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EPA computer models predict exposures to arsenic that echo reality

Overview

Arsenic exists naturally in rocks, soil, water and air. People's activities such as burning coal, preserving wood and managing food crops also contribute to arsenic in the environment.

The U.S. Environmental Protection Agency (EPA) has set the arsenic standard for drinking water at 10 parts per billion (less than one-tenth of a drop of water in a 53-gallon tub) to protect consumers served by public water systems from the effects of long-term, chronic exposure to arsenic. Along with protective limits for arsenic in drinking water, arsenic exposures in occupational settings are well described, and safeguards and limits have also been established.

However, exposure to arsenic among the general U.S. population from both food and water ingestion is not well-defined because the variables that impact people's exposures to contaminants are difficult to measure, or vary from person to person and community to community, including the types and amounts of food people eat, and water they drink.

Purpose of Research

A critical element of EPA's mission is to protect public health by managing risks from exposures to pollutants. To do this, EPA relies on science-based decision-making and innovative solutions.

EPA scientists recently conducted research to improve EPA's capability to estimate exposures to arsenic via two pathways (drinking water and ingesting food) for the general U.S. population.

Approach

Exposure estimates were developed using state-of-the-science computer models to combine available high-quality data on food people eat and water they drink with estimates of arsenic residues in foods and drinking water. The accuracy of the modeled estimates was then evaluated by comparing them against physical measurements from large-scale field surveys. Model development and evaluation were performed using large high-quality data sets from the U.S. Food and Drug Administration (FDA), Natural Resources Defense Council (NRDC), Centers for Disease Control and Prevention (CDC), and EPA.

EPA scientists specializing in modeling research used EPA's Stochastic Human Exposure and Dose Simulation (SHEDS)-Dietary model in this research. SHEDS-Dietary is a population-based model that incorporates real-world food consumption and chemical residue data, and applies advanced statistical methods to simulate individual exposures to chemicals over different time periods (e.g., daily, yearly).

EPA's modeled predictions were compared to arsenic intake from foods consumed by people participating in EPA's National Human Exposure Assessment Survey (NHEXAS) duplicate diet study, as well as urinary biomarker measurements provided by participants in CDC's 2003-2004 National Health and Nutrition Examination Survey (NHANES).

To predict the dose from people's arsenic consumption, SHEDS-Dietary estimates were linked to the MENTOR-3P modeling system. MENTOR-3P stands for Modeling ENvironment for TOtal Risk with Physiologically Based Pharmacokinetic Modeling for Populations.

Linking SHEDS' estimates of exposure and ingestion, with MENTOR-3P's estimates of internal dose, allowed researchers to understand the variability between and among individuals, and equipped EPA with the ability to develop arsenic dose predictions

that could be compared to biomarkers measured in urine.

Conclusions and Impact

In this study, EPA scientists were able to use the models to accurately predict dietary exposures to arsenic. The study's modeled estimates of arsenic exposures and doses for the general U.S. population from food and water were found to compare favorably with the physical measurements and observations from biomonitoring samples and dietary studies.

Study results showed that the foods we eat may be as or more important as sources of arsenic as the water we drink and cook with. Food groups that have been reported to contain arsenic include some fruits, fruit juices, rice, beer, flour, corn, and wheat, depending on the item and where it is grown.

The study found estimated arsenic exposures from diet to be low — approximately one-fifth the level set to protect consumers from the effects of long-term, chronic exposure to arsenic in drinking and cooking water alone.

This research strengthens EPA's capability to accurately predict dietary exposures to arsenic and other chemicals. It also expands and enhances EPA's suite of predictive modeling exposure assessment tools.

The study is detailed in a November 2009 peer-reviewed journal article: Xue, J., Zartarian, V., Wang S-W, Liu, S.V., Georgopoulos P, 2009. Probabilistic Modeling of Dietary Arsenic Exposure and Dose and Evaluation with 2003-2004 NHANES Data. *Environ Health Perspectives*, vol. 118, no. 3, p. 345-350.

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