2. Variability and Uncertainty

2.1 Variability versus Uncertainty

Accounting for variability and uncertainty is fundamental to exposure assessment and risk analysis. Characterizing and communicating uncertainty and variability should be done throughout all the components of the risk assessment process (NRC, 1994). Thus, careful consideration of the variabilities and uncertainties associated with the exposure factors information used in an exposure assessment is of utmost importance.

This section highlights some of the fundamental concepts of variability and uncertainty related to exposure factors data, as presented in Chapter 2 of the *Exposure Factors Handbook*.

2.2 Types of Variability

Variability in exposure potential is a function of the variability in human exposure factors (i.e., those related to an individual's location, activity, behavior or preferences at a particular point in time, or physiological characteristics such as body weight), as well as variations in contaminant concentrations (i.e., those related to pollutant emission rates and physical/chemical processes that affect concentrations in various media, e.g., air, soil, food, and water). Four types of variability can be distinguished: across locations (spatial), over time (temporal), within an individual (intra-individual), and among individuals (inter-individual).

2.3 Types of Uncertainty

Uncertainty in exposure analysis is related to the lack of knowledge concerning one or more components of the assessment process. U.S. EPA (1992) classified uncertainty in exposure into three broad categories: (1) uncertainty regarding missing or incomplete information needed to fully define exposure and dose (scenario uncertainty), (2) uncertainty regarding some parameter (parameter uncertainty), and (3) uncertainty regarding gaps in scientific theory required to make predictions on the basis of causal inferences (model uncertainty).

Because uncertainty in exposure assessment is fundamentally tied to a lack of knowledge concerning important exposure factors, strategies for reducing uncertainty necessarily involve reduction or elimination of knowledge gaps. Strategies for reducing uncertainty include: (1) collection of new data using a larger sample size, an unbiased sample design, a more direct measurement method, or a more appropriate target population; and (2) use of more sophisticated modeling and analysis tools, if data quality allows.

2.4 How the *Exposure Factors Handbook* Addresses Variability and Uncertainty

The *Exposure Factors Handbook* attempts to characterize variability of each of the exposure factors presented. Variability is addressed by presenting data on the exposure factors in one of the following three ways: (1) as tables with percentiles or ranges of values for various life stages, demographical variables, geographical regions, and sociodemographic variables where available and applicable; (2) as probability

distributions with specified parameters including confidence intervals; or (3) as a qualitative discussion.

The *Exposure Factors Handbook* addresses uncertainty by providing qualitative discussions of the limitations associated with each of the studies used to derive recommendations. Confidence ratings are also provided based on U.S. EPA's judgment of the data underlying such recommendations.

For more information about variability and uncertainty, refer to **Chapter 2 of the *Exposure Factors Handbook*** at http://www.epa.gov/ncea/efh/pdfs/efh-chapter02.pdf. Detailed information on variability versus uncertainty is provided in Section 2.1, types of variability in Section 2.2, addressing variability in Section 2.3, types of uncertainty in Section 2.4, reducing uncertainty in Section 2.5, analyzing variability and uncertainty in Section 2.6, literature review of variability and uncertainty analysis in Section 2.7, and presenting results of variability and uncertainty analysis in Section 2.8.