Examples of Biomonitoring IN PUBLIC HEALTH

By analyzing clinical specimens, biomonitoring measures the actual uptake by people of environmental chemicals of concern. This document contains just a few examples of how public health laboratories routinely use biomonitoring to support their state and local public health programs. As biomonitoring continues to be integrated into routine public health surveillance, the Association of Public Health Laboratories plans to add to these stories and examples. To learn more about biomonitoring, please read the companion to this document *Biomonitoring: An Integral Component of Public Health Practice*.

INFORM INDIVIDUAL AND CONSUMER CHOICES

In 2010, the California Department of Public Health (CDPH) conducted a study that analyzed the blood of families for multiple chemicals. When the Lopez family[1] signed up to participate, they never imagined what they would learn. The study found 482 µg/L of mercury in the mother's urine and 107 µg/L in the child's, while typical background exposure levels in the general population are 0-4 µg/L for adults and 0-2 µg/L for children.[2]

Figure 1. Examples of unlabeled skin cream from Mexico, courtesy of the Environmental Health Investigations Branch, California Department of Public Health.

An investigation identified 15 people in five households and two states—California and Virginia—with elevated urinary mercury levels linked to skin creams. Used in lightening skin creams, mercury interferes with the production of melanin.[3]

Exposed individuals included five children who were not cream users but were exposed through breastfeeding, direct contact with skin cream users, or secondary sources (e.g., touching contaminated items in the household). Six of those exposed experienced nonspecific symptoms of mercury poisoning, including numbness, tingling, dizziness, forgetfulness, headaches and depression.

The skin creams had been produced in Mexico; all came in unlabeled plastic containers (see photo). CDPH analyses of skin cream samples found mercury levels of 2% to 5.7% (20,000 – 57,000 ppm). To put that in context, the US

Food and Drug Administration (FDA) allows only 1 ppm in skin cream products.

In response, CDPH and the Virginia Health Department issued health alerts that advised the public to stop using unlabeled skin lightening creams or products that list mercury as an ingredient. CDPH also developed a public service announcement in Spanish that aired on Spanish-language radio stations statewide. Several other states including Minnesota, Texas and Maryland and New York City have identified similar cases and posted health alerts on their websites. The FDA also issued a Consumer Alert in 2012.

This example demonstrates how biomonitoring studies identify potential public health threats and prevent illness in the population. Biomonitoring data proves an indispensable means to ***inform individual and consumer choice*** if presented to consumers in an understandable manner. While test results of consumer products indicate the possibility of exposure, biomonitoring tests make it clear to consumers that the contaminant is found in their bodies; a more direct and clearer health message.

BASELINE LEVELS OF EXPOSURE

Volcanic geology, eating shellfish and a history of smelting all lead to potentially high levels of arsenic exposure in the state of Washington. But simply knowing it is in the environment does not mean that people are absorbing arsenic into their bodies. Working with CDC, the Washington State Public Health Laboratory conducted a statewide assessment of arsenic exposure, which serves as a reference for comparison with vulnerable subgroups in the state.

From September 2009 to August 2011, the Washington Environmental Biomonitoring Survey staff collected 1,422 urine samples from a statewide, representative sample of residents age 6 and older.[4] Samples were analyzed at the public health laboratory for total arsenic and the various (or speciated) forms of arsenic, 12 metals, and pyrethroid & organophosphate pesticide metabolites. Simultaneously, the Biomonitoring Project collected drinking water samples from 498 participants and the Washington Tracking Network paid to test the water for arsenic, cadmium, lead, thallium, uranium and manganese.

The survey levels were compared with national levels documented by CDC in the National Report on Human Exposure to Environmental Chemicals. Some of the major findings concluded that urine levels of total arsenic, cadmium and cobalt were higher in Washington compared to national levels, while cesium, lead and thallium were lower.

Results led to guidance from the health department on ways to avoid arsenic exposure, and also created a ***baseline level***[5] for subsequent studies aimed at monitoring levels of arsenic in the population. Biomonitoring data helped the health department implement a community health program to reduce exposures to heavy metals. From this point forward, researchers can use the background data to document whether new programs or policies resulted in an actual reduction in population exposure to harmful chemicals.

TARGETED PUBLIC HEALTH INVESTIGATION

In the 1960s and 1970s, a major perfluorochemical (PFC) manufacturer disposed chemical waste near Washington County, MN. A family of manmade chemicals created to make products that resist heat, oil, stains, grease and water, such as nonstick cookware, PFCs represent persistent and bioaccumulative chemicals that resist environmental degradation. A growing

number of human health studies have found associations between prenatal exposure to PFOS or PFOA and a range of adverse birth outcomes, such as low birth weight, decreased head circumference, reduced birth length and smaller abdominal circumference.[6]

When PFCs were discovered in drinking water wells near the disposal site, the Minnesota Department of Health (MDH) and Minnesota Pollution Control Agency responded with an investigation followed by remediation to reduce or eliminate exposure to these contaminants. A biomonitoring pilot project, mandated in 2007 by the state legislature, evaluated the range and distribution of PFCs in two potentially-exposed communities.

MDH collected almost 200 samples from participants from both communities combined, and measured seven PFCs including PFOA, PFHxS, and PFOS. MDH used the National Health and Nutrition Examination Survey (NHANES) as overall comparison data since MDH did not conduct a control study. They found that the geometric mean in both communities were slightly higher than the national average and the difference was statistically significant.[7]

Over the summer of 2009, MDH staff held community meetings to present results of the study to participants. Epidemiologists and health educators explained to community members the "so what" of the data. Attendees walked away more aware of the presence of the PFCs in their drinking water, an understanding that these chemicals were absorbed into their bodies, and ways they could reduce their exposure.

The state legislature, urged by the members of the two communities, recommended a follow-up study. The goal of the second biomonitoring study was to measure the two-year change in concentration in the residents and assess exposure reduction measures. This study was similar to the first study, but with a longer questionnaire to gather more information about drinking water and dietary habits. Preliminary assessments indicate that efforts to reduce exposures to PFCs in drinking water were effective.

This example of a ***targeted public health investigation*** of a potential community exposure also shows the value that the biomonitoring approach offers regarding evaluation of policies or interventions. Biomonitoring equips policy makers with the knowledge and understanding to pass new or improve existing policies, and to evaluate the effectiveness of those policies. In addition, it gives the affected population facts about whether their environmental exposure is leading to internal exposures, even when the exact health effects of the contaminant have not been conclusively established.

PUBLIC HEALTH SURVEILLANCE

Every year 25,400 deaths occur in the state of New York alone.[8] New York faces a total of $8.16 billion in medical costs to treat smoking caused disease.[9]

In response to these overwhelming numbers, the New York State Tobacco Control Program (TCP) aims to reduce morbidity and mortality and alleviate the social and economic burden caused by tobacco use in New York.[10] Since the inception of TCP, smoking in public spaces decreased drastically, compared to the national average.

In order to better understand the impacts of policies implemented by TCP, in 2004, the New York City Department of Health and Mental Hygiene (NYC) used data from their Health and Nutrition Examination Survey (NYC HANES). The tests in NYC HANES include serum cotinine levels—a biomarker for determining exposure

to tobacco smoke. The study found that more than half of the non-smokers in the study had cotinine concentrations at 0.05ng/mL or greater.[11]

NYC researchers compared the 2004 NYC HANES study to CDC's NHANES study, and found that NYC nonsmokers were exposed to more secondhand smoke than the nonsmokers elsewhere in the nation. This observation was attributed to the very dense urban setting. While NYC has a population density of approximately 26,000 people per square mile, the average national population density is only 80 people per square mile.[12]

Despite the efforts of the TCP, NYC and the state of New York recognized the need for further public health interventions and policies. The NYC HANES biomonitoring project remains a critical tool to monitor exposure over time. For example, NYC researchers conducted a follow-up NYC HANES in 2009 and compared results to the 2004 study to further observe smoking and secondhand smoking trends in NYC.

This ***public health surveillance*** effort allowed the detection and measurement of spatial and temporal differences in population exposures. It is also a way to evaluate the need for public health policies and interventions, and to quantify the effects of implemented policies.

DISEASE DIAGNOSIS

A few people mentioned that the coffee tasted funny, but it was not until 30 minutes later when those individuals began to feel light-headed and had stomach pains that they became concerned. The headline in the news read: "Tainted coffee served after Sunday services killed one and sickened 15. Some are still afflicted."

Over a dozen members of the Gustaf Adolph Lutheran Church in New Sweden, Maine became ill after consuming light refreshments following the morning service. All of the patients admitted to the hospital were in serious condition, three required immediate emergency medical attention and one died. Testing of the coffee by the Maine Health and Environmental Testing Laboratory combined with autopsy results indicated that the illnesses stemmed from acute arsenic poisoning. The State of Maine Department of Health and Human Services administered the stockpiled chemical threat heavy metal antidotes to patients. After chelation treatments, the hospital laboratory tested patients' urine to confirm the success of the prompt treatment. Swift diagnosis and treatment prevented many others from losing their lives.

As this example illustrates, biomonitoring assists with ***disease diagnosis and guiding medical treatment***, which remains necessary to effectively evaluate clinical measures in individuals and support diagnosis of poisoning and assessment for medical treatments in a timely manner.

CONCLUSION

Without biomonitoring, public health practitioners face challenges with understanding whether environmental contaminants are actually being absorbed into people's bodies. Given improvements in technology, the capabilities and expertise that exist in public health laboratories, biomonitoring is poised to become an integral component of public health practice. Such integration in the system will lead to more targeted interventions, policies and overall health, as described in the examples above. Perhaps most importantly, biomonitoring allows programs and policy makers to directly evaluate the impact of their work.

FOOTNOTES

1. The name of the family was changed for this story to protect their anonymity.
2. Based on the National Health and Nutrition Examination Survey http://www.cdc.gov/nchs/nhanes.htm.
3. Boyd, Alan, Donna Seger, Stephen Vannucci, Melissa Langley, Jerrold Abraham and Lloyd King. "Mercury exposure and cutaneous disease." Journal of the American Academy of Dermatology. Volume 43, Issue 1, pp 81-90. July 2000. http://www.jaad.org/article/S0190-9622(00)75915-9/abstract.
4. This story is adapted from "Efforts to Reduce Harmful Exposures to Washingtonians" in APHL's Lab Matters Magazine. Winter 2013, Issue 1. http://www.labmatters-digital.com/aphl/winter2013#pg10.
5. Baseline levels indicate 'background' levels in a population. Public health practitioners often use them as comparison for assessing the specific needs of a population and implementing a possible intervention to address those needs.
6. For more information, please visit the C8 Science Panel website: http://www.c8sciencepanel.org/prob_link.html.
7. For more information about the study, please see the East Metro PFC Biomonitoring Study: July 2009 Technical Report: http://www.health.state.mn.us/divs/hpcd/tracking/biomonitoring/projects/eastmetropfc2008.html.
8. New York State Tobacco Control Program. Leading the Way toward a Tobacco-Free Society: 2010-2013. http://www.health.ny.gov/prevention/tobacco_control/docs/leading_the_way_2010-2013.pdf
9. *Ibid*.
10. *Ibid*.
11. Gwynn, Charon, Renu Garg, Lorna Thorpe. "Contributions of a Local Health Examination Survey to the Surveillance of Chronic and Infectious Diseases in New York City." Am J Public Health. 2009 January; 99(1): 152–159. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2636612/#!po=19.2308
12. Ellis, J.A., C. Gwynn, R.K. Garg, R. Philburn, K.M. Aldous, S.B. Pearl, L. Thorpe and T.R. Frieden. "Secondhand Smoke Exposure Among Nonsmokers Nationally and in the New York City." Nicotine Tob Res (2009) 11 (4):362-370.doi: 10.1093/ntr/ntp021First published online: January 1, 2009. http://ntr.oxfordjournals.org/content/early/2009/01/01/ntr.ntp021.full.pdf+html

Association of Public Health Laboratories

The Association of Public Health Laboratories (APHL) is a national nonprofit dedicated to working with members to strengthen laboratories with a public health mandate. By promoting effective programs and public policy, APHL strives to provide public health laboratories with the resources and infrastructure needed to protect the health of US residents and to prevent and control disease globally.

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