Research Brief 189:
Use of Spatial and Temporal Analyses to Provide Insights into the Environmental Etiology of Cancer

Release Date: 09/01/2010

Superfund Research Program
http://www.niehs.nih.gov/srp/

Background

Since 1995, researchers at the SRP at Boston University (BU) have used Geographic Information System (GIS) data and increasingly sophisticated statistical methods to examine the geographical distribution of disease, which can provide important clues to the origins of the disease. These environmental epidemiological studies are complicated by factors including small sample size for case populations; the fact that disease registries only contain data on where people lived at the time of *diagnosis*, which may not be the time of *exposure*; and methodological problems of understanding, estimating and evaluating potential biases.

The BU SRP is committed to providing detailed information about their research findings and methods.

The BU SRP Research Resources page provides a range of tools including Open Source software and documentation, synthetic data sets, specific lab methods, and water models.

BU SRP research teams, led by Drs. David Ozonoff, Ann Aschengrau, Tom Webster, and Veronica Vieira, have developed new approaches that allow them to:

- Map disease "hot" and "cold" spots while accounting for known risk factors such as age and smoking. Using these tools, they identified lung cancer and breast cancer "hot spots" associated with two pollution plumes near the Massachusetts Military Reservation.
- Establish a link between prenatal perchloroethylene (PCE) exposure and adverse birth outcomes including cleft lip and neural tube defects.
- Determine that women living in more northern latitudes may be at greater risk for rheumatoid arthritis.

Advances

Drs. Aschengrau, Webster, and Vieira recently conducted an analysis to test the hypothesis that drinking water contaminated by municipal wastewater effluent from the Barnstable Water Pollution Control Facility (BWPCF) is associated with breast cancer incidence in upper Cape Cod, Massachusetts. Surveys of the wastewater and groundwater found suspected endocrine disruptors, including alkylphenols and other estrogenic phenolic compounds. The BU research approach included methods for analyzing the distribution of disease in both space and time.

The researchers assessed exposure based on three sets of information:

- Residential histories of both the case and control groups. These data identified which participants were living at residences during years when drinking water was impacted by effluent.
- Questionnaire data that identified the drinking water source (public or private) of the participants for each of their residences and whether women ever regularly used bottled water.
- Information on the public water distribution systems, which was used to determine when the drinking water wells were impacted by effluent from the BWPCF.
- The researchers began with MODFLOW, a modular software program publicly available from the USGS Web site, and modified the program to examine historical groundwater movement.

Their groundwater models showed that contamination of drinking water by effluent from the BWPCF was plausible and indicated that effluent from the BWPCF reached drinking water wells as early as 1966. The researchers found statistically significant positive associations between breast cancer and exposure to drinking water impacted by wastewater effluent from the BWPCF. The associations were strongest among women who were not regular bottled water users and among women exposed for long durations when latency periods were taken into account.

Significance

System-level biochemical modeling is a necessary and powerful tool for health researchers analyzing biochemical pathways of toxicological relevance. Computational models are valuable in demonstrating both the normal functioning of cellular signaling pathways and the nature and magnitude of perturbations when contaminants are introduced into the system. As such, they present an alternative to traditional dose-response evaluation techniques, and can serve as a foundation for larger, more detailed stochastic models, or even tissue- and organ-scale pharmacokinetic models. These system-level models can aid the assessment of low-dose toxicity for halogenated aromatic hydrocarbons (HAH) and other contaminants.

The researchers integrated groundwater modeling, residential mobility, and information about public water systems in GIS to assess exposure to drinking water impacted by wastewater effluent. Their historical groundwater model provided a method to explore the spatial and temporal relationship between a source of contamination and a possible exposure route for study participants.

When cancer clusters are discovered, there are many possible environmental factors that could be investigated. While a spatial relationship alone does not establish exposure, this study was able to determine a plausible route of exposure by also taking time into account. The researchers demonstrated that by incorporating additional data, such as residential histories of the participants and contaminant movement over time, hypotheses generated by spatial analyses can provide additional insights into the environmental etiology of breast cancer.

For more information, contact:

Ann Aschengrau, ScD
Boston University
Associate Chairman, Department of Epidemiology
Talbot, E328
Boston, MA 02118
Phone: 617-638-5228
Email: aaschen@bu.edu

Thomas Webster, DSc
Boston University
Associate Chairman, Department of Environmental Health
Talbot, 4W
Boston, MA 02118
Phone: 617-638-4620
Email: twebster@bu.edu

To learn more about this research, please refer to the following sources:

Gallagher, Lisa G., Thomas Webster, Ann Aschengrau, and Veronica Vieira. June, 2010. Using Residential History and Groundwater Modeling to Examine Drinking Water Exposure and Breast Cancer. Environmental Health Perspectives. 118:749-755.
doi:10.1289/ehp.0901547

Vieira, Verónica M., Jaime E. Hart, Thomas F. Webster, Janice Weinberg, Robin Puett, Francine Laden, Karen H. Costenbader, Elizabeth W. Karlson. July, 2010. Association between Residences in U.S. Northern Latitudes and Rheumatoid Arthritis: A Spatial Analysis of the Nurses' Health Study. Environmental Health Perspectives. 118(7):957-961.
doi:10.1289/ehp.0901861

Vieira, Verónica M., Thomas Webster, Janice Weinberg, and Ann Aschengrau. 2008. Spatial-temporal analysis of breast cancer in upper Cape Cod, Massachusetts. International Journal of Health Geographics 7:46
doi:10.1186/1476-072X-7-46

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
National Institutes of Health

NIEHS
National Institute of Environmental Health Sciences

SRP_ResearchBrief_188_08.10