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# Biomonitoring Studies of Exposure to Selected Metals in New Mexico, 2014-2017

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Biomonitoring allows for direct or more precise assessment of human environmental exposures rather than relying on modeling-based testing of air or drinking water samples,[1-3] as biomonitoring incorporates individual variability in exposure and the fate of a chemical in the body (e.g., absorption, distribution, metabolism and excretion) and represents human exposure from all sources (e.g. water, soil, dust, food, air, etc.). However, biomonitoring data alone do not identify the sources of exposure and thus should be combined with exposure assessment questionnaires and if feasible, testing of relevant sources of exposure, such as drinking water.

As a member of the Four Corners States Biomonitoring Consortium (along with Utah, Colorado and Arizona), the New Mexico Department of Health (NMDOH) Epidemiology and Response Division's (ERD) Environmental Health Epidemiology Bureau (EHEB) has been conducting biomonitoring since 2014. The purpose of this study, which ends in 2019, is to better understand how individuals are exposed to six metals through private well drinking water and/or other sources: arsenic (As), cadmium (Cd), manganese (Mn), mercury (Hg), selenium (Se), and uranium (U). Exposure to metals from private well drinking water was the focus because: 1) drinking water is likely the major source of human exposure to metals, 2) these metals are known to be prevalent in NM ground water, and 3) drinking water quality from private wells is not regulated in NM.[4-5] Previous testing has indicated that groundwater in the four corners states can have high concentrations of all or some of the six metals selected for testing.

These six metals are of concern because of the potential adverse health effects associated with long-term, excessive exposure. These concerns, depending on the metal, can include: cancer, neuropathy, cardiovascular disease, and kidney damage. Appropriate interventions can help to reduce these exposures.

**Methods**

Since 2014, NMDOH's Scientific Laboratory Division (SLD) and ERD-EHEB have conducted biomonitoring in three communities in San Juan, San Miguel, and Sandoval counties. The eligibility requirements to participate were that residents must: 1) use a private well for the majority of their drinking water; 2) provide a sample of this drinking water for analysis; 3) be willing to complete an exposure assessment questionnaire; and 4) provide a urine sample for analysis.

An individual was determined to have an excessive exposure if she had a urinary metal concentration greater than the National Health and Nutrition Examination Survey (NHANES) 95$^{th}$ percentile value[6] (or 95$^{th}$ percentile of their respective community's population for urinary Se for which there are no NHANES values available). For water, results were compared to Maximum Contaminant Levels (MCLs), which are standards set by the United States Environmental Protection Agency (EPA) for drinking water quality or the Health Advisory Level (HAL) for Mn, because no health-based drinking water standard/MCL has been set.[7]

All data were analyzed using SAS software, Version 9.4. Urine metal concentrations were creatinine corrected (µg/g creatinine) before statistical analysis. The 50$^{th}$ and 95$^{th}$ percentile values were calculated and compared to their respective 2013-2014 NHANES aggregate data for adults over the age of 20.[6] For urine metal concentration values that were below the lower detection limit (LDL), the concentration was calculated as LDL/√2. For water, the proportion detected, the range, and the mean were calculated. Water metal concentration values that were below the laboratory Minimum Reporting Limit (MRL) were calculated as MRL/2.

**Results**

Two hundred and thirty individuals from 140 households have participated in the study to date. All 230 participants answered exposure assessment questions and provided a urine sample, and at least one water sample was collected from each household (172 total water samples).

As, Mn, Se, and U were commonly detected in the water samples. Nearly half (47%) of the water samples contained As, while a large majority (85%) of the water samples contained at least some U. When compared to the MCLs and HAL (for Mn), there were 7 private wells (4%) with a water Mn concentration higher than the HAL (0.300 mg/L), 25 wells (15%) with a water As level exceeding the MCL for As (0.010 mg/L), and 1 well with a U water level exceeding the MCL for U (0.03 mg/L).

Most participants had metals detected in their urine (Table 1), with Se being the most commonly detected (98%) and Mn and U the least frequently detected (53% and 51%, respectively). The 50$^{th}$ percentile values for Cd, Mn, and U in NM urine samples were above the NHANES 50$^{th}$ percentile value (i.e., the average exposure of the general U.S. population). While the average exposure to As for the entire study population was below that of the U.S. general population, 42% of the study population had a urinary As concentration above the NHANES 50$^{th}$ percentile value. In the study population, the 95$^{th}$ percentile for urinary As was above the NHANES 95$^{th}$ percentile value (i.e., representing an excessive exposure level) and 6% of the study population had a urinary As result above the NHANES 95$^{th}$ percentile threshold.

The 50$^{th}$ and 95$^{th}$ percentile values for urinary U concentrations in this study population were above the NHANES 50$^{th}$ and 95$^{th}$ percentile values, with 51% of the study population above the NHANES 50$^{th}$ percentile and 20% above the NHANES 95$^{th}$ percentile value.

**Potential exposure sources for metals**

*Household Drinking Water*. As, Mn, and U were the only metals measured in private well drinking water at concentrations higher than their respective MCLs or HAL for Mn. Specifically, 31% (25 samples) of the water samples with As detected had concentrations greater than the MCL; 10% (7 samples) of the water samples with Mn detected had concentrations greater than the HAL; and <1 % (1 sample) of the water samples with U detected had concentration greater than the MCL.

*Sources Other than Household Drinking Water*. The majority (80 (60%)) of participants with an exposure to Cd above the NHANES 95$^{th}$ percentile reported smoking or using tobacco, 88 (66%) participants reported taking dietary supplements, and 41 (31%) reported drinking herbal teas. However, all ten (100%) participants with a Cd level above the NHANES 95$^{th}$ percentile reported smoking or using tobacco products and 60% of them reported taking dietary supplements. A large percentage (69%) of participants (159/230), reported using dietary supplements, in general.

**Discussion**

In NM, private drinking water wells are not regulated. About 20% of the population in NM (or an estimated 400,000 people) rely on private wells for drinking water.[5] We aimed to educate private well owners about their water quality and potential exposures, whether due to water or other sources. This study indicates that the three communities may experience exposures to certain metals that are higher than the representative U.S. population's exposure to these metals. The urinary 95$^{th}$ percentile for the study population was greater than the NHANES 95$^{th}$ percentile for As, Mn, and U.

Our recommendations for excessive exposure reduction focus on participants that had urinary metal levels above the NHANES 95$^{th}$ percentile because they are at the highest risk for potential adverse health effects. For this study population, 20% of participants had a urinary U level above the NHANES 95$^{th}$ percentile. Exposure to high levels of U for more than 2-5 years may affect the way kidneys work. However, changes in kidney function seem to go away when people stop drinking water with elevated U (if that is the primary exposure source). Therefore, for participants whose primary U exposure is in the water, we recommend that the water be treated to reduce excessive exposure.

For Mn, 13% of the study population had a urinary level above the NHANES 95th percentile. A Mn urinary level above the NHANES 95th percentile may be of less concern because a low level of Mn in the body is necessary for human health. Mn is required for the formation of healthy cartilage and bone, for example[6b]. However, high Mn exposure can potentially cause neurotoxicity (including muscle weakness, tremors, and muscle pain) so it is important to detect high Mn exposures early. Mn was detected in 39% of private wells in these communities; while drinking water is not generally considered a primary source of Mn exposure, any intervention to reduce Mn exposure would need to consider other exposure pathways in addition to drinking water[6b]. A multifaceted approach such as considering dietary supplements may empower participants to reduce excessive exposure to Mn and potentially avoid related health effects.

For As, 6% of the study population had a urinary level above the NHANES 95th percentile. This might be of concern for long-term effects of As exposure. Ingesting high levels of inorganic As for extended periods of time has been shown to increase the risk of cancer in the liver, bladder, and lungs[7]. Therefore, it is highly recommended if a participant has a urinary level above the NHANES 95th percentile that action be taken to remove the primary source of exposure. Since As was detected in 47% of private wells in these three counties, drinking water may be a main source of As exposure, which can be addressed with the installation of an appropriate water treatment system.

**Recommendations**

The NHANES includes biomonitoring data for a variety of environmental exposures within a representative sample of the U.S. population. However, its data do not necessarily reflect local and regional environmental exposures[8]. Developing and maintaining biomonitoring capacity and conducting studies aimed at investigating the magnitude of regional environmental exposures, including exposure to metals, are vital to understanding local environmental exposures. Interventions to reduce excessive exposures, and thus potentially prevent health impacts, need to be tailored to individuals.

In the three communities studied, 15% of private well water samples were above the As MCL and less than 1% (one sample) were above the U MCL. This supports the continued recommendation that private well owners in the three counties, and throughout NM, get their well tested at least once for As and U and periodically for other chemicals[4]. A water treatment professional should be consulted about the installation of a filter to remove any heavy metal water concentrations above the MCL. For more information about private well testing and treatment, visit https://nmtracking.org/environment/water/PrivateWells.html

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## Table 1. Water and urine analysis results for metals in select communities in San Juan, San Miguel and Sandoval counties, 2014-2017

| | Water | | Urine | | | Water and Urine | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Proportion detected in water (Number) | Proportion above MCL (Number) | Proportion detected in urine (Number) | Proportion above NHANES 50th percentile (Number) | Proportion above NHANES 95th percentile (Number) | Proportion detected in both water and urine (Number) | Proportion detected in water and above NHANES 50th percentile (Number) | Proportion detected in water and above NHANES 95th percentile (Number) | Proportion above MCL and above NHANES 50th percentile (Number) | Proportion above MCL and above NHANES 95th percentile (Number) |
| As | 47% (80) | 15% (25) | 76% (175) | 42% (97) | 6% (13) | 22% (50) | 18% (42) | 1% (3) | 8% (19) | 2% (4) |
| Cd | 0% (0) | 0% (0) | 86% (197) | 58% (133) | 4% (10) | 0 | 0 | 0 | 0 | 0 |
| Mn | 39% (67) | 4% (7) | 53% (122) | 35% (79) | 13% (29) | 19% (43) | 13% (29) | 4% (8) | 2% (4) | 1% (3) |
| Hg | 0% (0) | 0% (0) | 87% (201) | 15% (35) | 3% (7) | 0 | 0 | 0 | 0 | 0 |
| Se | 2% (3) | 0% (0) | 98% (226) | 50% (116) | 5% (12) | 0 | 0 | 0 | 0 | 0 |
| U | 85% (147) | < 1% (1) | 51% (118) | 51% (118) | 20% (42) | 73% (169) | 46% (105) | 17% (39) | <1% (1) | <1% (1) |