference on use of bioassays in evaluating ambient air pollutants and presentation of report on use of short-term pulmonary bioassays in evaluation of toxicity and potential health effects of urban particulates.

Engineering Company: Risk assessment for metals in soil at US Navy shipyard for RCRA clean closure.

New Jersey Dept. of Environmental Protection: Site assessment and risk assessment for specialty chemical manufacturing site in New Jersey involving volatile organic chemicals and DDT.

US EPA/Engineering Company: Development of work plan to conduct morbidity or mortality study, using readily available databases, for high ozone levels experienced in summer of 1988.

Law Firm: Risk assessment for arsenic-contaminated soil. Assessed human health risks *via* inhalation and ingestion and ecological risks to deer populations.

Utility: Review of regulations regarding disposal of incinerator ash. Also reviewed air emissions from RDF facilities in comparison with emissions from traditional incinerators.

Oil Refinery: Ecological and human health risk assessment for solvent extracted soils originally contaminated with petroleum waste, based on potential to contaminate nearby harbor in New Jersey.

Gas Research Institute: Assistance in preparation of exposure manual for MGP sites.

Law Firm: Evaluation of lead releases from consumer household product into drinking water and recommendations for studies.

Law Firm: Regulatory analysis for perchlorate in drinking water well in Massachusetts.

State Agency: Impact analysis for a potential toxicological exposure of a biologic product related to manufacturing.

Publications – Articles

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Greenberg, GI; Beck, BD. 2011. "Use of Years of Potential Life Lost (YPLL) for Risk Assessment at Hazardous Waste Sites." In *Encyclopedia of Environmental Health*. (Ed.: Nriagu JO), Elsevier Press, Burlington, MA, (5)602–607.

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Lewis, AS; Beck, BD. 2010. "Nonlinear low-dose extrapolations." In *Cancer Risk Assessment: Chemical Carcinogenesis, Hazard Evaluation, and Risk Quantification*, (Eds.: Hsu, CH; Stedeford, T), Wiley Press, pp. 659-680.

Meek, ME (Bette); Levy, L; Beck, BD; Danzeisen, R; Donohue, JM; Arnold, IMF; Krewski, D. 2010. "Risk assessment practice for essential metals." *Journal of Toxicol. & Env. Health.* 73(2&3):253-260.

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Prueitt, RL; Beck, BD. 2009. Commentary on "Toxicity Testing in the 21st Century: A Vision and Strategy." *Belle Newsletter.* 15(3):3-5.

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Beck, BD; Lewis, AS; Slayton, TM. 2008. "Arsenic." In *Encyclopedia of Quantitative Risk Analysis and Assessment (Volumes 1-4)*. (Eds: Melnick, EL; Everitt, BS), John Wiley & Sons, West Sussex, England.

Kenyon, EM; Klimecki, WT; El-Masri, H; Conolly, RB; Clewell, HJ; Beck, BD. 2008. "How can biologically-based modeling of arsenic kinetics and dynamics inform the risk assessment process? – A workshop review." *Toxicol. and Appl. Pharm.* 232:359-368.

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Bowers, TS; Beck, BD. 2007. Response to comments by Bergdahl, Hornung *et al.*, Jusko *et al.*, and Svendsgaard *et al.* on "What is the meaning of non-linear dose-response relationships between blood lead concentration and IQ." *NeuroToxicol.* 28:196-201.

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Beck, BD; Seeley, MR; Ghosh, RS; Drivas, PJ; Shifrin, NS. 2006. "Human health risk assessment of cyanide compounds in water and soil." In *Cyanide in Water and Soil: Chemistry, Risk, and Management.* (Eds: Dzombac, D; Ghosh, R; Wong-Chong, GM), Taylor & Francis, Boca Raton, FL, p309-330.

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Publications – Other Publications/Reports

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Invited Lectures/Other Presentations – 1985 – Present

4/10 – "Medical Monitoring and Environmental Exposures." Presented in a session entitled "Presenting Effective Arguments to Courts Against Awarding Medical Monitoring Damages" at the American Chemical Institute's Chemical Products Liability and Environmental Litigation Conference, Chicago, IL, April 28.

3/10 – "These Kids are Driving Me Crazy: The Science of Sensitive Subpopulations." Presented at the DRI Toxic Torts and Environmental Law Seminar, New Orleans, LA, March 18.

3/10 – "Weighing Complex Data in Risk Decisions: Concepts of Evidence-Based Toxicology." Roundtable discussion presented at the Society of Toxicology Annual Meeting, Salt Lake City, UT, March 9.

2/10 – "Buckyballs and Nanotubes: Insurance Issues Related to Nanotechnology." Panelist for talk presented at the American Bar Association's 18th Annual Insurance Coverage Litigation Committee Midyear Program. Phoenix, AZ, February 26.

1/10 – "Overview of Arsenic Epidemiology." Presented as part of the EPRI Arsenic Project Scientific Review Panel Meeting, Research Triangle Park, NC, January 28.

12/09 – "Current Risk from Exposure to Nanoparticles." Presented as part of webinar held by Day Pitney, LLP, December 9.

4/09 – "Testimony of Barbara D. Beck, Ph.D, DABT Regarding the Consumer Product Safety Improvement Act: The Need for a Risk-Based Approach." CPSIA Congressional Briefing, Washington, DC, April 1.

3/09 – "What is an Adverse Effect in the Age of 'Omics?" Roundtable discussion presented at the Society of Toxicology Annual Meeting, Baltimore, MD, March 18.

12/08 – "Inorganic Arsenic: Health Risks and Regulations." Presented at the University of Connecticut, School of Pharmacy, Storrs, CT.

5/08 – "Risk Assessment for Essential Metals: Considerations for 'The Path Forward.'" Presented at the Workshop on Health Risk Assessment of Essential Metals, Ottawa, Canada.

5/08 – "Nanotechnology: An Overview of Environmental Health & Safety Issues." Presented as part of webinar held by Day Pitney, LLP.

3/08 – "Challenge in Using Hazard-based Binning in Risk Assessment & Risk Management." Presented at the Society of Toxicology 47th Annual Meeting, Seattle, WA.

1/08 – "Determining Risks to Background Arsenic Using a Margin-of-Exposure Approach." Presented at the Society of Risk Analysis, New England Chapter Meeting, Boston, MA.

10/07 – "An Update on Risk Management Approaches for Nanotechnology: Recent Regulatory Activities and Trends Affecting Product Development." Presented at the Lux Executive Summit, Cambridge, MA.

9/07 – "Is Smaller Always Worse: What Do We Know Now About the Toxicity and Potential Risks of Nanoparticles? What More Do We Need to Know?" Presented at the PANWAT SOT Meeting, Seattle, WA.

7/07 – "The Role of Regulatory Science in Tort Litigation." Presented as part of the Environmental Law Institute's *Critical Developments in Toxic Torts Seminar Series*, Washington, DC.

3/07 – "Using Modeling to Inform the Risk Assessment Process for Arsenic." Presentation at the Society of Toxicology 46th Annual Meeting, Charlotte, NC.

2/07 – "Health Risks of Inorganic Arsenic: A Serious Threat or are there Better Ways to Spend our Resources?" Presented at the Risk Assessment Forum, Yale University, New Haven, CT.

12/06 – "Risk Assessment: An Overview." Presented at the University of Connecticut, School of Pharmacy, Storrs, CT.

12/06 – "Industry Challenges – Getting the Lead Out: Health Risk Considerations." Presented at Plumbing Manufacturers Association and Copper Development Association Roundtable, Chicago, IL.

10/06 – "Use of Nanoscale Zero-Valent Iron (NZVI) Particles for Groundwater Remediation: A Qualitative Risk Assessment." Presented at the University of Massachusetts Soils, Sediments, and Water Conference, Amherst, MA.

9/06 – "Overview of Science Issues Associated with Assessing Lead Health Effects." Presented at the Battery Council International Convention, Tucson, AZ.

4/06 – "Interpretation of Biomonitoring Studies to Assess Exposure and Risk of Inorganic Arsenic: Confounding by Other Sources of Arsenic." Presented at Toxicology and Risk Assessment Conference, Cincinnati, OH.

1/06 – "A Qualitative Risk Assessment to Evaluate the Remediation of Trichloroethylene by Nanoscale Zero-Valent Iron Particles." Presented at the 1st International Conference on Nanotoxicology: Biomedical Aspects, Miami, FL.

12/05 – "Regulation of Nanotechnology in the Environment and Workplace: Comparative Approaches." Presented at the 2005 Materials Research Society Meeting Session S9: Regulation of Nanotechnology and Nanomaterials, Boston, MA.

9/05 – "Recommendations for DMA Assessment." Presented on behalf of MAA Research Task Force, US EPA, Washington, DC.

9/05 – "Characterization of DMA Risk Using a Nonlinear Dose-Response Approach." Presented on behalf of MAA Research Task Force, US EPA, Washington, DC.

3/05 – "The Life of a Consultant." Society of Toxicology 44th Annual Meeting, New Orleans, LA.

3/04 – "Arsenic Methylation: Considerations for Risk Assessment." Society of Toxicology 43rd Annual Meeting, Baltimore, MD.

1/04 – "Lack of Relevance of DMA-Induced Rat Bladder Tumors for Human Risk Assessment: Metabolism and Disposition Studies of DMA and MMA." Presented to Office of Pesticide Programs, US EPA, Washington, DC.

12/03 – "Selected Comments on Draft EPA Exposure & Risk Assessments for CCA-Treated Wood Using SHEDS-Wood Model." Presented at FIFRA SAP Meeting, Washington, DC.

11/03 – "Risk Assessment: An Overview." University of Connecticut, School of Pharmacy, Storrs, CT.

10/03 – "Comparison of a Probabilistic/Mechanistic Approach to a Deterministic/Empirical Approach for Evaluating CCA-Treated Wood Exposures." Presented at 19th Annual International Conference on Soils, Sediments and Water, Amherst, MA.

4/03 – "Evaluation of Potential Human Health Risks from Copper Azole-Treated Wood." Presented at 99th Annual Meeting of the American Wood-Preservers' Association, Boston, MA.

11/02 – "A Case Study of Arsenic Risk Assessment and Risk Management." Presented at NIEHS DERT Science Retreat, Wilmington, NC.

10/02 – "CCA-Treated Wood: Science and Politics." Presented at University of Massachusetts, Amherst.

10/02 – "Research Activities to Refine Human Health Risk Assessment for CCA-Treated Wood." Presented to CPSC, Washington, DC.

8/02 – "Comments on EPA Background Documents Regarding SHEDS-Wood Model." Presented at Science Advisory Panel meeting, Washington, DC.

1/02 – "Principles of Toxicology." Harvard School of Public Health, Boston, MA.

12/01 – "Risk Assessment: An Overview." University of Connecticut, School of Pharmacy, Storrs, CT.

10/01 – "Comments on EPA Background Documents Regarding CCA-Treated Wood." Presented to Scientific Advisory Panel, Washington, DC.

10/01 – "Statement by Barbara D. Beck re: Arsenic in Drinking Water: An Update on the Science, Benefits and Cost." Presented at Congressional Hearing, Washington, DC.

8/01 – "Focused Evaluation of Health Risks from Exposure to Arsenic Associated with CCA-Treated Wood." Presented to Consumer Product Safety Commission, Washington, DC.

6/01 – "Adult:Child Differences in the Intra-Species Uncertainty Factor: A Case Study Using Lead." Presented at the Fifth Annual Workshop on Evaluation of Default Safety Factors in Health Risk Assessment, UMDNJ-New Jersey Medical School, Newark, NJ.

3/01 – "Risk Assessment for Metals: Physiologically-Based Pharmacokinetic Models for Metals." Society of Toxicology 40th Annual Meeting, San Francisco, CA.

6/00 – "EPRI-Sponsored Arsenic Research Program – Application to Arsenic Cancer Risk Assessment." SEGH Fourth International Conference on Arsenic Exposure and Health Effects, San Diego, CA.

5/00 – Invited Participant/Speaker to the Fourth Annual Workshop on Evaluation of Uncertainty/Safety Factors in Health Risk Assessment, Nutley, NJ.

4/00 – "Development of a Stochastic Physiologically-Based Pharmacokinetic Model for Lead." Toxicology and Risk Assessment Approaches for the 21st Century Conference, Kings Island, OH.

6/99 – "The Development of a Stochastic Physiologically-Based Pharmacokinetic Model for Lead." US EPA Workshop on Lead Model Development: Probabilistic Risk Assessment and Biokinetic Modeling, Raleigh-Durham, NC.

6/99 – "The Development of a Stochastic Physiologically-Based Pharmacokinetic Model for Lead." WHO/IARC Conference on Lead Exposure, Reproductive Toxicity and Carcinogenicity, Gargnano, Italy.

3/99 – "Strategies for Prosecuting and Defending Toxic Tort Litigation – A Toxicologist's Perspective." ABA Annual Conference on Environmental Law, Keystone, CO.

3/99 – "Principles of Toxicology." Harvard Center for Risk Analysis Course "Analyzing Risk: Assessment and Management," Boston, MA.

2/99 – "Comments on EPA Perchlorate RfD Draft Document." Perchlorate Peer Review Workshop, San Bernardino City Council Chambers, San Bernardino, CA.

1/99 – "Risk Assessment: An Overview." Harvard School of Public Health Principles of Toxicology Course, Boston, MA.

12/98 – "Risk Assessment: An Overview." University of Connecticut Advanced Toxicology Course, Storrs, CT.

11/98 – "EPA's Proposed Residential Lead Standards." US EPA's Children's Health Protection Advisory Committee Meeting, New Carrollton, MD.

10/98 – "What are the Characteristics of a Well-designed Environmental Lead/Blood Lead Study?" National Environmental Policy Institute's Conference "Protecting Children's Health: Assessing the Relationship of Soil Lead to Blood Lead," Washington, DC.

10/98 – "Principles of Toxicology." Harvard Center for Risk Analysis Course "Analyzing Risk: Assessment and Management," Boston, MA.

10/98 – "Cumulative Risk – Case Study." American Law Institute-American Bar Association Course of Study, "Risk Assessment and Risk Management in Environmental Law," Washington, DC.

10/98 – "Introduction to Recent Developments in Risk Assessment: Aggregate Exposure and Cumulative Risk." American Law Institute-American Bar Association Course of Study, "Risk Assessment and Risk Management in Environmental Law," Washington, DC.

4/98 – "Principles of Toxicology." Harvard Center for Risk Analysis Course "Analyzing Risk: Assessment and Management," Boston, MA.

3/98 – "Impact of Arsenic (As₃) Metabolism on Human Populations: Dose-Response Relationships in Arsenic-Induced Cancers." Society of Toxicology 37th Annual Meeting, Seattle, WA.

3/98 – "Effective Risk Communication: Avoiding the Pitfalls." Continuing Education Course, Society of Toxicology 37th Annual Meeting, Seattle, WA.

12/97 – "Key Issues Raised by EPA's Proposed Ozone Standards and Supporting Analysis." Society for Risk Analysis, Annual Meeting and Exposition, Washington, DC.

5/97 – "Testimony on Analysis of Risk Assessment Used by the EPA in Support of Its Proposed Ozone Standards." Before the Joint Hearing of the Health and Environment Subcommittee and the Oversight and Investigations Subcommittee, Commerce Committee, US House of Representatives, Washington, DC.

3/97 – "Principles of Toxicology." Harvard Center for Risk Analysis Course "Analyzing Risk: Assessment and Management," Boston, MA.

12/96 – "Risk Assessment for Criteria Pollutants *versus* Other Noncarcinogens: The Difference Between Implicit and Explicit Conservativism." Rutgers University 2nd Annual Workshop "The Evaluation of EPA 10X Safety Factors in Health Risk Assessment," Nutley, NJ.

9/96 – "The Quantitative Use of Information on Susceptibility in Risk Assessment: Where is it Working or Not Working? How Can We Make It Better?" Third Annual NHEERL Symposium on Susceptibility and Risk Assessment, Raleigh, NC.

9/96 – "Principles of Toxicology." Harvard Center for Risk Analysis Course "Analyzing Risk: Assessment and Management," Boston, MA.

8/96 – "The Role of Risk Assessments in Superfund." American Bar Association, Orlando, FL.

12/95 – "Use of Monte Carlo Arsenic (As) Model to Predict Distributions of Urine Arsenic at a Mining and Milling Site." Society for Risk Analysis, Honolulu, HI.

10/95 – "Use of Information on Variations in Susceptibility – Ozone." ILSI Risk Science Institute Workshop on Human Variability, Washington, DC.

10/95 – "Evaluation of Health Effects Resulting from Accidental Exposures." Michigan Society for Risk Analysis, Dearborn, MI.

9/95 – "Principles of Toxicology." Harvard Center for Risk Analysis Course on "Analyzing Risk: Assessment and Management," Boston, MA.

6/95 – "Validation of an Arsenic Exposure Model at a Mining and Milling Site through Urinalysis." "Use of an Arsenic Exposure Model at a Gold Mining and Milling Site." Second International Conference on Arsenic Exposure and Health Effects, San Diego, CA.

7/94 – "A Review of Scientific Issues Pertaining to Arsenic." Society for Environmental Geochemistry and Health Conference on Lead and Arsenic Exposure in the Rocky Mountains, Salt Lake City, UT.

5/94 – "Use of Lead Exposure Assessment in the Regulatory Process." International Lead Zinc Research Organization Lead Exposure Assessment Workshop, Research Triangle Park, NC.

3/94 – "Non-linearities in Arsenic Risk Assessment." Boston Risk Assessment Group, Cambridge, MA.

3/93 – "Basic Risk Assessment: Current Developments." Continuing Education Course, Society of Toxicology, New Orleans, LA.

3/92 – "A Review of the Bioavailability of Petroleum Constituents." West Coast Soils and Groundwater Conference, Long Beach, CA.

3/92 – "Bioavailability of Metals and Organics." Workshop on Human Health and Ecological Risk Assessments for Contaminated Sites, Toronto, Canada.

2/92 – "Improvements in Quantitative Noncancer Risk Assessment." Chair of Symposium of Society of Toxicology Meeting, Seattle, WA.

2/92 – "Perspectives on the Development of Soil Cleanup Levels at Mining Sites." Colorado Bar Association, Denver, CO.

11/91 – "Environmental Law Update: Toxic Torts and How Clean is Clean?" Squire, Sanders & Dempsey, Cincinnati, OH.

10/91 – "Risk Assessment for Indoor Air: Evaluating Risks to Susceptible Populations." NATO/CCMS-COST 613 Joint Workshop, Kloster Banz, Bavaria, Germany.

2/91 – "An Update on Exposure and Risks of Lead." Chair of Symposium at Society of Toxicology Meeting.

2/90 – "Inhalation Risk Assessment." Chair of Symposium at Society of Toxicology Meeting.

1/90 – "The Use of Structure Activity Relationships for Alkyl Phenol Risk Assessment." New England Society for Risk Analysis, Boston, MA; RJR/Nabisco, Winston-Salem, NC.

1/90 – "The Use of Structure Activity Relationships in Risk Assessment." Harvard School of Public Health, Boston, MA; Northeastern University, Boston, MA.

11/89 – "How Protection Levels are Developed and What They Mean." Course on Risk Assessment and Epidemiology for Lawyers, Harvard School of Public Health, Boston, MA.

9/89 – "An Environmental Health Case Study." Tufts Medical School, Boston, MA.

3/89 – "Impact of Lead Derived from Mining Sources on Blood Lead." Boston Risk Assessment Group, Boston, MA.

2/89 – "Ecological and Health Risk Assessment for Arsenic in Soil." Society of Toxicology, Atlanta, GA.

12/88, 1/89, 9/89, 10/89, and 4/90 – "Risk Assessment for Hazardous Waste Sites, Including a Perspective on Toxic Torts." Executive Enterprises, Inc., Washington, DC, Chicago, IL, Philadelphia, PA, and Orlando, FL.

10/88 – "Ozone Toxicology and Risk Assessment." Harvard School of Public Health, Boston, MA.

10/88 – "Risk Assessment for Arsenic in Soil." University of Massachusetts, Amherst, MA.

9/88 – "The Use of Animal Bioassays to Assess Lun26 Toxicity." NESCAUM, Princeton, NJ.

6/88 – "Review of Epidemiological and Toxicological Studies on Mining Derived Lead." US EPA, Philadelphia, PA.

3/88 – "Assessment of Impact on Blood Lead of Lead from Mining Sources." US EPA, Washington, DC.

2/88 – "Regulatory Toxicology." Tufts University School of Medicine, Boston, MA.

12/87 – "Risk Assessment for Soil." Harvard School of Public Health, Boston, MA.

12/87 – "Health Effects of Ozone and the Clean Air Act." New England Chapter for Society for Risk Analysis, Cambridge, MA.

11/87 – "Health Effects of Ozone." Harvard School of Public Health, Boston, MA.

9/87 – "Health Risk Assessment for Soil." University of Massachusetts, Amherst, MA.

4/87 – "Key Issues in Addressing Adverse Effects of Ozone." University of Massachusetts, Amherst, MA.

1/87 – "Risk Assessment for Dioxin in Soil." MIT, Cambridge, MA.

10/86 – "Pulmonary Toxicology." Harvard School of Public Health, Boston, MA.

10/86 – "Risk Assessment." University of Massachusetts, Amherst, MA.

10/86 – "Regulatory Toxicology." Tufts University School of Medicine, Boston, MA.

7/86 – "Health Effects of Indoor Air Pollutants." Region I US EPA, Lexington, MA.

6/86 – "Health Effects of Radon." Society of Women Engineers, Hartford, CT.

6/86 – "Contacting the Health and the Medical Community About the Adverse Effects of Ozone." US EPA, Washington, DC.

6/86 – "Animal Toxicology." US EPA Region I, Boston, MA.

4/86 – "Health Effects of Ozone." NESCAUM meeting, Newport, RI.

2/86 – "Pulmonary Toxicology." US EPA Region I, Boston, MA.

12/85 – "Toxicology of Dioxin." US EPA Dioxin Workshop, Lexington, MA.

11/85 – "Animal Bioassays." Harvard School of Public Health, Boston, MA.

11/85 – "Pulmonary Toxicology." Harvard School of Public Health, Boston, MA.

10/85 – "Indoor Air Pollution." Air Pollution Control Association meeting, Enfield, CT.

1/85 – "Indoor Air Pollution." NESCAUM workshop, Northampton, MA.

Editor

2010 to Present. Associate Editor. *Toxicology and Applied Pharmacology*.

2006 to 2010. Specialty Editor. *Toxicology and Applied Pharmacology*.

1995 to Present. *Human and Experimental Toxicology* (Editorial Board).

1991. *Trace Substances in Environmental Health: Supplement to Volume 14 (1992) of Environmental Geochemistry and Health. Proceedings of the 25th Annual Conference on Trace Substances in Environmental Health, May 20-23, Columbia, MO.*

Reviewer

Fundamental and Applied Toxicology; Toxicological Sciences; Cancer Research; Environmental Research; Annals of Internal Medicine; Human and Ecological Risk Assessment; Journal of Society of Environmental Geochemistry and Health; Human and Experimental Toxicology; Environmental Health Perspectives; Regulatory Toxicology and Pharmacology.

Continuing Education Courses

- Epigenetics in Toxicology: Introduction, Mechanistic Understanding, and Applications in Safety Assessment, Society of Toxicology, 2011.

- Technologies and Tools for Toxicity Testing in the 21st Century, Society of Toxicology, 2010.
- Immunology for Toxicologists, Society of Toxicology, 2009.
- Nanotoxicology: The Science of Developing a Safe Technology, Society of Toxicology, 2008.
- Dose-Response Modeling for Occupational and Environmental Risk Assessment, Society of Toxicology, 2008.
- Toxicology and Molecular Biology of Tissue Repair, Society of Toxicology, 2007.
- Use of Genome Databases for Toxicology, Society of Toxicology, 2006.
- Neuropathology for the Toxicologist, Society of Toxicology, 2006.
- Fundamentals of Nanotechnology: Chemistry, Exposure, Environmental/Health Assessments and Societal Impacts, Society of Toxicology, 2005.
- Integrating Toxicologic Pathology into Compound Evaluation and Risk Assessment, Society of Toxicology, 2002.
- Rodent Toxicity and Nongenotoxic Carcinogenesis: Knowledge-Based Human Risk Assessment from Molecular Mechanisms, Society of Toxicology, 2000.
- An Overview of the Tier 1 Screening Battery Proposed by EDSTAC, Society of Toxicology, 1999.
- Benchmark Dose, Society of Toxicology, 1997.
- Principles of Metal Toxicology, Society of Toxicology, 1997.
- Epidemiology for Toxicologists, Society of Toxicology, 1996.
- International Harmonization: Update on Scientific and Regulatory Issues. Part II: Toxic Substances and Environmental Issues, Society of Toxicology, 1994.
- Case Studies in Risk Assessment: Emphasis on Exposure, Society of Toxicology, 1992.
- Environmental Toxicology, Society of Toxicology, 1991.
- Target Organ Toxicity: Advanced Hepatotoxicity, Society of Toxicology, 1990.
- Toxicity of Agents: Pesticides, Society of Toxicology, 1990.
- Neurotoxicology, Society of Toxicology, 1989.
- Respiratory Tract Toxicology by Classes of Agents, Society of Toxicology, 1988.
- Mid-America Course in Toxicology, 1988.
- Pulmonary Pathophysiology, University of Vermont Medical School, 1979.