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Uses and issues of biomonitoring

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Abstract

In the last two decades, an explosion in information and literature on human biomonitoring data has occurred. Symposia, workshops, and workgroups have been formed to discuss all issues surrounding biomonitoring. One such workgroup, formed by the International Life Sciences Institute's Health and Environmental Sciences Institute (HESI), developed a wheel which has biomonitoring at its hub; its spokes depict the uses of biomonitoring. As it rolls and picks up speed, the biomonitoring wheel will no doubt gain additional spokes. In this manuscript, we describe and give examples of these biomonitoring uses and some of their further applications as well as some of the issues surrounding biomonitoring. Special emphasis is placed on the uses and limitations of large-scale representative cross sectional studies such as the National Health and Nutrition Examination Surveys in the United States. Priority setting, improved modeling methods for interpreting the biomonitoring data, and an increase in studies designed to associate health indicators and health risks to selected environmental chemicals are needed to increase the power of biomonitoring.

Keywords: Biomonitoring; Epidemiological studies; Population surveys; HESI

Introduction

"Biomonitoring," a contraction for "biological monitoring," is defined in the environmental public health field as the assessment of human exposure to an environmental chemical via the measurement of that chemical, its metabolite(s), or reaction product(s) in human blood, urine, milk, saliva, adipose, or other tissue in individuals taken separately but generally taken together to constitute a population.

This measurement of the biomarker of exposure to a particular chemical is then often linked to the concentration of the internal dose (Fig. 1). Potentially, the biomarker of exposure can also be directly linked to the target organ dose following the measurement of the biomarker in that target; however, target tissues, even if known for a particular chemical, are often impractical to collect in living humans. Therefore, in biomonitoring for environmental public health purposes we generally measure the biomarker in blood or urine and relate that concentration to the internal dose and then investigate the possibility of associating those data toward the effect end of the continuum (in the forward direction) or back to exposure and potentially the source of the exposure. Furthermore, any biomarker measurement to support a study in a given individual, community, or any population of course requires the appropriate study design and the execution of that design. Included in this design is the choice of the appropriate biological matrix and its proper collection,

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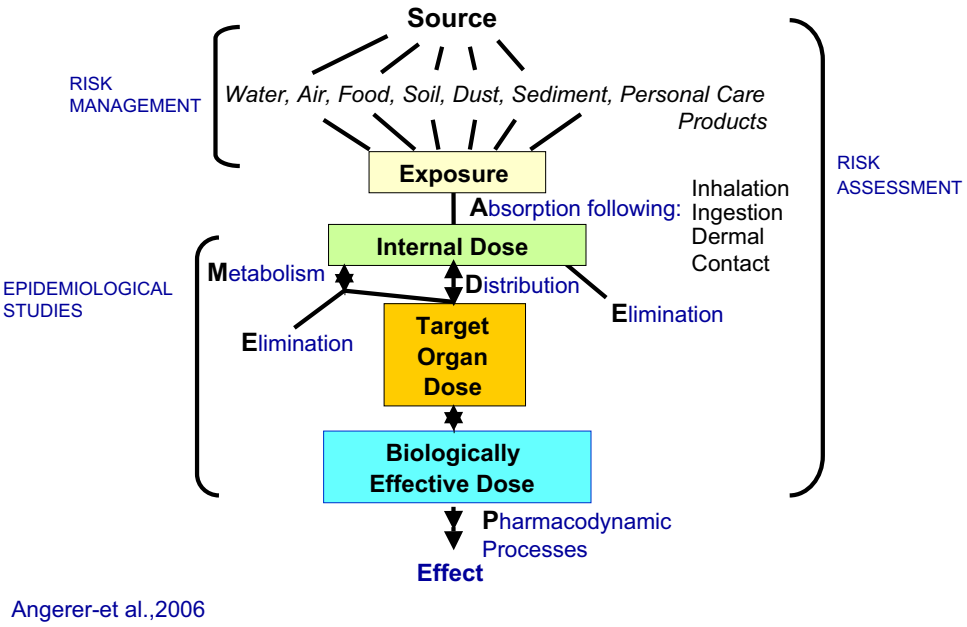

Fig. 1. Exposure-effect continuum for environmental chemicals (Angerer et al., 2006).

shipping, storage, and potential banking as well as the utilization of analytical techniques that meet the needed requirements to properly execute the designed study. These requirements, which should be defined for each study, include the following (Needham et al., 2002): accuracy, precision, specificity, limit of detection, linearity/range; and robustness/ruggedness.

Biomonitoring has many potential uses. The subcommittee on Biomonitoring of the International Life Sciences Institute/Health and Environmental Sciences Institute (HESI) has developed a wheel with biomonitoring at the hub (Fig. 2). Various spokes project from the hub depicting various applications of biomonitoring. Ultimately, these spokes lead to the inner wheel, which indicate that data from these "spokes" can be used for exposure assessment purposes or to study potential health effects/risks. The outer wheel better defines applications of these data. The spokes leading to exposure assessment include the development of reference ranges and the development of data on trends, both temporally and spatially. The spokes leading to health effects/risks include epidemiological investigations and emergency response investigations. No doubt in the future more spokes will be added to the wheel while others may be deleted as the world of biomonitoring continues to roll at even a faster rate. That faster rate began in the mid-1980s and continues today as noted in Fig. 3 which depicts the rapid increase in the number of publications over this period. Examples of the many uses and issues of biomonitoring will be given herein. This manuscript is based on a presentation we gave at the HESI annual meeting in San Juan, Puerto Rico in January, 2007. This annual meeting was preceded by a HESI International Biomonitoring Workshop held in Research Triangle Park, North Carolina in September, 2004. That Workshop consisted of a series of biomonitoring case studies that were the subjects of a mini monograph along with an overview paper on the use of biomonitoring data in exposure and health risk assessments (Albertini et al., 2006).

Selection of the biological matrix

The selection of the biological matrix is driven by the chemical monitored and its pharmacokinetics, the characteristics of the population, and other characteristics of the exposure scenario. Referring to Fig. 4, environmental chemicals can enter the body by three routes: ingestion, inhalation, and dermal contact. The chemicals are absorbed into the blood stream and following possible metabolism (biotransformation) are distributed within the body. In general, the chemicals, such as many congeners of polychlorinated dibenzo-*p*-dioxins, furans, and biphenyls, which have long biological half-lives (on the order of several years), are measured in blood or in fatty body compartments, such as adipose tissue; in lactating women, they can also be measured in their milk (Needham and Wang, 2002). Any of these matrices are potentially satisfactory for measuring these persistent chemicals because of the equilibrium established rather quickly in concentrations among the lipid portions of each of these matrices. Another persistent chemical is lead, which can be monitored in whole blood or in its deposition sites,