Exposure to Tungsten in Three Nevada Communities

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INTRODUCTION

In March and April 2002, the Health Studies Branch (HSB), Division of Environmental Hazards and Health Effects, National Center for Environmental Health (NCEH), Centers for Disease Control and Prevention (CDC), assisted the Nevada State Health Division (NSHD) in conducting a cross-sectional exposure assessment of selected environmental contaminants in Churchill County, Nevada[1]. NSHD and CDC undertook the assessment because of a statistically significant increase in the number of cases of childhood acute lymphocytic and myelocytic leukemia. A key finding of this exposure assessment was that approximately 68% of the study participants had urine levels of tungsten above the 95th percentile of the National Health and Nutrition Examination Survey (NHANES) reference population. However, there was no difference in tungsten levels between families with children with leukemia and families without children with leukemia. This finding raised the question of whether these higher levels are unique to the Churchill County community, or if tungsten exposures similar to those of Churchill County occur in other communities in Nevada.

Churchill County is an agricultural area irrigated by water from the Carson River. Groundwater in the Churchill County area also principally derives from Carson River water. Tungsten concentrations in Carson River water reportedly range from 1.5 to 23 μg/L.[2] The Carson River watershed contains numerous tungsten mines and prospects.[3] Geologically, tungsten is associated with intrusive granitic rocks. [3] Extensive outcrops of these rocks are in the headwaters of the Carson River. Drinking water in Churchill County is supplied by domestic and public supply wells.

Because research on tungsten is limited, especially regarding health effects and urinary levels of concern, the NSHD requested assistance from CDC in conducting a cross-sectional exposure assessment of tungsten in three other Nevada communities.

OBJECTIVES

The objective of this investigation was to assist state and local health officials in assessing the level of exposure to tungsten in three communities of Nevada, to determine whether the high levels of tungsten are unique to residents of Churchill County, Nevada.

METHODS

Study Design

This investigation employed a cross-sectional survey design to assess human exposure to tungsten. We administered questionnaires and collected urine, water, dust, and soil samples to test for tungsten.

Study Location

The NSHD chose the communities of Lovelock, Yerington, and Pahrump, Nevada, on the basis of these cities' hydrogeology and history of tungsten mining. None of our sample locations have any tungsten processing plants.

Lovelock is hydrologically similar to Churchill County. It is an agricultural area irrigated by water from the Humboldt River. Groundwater in the Lovelock area principally derives from Humboldt River water. Tungsten concentrations in Humboldt River water are unknown. The Humboldt River watershed contains numerous tungsten mines and prospects.[3] Like the Churchill County area, outcrops of granitic rocks are in the Humboldt River basin. The potential for tungsten to be found in Lovelock groundwater was considered high. However, all drinking water in the Lovelock area is supplied by a few adjacent wells located north of Lovelock near Oreana. Collecting numerous samples of tap water derived from these wells would not have provided evidence about the range of tungsten concentrations in Lovelock-area groundwater.

Yerington is hydrologically similar to Churchill County. It is an agricultural area irrigated by water from the Walker River. Groundwater in the Yerington area derives from Walker River water. Tungsten concentrations in the Walker River water and its tributaries reportedly range from 0.15 to 15 μg/L.[2,4] Tungsten concentrations in water from nine wells in the Walker River basin ranged from 8 to 128 μg/L and a spring in the basin contained over 300 μg/L.[4] No tungsten mines are in the Yerington area.[3] Like the Churchill County area, outcrops of granitic rocks are in the Walker River basin upstream of Yerington. The potential for tungsten to be found in Yerington groundwater was considered high, and like Churchill County, Yerington drinking water is supplied by domestic and public supply wells.

Pahrump is not hydrologically similar to Churchill County. No perennial streams flow through the basin. Pahrump is a rapidly growing suburban area and is not presently an agricultural area. During the 1960s, however, cotton was cultivated using groundwater supply for irrigation. No tungsten mines are in the Pahrump area,[3] nor are there outcrops of granitic rocks. The potential for tungsten in Pahrump groundwater was considered low. Like Churchill County, Pahrump drinking water is supplied by domestic and public supply wells.

Sampling and Data Collection

We collected data during February 13-21 and March 3-7, 2003. We selected a geographically random sample from each study region. We recruited 30 households from Yerington and Pahrump, and 11 households from Lovelock. The eligibility criteria for household enrollment were residence in the city for at least 1 month before the interview and presence of one adult and one child under 18 years of age who consented to participate in the study. We recruited a total of 141 participants (Table 1). Each consenting study participant submitted a spot urine sample for the analysis of tungsten metabolites and responded to a questionnaire detailing demographics and relevant exposures.

Table 1: Sample Location Sites and Number of Participants for Nevada Tungsten Assessment, 2003

Location	Households Recruited	Participants
Lovelock	11	21
Pahrump	30	60
Yerington	30	60
Totals	**71**	**141**

We collected a tap-water sample, a floor-dust sample, and a yard-soil sample from each household. These samples were analyzed for their tungsten content. The water samples were analyzed by the United States Geological Survey (USGS), National Water Quality Laboratory, Lakewood, Colorado, and the soil and dust samples were analyzed by DataChem Laboratories, an Environmental Protection Agency (EPA)-certified laboratory in Salt Lake City, Utah. The types of samples, their collection procedures, and their analytical parameters were determined on the basis of recommendations by the Agency for Toxic Substances and Disease Registry, the Nevada Division of Environmental Protection, the USGS, and the EPA. To maximize comparability, the sampling protocol used was identical to that used in the Churchill County study.[5] The exact location of each participating household was determined using geographic positioning systems.

RESULTS

Our study participants ranged in age from 2 to 65 years. The average age for children (< 18 years) was 9.4 years and for adults (>18 years), 38.9 years. Of our adult participants, 75% were female; 73% of participating children were male.

We compared levels of urinary tungsten and environmental tungsten between our study populations, the Churchill County study participants, and national reference levels, where applicable. We determined the geometric mean of tungsten levels in urine and water (Table 2).

Table 2: Geometric mean tungsten levels for urine and water samples

Location	Geometric mean tungsten level (95% confidence interval)			
	Urine (µg/L)			Tap Water (µg/L)
	Adults	Children	Total	
Lovelock	0.38 (0.33-0.45)	0.62 (0.50-0.76)	0.48 (0.34-0.68)	0.11 (0.07-0.19)
Pahrump	0.4 (0.38 - 0.53)	0.56 (0.48 – 0.66)	0.51 (0.37-0.69)	0.04 (0.02-0.06)
Yerington	1.04 (0.84-1.30)	1.18 (1.00-1.39)	1.11 (0.97-1.27)	3.32 (1.82-6.04)
Churchill County	0.81 (0.56 - 1.16)	2.31 (1.66 - 3.22)	1.19 (0.89-1.59)	4.66 (2.98-7.30)
National average*	>20 yrs 0.07 (0.07-0.08)	6–11 yrs 0.15 (0.12-0.18) 12-19 yrs 0.10 (0.09-0.12)	0.08 (0.07-0.09)	N/A

* From the *Second National Report on Human Exposure to Environmental Chemicals*[6], based on an NHANES reference population.

Tungsten Levels in Urine

All three of our study locations had geometric mean levels of urinary tungsten at or above the 95th percentile of the level established by the NHANES reference population (0.48 µg/L).[6] Pahrump and Lovelock had statistically identical levels, at 0.51 µg/L and 0.48 µg/L, while Yerington had levels significantly higher than both Lovelock and Pahrump (1.11 µg/L, $p = .0001$). Yerington's overall urinary tungsten levels were similar to those in Churchill County.

Children had consistently higher urinary tungsten levels than adults across all study populations.

Tungsten Levels in Water

Tap water samples were collected in each study household because water is the most likely source of tungsten exposure in these communities. Tungsten levels in water samples collected at study participants' homes differed significantly by city. Pahrump had the lowest average level (0.04 µg/L, range <0.01-1.0 µg/L), followed by Lovelock (0.11 µg/L, range 0.02-0.2 µg/L), and Yerington (3.32 µg/L, range 0.01-40 µg/L). For comparison, the mean for Churchill County was 4.66 µg/L (range <0.25-336.0 µg/L). Each city's water tungsten level differed significantly ($p < 0.0001$) from that of the other cities probably because of hydrogeologic differences between the water sources of each city. The geometric mean for both Lovelock and Pahrump's tungsten levels in water were significantly lower than Churchill County's ($p < 0.0001$), and Yerington's level did not differ significantly from Churchill County's.

Analysis of the relation between urine tungsten and water tungsten levels revealed a mixed picture. In Lovelock and Pahrump, we found no significant relation between the two levels, although we did find a correlation between urine and water tungsten levels in Yerington (Pearson correlation = 0.54; $p < 0.0001$). This finding is difficult to interpret because we did not collect detailed information about individual water consumption patterns.

Soil and Dust Tungsten Levels

Soil and dust samples were collected at each participant's house to further investigate other potential routes of exposure to tungsten. Analysis of the first 60 samples identified only six samples with detectable levels of tungsten. Because of the high limit of detection of this analytic method (50 µg/g) and the low number of samples with detectable levels of tungsten (<10%), no other samples were analyzed.

CONCLUSIONS

The primary objective of the study was to assess the level of exposure to tungsten in three Nevada communities, for the purpose of determining whether Churchill County, Nevada, is unique in the high levels of tungsten among its residents.

Our findings demonstrate that, like Churchill County, tungsten concentrations in urine of residents of all three of the study communities were at or above the 95^{th} percentile of the level established by the NHANES reference population. One city, Yerington, had levels of tungsten in urine and water samples that were statistically similar to Churchill County's samples. These findings are likely the result of Nevada's geology, which is rich in tungsten. The NSHD has not identified any excess leukemia in the three communities we studied.

Exposure to tungsten in Churchill County does not appear to be unique when compared to other communities in Nevada. People living in communities having similar water sources and geologic formations to Churchill County may be expected to have tungsten exposures well above those reported as national reference levels from the NHANES survey.

Tungsten has been nominated to the National Toxicology Program (NTP) for additional toxicologic testing.

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