

Tracking Drinking Water Contaminants

Examples, Issues and Recommendations

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What is Water Quality Data?

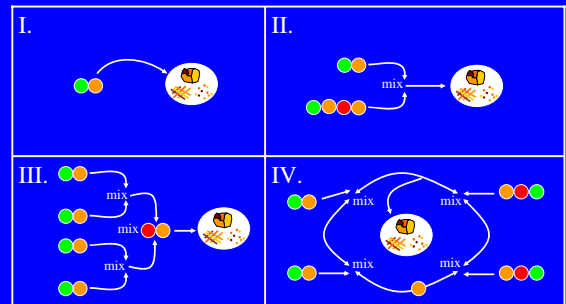
- Water quality data is routinely collected water sampling information to assist regulatory agencies in monitoring and enforcing water quality standards
 - In CA → Systems (~2K), Stations (~10K), and Samples (~4M)
- Since water quality standards were created to keep contaminants under a maximum concentration level (MCL), information about population-level exposures is not typically reportable, nor centralized

Water Quality Data is not Exposure Data

- Proximity to a water sample does not always imply an exposure
 - Water quality data does not tell us where water flows after sampling
- Water quality often changes after it's sampled
 - Treatment and mixing
- Other issues: consumption patterns (bottle vs tap), exposure period, etc.

Water Delivery can be Complex

● = source ● = sample ● = treatment 🍷 = consumers



Water "Exposure" Objectives

- Systematically link subjects to relevant (spatial/temporal) water quality samples
- Adjust and aggregate samples to reflect best approximation of water quality at downstream receptor site (home/work connection), given
 - History of detections and non-detections at station
 - Treatment downstream from station
 - Dilution downstream from station
 - Other factors influencing contaminant concentrations after sampling

Outline of Previous Method

- Linkage of subjects to systems
- Questionnaire mailed to systems**
- Compilation of surveys, QA/QC**
- Linkage of subjects to stations
- Linkage of subjects to samples

Red = bad for tracking

Method Assumptions

- One water system serves a single address range
- Relevant time period surrounding event date (e.g. n years before diagnosis)
- After adjusting for dilution and treatment, contamination levels at sampling stations indicative of levels at tap
- Subjects are being "exposed" to waterborne pollutants via drinking, showers, etc.
- Data quality is acceptable

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7

Linkage of Subjects to Systems

- Complete coverage of water system extents not available, so systems must verify service to address [range]
- Want to minimize number of systems contacted and number of address ranges presented to each system
- Developed weighting algorithm for each subject/system pair (see poster)

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8

Questionnaire Mailer

- Systems solicited for:
 1. Confirmation of water service during exposure window
 2. Identification of sampling stations (in sequence) upstream of residential connection
 3. Identification of treatment types used and whether they occur before or after sampling
 4. Best estimate of percent contribution volume of sampling location to downstream address range

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9

Survey Compilation

- Data manually entered from hardcopy or transferred from electronic spreadsheets into database
- Variables include:
 - Station code
 - Average volume contribution
 - Treatment codes
 - Flag whether treatment occurs before/after sample station
 - Time period of relevance
 - Alternate grouping identifier (recursive tree)
- Additional contact with water systems for wholesale scenarios and complex configurations

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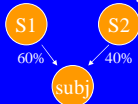
10

Linkage of Subjects to Stations

- Simple: 100% of volume at sampling stations contribute to downstream address range



- More Complex: unequal proportions of water at sampling stations contribute to downstream address range

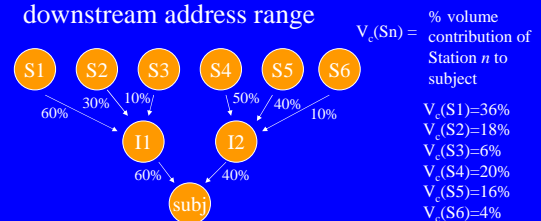


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11

Linkage of Subjects to Stations

- Quite Complex: unequal proportions of water at sampling stations dilute at intermediate points and contribute to downstream address range

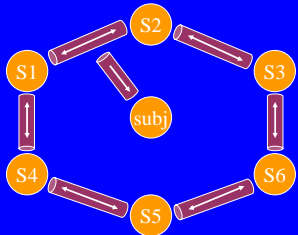


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12

Linkage of Subjects to Stations

- Very Complex: Loop-type system having sources within distribution system; Typical of flat, groundwater systems; bi-directional and demand-dependent flow



$$V_c(S_n) = \text{\% volume contribution of Station } n \text{ to subject}$$

$V_c(S1)=?$
 $V_c(S2)=?$
 $V_c(S3)=?$
 $V_c(S4)=?$
 $V_c(S5)=?$
 $V_c(S6)=?$

13

Treatment Adjustment

- Removal rate applied to raw water samples receiving treatment downstream from sampling station
 - chemical- and treatment-specific rates obtained from literature search
 - most conservative rates used

14

Linkage of Subjects to Samples

- Sample must have occurred during exposure window
- Non detect samples
 1. “Zero” concentration for NDs at stations never having detection
 2. “Half” detection limit (EPA) for NDs at stations with at least one detection in sampling history
- All non-zero samples adjusted for applicable post treatment and dilution
- Exposure metric is average of all sample values at stations linked to subjects

15

Issues

- Close contact with water systems results in useful information for single disease distribution and single exposure window
 - New disease distribution? Do it all over again.
- Can't systematically determine the supplier of drinking water for an address
 - Our best guess was right only 35% of the time
- 10-15% of population receives non-State reportable water

16

Issues

- Lack of centralized information on: 1. operation of stations, 2. Weighted contribution of flow at stations to downstream consumers
- Water transfers and water treatment information difficult/impossible to track temporally and along sequence of stations leading to receptors
- Water treatment info not collected in terms of non/target removal species or removal rates

17

Recommendations

- Establish tracking system(s) for individual level drinking water exposures!!!
 - State-specific? Nationwide?
- Pursue exploratory demonstration projects
 1. Survey water systems to identify requirements for establishing system-to-community and station-to-community linkages
 2. Perform an exposure assessment and validation study using existing water quality data and tap-water samples

18

Recommendations

- Create and maintain central tracking system for water system customer information. Collect address, connection start/end date, sub-zone (pressure), temporal-dependent demand metric
- For systems with multiple sources and/or sub-zones with high spatial concentration variations, create central tracking system for linking sampling stations to sub-zones. Collect temporal-dependent volume contribution metric.
- Don't need detailed infrastructure info like pipes, locations of pumps, valves, hydrants, pipe width/length

Recommendations

- Collect detailed water treatment information
- Collect sampling information for private sources
- It's unclear whether legislation will be needed for some or all of these recommendations
- BT event response could utilize these data and methods

Request for Supplemental Funding
Development of Methods for Tracking Exposures to Contaminants in Drinking Water

A Collaborative Effort of the EPHTN programs of CA, NJ, NM, WA, and WI

BACKGROUND

After two and a half years of work developing the foundations for an EPHTN, several states have found themselves facing similar, specific technical problems in the development of methods to track population exposures to contaminants in drinking water. Rather than each state trying to solve these problems on their own and share their results after their work has been completed, we propose to work on a number of these issues as a group, coordinating the assessment of different potential methods, and sharing the use of specialized technical resources.

The United States has one of the most reliable systems of public water supplies, delivering generally high quality water to hundreds of millions of citizens. While the infrastructure and regulations help to assure the quality of this water, there are still areas of the US where the existing contaminant levels may pose residual risks to the population. Further, there is a much lower level of assurance for those families served by small community water supplies not covered by the Safe Drinking Water Act, or by private domestic wells which are virtually unregulated.

To assess the extent of known or suspected population exposures to continuing hazards, and the concurrent linkages to disease, requires several pieces of information:

- water quality information, from both public water supplies (PWS), community water supplies and private wells,
- knowledge about water quality at consumers' taps, derived from sampling of the distribution systems, and/or from modeling the change in quality during treatment and distribution,
- information about the actual water supply and distribution systems, subsystems, and wholesale suppliers, which serve specific individuals, or small groups of individuals,
- data regarding the actual type/source of water consumed by residents, the amount consumed, and any household treatment of the water before consumption.

While there are gaps in each of the above, the most pressing issues for estimating exposures for the vast majority of the population are how to link individuals and/or small population groups to specific water distribution systems, and how to best use the existing water quality data to estimate water quality at the tap. Such methods would

help with both estimating population exposures and in response to citizen's concerns regarding drinking water quality and perceived disease clusters.

OBJECTIVES

A. Identify existing and potential methods for:

- linking individuals or small population groups to specific water supplies, and, if possible, hydraulically independent units within a distribution system;
- characterizing variations in water quality in water supply and distribution systems over time and within a distribution system;
- linking individuals or small population groups to small, unregulated water systems or private domestic wells; and
- estimating exposures to contaminants in water from these small systems when direct water quality observations are not available.

B. Assess the feasibility of incorporating the most promising methods into an Environmental Public Health Tracking Network in terms of:

- cost and effort;
- hardware, software and IT infrastructure;
- availability of current and historical data sources;
- required level of expertise;
- accuracy (if possible);
- external factors which affect the ability to use a method or to acquire additional water supply information (e.g. cooperation of outside parties or regulations that limit reporting requirements);
- characteristics of a situation or system which may make a method more or less appropriate.

C. Open communication lines with water systems to establish relationships, identify collaborative opportunities, and perform outreach/education in Environmental Health Tracking issues surrounding drinking water.

D. Disseminate the results to other states and other stakeholders through technical papers and 'how-to' documents..

WORK PLAN / METHODS

1. Gather information, from grantees and the literature, regarding potential methods for a) assigning individuals or small groups to specific water systems, b) estimating differences in water quality across distribution systems and over time, and c). estimating population exposures from individuals served by small water systems or private wells where water quality information may be scarce or lacking. Draft critical review of the literature regarding existing methods which may be applicable.
2. Identify technical experts in these areas. Conduct a feasibility planning meeting of the participating states and the identified experts to review the identified methods and identify the most appropriate and promising methods for the feasibility assessment. These methods may include, but are not limited to:
 - Survey of water purveyors to obtain listing of water customers
 - Delineation of water service boundaries and geographic linkage to specific addresses and/or census boundaries.
 - Gathering of hydraulic and distribution system data from purveyors and identification of hydraulically independent distribution zones
 - Implementation of water quality models for assessing changes in quality during distribution
 - Access and analyze existing information from purveyors to assess temporal and spatial variability in quality parameters
 - Determination of how frequent private water sources exist within geographic boundaries of public utility jurisdictions
 - Identify, access, and analyze information from external stakeholders that might already exist regarding enhancing drinking water monitoring information for distribution-level assessment (e.g. bioterrorism event response).
3. Create targeted Internet-accessible outreach/education materials for water purveyors.
4. Conduct a feasibility assessment of the identified methods. This may include a survey of selected water purveyors for method requirements gathering. The survey instrument would be designed to scale to any public water system in the U.S.
5. Conduct interim review meeting to review preliminary findings and generate revised plans.
6. Complete feasibility assessment.

7. Prepare a written 'technical' document of the results, and a less detailed 'how-to' manual for the most feasible and applicable method(s).
8. Disseminate technical documents through website and other pertinent mediums. Present findings at national meetings.

ADMINISTRATIVE ORGANIZATION

This work will be carried out by a group of states and non-State external technical experts forming a Water Exposure Tracking "Technical Steering Committee". The proposed activities would be funded through this supplemental grant, with possible additional funding through the state's previously approved funded activities. The State of California will act as the administrative lead to receive the funding from CDC. The other participating states will contribute technical input and oversight and will fully participate in forming work agenda. The participating states include: California, New Jersey, New Mexico, Washington, and Wisconsin. Letters of cooperation from each of these states as well as external technical experts are attached as Appendix A. Other EPHTN participants who have been conducting activities in the area of exposure assessment of drinking water exposures were asked to participate. Those that did not choose to be involved in this proposal will be contacted during the planning process for their input.

The California Environmental Health Tracking Program will hire a full-time research scientist with a background in environmental health and/or environmental engineering to conduct the feasibility assessment. Craig Wolff, M.S., Eng., will serve as the Principal Investigator and will provide day-to-day supervision of the Research Scientist. The overall work plan and regular input will be provided by a designated individual from each participating state through the three meetings, email, quarterly conference calls, and other conference calls when needed. The research scientist will work cooperatively with all participating states and non-State external technical experts. The specific geographic areas to be used in the assessment will be decided by the Committee based on the type of water systems and available data and will not be limited to the lead state.

BUDGET NARRATIVE

The Technical Steering Committee requests funds to support four types of activities:

1. travel and meeting-related costs to hold the three meetings described above;
2. salary and benefits to cover the research scientist and senior researcher at the host state;
3. the direct costs of the method assessment (e.g., software, mailing to purveyors, expert consultation, travel to other states);
4. incidental costs (phone, computer etc.).

The participating states and non-State external technical experts will be expected to fully participate, and the process will be managed and streamlined to minimize effort. Due to the relatively small amount of effort to be provided by each participating state, and the high administrative costs of executing contracts, the participating states will be expected to participate without direct funding.

DETAILED BUDGET

See Appendix B

TECHNICAL STEERING COMMITTEE BIOS

Jerald Fagliano (NJ), MPH, PhD, has worked for the New Jersey Department of Health and Senior Services since 1985. Currently, he is the manager of the Hazardous Site Health Evaluation Program, where he oversees public health investigations and epidemiologic research related to hazardous sites, drinking water contamination and air pollutants. Areas of investigation include asthma and air toxics, exposure pathways from hazardous waste sites, biomonitoring for heavy metals, emergency event surveillance, and environmental public health tracking. In the area of drinking water, he has conducted ecologic and case-control epidemiologic studies of exposure to chemical and radiological contaminants in relation to cancer incidence. In these studies, he has developed and applied methods of exposure assessment involving GIS mapping and assembly of historic water contaminant databases. In addition, he was the principal investigator of the Dover Township/Toms River childhood cancer cluster investigation, which incorporated complex water distribution system engineering modeling to address the problem of exposure assessment. Dr. Fagliano earned a Master of Public Health degree in environmental health from Yale University, and a Ph.D. in occupational and environmental epidemiology from The Johns Hopkins University.

Len Flowers (NM), MS, has 20 years of experience in environmental toxicology including human health risk assessments and environmental health impact analyses. She is the Principal Investigator for 5 CDC and NIOSH grants and Bureau Chief for the New Mexico Department of Health Environmental Health Epidemiology Bureau. This work includes developing and implementing a biomonitoring plan for New Mexico and meeting with public health partners throughout the State to identify exposure concerns and exposed populations. She is also leading a CDC grant to link arsenic in drinking water data to the New Mexico Tumor Registry data at the census tract level and developing tracking systems to link environmental data with health outcome data using GIS platforms. She has conducted more than 60 risk assessments at sites in the US, UK, Canada and EU with expertise in toxicity and exposure evaluations, risk communication, and risk-based decision making.

Kristen Malecki (WI), MPH, PhD, has recently completed her doctoral degree at Johns Hopkins University exploring the development of methods and tools for indicator development. Her work focused on the case study analysis of four indicators related to water quality and children's health in the state of Maryland. For the last year, Kristen

has also been working as a CDC/CSTE fellow at the Wisconsin Department of Health and Family Services in the Bureau of Environmental and Occupational Health as part of the Wisconsin Environmental Health Tracking Program. Kristen is working with the WI EPHT team to explore the development of exposure indices from multiple sources of drinking water sources in the state. Previously, Kristen worked on an epidemiologic investigation of arsenic exposure and cancer mortality in Wisconsin. Kristen's interests include exposure assignment and risk assessment of chemical contaminants in drinking water and linkages with children's health effects in particular, adverse birth outcomes and childhood cancer.

Jim VanDerslice (WA), MS, PhD, is the Senior Epidemiologist and manager of the Environmental Epidemiology section at the Washington state Department of Health. Dr. VanDerslice has a B.S. in Environmental Engineering with a focus in Water Quality, and a Master of Environmental Engineering and a Ph.D. in Water Resources Engineering from the University of North Carolina at Chapel Hill. He has over 25 years of experience designing studies to assess exposures to microbial and chemical exposures via drinking water. His work has included projects in the Philippines, Texas, New Mexico, and Northern Mexico. He is currently the PI on an EPA-funded study on infants' exposure to nitrate in drinking water from private wells, and the association with methemoglobin levels.

Craig Wolff (CA), MS, Eng., is a Research Scientist for the California Department of Health Services and IT/GIS Manager for the California Environmental Health Tracking Program. Mr. Wolff has a double B.S. in Mathematics and Geography from the University of California, Los Angeles and an MS in Environmental Engineering with a focus in Water Resources from the University of California, Berkeley. Prior to his work in Environmental Health Tracking, Mr. Wolff investigated the etiologic factors associated with California statewide incidence of testicular cancer. He led the drinking water exposure assessment portion of the project, responsible for the management, coordination and implementation of a data collection effort that characterized temporal and community-scale spatial variations in water quality for about 1000 California public water systems. The analysis included methods development and statistical analysis for integrating analytic water quality data in a case/control study design, accounting for volume and treatment effects in multi-source systems. He continues to translate the results of this project and the breadth of the experience into methods development and policy-oriented talking points so that the environmental health tracking of drinking water contaminants can be accomplished in the future.

TIMELINE

Task	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July
Hire research scientist										
Identify methods										
Identify experts										
Planning meeting										
Assessments										
Interim progress meeting										
Assessment										
Final meeting										
Prepare documents										
Disseminate through website, conferences and meetings										