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Urinary heavy metals in Hispanics 40–85 years old in Doña Ana County, New Mexico

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Abstract

As, Cd, Pb, and U exposure among older Hispanic adults residing in underserved communities in southern New Mexico was investigated. Personal information was obtained by standardized interview from 188 adults age 40–85y. Urinary metal concentrations were measured and compared to results from the National Health and Nutritional Examination Survey (NHANES). Urinary As and U in study participants significantly ($P < 0.05$) exceeded NHANES reference values. Elevated urinary As concentration was significantly associated with older age, Latin American birthplace, clinic site, private well drinking water, higher self-rated health, and diabetes. Higher urinary Cd was significantly associated with older age, clinic site, female sex, agricultural work, and current cigarette smoking. No personal characteristics were significantly associated with urinary Pb or U. Our results suggest elevated levels of As and U in this population.

Keywords

heavy metals; arsenic; cadmium; lead; uranium; Hispanic; Mexican-American; US-Mexico border region

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1. Introduction

Arsenic (As), cadmium (Cd), lead (Pb), and uranium (U) have been associated with adverse human health outcomes including kidney disease, diabetes, heart disease, neurological and developmental disability, and cancer^{1–8}. These metals are each dispersed into the environment through several routes.¹ Cd and As are found in foods including vegetables, grains, as well as tobacco, as a result of contaminated agricultural soils^{1, 9}. In addition to industrial emissions, elevated Pb in soils and indoor dust typically results from residual paint, and past combustion of leaded gasoline^{6, 10}. In regions where As and U are present naturally in groundwater, the use of groundwater for drinking may represent a significant exposure route for the local population^{8, 11–14}; Pb may contaminate drinking water through plumbing, but, in contrast, drinking water is rarely a source of Cd exposure.^{1, 15, 16}

Because of its unique geology and the history of the local metals production industry, southern New Mexico including Doña Ana County has potentially higher levels of both naturally occurring and anthropogenic metals. Releases of As, Pb, and Cd from smelters operating in the region for nearly a century have been documented¹⁷ and were the focus of epidemiological studies of childhood blood Pb levels.¹⁸ Despite continuing research and soil remediation, As, Cd, and Pb may remain prevalent in area soil.^{17, 19–22} Residents could be exposed through inhaled and ingested dust, particularly given the strong winds prevalent in the area and the lack of ground cover. In addition, New Mexico groundwater has higher levels of naturally occurring As^{13, 23} and U^{24, 25}.

We conducted a study to evaluate levels of As, Cd, Pb, and U in an underserved Hispanic adult population of Doña Ana County. This population is possibly exposed to higher levels of metals than other communities because of proximity to contaminated areas, historically less-developed infrastructure including water supplies, and frequent employment as agriculture workers, which has been linked to higher exposure to some metals.²⁶ Because our long-term interest was in the association of metal exposure with chronic diseases in this population, we focused on older adults (40–85 years of age).

2. Materials and Methods

2.1. Participant recruitment

Women and men age 40–85 were recruited by *promotoras* (community health workers) employed by the *La Clínica de Familia* primary care clinic network in southern New Mexico. *La Clínica de Familia* is a non-profit organization serving approximately 6,500 low income and rural residents of Doña Ana County, New Mexico. The population served by *La Clínica de Familia* is predominantly Hispanic, low income, and many reside in unincorporated areas (*colonias*). Participants were recruited in two time periods, June – August 2011 and January – April 2012. *Promotoras* were based at one of four different clinics in the region; to preserve confidentiality, clinics are referred to by letters A – D. Clinic clients were approached by *promotoras* at the *La Clínica* clinics.

2.2. Data and sample acquisition

A brief *promotora*-administered questionnaire gathered information about demographics, height and weight, smoking history, usual diet and supplement use, current health status, and current prescription medication use. The questionnaire was administered in either Spanish or English based on participant preference. Questionnaire data was double-entered into the Research Electronic Data Capture online database²⁷.

Following completion of the questionnaire, a spot urine sample was provided by participants in individually wrapped sterile polyethylene collection cups with unlined lids. Prior to launching participant recruitment, we analyzed samples of deionized water or 0.5N nitric acid left overnight in urine collection cups and cryovials (N=46 total); background levels were 0.002 µg/L for As, 0.002 µg/L for Cd, 0.08 µg/L for Pb, and 0.001 µg/L for U. Urine samples were refrigerated following collection at each clinic, and collected weekly from each clinic and transported in a cooler to [the laboratory (institution redacted for blinded review)]; transit time was less than one hour and temperature was maintained at 3–6 C. Samples were then aliquoted and frozen at –70 C until shipment to the analytic laboratory. Field blanks of deionized water were transported to each clinic to mimic the collection, aliquoting, storage and shipment to the trace metal analysis lab, to assess potential sample contamination.

2.3. Urine metals measurement

We selected As, Cd, Pb, and U as our primary metals of interest prior to beginning participant recruitment and sample analyses. Frozen (–70C) urine samples were shipped on dry ice to the Trace Element Research Laboratory at the Wisconsin State Laboratory of Hygiene (Madison, WI) for assay of As, Cd, Pb, and U using magnetic-sector (high-resolution) inductively-coupled plasma mass spectrometry (SF-ICP-MS). A Finnigan, Element 2, magnetic sector ICP-MS, interfaced with a high efficiency, low-flow nebulizer/autosampler was employed. The complete analytical system was located within a CLASS 100 trace metal clean room. This approach enabled accurate and precise quantification of low levels of elements in complex urine matrices. The formation of molybdenum oxide (MoO) was monitored throughout the analytical sequence, and where appropriate, a run position empirical correction was applied to the Cd data. Urine samples were diluted 1+5:6 and 1+9 with 2% (v/v) high purity 16M nitric acid (containing three internal standards) for analysis. A minimum of three replicate 180-second analyses were performed on each sample after a 60-second uptake and stabilization period. The long rinse with 2% high purity nitric acid + 0.01% Triton between samples virtually eliminated carry-over. The typical SF-ICP-MS batch included 20 participant samples, 2 sample matrix spikes, 2 blank spikes, 3 certified reference materials (CSRMs, including NIST 2670a, UTAK, and Seronorm), 3 matrix blanks, 2 method blanks, 2 sample duplicates, and a set of check blanks and calibration verification checks run at frequent intervals during the batch sequence. Final limits of detection and quantification (LOQ) were 15 ng/L and 75 ng/L for As, 0.5 ng/L and 3.5 ng/L for Cd, 1.5 ng/L and 10 ng/L for Pb, and 0.15 ng/L and 1 ng/L for U. For concentrations below the LOQ (N=1 for Cd and N=1 for U), we imputed a value of LOQ/ 2.

2.4. Urine creatinine

Urine creatinine was measured at the [name removed for blinded review] Biomarker Laboratory with a Roche Cobas Mira Plus Chemistry Analyzer using creatinine reagent set (cat no C7539, Pointe Scientific, Inc., Canton, MI), following manufacturer's instructions. The Chemistry Analyzer was calibrated with the Pointe Scientific creatinine standard (cat no C7513-STD). Samples were run in duplicate; median duplicate coefficient of variation (CV) was 1.7%. Each batch of 20 participant samples were bracketed by both a low and a high quality control (QC) sample (Pointe Scientific Human urine control set, cat no P7582-CTL). The low and high QCs had inter-batch CVs of 2.7% and 2.2%, respectively.

2.5. National Health and Nutrition Examination Survey (NHANES) Data

NHANES is an ongoing cross-sectional survey conducted by the Centers for Disease Control and Prevention (CDC) and the National Center for Health Statistics (NCHS)²⁸. Households are selected using a complex survey design to generate a representative sample of the non-institutionalized, civilian population in the United States. Survey components include in-person and computer-assisted interviews, medical examinations, and laboratory analyses of blood and urine samples. Documents detailing the structure and methodology of NHANES are available on the CDC NHANES webpages; de-identified NHANES data are publicly available from CDC along with analytical guidelines.^{28, 29}

Data for the 2003/4, 2005/6, 2007/8 and 2009/10 NHANES cycles were combined following CDC/NCHS analytic guidelines for survey weights^{28, 30}. We combined multiple NHANES cycles in order to increase sample size and thus the precision of estimates. Urine was collected on a sub-sample of participants for previously described analysis of creatinine, heavy metals, and total As²⁸. Limits of detection for NHANES urinary concentrations were 0.74 µg/L for As, 0.042 µg/L for Cd, 0.33 µg/L (2003–2004) and 0.1 µg/L (2005–2010), and 0.005 µg/L (2003–2004), 0.002 µg/L (2005–2008), and 0.0017 µg/L (2009–2010) for U.³¹ The percentages of NHANES urinary measurements below LOD for As, Cd, Pb, and U were 0.8%, 3%, 5%, and 15.8% for all NHANES; and 1.2%, 2.9%, 4.7%, and 5.8% for NHANES Mexican-Americans.

2.6. Statistical analysis

Of 199 participants interviewed, four were younger than age 40 and excluded from these analyses. Five participants did not provide urine samples. Two participants missing information on weight were excluded from analysis. Hence, N=188 participants were included in analyses.

Urinary concentrations of As, Cd, Pb, and U in study participants were compared to all NHANES participants, and to the NHANES subpopulation Mexican-Americans. Note that “Mexican-Americans” is a subpopulation identified by NHANES, distinct from all Hispanics and other Hispanic subpopulations, for which NHANES is designed to allow valid subpopulation inferences.²⁸ First, unadjusted mean urinary metal concentrations were estimated. Next, linear regression models were applied to each dataset (our New Mexico data, all of NHANES, and NHANES Mexican-Americans) to estimate associations of personal characteristics with log-transformed urinary metal concentrations. The linear

regression models included independent variables urinary creatinine (log-transformed), participant age (linear continuous), sex, and BMI (linear continuous). Using the regression estimates, predicted geometric mean urinary metals were calculated at representative or mean values of independent variables, resulting in “adjusted means”, separately for men and women, in each dataset.^{32, 33} Statistical analyses of NHANES data were conducted using the survey procedures in Stata 12 and 13 statistical computing software (College Station, TX) to take into account the complex sampling design of NHANES.^{28, 29} Unadjusted and adjusted geometric mean urinary metal concentrations in our New Mexico study participants were compared with all NHANES and the Mexican-American NHANES subpopulation with two-tailed t-tests of the null hypothesis that the means were equal ($\alpha=0.05$). We used Welch’s test which did not assume equal variance between populations. In sensitivity analyses, we repeated this procedure using only the NHANES 2009/10 cycle; fewer participants resulted in wider confidence intervals (hence, fewer significant differences) but similar geometric means.

Next, among New Mexico study participants, multivariable linear regression was applied to estimate associations of independent variables derived from questionnaire responses and log-transformed urinary creatinine with the dependent variables log-transformed urinary metals. Each metal was modeled separately with the same set of independent variables: interview/clinic site, year of interview, and participant age, body mass index (BMI, calculated as weight divided by the square of height), sex, urinary creatinine (log-transformed), fish consumption (servings/week), birthplace, education, current occupation, daily vitamin or supplement use, cigarette use, source of drinking water in the home, self-rated health, and self-reported physician diagnoses of diabetes. In a separate analysis restricted to women we added menopausal status and parity as independent variables. Hispanic ethnicity and race were not considered for analysis because few participants self-identified as non-Hispanic or non-white. Variables were categorized as displayed in Table 1, except for age, BMI, urinary creatinine, and fish consumption, which were entered in the model as linear continuous independent variables. Fish consumption was included because of recommended procedures regarding analyses of urinary As.³⁴ Participants missing information on categorical independent variables were included in a separate category of the variable (N=5 total). Results of a sensitivity analysis restricted to participants with complete information on all independent variables were not meaningfully different from the primary analysis.

The ratio of geometric means with 95% confidence intervals (CIs) was calculated by exponentiation of coefficients and 95% CI endpoints from linear regression models with log-transformed dependent variables. Results are presented as geometric mean ratio. Note that, equivalently, percentage change in urinary metal concentration associated with each one unit change in an independent variable is equal to 100% (geometric mean ratio – 1). $P<0.05$ was interpreted as statistically significant.^{28,32,33}

2.8. Ethical conduct of research

This study was reviewed and approved by Institutional Review Boards at [REDACTED]. All participants provided written informed consent. To protect participant confidentiality all

results are presented after removing geographic identifiers smaller than the county and no results are presented for groups of fewer than 5 participants.

3. Results

The majority of participants were female, and self-identified as white and Hispanic, and most responded to the Spanish language interview (Table 1). Nearly all participants (98%) were born in either the US or Mexico. Participant recruitment was nearly balanced by calendar year; however, three of four clinic sites contributed 85% of participants.

Arithmetic mean (SD) and median (intra-quartile range) urinary metals in all participants showed substantial variation overall (Table 1) and according to participant personal characteristics.

Geometric mean urinary As, unadjusted or adjusted for age, sex, BMI, and creatinine, were significantly higher in men and women in the Doña Ana County sample than in either of the NHANES populations evaluated ($P<0.01$ for each comparison; Table 2). Urinary U was higher in men compared to NHANES Mexican-Americans ($P<0.01$) and the general NHANES population ($P<0.001$); in women, urinary U exceeded the general NHANES population ($P<0.001$) but not NHANES Mexican-Americans. In contrast, urinary Cd and Pb concentrations in study participants were comparable to or lower than those of Mexican-Americans of similar age who participated in NHANES (Table 2), although every comparison did not reach statistical significance.

In multivariable linear regression models, all urinary metals were strongly and positively associated with urinary creatinine ($P<0.01$ for each metal). Each 1% increase in urinary creatinine was associated with 0.6% to 1.1% higher metal concentration (not shown). Older age, Latin American birthplace, home drinking water supplied by a private well, very good/excellent self-rated health, recruitment at clinic "C", and prevalent diabetes were all associated with elevated urinary As concentration (Table 3). Urinary As was elevated among participants with more than 8 years of education compared to those with fewer ($P=0.02$). Servings of seafood were not significantly associated with urinary As.

Urinary Cd concentration was independently and significantly associated with clinic site, age, sex, current occupation, and cigarette use (Table 3). In contrast to urinary Cd and As, no participant characteristics from questionnaires were strongly associated with urinary Pb or U.

4. Discussion

Comparison of urinary concentrations of As, Cd, Pb, and U from our population sample to reference values from NHANES suggested that As and U exposure may be somewhat higher among Hispanic adults in southern New Mexico adults than in the broader US and US Mexican-American populations, while Cd exposure may be lower. Urinary metal concentrations reported from NHANES are reference values, and may not be "optimum" values for health; conversely exceeding NHANES values may not imply additional health burden associated with metals. Nonetheless differences in urinary metal concentrations

between populations likely reflect differences in the prevalence of risk factors for metal exposure. That urinary As and U were elevated in the study participants compared to both NHANES Mexican-Americans and the larger NHANES population suggests that the differences were not a result of Hispanic identity, but were more specific to the Doña Ana County participants.

We sought to examine correlates of urinary concentrations of each metal in our study sample, and found different patterns for each metal. For example, in agreement with previous reports, we observed higher levels of urinary Cd associated with female gender, increasing age, and smoking.^{35–37} Higher urinary cadmium in women compared to men has been reported from numerous previous studies and is hypothesized to result from lower lifetime average iron stores, which potentiates cadmium uptake from food.^{35, 36, 38, 39} Urinary Cd reflects long-term cumulative body burden of Cd, and thus is higher in older persons.³⁵ The lower prevalence of smoking in our study participants compared to similarly aged adults represented in NHANES (~20% current smokers) likely explains the lower urinary Cd we observed.^{40, 41} Drinking water is typically not a source of Cd,^{15, 16} as our results suggest.^{40, 41}

We observed that private well drinking water was associated with elevated As, consistent with previous reports on water quality from southern New Mexico.^{13, 23–25}

No participant characteristics captured in our interview instrument were associated with urinary Pb or U. The possible reasons for the higher urinary Pb in women in this study compared to Mexican-Americans are therefore unclear. We were surprised that drinking water source was not significantly associated with urinary U given the documented higher U in some local drinking water.^{24, 25}

We identified a few unexpected correlates of exposure to metals that may deserve further investigation. A single clinic recruitment site was associated with elevated urinary Cd, but not other metals. The proximity of this site to an area of historic heavy metals contamination from a nearby smelter, which released As, Cd, and Pb pollution, is of interest and supports our findings.¹⁷ Although As and Pb were not elevated in the same participant samples, urinary Cd can reflect exposure decades earlier,^{9, 42} while urinary As, Pb, and U predominantly reflect much more recent exposure.^{11, 43–45} Blood, not urine, is generally preferred for Pb exposure assessment, although urinary Pb concentration is correlated with blood Pb and therefore also reflects recent exposure.^{44, 45} Perhaps consistent with the geographic differences in urinary Cd, urinary As concentration was lower in clinic C participants; clinic C is in a more rural location. While we must avoid reading too much into our single study, these results may be worthy of follow-up.

Current employment as an agricultural worker was associated with higher mean urinary Cd, but not other metals. Previous studies found agricultural workers had lower mean urinary Cd levels than the US population,⁴⁶ while Mexican agricultural workers in North Carolina were reported to have urinary Cd concentrations comparable to the US general population.²⁶ Differences between studies may reflect differences in agricultural practices between regions.

Having been born in Mexico, which included the majority of participants born outside of the US, was associated with higher As concentrations. Urinary As reflects recent exposure and thus differences between immigrants and US-born participants more likely result from different dietary or other habits, rather than different earlier exposures, and may be of interest for future study.

We noted that higher urinary As was associated with prevalent diabetes, consistent with published reports.^{47,34} Urinary As was not associated with reported seafood consumption; this may be due to error in assessment of this specific component of diet with our questionnaire. However we noted that when diabetes was not included in our multivariable model, fish consumption was associated with urinary As, and that diabetics reported slightly higher fish consumption (data not shown). Thus it may be that the relation between urinary As and diabetes indicates differences in dietary patterns among diabetics. Better self-rated health was also associated with elevated urinary As, which may indicate dietary habits or other health-related behaviors that are perceived by participants as healthful, but are associated with higher urinary As (e.g., eating more vegetables that may contain As). Assessment of the impact of higher As on health in this population, if any, will require further study.

Limitations to our study include its cross-sectional design. With the exceptions of diabetes and general health, however, variables we examined are not likely to have been influenced by urinary metal concentrations. It remains possible that unidentified and unmeasured correlates may explain the relationships we observed. Our sample was a “convenience” sample of modest size, recruited through primary care clinics, and may not accurately represent the larger population. Because we measured Pb in urine rather than blood, the preferred biological compartment for Pb exposure assessment, comparison with previously published studies may be hindered, although we did compare our measurements to NHANES values. For As, Cd, and U, urine is a generally accepted matrix for measurement.^{42, 48, 49} Finally, we were unable to conduct analysis of As speciation, a more in-depth analysis that might be warranted as a next step given the higher urinary As concentrations observed.^{50, 51}

In summary, we measured heavy metal and As concentrations in urine samples from a population of middle-age and older adult Hispanics in southern New Mexico near the US-Mexico border. This population may be at higher risk for exposure to these harmful pollutants, but documentation of levels of metals in biological samples from this group is rare. Our results suggest elevated exposure to As and U in this population, possibly due to drinking water^{13, 23–25} as well as possible geographic differences in exposure to Cd and As. Further studies are needed to better detail the sources of exposure in this region, and to investigate potential associations with chronic disease in older adults.

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Selected characteristics and arithmetic mean urinary As, Cd, Pb, and U of Doña Ana County, New Mexico study participants (2011–2012) included in statistical analyses.

Table 1

	N=188		Arsenic (µg/L)		Cadmium (µg/L)		Lead		Uranium	
Mean (SD)			18.7 (22.9)		0.45 (0.52)		0.83 (1.04)		0.053 (0.260)	
Median (IQR)			14.02 (8.2, 20.3)		0.30 (0.12, 0.60)		0.60 (0.32, 0.99)		0.0131 (0.006, 0.029)	
N	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Interview site/clinic										
A	58	31	18.5	19.2	0.32	0.25	0.74	0.78	0.25	1.55
B	48	26	18.7	31.3	0.36	0.34	0.67	0.38	0.02	0.02
C	27	14	9.7	4.8	0.25	0.16	0.71	0.73	0.03	0.03
D	55	29	24.2	26.3	0.50	0.35	0.93	0.88	0.06	0.30
Interview year										
2011	92	49	17.1	24.2	0.33	0.26	0.70	0.66	0.06	0.28
2012	96	51	20.8	24.1	0.42	0.34	0.85	0.78	0.14	1.20
Questionnaire language										
English	30	16	13.4	8.6	0.26	0.18	0.68	0.67	0.02	0.02
Spanish	158	84	20.0	25.9	0.40	0.32	0.79	0.74	0.12	0.96
Sex										
Male	28	15	18.3	23.3	0.31	0.31	0.61	0.34	0.08	0.29
Female	160	85	19.1	24.3	0.39	0.31	0.80	0.77	0.11	0.94
Age(y)										
40–49	78	42	17.4	26.5	0.31	0.27	0.72	0.77	0.19	1.34
50–59	64	34	20.0	20.3	0.41	0.29	0.93	0.82	0.02	0.02
60–69	34	18	22.0	28.9	0.41	0.34	0.71	0.48	0.03	0.03
70–85	12	6	14.8	7.8	0.56	0.45	0.54	0.28	0.21	0.64
Body mass index (kg/m ²)										
<25	25	13	14.8	6.6	0.42	0.44	0.76	0.57	0.11	0.44
25–29.9	81	43	16.0	10.8	0.37	0.27	0.71	0.51	0.02	0.01
30	82	44	23.2	34.4	0.37	0.30	0.85	0.92	0.19	1.30
Race ^a										

	N=188		Arsenic (µg/L)		Cadmium (µg/L)		Lead		Uranium	
Mean (SD)			Mean	SD	Mean	SD	Mean	SD	Mean	SD
Median (IQR)			18.7 (22.9)	14.02 (8.2, 20.3)	0.45 (0.52)	0.30 (0.12, 0.60)	0.83 (1.04)	0.60 (0.32, 0.99)	0.053 (0.260)	0.0131 (0.006, 0.029)
white	N	%								
	169	90	20.1	25.2	0.39	0.32	0.78	0.71	0.11	0.92
other	18	10	8.6	3.8	0.27	0.17	0.78	0.86	0.03	0.03
Hispanic ^a										
yes	179	95	19.3	24.7	0.38	0.31	0.79	0.74	0.11	0.90
no	3	2	13.6	9.5	0.38	0.34	0.44	0.13	0.01	0.00
Birthplace										
USA	27	14	11.8	7.1	0.37	0.27	0.57	0.49	0.02	0.03
Latin America	161	86	20.2	25.7	0.38	0.32	0.81	0.75	0.12	0.95
Employment ^a										
Agriculture	26	14	19.3	23.4	0.34	0.20	0.82	0.68	0.08	0.30
Industry/construction	8	4	46.2	75.2	0.26	0.20	0.58	0.33	0.01	0.01
Office/service	48	26	16.1	13.0	0.36	0.33	0.85	0.98	0.26	1.69
Unemployed/home	99	53	18.5	20.4	0.41	0.33	0.77	0.63	0.05	0.22
Residential water source										
Private well water	7	4	18.7	6.2	0.27	0.12	0.44	0.63	0.02	0.02
Municipal water	103	55	20.6	28.8	0.39	0.32	0.84	0.63	0.14	1.16
Bottled water	78	42	16.8	17.3	0.36	0.30	0.57	0.58	0.06	0.30
Cigarette smoking ^a										
Never	128	68	19.2	26.0	0.34	0.25	0.69	0.62	0.02	0.03
Former	42	22	17.5	17.4	0.38	0.37	0.92	0.57	0.39	1.84
Current	17	9	21.7	25.8	0.61	0.42	0.46	0.64	0.02	0.01
Seafood consumption (servings/wk)										
none	43	23	15.8	17.9	0.40	0.33	0.67	0.57	0.02	0.03
up to 2	41	22	17.9	13.7	0.34	0.22	0.86	0.64	0.31	1.83
2	104	56	20.7	29.1	0.38	0.33	0.69	0.61	0.06	0.26
Multivitamins & supplements use ^a										
less than once per week	72	38	16.5	16.6	0.34	0.30	0.43	0.59	0.05	0.26
at least once per week	114	61	20.6	28.0	0.39	0.32	0.82	0.61	0.14	1.11

	N=188		Arsenic (µg/L)		Cadmium (µg/L)		Lead		Uranium	
Mean (SD)			18.7 (22.9)		0.45 (0.52)		0.83 (1.04)		0.053 (0.260)	
Median (IQR)			14.02 (8.2, 20.3)		0.30 (0.12, 0.60)		0.60 (0.32, 0.99)		0.0131 (0.006, 0.029)	
	N	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Education ^a										
<8y	101	54	17.0	15.2	0.36	0.31	0.77	0.64	0.16	1.19
8–12y	61	33	23.9	36.7	0.42	0.34	0.75	0.62	0.05	0.20
12y	25	13	15.3	10.6	0.32	0.24	0.40	0.50	0.02	0.02
Health status ^a										
Poor/fair	61	33	16.9	15.5	0.43	0.36	0.68	0.62	0.06	0.28
Good	99	53	20.7	29.7	0.35	0.27	0.82	0.61	0.15	1.19
Very good/excellent	27	14	17.7	16.9	0.35	0.30	0.38	0.61	0.02	0.03
Diabetes										
no	120	64	15.1	14.0	0.35	0.27	0.81	0.62	0.13	1.08
yes	68	36	25.8	34.7	0.41	0.37	0.53	0.58	0.06	0.27
Parity ^b										
Nulliparous	8	5	16.3	14.5	0.27	0.19	1.20	0.51	0.02	0.02
1–3	95	59	18.2	25.2	0.33	0.26	0.62	0.58	0.14	1.20
3	57	36	20.9	24.1	0.50	0.36	0.90	0.72	0.07	0.29
Menopause ^b										
pre	50	31	19.6	31.8	0.38	0.33	0.85	0.56	0.25	1.66
post	110	69	18.9	20.3	0.39	0.30	0.74	0.65	0.04	0.21

^aNumbers do not sum to total due to missing information for some participants.

^bAmong women (N=160).

Comparison of geometric mean (GM) urinary arsenic, cadmium, lead, and uranium in a sample of southern New Mexico adults (2011–2012) and a comparable subpopulation in the National Health and Nutrition Examination Survey (NHANES 2003–2010).

Table 2

Doña Ana County, NM sample N=188				Mexican-Americans (NHANES 2003–2010) ^a N=723 ^c				All US (NHANES 2003–2010) N=4,293 ^c			
GM (µg/L)	(95% CI)	adjusted GM (µg/L) ^b	(95% CI)	GM (µg/L)	(95% CI)	adjusted GM (µg/L) ^b	(95% CI)	GM (µg/L)	(95% CI)	adjusted GM (µg/L) ^b	(95% CI)
Arsenic (µg/L)											
Men	20.3 (15.3, 26.9)	14.2	(10.7, 17.7)	11.0 ^{***}	(9.3, 12.9)	9.3 ^{**}	(8.0, 10.6)	10.5 ^{***}	(9.6, 11.4)	9.3 ^{**}	(8.6, 10.0)
Women	12.2 (10.7, 13.8)	13.2	(11.80, 14.49)	7.5 ^{***}	(6.5, 8.6)	9.7 ^{***}	(8.4, 11.1)	7.8 ^{***}	(7.1, 8.5)	10.2 ^{***}	(9.3, 11.2)
Cadmium (µg/L)											
Men	0.34 (0.21, 0.53)	0.18	(0.12, 0.25)	0.31	(0.28, 0.35)	0.25	(0.23, 0.27)	0.31	(0.30, 0.33)	0.26	(0.24, 0.27)
Women	0.24 (0.21, 0.29)	0.27	(0.23, 0.31)	0.30 [*]	(0.28, 0.33)	0.37 ^{***}	(0.33, 0.40)	0.28	(0.27, 0.30)	0.34 ^{**}	(0.33, 0.36)
Lead (µg/L)											
Men	0.87 (0.68, 1.11)	0.61	(0.47, 0.76)	0.95	(0.84, 1.08)	0.80	(0.72, 0.89)	0.74	(0.70, 0.77)	0.63	(0.60, 0.66)
Women	0.53 (0.47, 0.61)	0.60	(0.54, 0.65)	0.61	(0.57, 0.66)	0.75 ^{***}	(0.69, 0.82)	0.49	(0.47, 0.51)	0.59	(0.57, 0.62)
Uranium (µg/L)											
Men	0.026 (0.015, 0.046)	0.018	(0.011, 0.026)	0.010 ^{**}	(0.009, 0.012)	0.009 ^{**}	(0.008, 0.010)	0.006 ^{***}	(0.006, 0.007)	0.006 ^{***}	(0.005, 0.006)
Women	0.013 (0.011, 0.016)	0.014	(0.012, 0.016)	0.010 [*]	(0.009, 0.012)	0.012	(0.010,0.014)	0.006 ^{***}	(0.005, 0.006)	0.007 ^{***}	(0.007, 0.008)
Creatinine (mg/dL)											
Men	161 (133, 196)	100		118 ^{**}	(109, 128)	100		110 ^{***}	(105, 114)	100	
Women	86 (76, 97)	100		76	(71, 81)	100		71 ^{**}	(68, 73)	100	

^a Age 40y, self-reported Mexican-Americans.

^b Geometric mean adjusted to 100 mg/dL creatinine, age 50y, and BMI 30 kg/m².

^c N is number of NHANES participants (i.e., the sample). Survey weights were applied such that estimated means apply to the NHANES subpopulation indicated.

* P<0.05

** P<0.01

P<0.001 comparing mean to Doña Ana County, NM unadjusted or adjusted mean, as appropriate (i.e., comparison of unadjusted and adjusted to unadjusted and adjusted to adjusted means).

Table 3

Correlates of New Mexico adult sample (2011–2012, N=188) urinary arsenic, cadmium, lead, and uranium concentrations, expressed as ratio of geometric means (GM ratio) by category compared to referent category (Ref.).

	Arsenic		Cadmium		Lead		Uranium	
	GM ratio ^a	(95% CI)	GM ratio ^a	(95% CI)	GM ratio ^a	(95% CI)	GM ratio ^a	(95% CI)
Age (per 5y)	1.06	(1.01, 1.12)	1.11	(1.02, 1.20)	1.02	(0.97, 1.07)	1.03	(0.95, 1.13)
Sex								
Male	Ref.		Ref.		Ref.		Ref.	
Female	1.09	(0.82, 1.44)	1.52	(1.00, 2.31)	1.02	(0.78, 1.35)	0.91	(0.49, 1.68)
Body mass index (per 5 kg/m ²)	1.05	(0.99, 1.11)	0.97	(0.88, 1.07)	1.00	(0.94, 1.08)	1.07	(0.94, 1.23)
Clinic								
A	Ref.		Ref.		Ref.		Ref.	
B	0.81	(0.60, 1.09)	1.04	(0.68, 1.60)	0.99	(0.75, 1.30)	0.69	(0.40, 1.20)
C	0.50	(0.35, 0.71)	1.00	(0.62, 1.60)	0.88	(0.62, 1.23)	0.94	(0.48, 1.86)
D	1.05	(0.80, 1.38)	1.80	(1.21, 2.67)	1.12	(0.84, 1.51)	0.95	(0.54, 1.69)
Recruitment year								
2011	Ref.		Ref.		Ref.		Ref.	
2012	0.89	(0.73, 1.07)	1.29	(0.96, 1.74)	1.08	(0.89, 1.32)	0.63	(0.45, 0.88)
Birthplace								
USA	Ref.		Ref.		Ref.		Ref.	
Latin America	1.57	(1.23, 2.00)	0.81	(0.55, 1.20)	1.26	(0.94, 1.69)	1.23	(0.79, 1.91)
Current occupation								
Agriculture	Ref.		Ref.		Ref.		Ref.	
Industrial or construction	1.39	(0.74, 2.62)	0.38	(0.19, 0.77)	0.79	(0.49, 1.29)	0.59	(0.20, 1.69)
Office or service	0.78	(0.56, 1.08)	0.44	(0.28, 0.69)	0.91	(0.64, 1.30)	0.72	(0.36, 1.46)
Unemployed/home	0.75	(0.55, 1.04)	0.55	(0.36, 0.83)	0.87	(0.64, 1.18)	0.82	(0.45, 1.48)
Education								
fewer than 8 years	Ref.		Ref.		Ref.		Ref.	
8 to 12 years	1.28	(1.05, 1.57)	1.31	(0.97, 1.76)	1.03	(0.83, 1.28)	1.04	(0.67, 1.60)
12 or more years	1.18	(0.89, 1.56)	1.34	(0.82, 2.21)	0.95	(0.70, 1.28)	0.75	(0.42, 1.33)
Cigarette smoking status								

	Arsenic		Cadmium		Lead		Uranium	
	GM ratio ^a	(95% CI)	GM ratio ^a	(95% CI)	GM ratio ^a	(95% CI)	GM ratio ^a	(95% CI)
Never	Ref.		Ref.		Ref.		Ref.	
Former	1.02	(0.82, 1.27)	0.98	(0.62, 1.53)	1.04	(0.82, 1.34)	1.68	(0.89, 3.17)
Current	1.31	(0.96, 1.79)	1.96	(1.31, 2.93)	1.17	(0.85, 1.61)	1.25	(0.73, 2.14)
Residential water source								
Private well	Ref.		Ref.		Ref.		Ref.	
Municipal service	0.85	(0.61, 1.18)	1.38	(0.78, 2.45)	0.93	(0.55, 1.57)	1.47	(0.64, 3.39)
Bottled	0.61	(0.47, 0.80)	1.18	(0.65, 2.15)	0.80	(0.48, 1.35)	0.79	(0.36, 1.75)
Vitamins and supplements								
less than 1 per week	Ref.		Ref.		Ref.		Ref.	
1 or more per week	0.94	(0.78, 1.13)	1.15	(0.87, 1.51)	0.96	(0.78, 1.18)	1.23	(0.77, 1.96)
Self-rated health								
Poor/fair	Ref.		Ref.		Ref.		Ref.	
Good	1.21	(0.98, 1.48)	0.83	(0.63, 1.08)	0.99	(0.79, 1.23)	1.19	(0.81, 1.74)
Very good/excellent	1.57	(1.18, 2.11)	0.60	(0.38, 0.94)	1.04	(0.76, 1.43)	1.32	(0.79, 2.20)
Diabetes								
No	Ref.		Ref.		Ref.		Ref.	
Yes	1.35	(1.11, 1.64)	0.96	(0.74, 1.25)	0.86	(0.70, 1.06)	1.16	(0.83, 1.63)
Seafood consumption								
Per serving/week	1.01	(0.96, 1.07)	0.99	(0.92, 1.07)	1.00	(0.95, 1.05)	0.92	(0.85, 1.00)
Parity ^b								
Nulliparous	Ref.		Ref.		Ref.		Ref.	
1–3	0.82	(0.55, 1.23)	0.82	(0.46, 1.58)	0.95	(0.66, 1.36)	0.99	(0.55, 1.79)
>3	0.85	(0.52, 1.25)	0.80	(0.52, 1.25)	1.07	(0.74, 1.56)	1.03	(0.55, 1.95)
Menopause ^b								
pre	Ref.		Ref.		Ref.		Ref.	
post	1.00	(0.78, 1.27)	1.00	(0.78, 1.27)	1.23	(0.92, 1.64)	0.74	(0.46, 1.20)

^aadjusted for all other variable listed and urinary creatinine.

^bThese estimates are from analysis of women only (N=160), adjusted for all other variables listed.