

# The Challenge of Low-Level Workplace Exposures

Is our ability to detect ever smaller exposures to chemicals and other substances outstripping our understanding of what the exposures mean?

by *Howard M. Sandler, M.D.*

**T**he dose makes the poison" is probably the oldest toxicology truism. However, we are increasingly faced with reports that exposure to workplace and environmental agents at levels previously thought safe can produce adverse health effects. Scientific advances enable us to measure chemicals and other potential hazards at lower and lower levels. Soon, occupational safety and health professionals will be confronted with the dilemma of interpreting possible toxicological effects from exposure to a few molecules of a substance.

As we become more expert at detecting extremely low levels of chemical, biological and physical agents, interpreting the association between exposure and biologic changes, whether they are "physiological" or "pathological," will become a major challenge.

Numerous examples of low exposure concerns have become important occupational and environmental health issues, including: Neurotoxic effects of lead in children and adults; carcinogens; indoor air quality; environmental illness (multiple chemical sensitivity); pesticide residues; solvent encephalopathy; and cumulative trauma disorders.

In measuring health effects, medical science has provided us with a variety of tests which purport to show subtle changes in neurocognitive, behavioral, immune system, genetic, respiratory, hepatic, renal and other body organ system function. Unfortunately, all of us have seen medical practitioners use various tests of questionable clinical reliability when conducting independent

medical evaluations or the over-zealous interpretation of data by researchers, activist groups and the media.

When confronted with low-level exposure concerns, issues to be resolved include: Is the effect of clinical significance? Can a threshold be established? Can a causal association be made? What steps should be taken to limit future exposure? What is the potential regulatory impact?

## Clinical Significance

We can test memory, IQ, cerebral blood flow patterns, immune cell levels, liver enzymes and many changes in body physiology. However, we often do not know the clinical significance of these test results. Many tests require considerable interpretation by the evaluator. Setting normal-abnormal "cutoffs" for determination of pathology is frequently done without an adequate scientific foundation.

The same can be said of symptoms. For example, headache, sore throat, sinus congestion, cough, gastro-intestinal complaints, fatigue, pain and many other symptoms occur repeatedly in a very high percentage of the general population. Upper extremity pain, fatigue and discomfort also occur frequently in workers and nonworkers.

The mere fact that an employee has "abnormal" (if they truly are) test results or there are physical or mental complaints does not mean that he or she has a clinical disorder. More importantly, there is precious little information to ascertain whether mere test findings or symptoms will result in disease. This is

one of the critical problems OSHA faced in attempting to promulgate the ergonomics and indoor air standards.

## Setting Thresholds

Another rule of toxicology is that each hazardous agent requires a minimum-level dose, known as the threshold, to produce an effect. As anyone who has assisted in the development of a government criteria document or regulation knows, it is difficult to set exact exposure cutoffs to assure safety, even with clearly defined and diagnosable conditions at high, easily documented exposures. For low-level exposures, the difficulty rises steeply for a variety of reasons. They include:

- Differences between "hypersusceptible" populations, such as the elderly, young or infirm, and working groups.
- Potential differences in metabolism at low levels of exposure.
- "Effects" that may be temporary, such as cough and pulmonary function reduction in grain workers which return to prior baseline once exposure ceases.
- Effects that may be within "tolerance" of normal range. For example, low blood lead levels ( $\leq 25\text{mg/dl}$ ) in children allegedly produce changes of 1-6 points in IQ.

Let's take a concrete example of the difficulty in establishing a threshold at low exposure levels: Carcinogens. Our knowledge at the "genetic" level of the cancer process (initiation, promotion, etc.) continues to grow but is still quite limited. A major element missing from our understanding, for example, is what levels of exposure and time duration will cause the risk of developing cancer to rise above that of a nonexposed population.

A number of scientists ascribe to the "one molecule (one fiber for asbestos), one hit" theory, believing there is no threshold level for carcinogens. This

hypothesis means that it is conceivable that a single molecule of a chemical carcinogen can affect the body to produce a cancer. However, if this is indeed true, it is difficult to understand why we don't see a large rise in lung cancer in nonsmokers due to the fact that the average urban dweller has millions of asbestos fibers in his or her lungs.

### Causal Association

Proper scientific methodology to determine the existence of a causal association between an exposure and a health effect requires the rigorous application of what has been termed Hill's Criteria:

- Strength of Association
- Consistency
- Specificity
- Temporality
- Biologic Gradient
- Plausibility
- Coherence
- Experimental Evidence
- Analogy

Many occupational health practitioners have faced instances where employees are convinced there is something wrong with them. Their proof usually goes: "Well, I didn't feel like this before I began working here." However, people's memories are notoriously selective for many reasons. Individuals may be experiencing a symptom intermittently, for example, without really recognizing it until a specific event, such as a spill, occurs. Thus, even the relatively simple criteria of temporality often is not met in a given case under study.

Claimed neurobehavioral effects from low-level solvent exposure also illustrate some causal association difficulties. One of the more frustrating aspects of neuropsychometric testing is that invariably, a large battery of individual tests and subtests is employed. The majority of the test results are usually normal. But for a given group or individual, it is not surprising to find one or more test results which are statistically significantly different from the "normal" value. Further, it is frequently found in group studies that there is a large variation in which tests within a specific battery are considered indicative of an abnormality.

Frequently, the only source of information about exposure is job classification, which is usually inadequate in low-level instances. With high exposures to certain solvents, certain patterns have

appeared in neurocognitive testing, such as visuospatial and memory problems. However, questions of adequate controls for confounding variables exist even in high-level exposure studies.

Should such testing find an association at high levels, does this mean that the same effect(s) occurs at low levels, only to a lesser degree? Is there any clinical effect? The fact is, one cannot simply assume that the same mechanism of toxicity occurs at low exposures.

For example, cigarettes contain a number of solvents, including benzene and toluene. Does this mean that smokers experience "toxic encephalopathy"? Obviously no one would advocate smoking for its health benefits. The simplistic approach that all we need are more "sensitive" tools which will show toxicity at levels once thought safe is fraught with dangerous assumptions about basic low-exposure toxicological principles.

Additionally, consideration must be given to the likely potential that simultaneous exposure to various substances may produce the opportunity for the potential effects from low-level exposures to be expressed at levels lower than would normally occur without the influence of "mixture effects."

### Setting Internal Limits

While Environmental Illness (EI) remains a theory, occupational health professionals still face the everyday reality of dealing with individuals who allege they are becoming sick because of exposures to very low levels of chemicals in the environment.

From an employee placement standpoint, these individuals may request an accommodation under the Americans with Disabilities Act as "qualified" individuals. Assuming for the moment that EI is determined to have disabled the worker (certainly a routine potential finding if one includes the psychiatric basis for many EI "sufferers"), safety and health professionals have to determine what constitutes the "chemically free" environment often recommended as a medical work restriction. In the instance of EI, chemically free is not defined by "measurable" levels of the actual substances/agents, but by the symptomatology of the individual. This usually means "Since I feel bad, I

am being exposed" or "I can smell something, so I am being exposed."

A recent experiment in California illustrates the inherent problem. A federal grant helped underwrite the construction of a chemically free "garden apartment" complex. Careful attention in construction design and materials was brought to bear, resulting in non-detectable levels above ambient air.

However, EI sufferers continued to complain of myriad symptoms months after they moved into the complex.

Setting internal standards to stop all health complaints in the workplace is doomed from the start. Typically, when an actual low-level effect occurs, the workers with concerns and/or complaints

break down into three main groups:

- Workers with actual exposure-produced problems.
- Workers with medical problems not related to the exposure.
- Workers with personal and work-related psycho-social factors.

Pursuing low exposure limits may address the first group to some extent, but only education and dealing with labor-management issues will solve the concerns and complaints of the others.

Setting limits becomes an even more difficult problem once a true "injury" has been diagnosed. Workers with musculoskeletal conditions, such as carpal tunnel syndrome, derived from activities with repetitive motion and other alleged ergonomic risk factors may also create "limit setting" problems. How much upper extremity repetition, force, sustained posture, etc. is safe for a worker with CTS? Is one repetition per minute too much? The question becomes more difficult when determining what is a safe exposure limit for "hypersusceptible" and currently impaired populations.

### Regulation

It is not possible to provide a "blueprint" for regulatory approaches for limiting low level exposures; the science needs to evolve. The OSHA law requires the demonstration of a significant health effect prior to embarking on health standard setting. Symptoms, abnormal test results, etc. should not necessarily be considered adverse health effects.

When OSHA issued its proposed in-

**For information on Occupational Health products and services, see page 140 of the 1997 Directory.**


door air quality standard, one of the "health effects" which served as a basis for the standard was headache. Considering the extremely subjective nature of the complaint as well as its ubiquity in the general population, it is hard to objectively create "triggers" delineating the presence of a work-related problem and requisite activities under the standard once the trigger has been met.

For example, if the background rate of headaches is 30 percent in the general population, should a standard "kick in" once more than 30 percent of the current work force complains of headaches over a given time frame? Or should the trigger for required exposure testing, education, medical removal, etc., be the frequency of the complaint, or the extent of the complaint? Must it occur in more than one work group at a certain level? What do you do if all exposure testing fails to find a chemical "culprit"?

When regulations move away from actual exposure levels and are based on effect, employers are left with a subjective, moving target of nondocumentable complaints. Regulations must also establish clear and consistent criteria to address the "test result" as a significant health effect. Does an elevated enzyme level mean that workers will develop disease? Ignoring the myriad causes of abnormal test results, such as psychological problems and neurobehavioral testing or alcohol use and liver function tests, can muddy the etiologic waters. Do you simply set a standard because of a statistically significant difference in a test result even though there may be no clinical relevance to the finding and the difference in exposure levels is slight?

### **Guidance Needed**

As we move toward reducing hazardous exposures in the workplace, we are faced with determining "What is a safe exposure level?" Our ability to measure extremely low levels of substances is becoming quite sophisticated, as is our rapidly expanding knowledge in measuring bodily functions. Clear-cut effects and dose-response levels for those effects are fading into the mysteries of "low-level exposure" and associated "health effects." It is critical to outline clear and consistent scientific guidance for employers, regulatory agencies, researchers, clinicians and labor to assure that precautions are taken when appropriate, not because expo-

sure at any level is deemed hazardous until proven innocent. 



Contributing Editor Howard M. Sandler, M.D., is president of Sandler Occupational Medicine Associates Inc., a Melville, N.Y., occupational and environmental consulting firm. Dr.

Sandler is a former medical officer with NIOSH and has consulted for EPA, OSHA and the Consumer Product Safety Commission.

