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Drinking Water Arsenic and Cancer Risk in New Mexico

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Arsenic is a naturally occurring element present in both terrestrial and aquatic environments. The level of arsenic in public drinking water is regulated under the federal Safe Drinking Water Act (SDWA), and for many years the arsenic maximum contaminant level (MCL) was set at 50 µg/l. In 2001, the U.S. Environmental Protection Agency (USEPA) lowered the arsenic MCL to 10 µg/l (effective 2006) out of concern that the former 50 µg/l standard was not sufficiently protective of public health. In New Mexico, 96 public water systems were identified in 2004, serving about 40% of the state population, which had one or more drinking water supply sources exceeding the new 10 µg/l arsenic standard[1]. The majority of these systems were small, serving less than 500 persons, but larger systems were affected as well, including those serving Santa Fe, Rio Rancho, and Albuquerque. Compliance with the new arsenic MCL has required the water systems to make changes in their source water supplies and/or install arsenic-removing treatment technology.

The USEPA decision to reduce the arsenic MCL was based largely on an extrapolation of human health data from international studies (Taiwan, Chile, Argentina) that linked elevated rates of bladder and lung cancer with long-term consumption of drinking water containing arsenic in excess of 150 µg/l [2]. Studies at lower drinking water arsenic levels (<50 µg/l), as are more typical in the U.S., have reported inconsistent findings on cancer risk, leading some to question the prudence of the USEPA action, while causing others to call for an even more stringent arsenic standard. Furthermore, additional health studies conducted over the past decade have suggested a link between drinking water arsenic exposure and various other health outcomes, including other forms of cancer, as well as non-cancer diseases, such as diabetes, cardiovascular disease, and cerebrovascular disease.

In light of the existing scientific uncertainties on the adverse health effects of chronic exposure to low levels of arsenic in drinking water, the New Mexico Department of Health Environmental Public Health Tracking (EPHT) Program has sought to characterize historical and current drinking water arsenic levels in New Mexico, and compare health outcome rates in areas of the state that differ by drinking water arsenic levels. This report provides results from a county-level analysis of bladder and lung cancer incidence rates in three counties of New Mexico where historic drinking water arsenic levels are estimated to have exceeded the current 10 µg/l regulatory level.

Methods

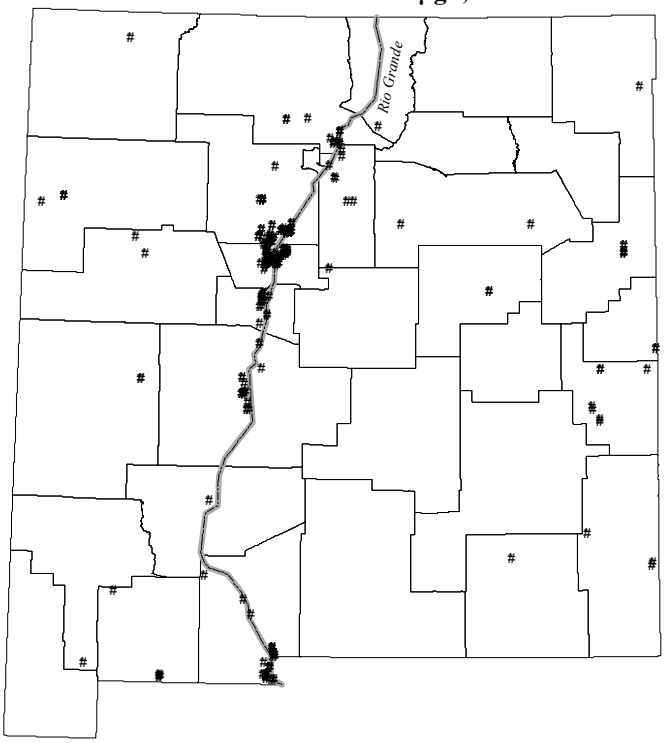
Estimation of Drinking Water Arsenic Levels

The SDWA requires public water systems to monitor levels of regulated contaminants, such as arsenic, in order to determine if they meet national drinking water standards. In New Mexico, roughly 600 public systems supply drinking water to about 85% of the state population, with the remaining 15% of state residents on private wells, which are not regulated under the SDWA. The New Mexico Environment Department (NMED) enforces the SDWA, and maintains a safe drinking water information system (SDWIS) database containing laboratory results from drinking water samples analyzed for arsenic, as well as other regulated contaminants. USEPA rules require systems to sample water at every point of entry to their distribution system.

Estimates of historic arsenic concentrations in New Mexico drinking water were compiled from the SDWIS database containing arsenic sampling

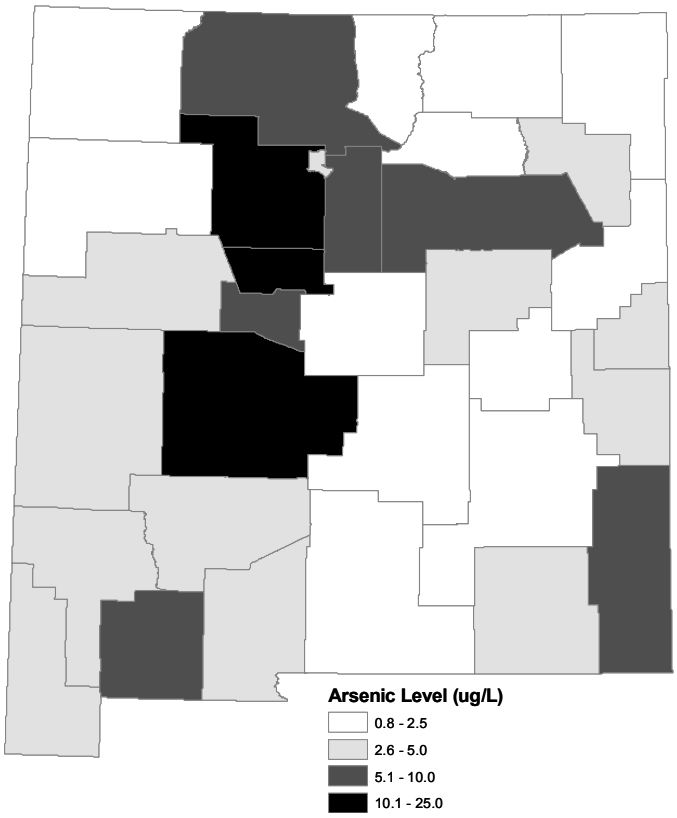
concentrations obtained between 1990 and 2005. The database included 5,500 individual arsenic concentration measurements from 2,200 different sampling locations, many of which were individual water supply wells. Arsenic concentration data were averaged at each respective sampling location, which yielded a range of <1 to 184 µg/l, with 234 locations having mean arsenic levels exceeding 10 µg/l. Locations where arsenic levels exceeded the current MCL tended to cluster along the middle Rio Grande valley, including areas of Santa Fe, Sandoval, Bernalillo, Valencia, and Socorro counties (Figure 1). Groundwater aquifers in this region of the state typically are formed in volcanic soils rich in arsenic, which can leach into groundwater over time.[3]

Figure 1. Drinking Water Sampling Locations With Mean Arsenic Concentrations > 10 µg/l, 1990-2005



County-level arsenic exposure levels were calculated using methodology described by Frost et al.[4] Mean arsenic levels for each water system in the state were computed from the SDWIS database by averaging the estimated arsenic concentrations for all sampling locations within a given system. Most systems had data from two or more different sampling locations, some of which varied considerably in arsenic content. Because water production data by source are not included in the SDWIS database, we assumed that each source contributed an equal amount of water to the system. Under this assumption, 1990-2005 mean arsenic concentrations for New Mexico public water systems ranged from <1 to 88 µg/l, with a median of 2 µg/l, and with 54 systems exceeding 10 µg/l. To derive each county-level arsenic exposure measure, the mean arsenic concentration for each water system was weighted by the system's service population size (tabulated from SDWIS database), and the weighted means were then summed for all systems within a given county. Three counties were identified with historic drinking water arsenic levels estimated to exceed the current arsenic MCL: Socorro County (23.3 µg/l), Sandoval County (17.9 µg/l), and Bernalillo County (13.0 µg/l). The overall mean arsenic level for the remainder of the state (30 counties) was 4.4 µg/l. Arsenic levels in these counties ranged from 0.8 to 10.0 µg/l. Twelve counties, mostly in eastern New Mexico, had arsenic concentrations estimated at 2.5 µg/l or less (Figure 2).

Figure 2. Mean Drinking Water Arsenic Concentrations by County, 1990-2005



Calculation of Cancer Incidence Rates and Ratios

Data on bladder and lung cancer newly diagnosed in New Mexico between 1992 and 2006 were obtained from the New Mexico Tumor Registry (NMTR). Racial/ethnic-specific average annual incidence rates, incidence rate ratios (IRR) and corresponding 95% con

fidence intervals (CI) were computed for each of the three high arsenic counties as well as the remainder of the state, which served as a low arsenic referent population for the IRRs. All rates and IRRs were age-adjusted to the 2000 Census population. The analysis was limited to non-Hispanic Whites and Hispanics due to the small number of cases involving other racial/ethnic groups in the three high arsenic counties. An IRR lower CI exceeding one indicates the high arsenic county rate is significantly elevated over the low arsenic state reference rate. Conversely, an IRR upper CI less than one indicates the high arsenic county rate is significantly lower than the state reference rate.

Results

Bladder cancer incidence rates were significantly elevated by 21% and 51% among Sandoval County non-Hispanic whites and Hispanics, respectively (Table 1). Corresponding bladder cancer incidence rates in Bernalillo and Socorro counties were similar to those in the remainder of the state. A different trend was observed for lung cancer, where incidence rates were significantly lower by 10% and 11% among Sandoval and Bernalillo county non-Hispanic whites, respectively. The lung cancer incidence rate for Socorro county non-Hispanic whites was also lower than the comparison state rate, but the 8% deficit did not reach statistical significance. Among Hispanics in the three high arsenic counties, lung cancer incidence rates were slightly higher than the comparison state rate, however, none of these minor elevations achieved statistical significance.

Discussion

The USEPA lowered the arsenic MCL based largely on concern that long-term consumption of drinking water containing arsenic in the range of 10 to 50 µg/l is associated with excess risk of bladder and lung cancer. The actual magnitude of risk in this low-dose exposure range remains unknown, but is thought to be small relative to that due to smoking, a major risk factor believed to account for roughly 50% and 90% of the bladder and lung cancers diagnosed each year in the U.S., respectively. No evidence was found that lung cancer incidence was elevated in any of three counties in New Mexico (Bernalillo, Sandoval, and Socorro) ascertained to have a mean historic arsenic concentration in excess of 10 µg/l. In fact, a deficit in lung cancer rates approaching 10% was observed among non-Hispanic whites in both Bernalillo and Sandoval counties, suggesting a lower historical prevalence of smoking in these populations compared to the remainder of the state.

Mixed results were observed with bladder cancer, where a modest elevation in incidence was observed in Sandoval County, but not in Bernalillo or Socorro counties. The fact that the bladder cancer incidence rate was elevated in both non-Hispanic whites (IRR=1.21) and Hispanics (IRR=1.51) in Sandoval county suggests that a common element may underlie the modest excess observed. Based on the analysis of lung cancer rates, it does not seem likely that smoking alone could account for the elevation. Other causes of bladder cancer, particularly in non-smokers, remain unknown, so we cannot speculate on the role of such factors at this point. In regards to drinking water arsenic, the ecologic nature of this study, in which individual arsenic exposure levels were crudely estimated by mean county-level measures, limits any direct inference on the role of drinking water arsenic and the elevated bladder cancer incidence observed in Sandoval County. Nevertheless, given the current scientific uncertainty on low-dose arsenic-related health effects, continued public health surveillance in areas of the state differing in both past and current drinking water arsenic levels is warranted and current efforts are underway to more fully analyze these data demographically, as well as at smaller geographic scales, such as census tracts.

Acknowledgements

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Table 1. Cancer Incidence Rate Ratios and 95% Confidence Intervals (CI) for Three New Mexico Counties with Historic Mean Drinking Water Arsenic Concentrations Exceeding 10 ug/l, 1992-2006

Cancer Site	County	Non-Hispanic White		Hispanic	
		Cases	Rate Ratio[a] (95% CI)	Cases	Rate Ratio[a] (95% CI)
Bladder	Bernalillo	1,028	0.99 (0.92-1.07)	221	0.97 (0.82-1.14)
	Sandoval	194	1.21* (1.04-1.41)	36	1.52* (1.05-2.14)
	Socorro	25	1.03 (0.66-1.54)	7	0.66 (0.26-1.34)
Lung	Bernalillo	2,705	0.89* (0.85-0.93)	777	1.06 (0.97-1.16)
	Sandoval	427	0.90* (0.81-0.99)	84	1.14 (0.90-1.41)
	Socorro	66	0.92 (0.70-1.17)	35	1.06 (0.74-1.48)

[a]Referent population = rest of New Mexico (n=30 counties). * Rate ratio significantly different from unity ($p<0.05$)
*Source: New Mexico Tumor Registry via Online SEER*Stat*