Health Surveillance Report

(Biological Monitoring and Biological Effect Monitoring – Path report)

Back to Basics "What should a BM and BEM report look like?" Part 3

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In this the third part in our series on what a BM and BEM report should look like, biological exposure indices and sampling are discussed in extracts from the ACGIH's introduction to Biological exposure indices®.[1]

BIOLOGICAL EXPOSURE INDICES

"Biological monitoring provides one means to assess chemical exposure and health risk to workers. It entails measurement of the concentration of a chemical determinant in the biological media of those exposed and is an indicator of the uptake of a substance. Biological exposure indices (BEIs®) are guidance values for assessing biological monitoring results. BEIs represent the levels of determinants that are most likely to be observed in specimens collected from healthy workers who have been exposed to chemicals to the same extent as workers with inhalation exposure at the Threshold Limit Value (TLV®).[1] The exceptions are the BEIs® for chemicals for which the TLVs® are based on protection against non-systemic effects (e.g., irritation or respiratory impairment) where biological monitoring is desirable because of the potential for significant absorption via an additional route of entry (usually the skin.) Biological monitoring indirectly reflects the dose to a worker from exposure to the chemical of interest. The BEI® generally indicates a concentration below which nearly all workers should not experience adverse health effects. The BEI® determinant can be a chemical itself; one or more metabolites; or a characteristic, reversible biochemical change induced by the chemical. In most cases, the specimen used for biological monitoring is urine, blood, or exhaled air. The BEIs® are not intended for use as measures of adverse effects or for diagnosis of occupational illness.

Biological monitoring can assist the occupational health professional detect and determine absorption via the skin or gastrointestinal system, in addition to that by inhalation; assess body burden; reconstruct past exposure in the absence of other exposure measurements; detect non-occupational exposure among workers; test the efficacy of personal protective equipment and engineering controls; and monitor work practices.

Biological monitoring serves as a complement to exposure assessment by air sampling. The existence of BEI® does not indicate a need to conduct biological monitoring. Conducting, designing and interpreting biological monitoring protocols and the application of the BEI® requires professional experience in occupational health and reference to the current edition of the Documentation of the Threshold Limit Values and Biological Exposure Indices (ACGIH®)".[1]

DOCUMENTATION

BEI recommendations are developed by Committee consensus and ACGIH® Board of Directors ratification through an analysis and evaluation process. "The detailed scientific criteria and justification for each BEI can be found in the Documentation of the Biological Exposure Indices.[2] "The principal material evaluated by the BEI Committee includes peer-reviewed, published data taken from the workplace (i.e., field studies), data from controlled exposure studies, and from appropriate pharmacokinetic modelling when available. The results of animal research are also considered when relevant. The Documentation provides essential background information and the scientific reasoning used in establishing each BEI®. Other information given includes the analytical methods, possible potential for confounding exposures, specimen collection recommendations, limitations, and other pertinent information."[1]

In recommending a BEI to the ACGIH® Board of Directors, the Committee "considers whether published data are of reasonable quality and quantity and may also consider unpublished information if verified. There are numerous instances when analytical techniques are available for the measurement of a biological determinant, but published information is unavailable or unsuitable for determining a BEI. In those instances, occupational health professionals are encouraged to accumulate and report biological monitoring data together with exposure and health data."[1]

RELATIONSHIP OF BEIs TO TLVs

Each BEI determinant is an index of an individual's "uptake" of a chemical or chemicals. "Air monitoring to determine the TLV indicates the potential inhalation "exposure" of an individual or group. The uptake within a workgroup may be different for each individual for a variety of reasons, some of which are indicated below." Most BEIs® are based on a direct correlation with the TLV – TWA: the concentration of the determinant which can be expected when the airborne exposure is a TLV –TWA. "Some of the BEIs® (e.g. lead) are not derived from the TLV but directly relate to the development of an adverse health effect. The basis of each BEI® is provided in the Documentation."[1]

"Inconsistencies may be observed between the information obtained from air monitoring and biological monitoring for a variety of reasons, including, but not limited to, work-related and methodological factors. Examples are listed below:

- Physiological makeup and health status of the worker, such as body build, diet (water and fat intake), metabolism, body fluid composition, age, gender, pregnancy, medication, and disease state.
- Occupational exposure factors, such as the work rate intensity and duration, skin exposure, temperature and humidity, co-exposure to other chemicals, and other work habits.
- Non-occupational exposure factors, such as community and home air pollutants, water and food components, personal hygiene, smoking,

alcohol and drug intake, exposure to household products, or exposure to chemicals from hobbies or from another workplace.
- Methodological factors, such as specimen contamination or deterioration during collection and storage and bias of the selected analytical method.
- Location of the air monitoring device in relation to the worker's breathing zone.
- Particle size distribution and bioavailability.
- Variable effectiveness of personal protective devices."[1]

COLLECTION OF SPECIMENS

Because the concentration of some determinants can change rapidly, the specimen collection time (sampling time) is very important and must be observed and recorded carefully. The sampling time is specified in the BEI® and is determined by the duration of retention of the determinant. Substances and determinants that accumulate may not require a specific sampling time."[1] An explanation of the BEI® sampling time is as follows:

Sampling time	Recommended collection
1. Prior to shift	16 hours after exposure ceases.
2. During shift	Anytime after 2 hours of exposure.
3. End of shift	As soon as possible after exposure ceases.
4. End of the workweek	After four or five consecutive working days with exposure.
5. Discretionary	At any time.

ACCEPTABILITY OF URINE SPECIMENS

"Urine specimens that are highly dilute or highly concentrated are generally not suitable for monitoring. The World Health Organization has adopted guidelines for acceptable limits on urine specimens as follows:

Creatinine concentration :>0.3 g/L and <3.0 gL

or

Specific gravity:>1.010 and <1.030

Specimens falling outside either of these ranges should be discarded, and another specimen should be collected. Workers who provide consistently unacceptable urine specimens should be referred for medical evaluation.

Some BEIs® for determinants whose concentration is dependent on urine output are expressed relative to creatinine concentration. For other determinants, such as those excreted by diffusion, correction for urine output is not appropriate. In general the best method may not be available. When the field data are only available as adjusted for creatinine, the BEI® will continue to be expressed relative to creatinine; in other circumstances, no correction is recommended, and the BEI® will be expressed as concentration in urine."[1]

ASSURANCE OF QUALITY

"Each aspect of biological monitoring should be conducted within an effective quality assurance (QA) program. The appropriate specimen must be collected, at the proper time, without contamination or loss, and with use of a suitable container. Donor identification, time of exposure, source of exposure, and the sampling time must be recorded." The analytical method used by the laboratory must follow routine quality control rules and the laboratory should participate in an external proficiency program.

The occupational health professional should provide known blind challenges to the laboratory along with worker specimens (e.g., blanks, purchased or spiked specimens containing the determinant, or split specimens). These blind challenges will enable the occupational health professional to assess the ability of the laboratory to process, analyse, and report results properly and to have confidence in the laboratory's ability to accurately measure the worker's BEI®. When blind challenges are used, the spiked determinant should be in the same chemical form and matrix as that being analysed by the laboratory."[1]

NOTATIONS

B denotes background, and refers to a determinant that may be present in biological specimens collected from non-occupationally exposed subjects, at a concentration which could affect interpretation of the result. The BEI® value incorporates these background concentrations.

Nq meaning nonquantitative, indicates compounds for which biological monitoring should be considered. This is based on the review, although there was insufficient data to determine a specific BEI®.

Ns refers to nonspecific determinants, as they are also observed after exposure to other chemicals.

Sq, i.e. semiquantitative, refers to a biological determinant that is an indicator of exposure to the chemical, although the quantitative interpretation of the measurement is ambiguous. These should only be used as screening tests if quantitative tests are impractical or as confirmatory tests if the quantitative test is nonspecific and the determinant's origin is questionable.[1]

Note: It is essential to consult the specific BEI Documentation before designing biological monitoring protocols or interpreting BEIs.

The application of BEIs and interpretation of results will be discussed in the March/April 2013 issue.

REFERENCES

1. American Conference of Governmental Industrial Hygienists. Products. Biological Exposure Indices (BEI®) Introduction. Ohio, USA: ACGIH. Updated 02/01/2012. Available at: http://www.acgih.org/Products/beiintro.htm Accessed on 13 January 2013.
2. American Conference of Governmental Industrial Hygienists. TLVs® and BEIs®. Guide to occupational exposure values. Documentation of the threshold limit values and biological exposure indices. 7th ed. Cincinnati, Ohio: ACGIH; 2012.
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4. SASOM Guidelines. Pretoria: SASOM; 2010.

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