Prevalence of Chronic Diseases in Adults Exposed to Arsenic-Contaminated Drinking Water

Kristina M. Zierold, PhD, Lynda Knobeloch, PhD, and Henry Anderson, MD

Inorganic arsenic is naturally occurring in groundwaters throughout the United States. This study investigated arsenic exposure and self-report of 9 chronic diseases. We received private well-water samples and questionnaires from 1185 people who reported drinking their water for 20 or more years. Respondents with arsenic levels of 2 µg/L or greater were statistically more likely to report a history of depression, high blood pressure, circulatory problems, and bypass surgery than were respondents with arsenic concentrations less than 2 µg/L. (*Am J Public Health.* 2004;94:1936–1937)

Inorganic arsenic is commonly found in groundwaters throughout the United States. In October 2001, the US Environmental Protection Agency reduced the maximum contaminant level drinking water standard for arsenic from 50 µg/L to 10 µg/L. By 2006, all public drinking water supplies in the United States are required to comply with the new standard. This new standard is based on existing epidemiological evidence documenting the association between arsenic exposure and cancers of the lung and bladder. The health effects associated with inorganic arsenic exposure are numerous and include basal cell cancer of the skin; tumors of the bladder, kidney, liver, and lung[1–4]; blood vessel damage[5]; peripheral vascular and cardiovascular disease[4,6–8]; numbness in the hands and feet[9,10]; and diabetes mellitus.[11,12]

Many studies have documented associations between arsenic exposure and chronic illness; however, most have focused on high exposures and cancers.[2,4,5,13–15] Less studied have been the effects of low-level arsenic exposure.

In 1987, a groundwater study conducted by the Wisconsin Department of Natural Resources identified arsenic in groundwater above the maximum contaminant level coincident with a bedrock layer at the interface of the St. Peter Sandstone and Sinnippee Dolomite. The geologic formation exists beneath more than 20 000 private water supply wells throughout several Wisconsin counties. Water samples collected from 1943 private wells between 1992 and 1993 contained arsenic concentrations that ranged from less than 2 µg/L to 12 000 µg/L. Nearly 20% of the water samples contained concentrations that exceeded the new federal drinking water standard of 10 µg/L.[16]

The principal objective of this research was to evaluate the prevalence of 9 different chronic diseases in adults who drink water from privately owned wells in the at-risk area.

METHODS

Between July 2000 and January 2002, 19 townships in the arsenic-contaminated area sponsored well-water testing programs to promote arsenic awareness and remediation options. All township homeowners were eligible and encouraged to obtain a well-water sample kit from the local town hall. A survey, which contained questions about lifetime residential history, usual drinking water consumption, use of water-treatment systems, and family health status, was included in the kit. The homeowners' collected water sample and completed surveys were returned to the town hall for analysis. All the surveys were returned before the homeowners received the results of their water tests.

At the completion of the awareness campaign (approximately 1 month after all samples were returned), homeowners were invited to an informational meeting at the local town hall. During this meeting, they received the results of their well-water tests and were given the opportunity to ask state experts questions.

Data from the surveys were analyzed with SAS, Version 8.2 (SAS Institute Inc, Cary, NC). Arsenic water concentrations were grouped into 3 strata (<2 µg/L, 2–10 µg/L, >10 µg/L). Analysis was limited to those aged 35 years or older who reported drinking their well water for 20 or more years. To evaluate the magnitude of any association between arsenic water concentrations and chronic disease status, multivariate logistic regression was used to calculate adjusted odds ratios (ORs) and 95% confidence intervals (CIs).

RESULTS

The mean age of the 1185 respondents who met our inclusion criteria was 62 years (SD=12 years). The respondents reported drinking their well water for 20 to 83 years (mean=30 years; SD=10 years). The arsenic water concentrations ranged from 0 µg/L to 2389 µg/L, with a median of 2 µg/L. Most (84%) of the water samples had arsenic concentrations of 10 µg/L or less.

The results of the logistic regression analysis are shown in Table 1. Individuals with wells in the mid strata of arsenic concentrations (between 2 µg/L and 10 µg/L) were significantly more likely to report having depression than were respondents in the lowest strata (arsenic concentrations <2 µg/L) (adjusted OR=2.74; 95% CI=1.14, 6.63). Additionally, respondents with well-water arsenic concentrations greater than 10 µg/L were significantly more likely to report having had cardiac bypass surgery, high blood pressure, and circulatory problems than were respondents whose well water had arsenic concentrations less than 2 µg/L.

DISCUSSION

Our study is consistent with other studies that have found an association between arsenic exposure and cardiac disease,[4,6–8,17] but the association between arsenic water concentration and depression is novel and

TABLE 1—Associations Between Reported Chronic Illness and Arsenic (As) Exposure

	2 μg/L ≤ As ≤ 10 μg/L		As > 10 μg/L	
Reported Chronic Illness	Crude OR (95% CI)	Adjusted OR (95% CI)[a,b]	Crude OR (95% CI)	Adjusted OR (95% CI)[a,b]
Bypass	1.54 (0.84, 2.82)	1.77 (0.95, 3.30)	1.91 (0.94, 3.87)	2.34 (1.12, 4.90)*
Angina	2.05 (0.85, 4.90)	2.27 (0.92, 5.59)	1.04 (0.28, 3.90)	1.07 (0.28, 4.07)
Heart disease	1.31 (0.87, 1.97)	1.52 (1.00, 2.35)	1.30 (0.78, 2.17)	1.54 (0.90, 2.68)
Heart attack	1.19 (0.63, 2.23)	1.31 (0.70, 2.50)	1.83 (0.91, 3.68)	2.08 (1.10, 4.31)*
High blood pressure	1.09 (0.80, 1.50)	1.15 (0.82, 1.59)	1.57 (1.10, 2.31)*	1.68 (1.13, 2.49)*
Stroke	0.85 (0.37, 1.93)	0.93 (0.40, 2.14)	1.18 (0.46, 3.06)	1.53 (0.60, 4.07)
Circulatory problems	1.22 (0.56, 2.62)	1.31 (0.60, 2.86)	2.38 (1.10, 5.26)*	2.64 (1.17, 5.95)*
Type 2 diabetes mellitus	1.29 (0.75, 2.20)	1.35 (0.78, 2.33)	1.10 (0.50, 2.10)	1.02 (0.49, 2.15)
Depression	2.70 (1.12, 6.50)*	2.74 (1.14, 6.63)*	2.40 (0.90, 6.98)	2.32 (0.80, 6.82)

Note. OR = odds ratio; CI = confidence interval.
[a]Referent group = As < 2 μg/L.
[b]Adjusted for gender, age, smoking status, and body mass index.
*Significant at $P \leq .05$.

merits further investigation. Only a few studies have evaluated the effect of arsenic exposure on brain function.[18–20] Calderon et al.[18] found that arsenic exposure is associated with lower verbal IQ and poorer long-term memory in children. The Agency for Toxic Substances and Disease Registry[17] has stated that acute toxic exposures to inorganic arsenic have been shown to lead to emotional lability and memory loss. A mechanism of action has not been identified, but perhaps long-term exposure to arsenic may interfere with the neurotransmitters associated with depression. Mechanistic research into effects on the brain and mental development is needed to understand the role arsenic may play in the development of neurological disease.

Caution in interpretation of our results is warranted because the health data are self-reported and not verified by medical record review. Also, we did not know the arsenic levels in the homeowner's drinking water over the entire period of more than 20 years or how much arsenic was actually ingested. We assumed that our arsenic water concentration strata assignment was a reasonable surrogate for exposure and would have remained constant over the period. The possibility of other co-minerals and metals in the water samples contributing to health outcomes was not evaluated. ■

About the Authors

Kristina M. Zierold is with the Department of Environmental Health Sciences, Arnold School of Public Health, University of South Carolina, Columbia. Lynda Knobeloch and Henry Anderson are with the Wisconsin Division of Public Health, Bureau of Environmental Health, Madison.

Requests for reprints should be sent to Kristina M. Zierold, PhD, Department of Environmental Health Sciences, Arnold School of Public Health, 800 Sumter St, University of South Carolina, Columbia, SC 29208 (e-mail: zierold@gwm.sc.edu).

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Contributors

K.M. Zierold conducted the analyses and led the writing of the brief. L. Knobeloch conceived the study and supervised its implementation. H. Anderson assisted with the study and the analysis. All authors helped to conceptualize ideas, interpret findings, and review and edit drafts of the brief.

Human Participant Protection

No protocol approval was needed for this study.

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