Editorial

Towards comprehensive health risk assessments of chemicals for occupational and environmental health

Exposure to chemicals in the workplace or in the environment has led to devastating health problems. Some cases involve exposure to chemicals at unsafe concentrations or at high doses; others involve life-long exposure to low levels of chemicals that are contaminated in food, water, or air. The historical evidence indicates societies often placed profits and prosperity before health and environmental concerns. However, these incidents have also led to a gradual understanding of the associated human and environmental costs and generated common interest in protecting human health and preserving the environment. Various international organizations, national authorities, and non-governmental bodies have made significant efforts to assess the potential health risks posed by chemicals and to safeguard individuals from hazards both in the workplace and in the general environment. In particular, chemicals occurring in commercial products or in the environment are generally subject to risk assessments.

This article seeks to describe some typical characteristics of workplace and environmental chemical risk assessments to identify potential problems and to envisage an integrated risk assessment paradigm. A vast store of information on various chemicals, including data on characteristics, behavior when released into the environment, and toxicity in humans and laboratory animals, has been accumulated to date and is available as common scientific assets for risk assessments. Data-driven standards and guidelines derived from risk assessments are widely used as safeguards to protect people in the workplace and for public health. Health risk assessments seek to estimate risks posed by exposure to a particular agent for a given target organism, system, or population or subpopulation, including identification of attendant uncertainties, based on the inherent characteristics of the agent and the characteristics of specific target systems. As is well established, the risk assessment process begins with the formulation of the problem or issue and includes four additional steps: 1) hazard identification; 2) hazard characterization; 3) exposure assessment; and 4) risk characterization[1)]. This paradigm is applied to both occupational and environmental health risk assessments.

The concept of maximal allowable concentration (MAC) was first proposed at the American Conference of Governmental Industrial Hygienists (ACGIH) in 1941, and the threshold limit value (TLV) in 1956. This idea likely involves the earliest attempt, before the introduction of the risk assessment paradigm, to establish guideline values for exposure to specific chemicals at the workplace. The number of chemicals currently registered with TLVs exceeds 700[2)]. In 1961, the Japan Society for Occupational Health (JSOH) began promulgating Occupational Exposure Limits (OELs) as reference values to safeguard workers from the adverse effects of exposure to chemical substances and other physical agents[3)]. Similar guidelines have been proposed and adopted by other countries as part of their domestic regulations. In the past, the target population envisioned typically consisted of healthy adult males; now, target populations typically assume healthy male and female workers, working 8 h a day and a total of 40 h weekly, engaged in tasks of moderate intensity. In occupational exposure scenarios, inhalation is the primary route of exposure, followed by the potential secondary route of dermal exposure. Acute and chronic toxicities, carcinogenicity, immune sensitivity, and reproductive toxicity are the main possible endpoints.

Based on empirical evidence, health risk assessments of chemicals generally adopt two types of modes of action in dose-response relationships: non-cancer endpoints are assumed to have thresholds, whereas cancer endpoints are assumed to lack thresholds. Thus, reference values corresponding to an excess lifetime cancer risk (ELCR) are estimated for chemicals classified as human carcinogens. While most such reference values fall in the range of 10^{-3} to 10^{-4}, these values are not recommended acceptable safety levels by the JSOH. In addition, certain chemicals, like ethylene oxide and trichloroethylene, are assigned both an OEL value for a non-cancer endpoints and a value for a cancer endpoint. The presence of two guideline values, the OELs and reference values, can force occupational health experts to make difficult decisions on how best to

minimize cancer risks.

The exposure scenarios for individuals living in the general environment differ significantly from the workplace. The sub-populations most at risk in the general population include pregnant women, babies, infants, the elderly, and others with unusual sensitivity to chemical exposure, all of whom are assumed to face potential exposure throughout the day over the course of their lives, primarily via food, drinking water, and the atmosphere, and potentially via other environmental media (for example, soil and standing bodies of water). As in health risk assessments of occupational settings, standard or guideline values, such as allowable daily intake (ADI) and tolerable daily intake (TDI), have been established for non-cancer endpoints, while the virtually safe dose (VSD) concept is applied to cancer risks. The latter assesses individual ECLRs and assigns values on the order of parts per 10^{-5} to 10^{-6}. Internationally, the World Health Organizations and the UN Food Agricultural Organization jointly issue recommendations for guideline values for chemicals occurring in commercial food products; the same is done nationally by governmental authorities, like the Food Safety Commission in Japan. Based on these guideline values, national governments, including the Ministry of the Environment in Japan, implement standard or guideline values to preserve environmental quality and to protect human health.

From a health protection perspective, risk assessments of chemicals in the occupational health and environmental health disciplines have progressed side by side, based on an empirical data-driven approach. Human data obtained from occupational settings are often highly informative and useful in identifying health hazards. Biomonitoring data obtained in routine screenings by the ACGIH or JSOH, typically in urine or blood specimens from workers exposed to specific conditions, can provide useful information on dose-response relationships and risk characterization. Non-adverse effect levels (NOAEL) or related parameters estimated from epidemiological studies of populations exposed to chemicals in the general environment are also used for risk assessments in occupational settings. The growing numbers of female employees of reproductive age in recent years at workplace point to the need for more attention to reproductive health issues within the paradigm of health risk assessment.

In closing, the following points may be useful in the future development of risk assessments of chemicals for both occupational and environmental health. First, as to a given chemical, individual data sets generated in the occupational settings and environmental settings are not always consistent each other, in terms of standard/guideline values, such as the OELs, ADI/TDI, and VSD, as well as uncertainty (safety) factors. Various risk assessment for occupational and environmental health have generated significant data sets for many chemicals, and these data sets may need to be revisited for consistency and harmonization. Second, humans are continuously exposed to low levels of chemicals in a daily life in ways that may not generate overt signs of toxicity. Accumulating experimental evidence suggests epigenetic changes affecting specific genes in fetuses may contribute significantly to health status and adulthood diseases, a field of study now widely known as developmental origins of health and disease (DOHaD). Work to assess this threat may well require approaches other than the ones traditionally taken to evaluate reproductive toxicity in offspring (post-weaning growth, behavior, function, sexual maturation, carcinogenesis, accelerated aging, and other processes). Third, assessments of neurotoxicity risks have a long history in occupational settings and in environmental health. In the former, inhalation of organic solvents or metal vapors pose significant risk of brain damage at poorly-controlled workplaces worldwide; in the latter, low levels of exposure to neurotoxicants, including methyl mercury, endocrine disrupting chemicals, and pesticides[4], have been suspected to affect the developing brain. Due to cost issues and obsolescence, the current developmental neurotoxicity (DNT) test guideline, established by the Organisation of Economic Cooperation and Development (OECD), has not been often implemented. Now may be the time, in light of other test guidelines, to begin developing the foundations required for a new set of DNT guidelines[5].

References

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