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Monitoring Chemicals in Humans and the Environment: New Directions

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Tracking Chemical Exposures with Biomonitoring

Suzanne Snedeker, Ph.D., BCERF Associate Director for Translational Research

Changes in Monitoring Chemicals in Humans

While scientists have monitored levels of chemicals in exposed workers to assess the cancer risk of many chemicals, little data have been available on actual exposures in the general population. Until recently relatively large blood samples were needed to conduct laborious tests for even one chemical.

This is changing. Over the past decade, there have been rapid advances in the analytical techniques used to measure levels of chemicals in people. Now, researchers can quickly determine low levels of a variety of environmental chemicals in small samples of blood, urine or other tissues. The rapid advances in techniques have also lowered the cost of many tests, making the possibility of monitoring levels of chemicals in the general public more feasible.

Biomonitoring is the direct measurement of a chemical in human tissues or fluids

While human tissues monitored most often are blood and urine, researchers have also used fat, hair, nails, breast milk, and even expired air samples to monitor chemicals of interest. Chemicals monitored may be "natural" (e.g. phytoestrogens from food, metals like cadmium or arsenic contained in the earth's crust), or "synthetic" chemicals (e.g. polychlorinated biphenyls, dioxins, and pesticides).

It is important to consider the strengths and limitations of biomonitoring. While the technology to detect low levels of chemicals has rapidly advanced, our ability to interpret the data is still in its infancy (Stokstad, 2004). Detection of a chemical in blood or urine does not necessarily mean it will cause a harmful health effect. For most chemicals, we lack data on what ranges may affect health endpoints, whether it be asthma, cancer, or reproduction.

Call for the Creation of a National Public Health Tracking System

Scientists increasingly realized that while the US had excellent systems to track infectious diseases, and monitor blood lead levels in children, our ability to track a variety of illnesses resulting from other types of environmental exposures was sorely lacking. In 1995, Dr. Lynn Goldman, an EPA administrator, noted that our environmental surveillance systems were fragmentary. We lacked basic information on the magnitude and range of chemical exposures in the general population. She called for the development of human tissue banks that would be integrated with information from vital statistics, cancer and birth defect registries, and other health-based databases. She stated that an integrated system could form the basis for setting priorities to be addressed by both public health and regulatory programs (Goldman, 1995).

Dr. Goldman's recommendations were mirrored in a later assessment made in 2000 by the Pew Environmental Health Commission. The commission also found the current environmental public health tracking system to be "fragmented, neglected, and ineffective." (McGeenhin, 2004)

> *"As a result of decades of neglect, we have a public health system that is working without the most basic information about chronic disease and potential environmental factors. The Commission found information on trends in health conditions potentially related to the environment is largely unavailable."*
>
> *(Pew Commission, Technical Report, 2000)*

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The Pew Commission called for the creation of a national environmental public health tracking network. This network would link information on human exposures (from biomonitoring), and environmental hazards, to environmentally related diseases (McGeenhin, 2004; Litt, 2004; Ritz and Balmes, 2005).

In response, Congress provided funding to the Centers for Disease Control (CDC) to both initiate a national human biomonitoring program, and build the infrastructure needed to link monitoring programs with disease tracking and chemical hazard programs. The first step was to use an existing survey, called the National Health and Nutrition Examination Survey (NHANES), to monitor chemicals in blood and urine samples in the general population. The NHANES collects blood and urine samples, and nutritional and health information on persons across the US. In the first biomonitoring report released in 2001, 27 chemicals were monitored. In the second report released in 2003, 116 chemicals were monitored over a two year period (1999 to 2000), and in the third report released in July 2005, biomonitoring was expanded to include 148 chemicals (see insert pages 3 and 4). Chemicals monitored include metals, pesticides, phthalates (used in plastics and cosmetics), phytoestrogens, polyaromatic hydrocarbons (PAHs), dioxins, furans, polychlorinated biphenyls (PCBs), and cotinine (as index of tobacco smoke exposure). The third report includes blood and urine levels of chemicals monitored during 2001 to 2002 in males and females of different ages, as well as for different ethnic groups. (See References and Resources below for links to the third *National Report on Human Exposure to Environmental Chemicals.*)

Building on Current Biomonitoring Efforts

Currently, the CDC biomonitoring program is largely limited to surveillance, because the crucial infrastructure and information networks still need to be developed to interpret the data. But, this biomonitoring program is already yielding important information. For instance, baseline levels of chlorpyrifos, a commonly used insecticide that was recently phased out of household use were established in the second report. Future studies will determine if levels of chlorpyrifos, a known neurotoxin, are staying the same or are declining. The number of young children with elevated blood lead levels is declining. Exposure to the persistent pesticide DDT and its metabolite DDE was found to be several fold higher among Mexican

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References and Resources

CDC National Biomonitoring Program

Overview: http://www.cdc.gov/biomonitoring/overview.htm

3rd National Report: http://www.cdc.gov/exposurereport/
(Note: summary is 18 pages; full report is almost 500 pages)

3rd Report, Chemical list:
http://www.cdc.gov/exposurereport/pdf/third_report_chemicals.pdf

3rd Report, fact sheets:
http://www.cdc.gov/exposurereport/factsheets.htm

CDC National Environmental Public Health Tracking Program

General: http://www.cdc.gov/nceh/tracking/

Background-Needs:
http://www.cdc.gov/nceh/tracking/background.htm

Accomplishments:
http://www.cdc.gov/nceh/tracking/pib.htm#accomplish

Other References:

Stokstad, E. (2004) Pollution gets personal, Science, 304:1892-1894.

Goldman, L.R. et al. (1995), Banking of human tissue for biomonitoring and exposure assessment: utility for environmental epidemiology and surveillance, *Environmental Health Perspectives*, 103 (Suppl. 3):31-34, 1995. (for HTML of article, go to http://ehp.niehs.nih.gov/docs/1995/Suppl-3/goldman-abs.html)

Pew Commission (2000), links to the Pew Environmental Health Commission's report, *American's Environmental Health Gap: Why the Country Needs a Nationwide Health Tracking Network*, John Hopkins School of Hygiene and Public Health, can be found at http://www.cdc.gov/nceh/tracking/publications.htm#pew (note: the Companion Report is 21 pages long; the Technical Report is 92 pages long).

For on-line access to archive articles published in *Environmental Health Perspectives* (EHP) go to:

General: http://ehp.niehs.nih.gov/docs/admin/openaccess.html

EHP: http://ehp.niehs.nih.gov/docs/montharch.html

EHP Supplements: http://ehp.niehs.nih.gov/docs/suparch.html

McGeehin, M.A. et al. (2004) National environmental public health tracking program: bridging the information gap, *Environmental Health Perspectives*, 112:1409-1413. (for HTML of article, go to http://ehp.niehs.nih.gov/members/2004/7144/7144.html)

Litt, J. et al. (2004) Identifying priority health conditions, environmental data, and infrastructure needs: a synopsis of the Pew Environmental Health Tracking report, *Environmental Health Perspectives*, 112:1414-1418. (for HTML of article, go to http://ehp.niehs.nih.gov/members/2004/7147/7147.html)

Ritz, B. and Balmes, J. (2005) Can lessons from public health disease surveillance be applied to environmental public health tracking? *Environmental Health Perspectives*, 113:243-249. (for HTML of article, go to http://ehp.niehs.nih.gov/members/2004/7450/7450.html)

Suk, W.A. et al. (1996) Human biomonitoring: research goals and needs, *Environmental Health Perspectives* 104 (Suppl 3): 479-483. (for HTML of article, go to http://ehp.niehs.nih.gov/members/1996/Suppl-3/479-483suk/suk-full.html)

Exposure data on the following chemicals or classes of chemicals will appear in CDC's *Third National Report on Human Exposure to Environmental Chemicals*, which is slated for publication in early 2005. The *Third Report* provides updated exposure information on the chemicals in the *Second Report* and first-time information on additional chemicals (in bold).

Metals

Lead
Cadmium
Mercury
Cobalt
Uranium
Antimony
Barium
Beryllium
Cesium
Molybdenum
Platinum
Thallium
Tungsten

Organochlorine Pesticides

Hexachlorobenzene
Beta-hexachlorocyclohexane
Gamma-hexachlorocyclohexane
Pentachlorophenol
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
p,p'-DDT
p,p'-DDE
o,p'-DDT
Oxychlordane
trans-Nonachlor
Heptachlor Epoxide
Mirex
Aldrin
Dieldrin
Endrin

Organophosphate Insecticides: Dialkyl Phosphate Metabolites

Dimethylphosphate
Dimethylthiophosphate
Dimethyldithiophosphate
Diethylphosphate
Diethylthiophosphate
Diethyldithiophosphate

Organophosphate Insecticides: Specific Metabolites

para-Nitrophenol
3,5,6-Trichloro-2-pyridinol
2-Isopropyl-4-methyl-6-hydroxypyrimidine
2-(diethylamino)-6-methylpyrimidin-4-ol/one
3-chloro-7-hydroxy-4-methyl-2H-chromen-2-one/ol

Pyrethroid Pesticides

4-Fluoro-3-phenoxybenzoic acid
Cis-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid
Trans-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid
Cis-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane carboxylic acid
3-Phenoxybenzoic acid

Other Pesticides

2-Isopropoxyphenol
Carbofuranphenol
N,N-diethyl-3-methylbenzamide
ortho-Phenylphenol
2,5-Dichlorophenol

Herbicides

2,4,5-Trichlorophenoxyacetic acid
2,4-Dichlorophenoxyacetic acid
2,4-Dichlorophenol
Atrazine mercapturate
Acetochlor mercapturate
Metolachlor mercapturate

Phthalates

Mono-methyl phthalate
Mono-ethyl phthalate
Mono-n-butyl phthalate
Mono-iso-butyl phthalate
Mono-benzyl phthalate
Mono-cyclohexyl phthalate
Mono-2-ethylhexyl phthalate
Mono-(2-ethyl-5-oxohexyl) phthalate
Mono-(2-ethyl-5-hydroxyhexyl) phthalate
Mono-(3-carboxypropyl) phthalate
Mono-n-octyl phthalate
Mono-isononyl phthalate

Phytoestrogens

Daidzein
Enterodiol
Enterolactone
Equol
Genistein
O-Desmethylangolensin

Polycyclic Aromatic Hydrocarbons

1-Hydroxybenz[a]anthracene
3-Hydroxybenz[a]anthracene and **9-Hydroxybenz[a]anthracene**
1-Hydroxybenzo[c]phenanthrene
2-Hydroxybenzo[c]phenanthrene
3-Hydroxybenzo[c]phenanthrene
1-Hydroxychrysene
2-Hydroxychrysene
3-Hydroxychrysene
4-Hydroxychrysene
6-Hydroxychrysene
3-Hydroxyfluoranthene
2-Hydroxyfluorene
3-Hydroxyfluorene
9-Hydroxyfluorene
1-Hydroxyphenanthrene
2-Hydroxyphenanthrene
3-Hydroxyphenanthrene
4-Hydroxyphenanthrene
9-Hydroxyphenanthrene
1-Hydroxypyrene
3-Hydroxybenzo[a]pyrene
1-Hydroxynapthalene
2-Hydroxynapthalene

Polychlorinated Dibenzo-p-dioxins and Dibenzofurans

1,2,3,4,6,7,8,9-Octachlorodibenzo-*p*-dioxin (OCDD)
1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin (HpCDD)
1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin (HxCDD)
1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin (HxCDD)
1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin (HxCDD)
1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin (PeCDD)
2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (TCDD)
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)
2,3,7,8-Tetrachlorodibenzofuran (TCDF)

Polychlorinated Biphenyls

2,2',5,5'-Tetrachlorobiphenyl (PCB 52)
2,3',4,4'-Tetrachlorobiphenyl (PCB 66)
2,4,4',5-Tetrachlorobiphenyl (PCB 74)
3,4,4',5-Tetrachlorobiphenyl (PCB 81)
2,2’,3,4,5’-Pentachlorobiphenyl (PCB 87)
2,2',4,4',5-Pentachlorobiphenyl (PCB 99)
2,2',4,5,5'-Pentachlorobiphenyl (PCB 101)
2,3,3',4,4'-Pentachlorobiphenyl (PCB 105)
2,3,3’,4’,6-Pentachlorobiphenyl (PCB 110)
2,3',4,4',5-Pentachlorobiphenyl (PCB 118)
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)
2,2',3,3',4,4'-Hexachlorobiphenyl (PCB 128)
2,2',3,4,4',5' **and 2,3,3’,4,4’,6-Hexachlorobiphenyl (PCB** 138**&158)**
2,2',3,4',5,5'-Hexachlorobiphenyl (PCB 146)
2,2’,3,4’,5’,6’-Hexachlorobiphenyl (PCB 149)
2,2’,3,5,5’,6-Hexachlorobiphenyl (PCB 151)
2,2',4,4',5,5'-Hexachlorobiphenyl (PCB 153)
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)
2,2',3,3',4,5,5'-Heptachlorobiphenyl (PCB 172)
2,2',3,3',4,5',6'-Heptachlorobiphenyl (PCB 177)
2,2',3,3',5,5',6-Heptachlorobiphenyl (PCB 178)
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)
2,2',3,4,4',5',6-Heptachlorobiphenyl (PCB 183)
2,2',3,4',5,5',6-Heptachlorobiphenyl (PCB 187)
2,3,3’,4,4’,5,5’-Heptachlorobiphenyl (PCB 189)
2,2’,3,3’,4,4’,5,5’-Octachlorobiphenyl (PCB 194)
2,2’,3,3’,4,4’,5,6-Octachlorobiphenyl (PCB 195)
2,2’,3,3’,4,4’,5,6’ and 2,2’,3,4,4’,5,5’,6-Octachlorobiphenyl (PCB196&203)
2,2’,3,3’,4,5,5’,6-Octachlorobiphenyl (PCB 201)
2,2’,3,3’,4,4’,5,5’,6’-Nonachlorobiphenyl (PCB 206)

Tobacco Smoke

Cotinine

Americans than whites and blacks. In the third report, ranges of exposures called "reference levels" were available for the first time for over 38 chemicals. In addition, more sensitive methods were available for the detection of dioxins, furans and the plasticizers called phthalates. The third report also documents possible widespread exposure to commonly used pesticides call pyrethroid insecticides.

The CDC is partnering with other federal and state programs to establish the Environmental Public Health Tracking network. This includes state departments of health (see related article on CDC-funded programs in NYS), the US Geological Survey (monitoring contaminants in the water supply; see related article), NASA, and the EPA.

Ultimately, it is hoped that a biomonitoring system can be used in the prevention of human disease due to environmental exposures. Dr. William Suk and colleagues at the National Institute of Environmental Health Sciences (NIEHS) wrote that "…biomonitoring … may lead to identification of potentially hazardous exposures before adverse health effects appear and to establish exposure limits for minimizing the likelihood of significant health effects" (Suk, 1996).

CDC-Funded Environmental Public Health Tracking Efforts in New York State

Carmi Orenstein, M.P.H., Editor

The Centers for Disease Control (CDC) are supporting states, cities, Centers of Excellence, and multiple collaborations in an effort to achieve the goals mentioned in the previous article: the initiation of a national human biomonitoring program, and the construction of the infrastructure needed to link monitoring programs with disease tracking and chemical hazard programs.

Here in New York State (NYS), the Department of Health (DOH) received a grant to conduct environmental public health tracking projects, as did New York City. These pilot projects begin to pave the way toward a more comprehensive system on both the state and national level.

One project being conducted directly contributes to an improved ability to share data and analyze trends across different agencies, locations, etc. This project, "Pilot Data Exchange Implementation," addresses the need to establish the continuous and automated exchange of data between the NYS DOH and Department of Environmental Conservation (DEC). The project will provide data about environmental hazards, exposures, and health effects throughout NYS, over time. The benefits of this highly technical effort will include the availability of more timely data to support improved collaboration and decision-making.

The NYS DOH is conducting two pilot projects that aim to improve the identification of geographic patterns, clusters and trends with regard to environmental exposures and health outcomes. These projects have a particular emphasis on children's environmental health.

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Recent Developments in Water Monitoring

Ellen Hartman, Staff Writer, BCERF

Monitoring levels of chemicals in water is one type of environmental monitoring. Beyond the goals of discovering what contaminants, in what quantities, are in the water supply, water monitoring can provide information about the behavior, interactivity, and persistence of water contaminants.

Emerging Contaminants

At the BCERF Cancer and Environment Forum on June 10, 2005, Patrick Phillips of the United States Geological Survey (USGS) in Troy, New York, spoke about that agency's efforts to monitor contaminants in water (see also Forum overview in this issue).

Mr. Phillips focused on the area of emerging contaminants: chemicals (synthetic or natural) that have not been monitored in the past but that enter the environment and may have the potential to cause adverse ecological or human health effects. We have increased ability to study these emerging contaminants now because scientists have recently developed more sensitive methods to detect lower levels of chemicals, and are gaining a better understanding of their environmental fate.

Discharge of industrial chemicals from manufacturing plants and run-off of chemicals from agricultural practices have been the focus of some monitoring efforts by federal agencies. Emerging contaminants entering the waste stream can also include household chemicals, human and veterinary pharmaceuticals, and personal care products – chemicals from these other points of use are just beginning to receive attention.

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CDC-Funded Environmental Public Health Tracking Efforts in New York State

The first looks at the geographic distribution and trends of asthma hospitalization and air pollution levels. The second considers patterns of birth outcomes and levels of contaminants in public drinking water supplies.

The New York City project, conducted by the Department of Health and Mental Hygiene, addresses the issue of urban pesticide use. The new Urban Pesticide Tracking System addresses "the use and misuse of pesticides." The NYS Pesticide Use and Sales Registry, as well as other data sources, identify New York City as having amongst the state's highest pesticide use, as well as a set of unique use and exposure problems.

These NYS projects are amongst the dozens of focused CDC-funded efforts to build a National Environmental Public Health Tracking system. For an overview of the most recent conference sharing information on all projects nationally, that took place in Atlanta this past April, please see: http://www.cdc.gov/nceh/tracking/conf05/presentations.htm

New York State Assemblyman David Koon (135th Assembly District) and Senator Jim Alesi (55th Senate District) and their colleagues will be re-introducing bills (A969-A and S2626-A) next session calling for the development of a more comprehensive environmental health tracking system within the state.

Recent Developments in Water Monitoring

Focused USGS Efforts

Several programs are now actively collecting water-monitoring data. At the USGS, the National Water Quality Assessment (NAWQA) program, the Toxic Substances Hydrology (Toxics) program, and the Biomonitoring of Environmental Status and Trends (BEST) program are approaching the water monitoring issue each from slightly different directions.

The NAWQA program tracks changes in river basins and aquifers over time. The program is collecting consistent, long-term data that can be used to compare changes and provide information about how human activities affect the water sources.

The Toxics program focuses on the behavior of toxic substances in water and specifically on three areas of inquiry:

- **Improving measurement:** developing methods to measure contaminants at low levels in all stages of their transportation and ultimate fate.
- **Revealing processes:** learning how chemicals migrate, transform, and degrade in the water supply.
- **Understanding environmental health:** mapping the ultimate fate of contaminants and understanding potential effects on human and environmental health, describing the effects of contaminants on organisms, ecosystems, and the food chain. Developing simulation models, designing waste-disposal facilities, monitoring networks, and remediation plans.

The BEST program examines the response of biological resources to contaminants. This program is measuring and assessing the effects of contaminants on species and habitats, developing tools and processes for biomonitoring and application, and delivering the tools to the US Department of the Interior for use on federal lands.

In a report released in 2002, titled "Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in U.S. Streams, 1999-2000: A National Reconnaissance," the USGS measured concentrations of 95 organic wastewater contaminants in 139 streams across 30 states (Kolpin, 2002). The study found 82 of the 95 target contaminants in samples. The compounds found most frequently were coprostanol (fecal steroid), cholesterol (plant and animal steroid), N,N-diethyltoluamide (DEET), caffeine, triclosan (antimicrobial disinfectant), tri(2-chloroethyl)phosphate (fire retardant), and 4-nonylphenol (estrogenic detergent metabolite).

The report, which is available online (http://pubs.acs.org/hotartcl/est/es011055j_rev.html), highlights the fact that water monitoring is in its beginning stages. Measurement and collection techniques are still being developed, and contaminants being identified. Much more information is needed about the migration and persistence of contaminants, current levels in water, what levels may pose a hazard to human or environmental health, and interactivity of contaminants and possible health effects.

Other Federal Activity

The Centers for Disease Control and Prevention (CDC) are developing a national Environmental Public Health Tracking (EPHT) program to draw together human biomonitoring information in a national registry. (See cover article on biomonitoring.) Water monitoring data will be an important part of this effort. In New Hampshire, the state EPHT program is working with the CDC biomonitoring program to study the levels of arsenic in drinking water. This data will be used in the state program to track arsenic exposure and incidence of bladder cancer. The

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Regional Cancer and Environment Forum

BCERF HELD ITS SPRING CANCER AND ENVIRONMENT FORUM ON JUNE 10, 2005 IN MILLBROOK, NY AT THE FARM AND HOME CENTER. CORNELL COOPERATIVE EXTENSION (CCE) DUTCHESS COUNTY SERVED AS HOST TO THIS EVENT, WHICH WAS ATTENDED BY APPROXIMATELY 60 PEOPLE FROM THROUGHOUT THE LOWER HUDSON VALLEY AREA, PLUS NEW YORK CITY, LONG ISLAND, AND THE CATSKILL REGION.

Patrick Phillips' (US Geological Survey) presentation *"Emerging Contaminants in New York and the United States,"* set the stage for the majority of the day's discussion about new efforts to understand chemical contaminants in the environment and human exposures. Emerging contaminants was broadly defined as "any synthetic or naturally occurring chemical or microorganism that is not commonly monitored in the environment, but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects." Phillips emphasized that actual occurrence in the environment may not be new, but ability to detect low levels in the environment may be. These emerging chemical contaminants tend to be produced industrially but are dispersed to the environment from domestic, commercial and industrial uses. In addition to a baseline evaluation of emerging contaminants, Phillips focused on wastewater treatment processes and their effects on the presence of these contaminants.

Dr. Betsy Lewis-Michl (NYS Department of Health) provided an example of a new human exposure monitoring effort. She presented a talk on the *"New York State Volatile Organic Compounds Exposure Registry: Health Outcome Surveillance for Exposed Populations."* Exposure registries document individual-level exposures in the hopes of learning about any subsequent health outcomes. She described how registries work in general, and the specifics of this project. Additional sites have been added following the two original sites selected for their historic contamination with the solvents TCE (trichloroethylene) and PCE (tetrachloroethylene), for a current total of nine sites and 865 individuals. Dr. Lewis-Michl discussed challenges to the registry such as low response rates; participants were able to offer some ideas to address this challenge.

The afternoon session featured a panel of community representatives (three cancer advocates, a representative of the Dutchess County Environmental Management Council, and an elected official, Representative Marge Horton of the Dutchess County Legislature). Panelists were invited by Dr. Rodney Page, Director of BCERF and facilitator of the Forum, to provide background on their organizations' objectives as well as their responses to the morning's presentations. They were also asked to comment on how they thought Forum participants – whether they are professionals involved with these issues, or simply as concerned citizens – could get involved to address the day's issues.

The final presenter, Dr. Barbour Warren, BCERF Research Associate, gave an overview of the USDA-funded project, *"Obesity Prevention and Breast Cancer Risk Reduction in Rural Areas."* He described the project's scientific rationale and the environmental approach to modifying risk. This includes looking at community influences of the built and social environment. Dr. Warren provided an update on the BCERF pilot project in Stamford, NY that is testing the approach of community leaders identifying and implementing locally selected interventions. (See also *"Obesity and Breast Cancer: An Environmental Approach"* in this issue.)

Next Cancer and Environment Forum will be held on
Friday, Sept. 30 in Albany, NY
Room to be announced
10:00am – 3:00pm
Contact Carmi Orenstein for more details (607) 255-1185 or cso1@cornell.edu

Monitoring Chemicals in Humans and the Environment: New Directions *continued from page 6*

New York State biomonitoring program plans to work with the EPHT on a pilot-scale biomonitoring project relating to drinking water contaminants (e.g., trihalomethanes or other disinfection byproducts) and birth outcome data (see article on EPHT efforts in New York State).

Human activities from heavy industry to farming to housecleaning and personal care make an impact on the fresh water supply. Water monitoring is a complex, interdisciplinary area of study: increased activity and collaboration in this area is a welcome development.

Kolpin, D. W. et al. (2002). Pharmaceuticals, Hormones, and Other Wastewater Contaminants in US Streams, 1999-2000: A National Reconnaissance. *Environmental Science and Technology 36*: 1202-1211.

Challenges to Estimating Past Exposures to Pesticides

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O'Leary, E., Vena, J.E., Freudenheim, J.L. and Brasure, J. (2004) Pesticide exposure and risk of breast cancer: a nested case-control study of residentially stable women living on Long Island, *Environmental Research* 94: 134-144.

Researchers are using new approaches and methods to tackle one of the most difficult problems in cancer epidemiology; how can past exposures to environmentally relevant chemicals be estimated when evaluating cancer risks with long latencies? Breast cancer poses a particular challenge, since the disease may take 10, 20 or more years to develop. Therefore, to evaluate whether a chemical has a role in a breast cancer case diagnosed today, researchers have the challenge that they must estimate exposures to chemicals that occurred decades ago.

O'Leary and colleagues made use of a wide variety of methods to estimate historical exposures to pesticides in 105 women diagnosed with breast cancer between 1980 and 1992. Controls included 210 age and race matched controls without the disease. The authors hypothesized that exposures to pesticides that may have a role in the development of breast cancer occurred after 1950 but before the 1970s, when many of the organochlorine pesticides were banned.

One of the greatest strengths of the study was the residential stability of the subjects. On average, they lived at the same address on Long Island, New York for at least 18 years. The researchers used geographic information system (GIS) software to determine the distance between where the women lived (residence) and hazardous waste sites containing pesticides. They also used records of pesticides in wells obtained between 1972 and 1992 to estimate exposures [pesticides detected in well water included 2,4-D, delta-BHC (benzene hexachloride), chlordane, dieldrin, heptachlor epoxide, and 1, 2 dichloropropane]. One question researchers asked was whether past agricultural use of the land may be related to the risk of breast cancer. They used aerial photographs taken nearly 50 years ago between 1947 and 1950, and street maps from 1946 to determine past land use. However, information on specific crops planted and types and amount of pesticides was either incomplete or not available. Land was defined as "farmland," "next to farm land," "residential," "wooded," "sand," "greenhouse," "open land," or "may have been farm land."

There are limitations to this approach. Past land use and distances to hazardous wastes sites can only approximate past exposures to environmental chemicals. This approach is a proxy for exposure, but proximity is not a measure of the actual exposure to a person. This can only be determined by biomonitoring (the internal dose to the body determined by measuring levels in blood, urine, or breast milk). But, again, the challenge with a disease like breast cancer is estimating exposures that occurred many years in the past.

Risk (odds ratio) of breast cancer was not related to residence in a water district where pesticides were detected in well water. However, residence within one mile of a hazardous waste site containing organochlorine pesticides carried nearly three-fold higher risk of breast cancer (odds ratio = 2.9, 95% confidence interval = 1.1-7.2). Breast cancer risk was over six times higher in women living on land previously used for agriculture, but this finding was limited to women who had never had children or were over 26 years old when they had their first child (odds ratio= 6.4, 95% confidence interval 2.2-18.2).

The greatest limitations of this study were the very small number of women who lived within a mile of a hazardous waste site (12 cases and 11 controls), and the lack of information on specific types of pesticide exposure. While information was given on the types of chemicals contained in the various waste sites, other information including quantities and proportions of the chemicals, condition of the site, known leaching, etc. was not available. Therefore, testing of the area around the waste sites for residues could help define the extent of potential exposures to specific chemicals.

The authors did find a higher breast cancer risk in women with a late age of first birth or no children, who also lived on land previously used for agriculture. While the authors hypothesized that these women may have had a higher exposure to environmental chemicals that were estrogenic, this is conjecture and was not confirmed by any analysis. Other factors mentioned by the authors, such a lack of protective effects from early pregnancy and lactation, would be plausible reasons as to why these

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National Academy Panel Decides All Levels of Radiation Exposure Carry Some Risk

Barbour Warren, Ph.D., Research Associate, BCERF

The National Academies of Science recently released a report on the health effects of low levels of radiation. This report was the most recent addition to a long-standing series of studies examining the effects of radiation.

The new report was prepared over a period of six years, and it updated and expanded upon an earlier report completed in 1990. The panel members for this assessment had access to a large amount of new data including up-to-date values on cancer incidence in A-bomb survivors, new data from studies of persons exposed to radiation for medical reasons, and new data from studies of nuclear workers.

This report supported earlier risk estimates for the association of radiation exposure with cancer and leukemia. The addition of the new data led to an increase in the confidence of the accuracy of these estimates. Importantly, this study put forth strong support for what is called a linear-no-threshold model of radiation exposure and cancer risk. This model indicates that cancer risk increases with the level of radiation exposure and that a graph of cancer risk versus radiation exposure would be a straight line. The most controversial aspect of the relationship between cancer risk and radiation exposure has been how risk changes at low levels of radiation exposure. Some scientists have argued that there is a threshold of radiation exposure below which there is no effect on risk. The panel came down firmly against this idea. The major implication of the adoption of this model is the acceptance of the idea that there is no level of exposure to radiation which does not carry a cancer risk with it. Nonetheless, it must be kept in mind that at low levels of exposure, the risk will be very small.

The major implication... is the acceptance of the idea that there is no level of exposure to radiation which does not carry a cancer risk with it.

These findings do not indicate that women should avoid mammograms as the level of radiation used in them is very low. However the report cautions that the effects of low doses of radiation should be taken into consideration for individuals who receive multiple full-body computed tomography (CT) scans. These procedures utilize about 100 times more radiation than a mammogram and the effect on cancer risk of a large number of CT scans could be substantial. For a more thorough discussion of this topic see BCERF Fact Sheet #52, *Radiation and Breast Cancer Risk*. Both the entire text of this report (750 pages) and a summary (56 pages) can be viewed at http://books.nap.edu/catalog/11340.html.

RESEARCH COMMENTARY

Challenges to Estimating Past Exposures to Pesticides *continued from page 8*

women may have been more susceptible to the chemical's cancer-causing effects.

Other limitations of the study include a lack of data and appropriate control for other factors known to affect breast cancer risk such as age at menarche, age at menopause, benign breast disease, menopausal status, hormonal therapy use, diet including alcohol consumption, and exposure to ionizing radiation. Authors did control for age, race, years of education, and age at first birth.

Despite these limitations, as methods improve for modeling using GIS systems, the approach used by these authors will become more common in epidemiological studies. Studies in future will, as this study has done, not just focus on overall breast cancer risk, but identify subpopulations that may be at added risk because of chemical exposures. Therefore, identification of higher risk groups, such as women with a late age at first birth or no children, may be particularly important in helping to define the factors that affect the risk of breast and other cancer in women exposed to environmental chemicals.

Clues

By Mary Lorson

I gave birth to my son in July 2002. I started working as an administrative assistant at the College of Veterinary Medicine when he was four months old, with four newly-hired geneticists. At lunchtime my (now) husband and son would come to the Vet School drop-off area and I'd nurse the baby in the minivan. When he was around a year old, I started to think about weaning, but no sooner did I consider it than he did it himself, very suddenly. One day he tasted the milk, wrinkled his nose, turned his head away and cried, and while I offered it at the usual intervals for another two weeks, he never accepted milk from me again. It made me sad, to have this gentle, intimate relationship truncated so abruptly, but my kid had made his decision and there was nothing I could do to change it. "Get used to being a parent," said a lab manager co-worker of mine. "My son did the same thing."

A month or two went by, and I realized that I'd never had a mammogram. You're supposed to have one when you're forty, but I'd skipped it because I was breastfeeding. My long-term temp job was coming up for review and I wasn't completely confident that I would be renewed, so I scheduled the test. There was no history of breast cancer in my family; I made the appointment because I was afraid my insurance would run out. But, looking back, I have to admit that in the month or two prior to my diagnosis, I had been filled with unease, some psychological dread I couldn't attribute to any one definite cause.

I'd been taking an undergraduate English class at Cornell. As an employee I'm allowed to take four free credits per semester, so I enrolled in English 355, Decadence. Poe, Verlaine, Baudelaire, Wilde, Masoch, the literature of the aesthete. The lecturer's grasp of the material was impressive, and he brought an entertaining flair to the material, reminding me of my undergrad days and those button-pushing college professors who were instrumental in busting up my own youthful suburban ideas. But I didn't really take to the course; I couldn't identify with the reading, was distracted by something unidentifiable. My strolls home from class at 9:00pm on Mondays and Wednesdays were filled not with aesthetic stimulation but anxiety. In my city-dwelling days, night-time walks were plagued with fear of rapists and muggers, but that fall my brain struggled with inner troubles. I felt guilty about the extra hours the class took away from my child, but it was more than that. I sort of chalked it up to a combination of things: generalized anxiety from being a new parent; career frustration; money worries; relationship issues; post-breastfeeding hormonal changes (a variation on the post-partum depression theme? Perhaps now that my son no longer needed my nourishment, I was less in control of his wellbeing?) No one explanation felt definitive. The semester progressed. I went for my mammogram, and suddenly the fear made real sense.

"See, that's the thing," said the radiologist. "That's what I don't like." A crystalline speck on the mammogram twinkled like a little star, white, bright, undeniable.

"That?" It looked kind of pretty.

"That lesion is what I do not like. We'll do a biopsy to confirm, but in the meantime we'll put you in contact with a surgeon so we can act quickly."

"Why do we need to talk to a surgeon if we haven't even done the biopsy yet?" I barely choked the words.

"Honey," said the radiologist, realizing that I didn't get it, "all I do, all day long, is read mammograms. I'm telling you, I know what I'm looking at."

You sit there and you're cold inside and out because you're wearing a thin printed gown and because in one short minute you've gone from late-to-work to afraid-for-your-life. If you are lucky like me, you have a partner there with you who holds your hand and asks intelligent questions while you cry, who hugs you in the parking lot and tells you he or she is with you all the way, who is the right combination of stoic and vulnerable which lets you know that you can lean on them but also that they feel the gravity of the thing. And, if you're lucky like me you have a vibrant and singular 15-month-old son who reaches for you and learns something you have taught him every single day and who grips your heart with a

I went for my mammogram, and suddenly the fear made real sense.

will to live, which is indeed a gift though it's also he who makes you so afraid (that is, the fear of missing his life, of him not even remembering you), that makes the whole thing so awful.

I was told that I would probably lose my left breast, but that the extent of the cancerous activity could not be known until the mastectomy and other tests were done. We left the office, put our son in the car seat, cried a bit in the parking lot, and went home.

I had been all but diagnosed, but final laboratory pathology results would need to confirm the radiologist's findings before treatment plans could be pursued. So we had to wait another day, and I had to work that day because Dr. Robert Weiss, a faculty member I support, was submitting a grant proposal to the American Cancer Society.

Grant deadlines can be pretty heated around here. Busy faculty often can't find the time to focus on their proposals until the submission dates are imminent, and the pressure is intense for them to succeed; grant money is survival money for researchers. Submission guidelines are stringent, and University protocol requires multiple internal approvals of each proposal, so the days leading up to submission are busy and serious. I arrived at work on time that day, and informed Dr. Weiss that I'd be receiving a phone call at some point that day confirming or denying my breast cancer diagnosis. A respectful and gracious person, he let me know that he understood the gravity of the situation, and then we got to work.

I'm a writer and musician, with an undergraduate degree in Art. Being a word person can be something of a lifeboat when one is immersed in patently foreign intellectual waters, so I'd picked up some terminology here and there, but I'd never before tried to really understand what my faculty members do. On this day, looking down at my screen, I noticed that Bob's grant proposal was titled, "The Hus1 Cell Cycle Checkpoint Gene in Mammary Development and Tumorigenesis." I smiled sheepishly to myself, for never having noticed this connection before. Suddenly there was an almost humorous irony to the task at hand, an uncommon link between my job and the very emotional drama taking place in my life. I wanted to say, "Dr. Weiss, is one of us gonna have to make a joke about this?" but I didn't, since I didn't want to seem macabre. I wanted to be professional, and I wanted to savor these last few hours of normalcy. My lab-manager friend stopped by to ask about my news. I said I'd had none yet. "I'd be going crazy," she said. "I'd just want to *know*." "I can wait," I said. "I feel like that one phone call's going to change my whole life."

I did my best to stay on task, typing and cutting-and-pasting information into the form pages of the proposal to study a potential genetic cause for the genesis of breast cancer tumors. I kept making mistakes I should have spotted—inconsistencies in punctuation, spaces, font-sizes and biosketch formatting. I kept wondering whether, right across the hall, Bob could actually be developing a key to the understanding of how breast cancer begins and helping to create a mode of prevention. I wondered about my son, if he could tell how upset I was; I wondered about my husband's emotional state; my poor mother. I was deeply afraid inside, but functional on the surface. The grant went back and forth between Dr. Weiss and the grant contract officer's office until all parties agreed that it was suitable for submission. We finished a little early, and the only calls I'd gotten were from home. Finally, the grant done, I called my doctor's office, the 4:00pm sky already darkening. They put me on hold for a few minutes, and came back. "Mary, can you come in and talk with the doctor this evening?" I said yes, and we did. They don't give you bad news over the phone.

Since my own diagnosis I have known eight women diagnosed with breast cancer... what makes this such a common disease?

I had a mastectomy, and six months of chemo, and am now proceeding with my life. Early detection has provided me with a completely justified optimism. Did my son taste a difference in my milk? Did he save my life by sending me that clue? I will always wonder about that. Since my own diagnosis I have known eight women diagnosed with breast cancer. I'm outwardly hopeful for my own future and inwardly cheering my employers and their colleagues on in their efforts to determine what it is that makes this such a common disease. I really do see them as heroes, working in those labs every day – or as detectives, looking for clues.

Mary Lorson was an administrative assistant in the College of Veterinary Medicine from 2001-2005. She will begin teaching high school English in Fall 2005.

A BCERF RESEARCH PROJECT

Obesity and Breast Cancer: An Environmental Approach

By Mary Maley, Health Educator, BCERF

Over the last twenty years, the levels of overweight and obesity in the United States have increased to epidemic proportions, with 62% of the population considered either overweight or obese (BMI> 25) (Natl. Ctr. Health. Stats. CDC, 2000). Obesity has been linked to a substantial increase in the relative risk of postmenopausal breast cancer. This risk is progressively increased with greater body weight and may be decreased as levels of obesity are reduced. Preventing overweight and obesity can potentially contribute to a substantial reduction of breast cancer risk and to increased breast cancer survival.

A number of factors contribute to obesity, including genetics, behavior, environment, and culture. However, the current consensus is that the recent increase in overweight and obesity appears to stem from changes in our environment that encourage overeating and discourage physical activity, rather than changes in biology. Our current living environment is considered "obesogenic."

In response to this problem, BCERF is taking an environmental approach to obesity prevention for breast cancer risk reduction, with funding from the US Department of Agriculture/Cooperative State Research, Education and Extension Service.

TABLE 2

THE BAGEL SWITCH	
Environmental Action:	Switch from medium bagels (292 calories) to mini bagels (71 calories) at the office snack counter
Energy Deficit in a Year:	344,760 calories (10 workers eat a mini bagel instead of a large bagel three days per week)
Group Weight Gain Prevented:	98 pounds among 10 people (9.8 pounds each)
THE LUNCH STROLL	
Environmental Action:	Co-workers walk 30 minutes at lunch 3 days per week (3 mph)
Energy Deficit in a Year:	157,950 calories (10 workers walk 3 days per week)
Group Weight Gain Prevented:	45 pounds among 10 people (4.5 pounds each)
A BIG DRINK OF WATER	
Environmental Action:	Install a water cooler instead of a soda machine
Energy Deficit in a Year:	403,000 calories (10 workers drink water instead of a 12-ounce soft drink every day for a year)
Group Weight Gain Prevented:	115 pounds among 10 people (11.5 pounds each)

What is an environmental approach to obesity prevention?

An environmental approach to obesity prevention takes all aspects of obesity (individual, social, economic, policy and physical) into consideration when planning an intervention. It also specifically focuses on the changeable aspects of an environment rather than the changeable aspects of an individual. Environment-based interventions make it easier for people to live healthy lives.

TABLE 1 Comparison of Individual and Environmental Approaches to Obesity Prevention

Individual Approaches	Environmental Approaches
Focus on changing the person.	Focus on changing the community.
Focus on individual behavior change.	Focus on structural, social, economic or policy change.
Responsibility for change lies with the individual working with health professionals	Responsibility for change lies with community leaders, policy makers, and health professionals working with citizens.
Reach people who are interested in changing.	Reach everyone in the environment.
Educational approach.	Community development approach.

Table 1 can further explain the differences between an individual and an environmental approach to obesity prevention:

Examples of Environmental Interventions

Table 2 offers a few examples of interventions that a workplace community might choose to prevent weight gain within its population.

Community Participation

An important element of an environmental approach is the participation of stakeholder groups and members of the community in assessing the environment and identifying opportunities to change the environment. Participation is key to identification of unique social and physical features of a community that might present sustainable opportunities for intervention.

TABLE 3 The Community Assessment

Environmental Dimension	Measure
The Built Environment for Healthy Eating	Observation Checklist: grocery and convenience store price and availability for 17 healthy foods Random Sample Telephone Survey: foods and beverages available at work and in the community, including grocery stores, farm markets, restaurants, cafeterias and vending machines
The Built Environment for Active Living	Observation Checklist: availability of sidewalks, walking trails, recreational facilities such as tennis courts, basketball courts, gyms and health clubs and worksite facilities Random Sample Telephone Survey: use availability and accessibility of features and facilities related to active living
The Social Environment for Healthy Eating	Individual Interviews and Focused Discussion Groups: included locally concerned citizens from business, education, local government, clergy, health care and general population to assess the attitudes, perceptions, values and beliefs around healthy eating in a community Random Sample Telephone Survey: social environment for food at work, at community events and in restaurants
The Social Environment for Active Living	Individual Interviews and Focused Discussion Groups: included locally concerned citizens from business, education, local government, clergy, health care and general population to assess the attitudes, perceptions, values and beliefs around active living in the community. Random Sample Telephone Survey: social environment for active living in the community

A BCERF Research Project:

Building Capacity to Address Obesity to Reduce Breast Cancer Risk in Rural Communities: An Environmental Approach

The current BCERF project will provide tools and strategies for use by community members in a comprehensive, integrated approach to obesity prevention. This will include community assessment through the intervention and evaluation stages. As a result of this work, health professionals, extension educators, community leaders, and the public will increase their understanding of the relationship between overweight and obesity and breast cancer risk. In addition, they will improve their capacity to take an environmental approach to breast cancer risk reduction through obesity prevention in their community.

The pilot project began in 2004, with coalition building and an environmental needs assessment in Stamford, NY, a rural northern Catskill community. The assessment process consisted of multiple measures of the built and social environments for healthy eating and active living. This was conducted in partnership with the Delaware County Cancer Coalition and Cornell Cooperative Extension of Delaware County, a community project steering committee and others representing businesses, schools, medical, civic and religious organizations.

During the first project year, the built and social environments for healthy eating and active living were assessed using several different measures, as described in Table 3.

Community Assessment Data Presented

A group of interested community members met in June 2005 to discuss the results of the community assessment and begin to identify opportunities for intervention. Participants included representatives from churches, the local cancer coalition, the American Cancer Society, the office of a local assemblyman, Rotary, local government, employers, schools, banks, and other businesses, as well as Delaware County Cooperative Extension and Cornell University staff and faculty. During the discussion, emphasis was placed on identifying small, sustainable changes to prevent weight gain; "tipping the balance" of

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calories taken in and calories expended.

Next Steps

During the coming year, work will continue with the local leadership team to select and implement a locally relevant and sustainable intervention in Stamford, NY, to combat the rising rates of obesity and reduce the risk of breast and other cancers. In addition, BCERF researchers will continue their critical evaluation of the literature addressing built and social environments and possible relationships to overweight, obesity, and breast cancer.

Working together in small groups, members of the Stamford, NY community gathered in June to discuss the results of the local environmental assessment and identify opportunities for healthy eating and active living.

The tools, strategies and results of this project will be made available on the BCERF web site for use by other communities interested in an environmental approach to obesity prevention for breast cancer risk reduction.

For more information on this project contact BCERF Health Educator Mary Maley by email at mm153@cornell.edu or by calling (607) 255-1871.

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