



Measuring Chemicals in People – What Would You Say?
A Boston Consensus Conference on Biomonitoring

BIOMONITORING BRIEFING PAPER

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- I. Introduction
- II. What is biomonitoring?
- III. Why do biomonitoring?
- IV. Uncertainty about health effects
- V. Ethical concerns
- VI. Questions of government policy
- VII. Conclusion

There are tens of thousands of chemicals in our environment today. Some occur naturally, and others are manmade. These chemicals can enter our bodies in the food we eat, the water we drink, and the air we breathe. Some chemicals can be taken in through the skin.

Scientists can now measure chemicals in our bodies in very small amounts. Measuring foreign chemicals in the body is called *biomonitoring*, and it is being used more and more, for a number of purposes. It is an important tool in identifying potentially harmful chemicals in people's bodies. And having this information could help people lower their exposures. But for most chemicals, we do not know what the levels found in people's bodies mean for their health.

The growing use of biomonitoring raises many questions. How should it be done responsibly? How should results be used? What should people be told? These are the kinds of problems we would like you to address in the Consensus Conference.

WHAT IS BIOMONITORING?

Even if you have not have heard the term "biomonitoring," you are probably familiar with some common examples:

- A young girl's blood is tested for lead at her annual check-up. If her blood lead level is above what is considered "safe," she is placed in a special program to reduce her lead exposure.
- A man who appears to be driving while drunk is stopped by the police and given a breathalyzer test. He breathes into a device and it measures the level of alcohol in his breath.
- A woman applying for a job is required to have a drug test. She provides a urine sample, which is tested for the presence of various drugs.

As you can see, biomonitoring can be used for very different purposes. And it can be done in many different ways.

Biomonitoring can measure chemicals in body fluids (for example, blood) or tissues (for example, fat). Measurements can also be made in something that is produced by the body, such as urine, breast milk, exhaled air, or even hair or fingernails. The concentration of a chemical detected in these ways is related to a person's "body burden" of the chemical. This is the total amount of the chemical that the person is carrying around in his or her body. Some biomonitoring methods don't measure the chemical itself, but instead measure signs of the chemical's presence in the body.

When a chemical is taken into the body, several things may happen. The chemical may be eliminated from the body immediately. Or it may be taken into the blood stream, changed or broken down into other chemicals, or stored in body tissues. Some chemicals are stored in fat or bone and can accumulate in the body for years. Other chemicals are broken down rapidly and go out in urine within hours or days of exposure. Biomonitoring

is more difficult for chemicals that break down quickly. This is because the amount or level of a chemical in blood and urine changes so quickly that the timing of testing is critical.

WHY DO BIOMONITORING?

Biomonitoring has been used for many years to see if people are exposed to unsafe levels of chemicals at work. But more and more, biomonitoring is being used for other purposes also. This is partly because of advances in technology over the last 15 years.

Scientists can now measure more kinds of chemicals in a sample of blood (or some other body fluid or tissue). Modern tests can also be done using a smaller sample of blood, body tissue or fluid. In addition, we can now detect chemicals at amazingly low levels: parts-per-billion (for example, one part lead in a billion parts blood), parts-per-trillion, and even parts-per-quadrillion in some cases. With these advances, biomonitoring is being used for more purposes.

Testing in a clinical setting

Doctors commonly do blood or urine tests to see if a patient has elevated levels of certain chemicals that cause health problems. Testing blood for lead is probably the most common example. In Massachusetts, all children must be tested for lead at the ages of 9-12 months, two years, and three years. If a child is found to have a level above the concentration considered “safe” that has been established by scientific studies, the child enters a program to reduce exposure. Then the child is tested each month to see if the lead level is decreasing.

Health studies

Scientists often do research to find out if exposure to a chemical makes people sick. In health studies, scientists need to learn whether the people in the study have been exposed to a chemical, and how much they were exposed. Then they try to figure out how much exposure is needed to make people sick, and whether more exposure makes them more sick.

Biomonitoring plays an important role in answering these questions in health studies. If scientists don't measure the chemical in the body, then they have to make a lot of estimates and guesses. For example, they try to figure out people's exposure to mercury by measuring how much comes out of an incinerator's smokestack. Then they use a computer to “model” the amount of mercury from the smokestack that reaches each person. Biomonitoring is a more direct way to measure exposure—it tells us the level of mercury in each person's body at a certain time.

Groundbreaking health studies of lead exposure and its effect on children's brain development used biomonitoring. These studies measured lead levels in blood and in kids' baby teeth that had fallen out. As a result of recent advances, it is now common to use biomonitoring as a part of a health study. Here are a few titles of recently published scientific articles: “Biomonitoring of Chemical Exposure Among New York City

Firefighters Responding to the World Trade Center Fire and Collapse,” “Body Burdens of Polybrominated Diphenyl Ethers Among Urban Anglers,” “Using Biologic Markers to Assess Exposure to Multiple Environmental Chemicals for Inner-City Children 3-6 Years of Age.”

Monitoring levels in the population

“Surveillance biomonitoring” measures levels of chemicals in the general population rather than in a small group of people in a study. In public health, surveillance has a long definition: “the ongoing, systematic collection, analysis, and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know.” In practice, it simply means trying to get an idea of what people take into their bodies as they go about their daily lives.

The only US national biomonitoring surveillance program is run by the US Centers for Disease Control and Prevention (CDC). The surveillance program is part of the National Health and Nutrition Examination Survey (NHANES). Every year, this project surveys a sample of Americans, asking questions about their health. It also collects blood and urine samples which are tested for chemicals. It is designed to give information on what the average American might be exposed to. The *National Report on Human Exposure to Environmental Chemicals* comes out every two years and has information on Americans’ exposure to different chemicals according to their age, sex, and ethnicity. CDC’s *Third National Report* (2005) tested for 148 chemicals. Results are reported for the nation, not by state, and no testing is done on children under age six, except for lead.

In June 2006, the California legislature passed a bill creating the first state-wide biomonitoring surveillance program. This program will measure a range of different chemicals in about 2,000 Californians every two years. Minnesota and other states are considering similar programs. The federal government has funded a few states, including New Hampshire and New York, to do some biomonitoring programs, but the funding is limited. Many states, including Massachusetts, already have childhood blood lead surveillance programs. New York City also has a biomonitoring program.

Here are some ways that biomonitoring information from national, state and local surveillance programs can be used.

1. Track trends over time

A main function of CDC’s *National Report* series is to determine the levels of certain chemicals present in peoples’ bodies, and to track these levels over time. For example, in the last decade there has been a decrease in blood levels of cotinine. This is a chemical that shows exposure to tobacco smoke. This result probably reflects two changes: fewer people in the study were smokers, and people had lower exposures to second-hand smoke.

2. Show differences in exposure across groups of people

It is useful to have surveillance information for different groups of people, such as people of certain ages or ethnicities. This information can help researchers figure out if some groups are more exposed than others. For example, the CDC's *Third National Report* described urine levels of chemicals called phthalates. (These chemicals are in many cosmetics, including hair spray and nail polish.) Women aged 20-40 had higher levels of phthalates in their urine than women of other ages or men. The report also described urine levels of chemicals that show exposure to pesticides. Mexican-Americans had higher urine levels of these chemicals than did Americans of other ethnic groups.

This kind of information is also useful in another way. It gives national benchmarks for subgroups of Americans, such as Mexican-Americans or women of child-bearing age. As researchers do health studies, this information lets them identify people in these groups who have unusually high or low exposures.

3. Identify subgroups or individuals with worrisome exposures

CDC's *First National Report* showed that 8 percent of women of child-bearing age had mercury levels in their blood higher than the level considered "safe" by the US Environmental Protection Agency (EPA). Other data have shown that some kinds of fish are high in mercury. CDC's finding suggested that women in this age group should not eat much of those fish. As another example, the New York City surveillance program identified a woman with an extremely high level of mercury in her blood. Surveillance workers got in touch with the woman. The source of her exposure turned out to be skin creams contaminated with mercury. In response, the city established a program to educate residents about mercury in certain beauty products.

4. See if public health efforts to reduce exposure have been successful

In the 1970s, the United States began to phase out leaded gasoline. Early in this process, biomonitoring studies showed that blood lead levels in adults and children had gone down 10 times more than expected. This was strong evidence that banning leaded gasoline was successful in reducing exposure to lead. This evidence was important in the government's decision to phase out lead more quickly.

5. Identify new chemicals of concern, and set priorities for research or regulation

Many products now contain flame retardants—chemicals that slow the spread of fire. In Sweden and Germany, there is biomonitoring data on breast milk going back to the 1970s. The data showed that levels of flame retardant chemicals in breast milk had been doubling every five years over the last 25 years. The health consequences of these chemicals at these levels are not known, but studies in animals suggest that they may harm people. In response, the European Union approved a ban on certain flame retardants that takes effect in 2006. Some US states have taken similar actions, and the US EPA now regulates these chemicals more closely. Chemical manufacturers have now voluntarily phased out all but one type of these chemicals.

Addressing community concerns

In recent years, some community groups have used biomonitoring. These groups often work with university or government researchers. Usually community groups believe that a local polluter, such as a manufacturing plant, is causing health problems. By showing higher-than-expected exposures, they hope to strengthen their call for clean-up and medical help.

For example, Anniston, Alabama, is a mostly African-American community that used to be the site of a manufacturing plant. The plant was contaminated with chemicals called PCBs. A local citizens' group worked with federal and state government agencies to collect blood from residents and test it for PCBs. The attorneys who were suing the company on behalf of residents arranged to test thousands more people. Anniston residents were shown to have higher PCB levels than would be expected, based on surveillance information. The community group is using this fact to call for both a clean-up and compensation. Still, no-one knows how PCBs exposures have affected the health of Anniston residents—or may in the future.

Raising political awareness of chemical pollution

Environmental advocacy groups have also used biomonitoring. Their goal is to make the public more aware of chemical pollution. Hoping to make the issue newsworthy, these groups test small numbers of people—some famous and some ordinary.

In 2003, the Environmental Working Group released *Body Burden: The Pollution in People*, a report that tested nine people for 210 chemicals. Later studies by the Environmental Working Group tested breast milk and the blood from newborn babies' umbilical cords. Other groups have done similar studies. A May 2006 study by the Toxic Free Legacy Coalition in Washington tested the hair, blood, and urine of 10 Washington residents. The group used the results to call for reform of US chemical laws.

Groups doing these studies do not claim they are representative of the larger US population. Still, this use of biomonitoring has become the most controversial. Some feel that these very small studies don't provide scientifically useful information, and that it is irresponsible for advocacy groups to use them to cause alarm in the general public. Others feel it's important for people to know that we all have foreign chemicals in our bodies.

UNCERTAINTY ABOUT HEALTH EFFECTS

What do biomonitoring results mean for a person's health? The answer is often unclear. For most of the chemicals we can measure in our bodies, we do not have enough scientific information to say what levels cause harm or what the health effects may be. This sort of information comes from scientific studies which can take years to conduct and even then may not give clear results. The mere presence of a chemical in the body does not mean it is causing harm. On the other hand, "usual" or average levels are not necessarily safe.

This uncertainty creates difficult challenges. A study participant, knowing that his or her body has “elevated” levels of a chemical, can become confused and anxious about health risks. And, when study results are reported in the media, they can be confusing to the general public—who may want to use the information to make choices about products to buy or foods to eat.

For example, when the CDC released its *Third National Report*, some newspaper headlines were upbeat: “Fewer Exposed to Secondhand Smoke or Lead” (*The Oregonian*). Other headlines took the opposite approach: “Toxic America; Tracking the hazardous chemicals that seep stealthily into our bodies” (*San Francisco Chronicle*). Still others gave a mixed message: “Broad Study Finds Lower Level of Old Chemicals, but New Trends Are Called Worrying” (*New York Times*).

Studies that test breast milk for chemicals are especially difficult to talk about. Researchers and others worry that telling a woman her breast milk contains chemicals will cause her to stop breastfeeding, even though research shows that breastfeeding is better than using formula. To a researcher, it may be clear that the health effects are unknown. But a mother may still be worried about the presence of chemicals in her breast milk.

ETHICAL CONCERNS

As already described, biomonitoring is done for different reasons—for clinical testing, for research, for monitoring the population, and for activism. These uses raise some distinct ethical questions, though they also have some in common. Some of these are discussed below.

To think about ethics, it is important to consider how biomonitoring could harm individuals or communities. An individual might face a small risk of physical harm from having blood drawn. There could be emotional harm from not knowing what health problems might result from measured levels of a chemical. And many kinds of harm could result if a person’s employer gets test results and uses them to make decisions about the individual’s job. Similarly, testing a group of people, such as residents of a neighborhood where there is pollution, can lead to harm. The community may be stigmatized, discriminated against, or see their property values go down.

Research in people

Since being in a study may pose risks, researchers must follow certain guidelines. Special committees called Institutional Review Boards (IRBs) review studies by universities and government, and even some private studies. The purpose of this review is to be sure that participants’ basic rights are protected. In particular, participants must know the risks of the study before they agree to take part. Agreement or “consent” to be part of a research study must be given freely, without coercion, and with full information about risks involved in the study. It is also important to make sure that information gathered in the study will be kept confidential. Researchers must guarantee that personal information will not be shared with anyone else unless the person agrees.

Reporting results

For most chemicals, we cannot say whether a certain level in the body is causing harm, or even recommend ways to reduce exposure. This raises questions about whether biomonitoring results should always be reported back to the individuals who have been tested. Do people have a right (or a need) to know this information? If so, how should this reporting be done? It is challenging to explain what is known and not known about health effects while still meeting the needs of participants.

And should information should be reported to the general public? If so, how should this be done so that it is informative but not more alarming than necessary?

Use of information

There are concerns about how biomonitoring information could be used in the future. This is related to the issues of confidentiality and privacy in research studies mentioned above, but is relevant to all uses of biomonitoring. For example, if a health insurance company or employer had access to information on a person's exposure level, they might decide not to insure or employ the person, even if the meaning of the results was unknown.

Access to testing

As biomonitoring becomes more widespread, there will be social and economic differences in who is able to get tested. Though prices have dropped, biomonitoring tests for many chemicals are still expensive. Biomonitoring is not covered by insurance or government testing programs. Testing can cost up to \$1000-2000 for some chemicals. Since testing is often conducted by doctors, people with regular access to medical care may be more likely to get tested.

Medical follow-up

Suppose a person in a biomonitoring study is found to have levels of a chemical above what is considered "safe." What should be done next? Is there an obligation to give feedback or provide medical care? This is not an issue in clinical testing since the person is already seeing his or her doctor. But this question must be considered for research studies and monitoring programs.

QUESTIONS OF GOVERNMENT POLICY

Advances in biomonitoring have also raised a number of questions related to government policy.

Shaping policy

People in government can use biomonitoring information to help make policy decisions. For example, when they decide whether to regulate certain chemicals, they could use information about exposure in the population. Or they could focus resources on groups that have unusually high exposures.

But sometimes this is more complicated in practice. By itself, biomonitoring says nothing about health effects or risk. Information from biomonitoring must be joined with information about health effects. This information might come from research studies in people, or animals, or even test tubes. The question for policymakers, scientists, and citizens is how to put these different pieces of information together to develop good policy.

Scientists, environmental advocacy groups, and the chemical industry see this issue differently. The journal *Science* summarizes one difference in viewpoints on this question: “while environmentalists herald biomonitoring as a valuable tool for precautionary action, chemical manufacturers worry that it will spark unjustified alarm and costly regulations that may not provide much real benefit to public health.”

National surveillance programs

There is a basic question about the need for national biomonitoring surveillance programs such as the CDC’s *National Report on Human Exposure*. At the same time, more funding could address the report’s limitations or buy additional studies. The National Children’s Study proposed to follow a large group of children from before birth throughout childhood. However, the study’s funding was cut in the budget proposed by President Bush. It is currently being debated by members of government.

State surveillance programs

Are state-based surveillance programs needed in addition to the CDC program? If so, what should these programs look like? California recently established the first voluntary state-wide biomonitoring program. Governor Schwarzenegger signed the bill in September 2006. The program will test around 2,000 Californians every two years and will report results to the public. Participants can get their individual test results. To start, the program will measure the same chemicals that are in the national CDC study. However, a scientific advisory group can add more chemicals. Smaller studies may be done of groups suspected to have higher exposures. Dr. Richard Jackson, formerly California’s top medical officer, supported the bill, saying, “Biomonitoring gives you a chance to do a snapshot and look at levels across the state. Do we have hot spots? Are there people we should be looking at? Do our regulations work? Unless you can measure it, you can’t give people decent advice.”

A similar bill was originally proposed three years ago. A number of environmental groups supported it, but the Governor opposed it. Business and industry groups also opposed it. There was disagreement on some critical issues: how the program was designed, its source of funding, the make-up of the advisory group, whether participants should receive test results, and which chemicals should be monitored. After changes addressed these concerns, business and industry groups withdrew their opposition.

CONCLUSION

The field of biomonitoring has advanced quickly over the last 10 years. Biomonitoring has great promise for telling us more about our exposure to chemicals. This rapid progress also raises many scientific, social, ethical, and policy questions about how the technology should be used. These issues are rarely discussed outside of scientific and political circles, except for an occasional news story. The topic needs careful public consideration and debate. This Consensus Conference is the first to give lay people a voice in this important problem.

Here are some of the key issues that you may choose to consider, along with others that come up in your discussions. The ultimate shape and contents of your findings are in your hands.

- Are biomonitoring surveillance programs needed or desirable, at the federal or state level or both?
- Should information from biomonitoring be used in making policy decisions? If so, how?
- What are the key ethical issues related to biomonitoring? How should it be done responsibly when full information on health effects is not known? Who should be tested, and with what safeguards?
- How should results be communicated to those tested and to the public?