Arsenic in Drinking Water and Bladder Cancer Incidence in New Mexico: An Exploratory Ecologic Analysis

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SUMMARY

Arsenic is an established human carcinogen that occurs naturally in drinking water. Studies have shown that chronic consumption of water containing arsenic in excess of 400 micrograms per liter (ug/l) is associated with increased risks of skin cancer and various internal cancers, particularly bladder and lung. In 2001, the USEPA lowered the maximum contaminant level (MCL) standard for arsenic in drinking water from 50 to 10 ug/l based on low-dose extrapolation of the international data. In New Mexico, an estimated 100 public water supply systems in the state, representing a service population approximating 756,000, or 40% of the state population, were identified in 2004 which likely are affected by the new MCL.

This exploratory ecologic study was conducted to examine age-adjusted bladder cancer incidence rates in New Mexico in relation to drinking water arsenic levels. Information on bladder cancer newly diagnosed among New Mexico residents between 1988 and 2002 was obtained from the state cancer registry and linked at the census tract level with drinking water arsenic regulatory compliance data. Census tracts were classified as either above or below the arsenic MCL and sex- and racial/ethnic-specific rates and rate ratios (RRs) computed across various covariates and potential confounder attributes. For exposure assessment, arsenic compliance monitoring data were spatially interpolated with a geographic information system (GIS) to generate a continuous surface map of drinking water arsenic concentrations across the state. The arsenic map was then overlaid with a boundary map for the 456 census tracts defined in New Mexico for the 2000 Census. The primary goal was to identify areas of the state where water supplies historically contained arsenic likely exceeding the current MCL for arsenic of 10 ug/l. Census tracts were dichotomized into groups either above or below the arsenic MCL, and racial/ethnic-specific bladder transitional cell carcinoma incidence rates calculated for each group over the aggregate time period. A secondary analysis grouped the census tracts according to four arsenic levels in order to assess dose-response relationships.

A positive significant association was observed between arsenic in drinking water and the age-adjusted incidence of bladder transitional cell carcinoma in the White population of New Mexico, but not the Hispanic population. Among Whites, bladder cancer incidence in areas above the arsenic MCL was statistically-elevated by 16% over that in areas below the MCL. The excess incidence was observed in both males (RR=1.17) and females (RR=1.15), achieving statistical significance in males (p=.008), but not in females. Dose-dependent variation in risk was observed within the above MCL group. Excess incidence in areas with drinking water estimated to contain more than 20.0 ug/l arsenic (RR=1.30, p=.022) was roughly twice that of areas with between 10.1 and 20.0 ug/l arsenic (RR=1.12, p=.059). The risk estimates remained largely unchanged when analyzed across various potential confounders, including area education and poverty measures, population density, nativity, residential mobility, and tumor stage at diagnosis and sequence.

A second study of bladder cancer incidence and drinking water arsenic limited to the Albuquerque public water system was conducted using a different exposure assessment methodology. Publicly available information on the system service area and recent drinking water arsenic levels were used to generate a digital map of average water arsenic content within each of the 19 water distribution zones comprising the entire system. The zones were classified as either above or below the arsenic MCL and the resultant map overlaid with a Bernalillo county census tract boundary map in order to first identify those tracts wholly or largely contained with the water system, and subsequently, to dichotomize those tracts based on the MCL. A total of 116 census tracts were identified as comprising the system, of which 100 were entirely contained within an area estimated to be either above or below the MCL. A population-weighted average arsenic measure was computed for the remaining 16 tracts, which was then used to dichotomize each tract as above or below the MCL. Bladder transitional cell carcinoma incidence rates in White males 50 years and older at diagnosis were calculated for areas above and below the MCL using the fully-inclusive set of 116 tracts, as well as the restrictive subset of 100 “wholly-contained” tracts. Results of the analysis with the restricted subset of tracts revealed a statistically-significant 21% elevation of bladder cancer incidence in areas above the MCL compared to those below. A nearly significant 15% excess was observed when the analysis was broadened to include all census tracts in the water system, a finding similar to that observed in the statewide study using a different exposure assessment methodology.