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EDITORIAL

The promise of exposure science and assessment

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From the earliest days of the birth of the field, exposure assessment has been recognized as an important element of environmental risk assessment. Exposure assessment defines the nature of the risk for individuals or populations or life stages in the face of a characterized hazard. It has evolved as better understandings, estimation and measurement tools, and more sophisticated models have become available. Refined understandings of fate and transport in the environment, of human toxicokinetics, and of subtle biomarkers of human exposure have all contributed to this evolution. The relationship of exposure assessment with toxicodynamics, and ultimately with susceptibility, is elucidated at the genetic or molecular systems level. These advances have offered risk practitioners the promise of more robust assessments and decision-makers the hope of better information to inform policy implementation. Exposure assessment has been seen by some as the answer to successfully unraveling the complex issues of risk of background radiation or of chemical residues in human blood and adipose tissue. This would then lead to better individual decisions and improved policies regarding public health.

Papers in this issue illustrate examples of best-practice approaches to exposure science and risk assessment. They also provide information to inform public policy. The papers also illustrate the importance of putting exposures in context. Although this has always been a challenge, these authors are tackling long-standing problems of environmental and social importance involving environmental exposure to radiation and chemicals. Several of these papers illustrate the value of community-based assessments and broad-based investment in data collection. In addition, we are introduced to a perspective on the future of exposure science and assessment. Taken together, they serve to advance the notion that improved exposure science and assessment can have a real impact on individual and public policy-based risk decisions.

Historically, however, exposure assessment has been used as a speculative tool in environmental risk characterization. It allowed risk assessors to infer risk under certain, often low-probability, scenarios in the real world. For almost any hypothesized set of exposure circumstances, one could find an example, or at least not rule out its existence. Although this approach held interest as an academic exercise, and had value to raise our consciousness about potential risks, it often muddied the waters of environmental protection and public-health decision making. It led us to focus our attention on potential low-probability–high-impact situations rather than understanding and dealing with higher-probability–lower-impact exposures. The reasons are understandable. Scientists wanted to demonstrate the significance of particular exposures and characterize the uncertainty around potential outcomes. Here we encounter the classic "signal-to-noise" problems. Exposures were often assessed one at a time. Their impact was assessed given our knowledge of high, experimental exposures wherein outcomes were discernable in small numbers of animals raised in controlled environments in toxicology studies. "Factors" were used to make up for a lack of real understanding. Under these approaches, the promise of exposure assessment as an important aid to environmental and public-health decision making was elusive.

Thankfully, a new paradigm in environmental exposure and risk assessment is emerging to address this promise. It is led by those who realize the value of new tools and technologies in addressing the shortcomings of our past approaches. It is fueled by the National Research Council's views on twenty-first century toxicology. Systems approaches to understanding human biology, coupled with the knowledge of systems-level perturbations caused by human–environment interactions, hold the key to understanding biologically relevant exposures. Although limited examples of such an approach are available today, we are seeing progress. Genomic and transcriptomic markers of exposure are being linked with susceptibility to adverse outcomes. Coupling these successes with advances in sensor technology will allow us to detect multiple environmental chemicals in environmental media, at the human–environment interface, and *in vitro* and *in vivo*. In turn, this information, over time, will allow the development of a comprehensive knowledge base for environmental and public-health decision making. This knowledge base will allow assessment of complex exposures in a systematic way. It holds the promise of more robust risk characterization.

Strategic investments in exposure science will be needed to make this promise a reality. Owing to the importance of exposure assessment in risk characterization, the cost of failing to make these investments will remain high. Lack of real understanding of our most important environmental risks, of approaches to interdicting them, and of strategies for improved public health will persist. With that will come poorly informed and, in some cases, counterintuitive personal decisions, as well as less than cost-effective use of public funds to address environmental public health issues.

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