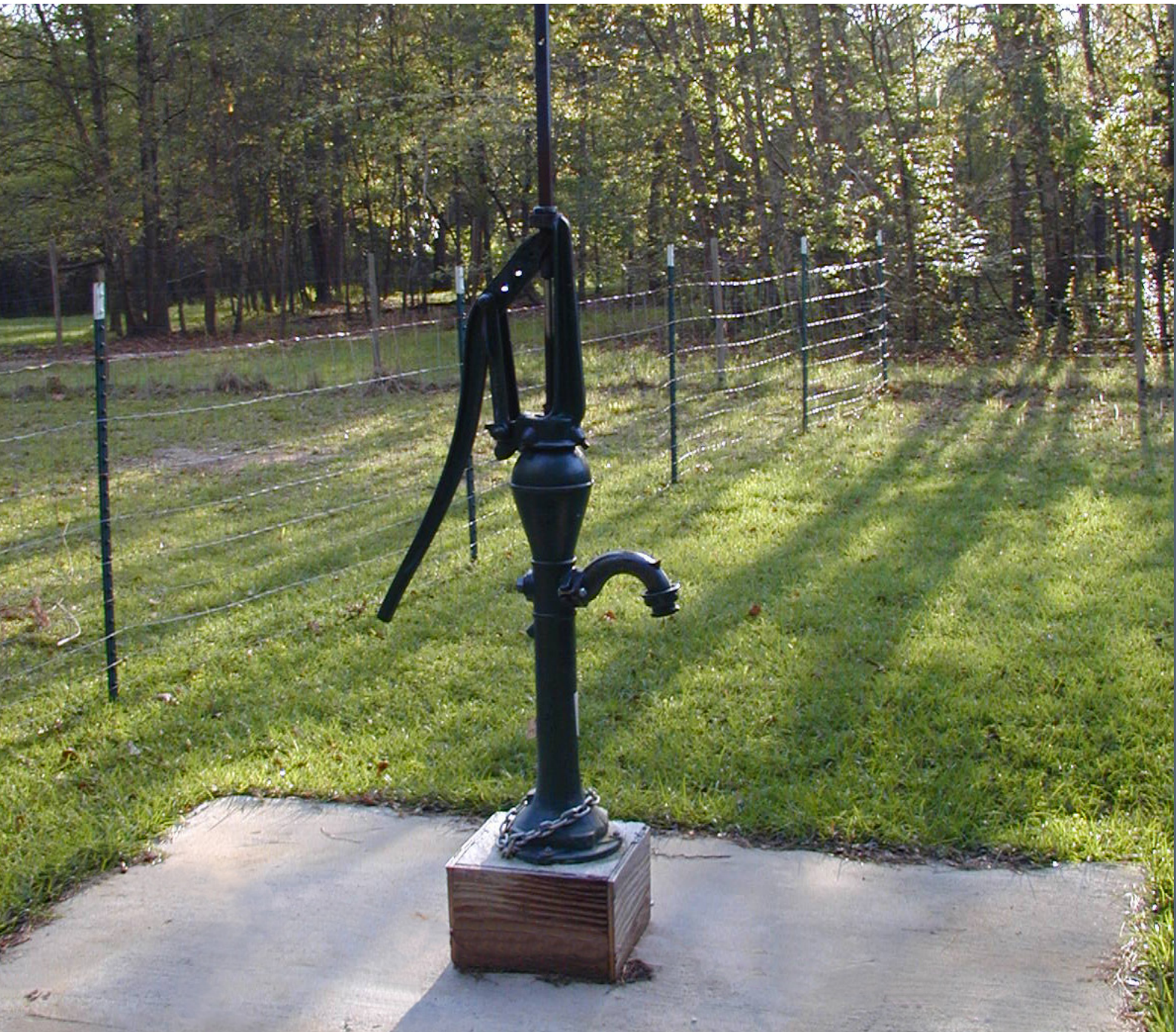
2013 Hernando County Arsenic Study

Project Summary



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Executive Summary

Drinking water wells have been sampled by the Florida Department of Health in many central Florida counties and have been found to contain elevated levels of arsenic. In Hernando County, nearly 400 drinking water wells out of approximately 1,200 tested have been found to have arsenic above 10 µg/L (micrograms per liter), which is the Maximum Contaminant Level established by the U.S. Environmental Protection Agency. This does not represent a random sample of wells tested, but rather targeted testing based on suspected areas of concern.

The purpose of this study was to:

1. Measure the amount of arsenic in tap water, and inform residents so safe water could be restored where arsenic levels exceed the Maximum Contaminant Level.

2. Find out more about home water use including drinking, cooking, and bathing behaviors through a short survey.

3. Measure individual, short-term arsenic exposure through a urine test (for children and adults on a voluntary basis). Multiple people from a single house may have been tested.

This project benefits the public by assessing how people may be exposed to arsenic through water, facilitating access to safe water where needed, and analyzing arsenic urine levels in relationship to drinking and bathing patterns. In the future, the results of this project may be used to examine the current Maximum Contaminant Level for arsenic in drinking water wells and to guide safe water restoration efforts.

From April through July of 2013, 360 participants from 166 households participated in the study. Participants were asked to provide urine and water samples to test for arsenic, and they completed a questionnaire on water consumption and exposure patterns, dietary history, and other possible sources of arsenic exposures. Nearly 50% of the participants were from "control" households with well water arsenic levels below 8 µg/L, while the other half were classified as "case" households with arsenic levels exceeding 10 µg/L.

Overall, there were no significant differences between the case households and the control households in terms of mean arsenic levels in urine. Two homes were identified with arsenic drinking water levels exceeding 10 µg/L that did not have a filter or bottled water present and were referred to the safe water restoration program. One of these homes was a control household that had previously tested below 8 µg/L. The second was a case household but the study found this household was not using a POU filter or bottled water.

2013 Hernando County, Florida
Arsenic Study

Introduction

Arsenic is a naturally occurring element found throughout the world and in many different forms. It may be found in soil, water and food. Inorganic arsenic is a carcinogen when consumed over many years, while organic arsenic (typically found in some foods such as seafood) is generally considered harmless. One source of arsenic in the environment is pesticides and herbicides. For example, arsenic compounds were used in cattle dip vats for many years to kill ticks. Arsenic-based herbicides were used for many years on railroad right of ways, roadsides, golf courses and turf farms as a weed killer. Long term ingestion of elevated levels of inorganic arsenic can increase the risk of skin cancer and cancer of the lungs, bladder, kidney, liver and prostate (1).

Due to a combination of natural deposits and some man-made processes, inorganic arsenic has been a persistent problem in groundwater in some Florida counties. Private wells that tap such groundwater for home drinking water could be exposing residents who use this water to unsafe levels of arsenic. The Florida Department of Health (DOH) samples well water for arsenic in drinking water (F.S. 381.006), as a result of a contract with the Florida Department of Environmental Protection (DEP). The U.S. Environmental Protection

Agency (EPA) is responsible for setting drinking water standards to protect public health. The EPA has established a Maximum Contaminant Level (MCL) for arsenic of 10 µg/L (micrograms per liter) (2). Arsenic levels that exceed 10 µg/L are in violation of the EPA MCL, and programs exist within Florida to assist homeowners whose wells test above 10 µg/L to restore safe water to the household.

Since 2007, DOH has sampled over 11,000 wells for arsenic statewide and found nearly 1,600 wells with arsenic levels above 10 µg/L (note: this is NOT a random sample). Residents can request well sampling from DOH, which is usually provided at no charge if a history of contamination is found in the surrounding geographic area. Some counties, especially from Dixie south to Hillsborough, have a relatively large number of private wells with arsenic levels above acceptable limits. Households with well water arsenic test results above the EPA MCL are provided bottled water and/or water filters by DEP.

Typically, MCLs are set very cautiously (sometimes well below levels that are anticipated to cause chronic health effects). Individual routes of exposure to arsenic in water are often not clear for residents with these contaminated wells. It is also unclear whether or not the arsenic levels found in most Florida wells are harmful to health. Furthermore, little is known about drinking water consumption patterns for people with private wells.

Households with arsenic levels in drinking water above 10 µg/L but less than 50 µg/L are typically offered a point-of-use (POU) filter, which is installed beneath the kitchen sink. For households above 50 µg/L, a point-of-entry (POE) filter is installed. A POU filter only filters the water used from the kitchen sink faucet, while the POE filters all water coming into the home. It is commonly assumed that ingestion of water from unfiltered sources in homes with a POU filter (for example, bathing, brushing teeth, cooking) does not contribute a significant risk of arsenic exposure to residents of homes found to have arsenic between the 10 and 50 µg/L threshold. This study seeks to test this assumption to see if differences in urine arsenic levels can be detected between individuals living in homes with only POU systems compared with a control group of homeowners using well water that is below the MCL (<10 µg/L) for arsenic. In other words, are individuals with a POU filter in the kitchen sink ingesting unsafe levels of arsenic through other unfiltered tap water in the home?

- **Inorganic arsenic is a carcinogen when consumed over many years, and is the kind of arsenic that is associated with well water.**
- **The Maximum Contaminant Level (MCL) for arsenic in drinking water established by the U.S. Environmental Protection Agency is 10 µg/L (micrograms per Liter).**
- **The Florida Department of Health offers private well testing for arsenic.**
- **The Florida Department of Environmental Protection offers filters and other solutions to households with arsenic levels above the MCL.**

- **"Case" households were identified as households with previous well water arsenic levels exceeding 10 µg/L (micrograms per liter), the Maximum Contaminant Level established by the U.S. Environmental Protection Agency for drinking water.**
- **"Control" households were randomly selected from households with previous well water arsenic levels of less than 8 µg/L to serve as a comparison group for the cases.**
- **Selected households were mailed recruitment letters with information on the study and how to enroll**
- **Participants scheduled a home visit with a study coordinator who collected water and urine samples and completed a short questionnaire.**

Study Design

Hernando County was selected to participate in this study because it is known to have a large number of wells with arsenic levels above the EPA MCL.

From 2007 through 2012, there were 312 unique wells identified in Hernando County with confirmed levels of arsenic greater than 10 µg/L, excluding households that have a point of entry filter. These 312 households were considered "case" households, and all were mailed letters introducing the study and requesting their participation. "Control" households were recruited from Hernando County among the 789 unique wells with arsenic levels < 8 µg/L. These households served as a reference to understand urine arsenic levels in homes with relatively low levels of arsenic and allowed us to examine the influence of dietary intake of arsenic from certain foods. Because arsenic levels in groundwater can vary, a more conservative threshold of < 8 µg/L was used to define the control group instead of < 10 µg/L. From the 789 unique wells with arsenic levels below the MCL, 311 control households were randomly selected to participate in the study and were mailed recruitment letters. In total, recruitment letters were mailed to 623 households.

The recruitment letters explained the voluntary nature of this study and instructed interested households to return an opt-in card and consent form to the DOH office in Hernando County. The study coordinator, located in Hernando County,

then contacted households that returned the opt-in card to schedule a home visit. Participants were mailed a urine collection kit and instructions for collecting and storing a urine sample several days prior to the home visit. On the day of the home visit, the study coordinator picked up the urine sample(s) and administered a survey on drinking water consumption, diet, and other possible sources of arsenic exposure. Multiple participants from each household were allowed to submit samples. The study coordinator also collected two water samples from within the house – one from the main source of drinking water and one from an unfiltered location such as a bathroom. Follow-up (reminder) recruitment letters were mailed two months after the initial mailing to those who had not responded. The study coordinator was responsible for packaging and shipping the urine and water samples to the DOH laboratory in Jacksonville for analysis and for mailing laboratory results letters to participants, which included contact information for state toxicologists to answer any questions from participants.

Response Rates

From the 623 recruitment letters that were mailed, 60 were returned as undelivered (30 from case households and 30 from control households). Mail may be coded as undeliverable for many reasons, including an incorrect or incomplete mailing record or a house that is vacant. From the 563 households that received recruitment letters, 360 people participated in the 2013 Hernando County Arsenic Study from 166 households. The overall household response rate was 29.5%.

Response rates for case and control households were similar. Of the total 360 participants from 166 households, 188 participants from 86 households were part of the case group and 172 participants from 79 households were from the control group. The household response rates were 30.5% for the case group and 28.1% for the control group.

- **312 case households identified and sent letters requesting participation**
- **311 control households randomly selected and sent letters requesting participation**
- **360 Hernando County residents from 166 households participated**
  - **188 participants from 86 case households**
  - **172 participants from 79 control households**
- **Overall household response rate of 29.5%**
  - **30.5% among case households**
  - **28.1% among control households**

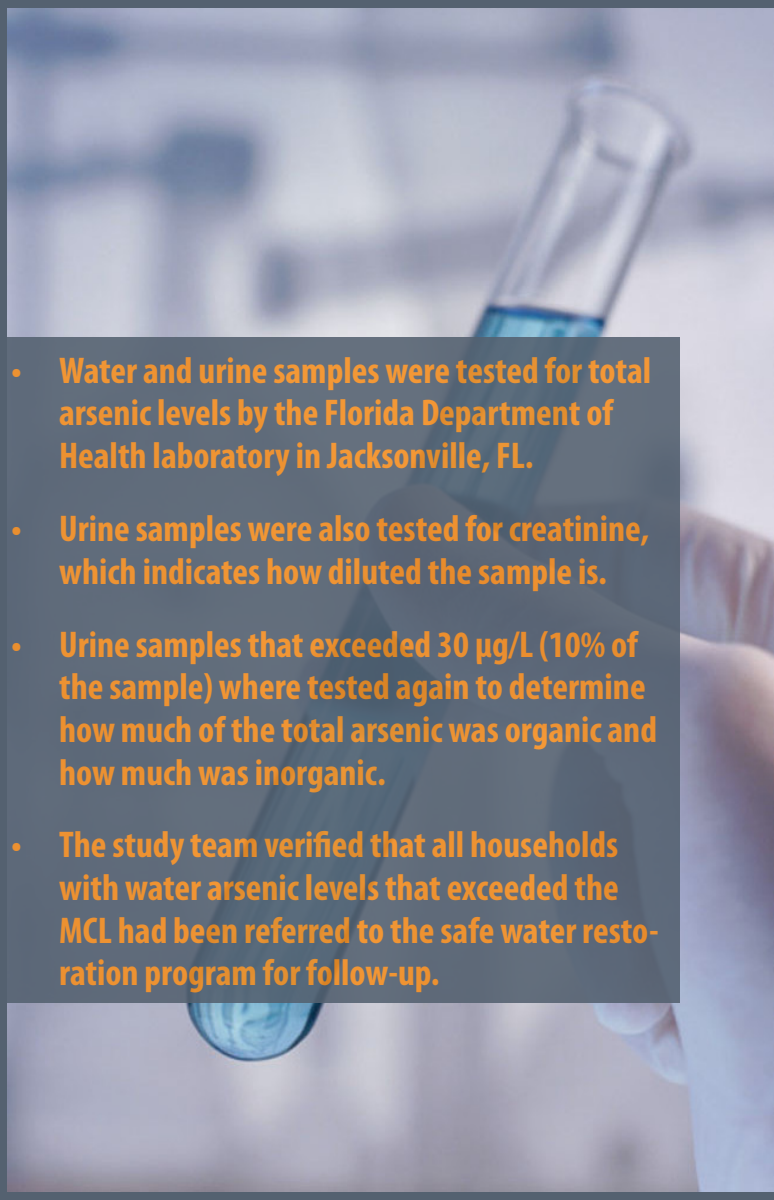
Laboratory Analysis

All water and urine samples were sent to the DOH laboratory located in Jacksonville, Florida for analysis (with some additional assistance provided by Quest Diagnostics and the Mayo Clinic). Participants were sent the results and laboratory reports typically within one month of submitting the samples. The results letter provided reference information for interpreting the laboratory results.

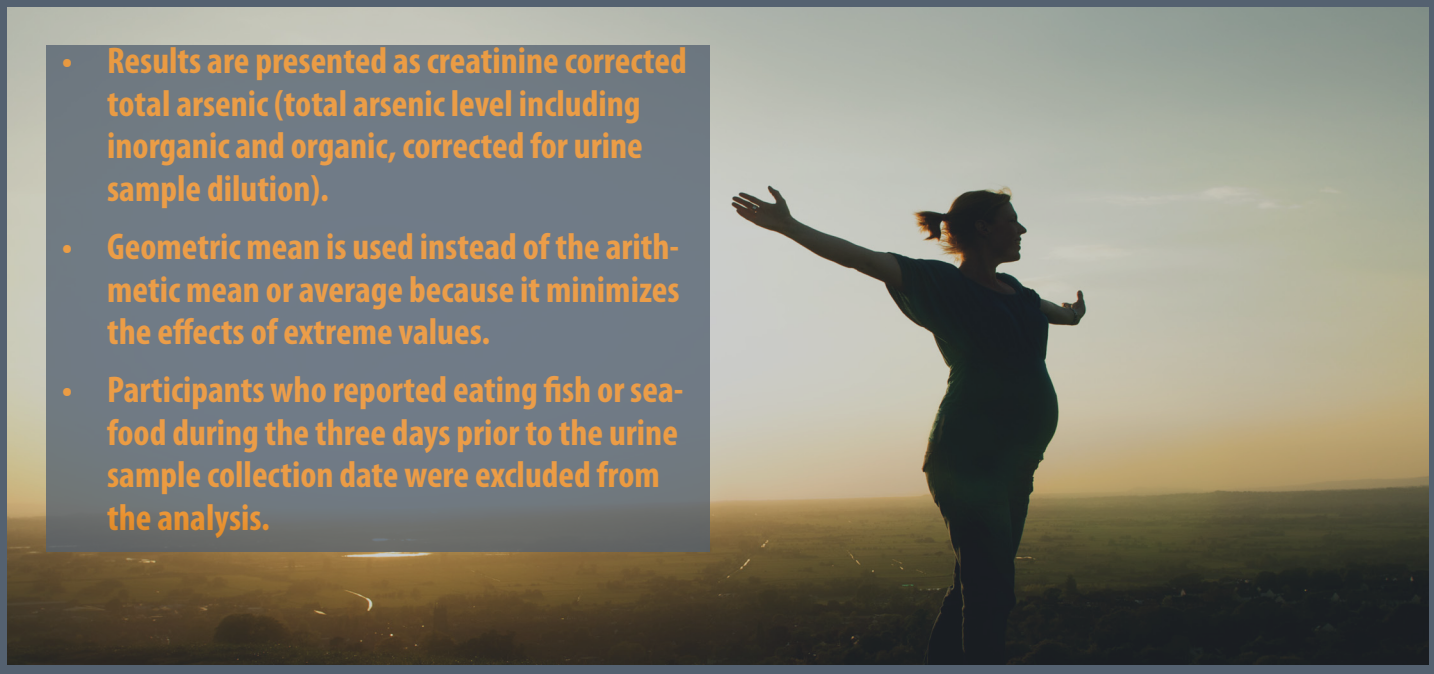
Additional testing was performed for creatinine level in urine. Creatinine is often used in laboratory analysis and reporting to indicate how diluted a urine sample is (3). For this study, creatinine was used to calculate "creatinine corrected" urinary arsenic values, which are summarized below.

Approximately 10% of the urine samples in this study were at or above 30 µg/L (N=36). For these samples, additional laboratory tests were conducted to determine how much of the total arsenic contribution was from inorganic arsenic and how much was from organic arsenic. This kind of test is usually called speciation, because it is used to identify the species of arsenic present in the urine sample. The results of this test were also mailed to those participants with total arsenic levels greater than or equal to 30 µg/L. For the majority of participants (94.4% of this subset), organic arsenic, most likely from seafood or other dietary sources, was the major contributor to the overall arsenic values.

Results from the water sampling were reviewed by the study team to ensure that all households in which the arsenic levels exceeded the 10 µg/L MCL were using a POU filter or bottled water to limit their arsenic exposure. We identified two households whose primary drinking water source had arsenic levels above 10 µg/L that had no documented protective measure in place. One household was part of the control group. The second household was part of the case group but the study found this household was not using a POU filter or bottled water. These households were referred to the safe water restoration program for follow-up.



- **Water and urine samples were tested for total arsenic levels by the Florida Department of Health laboratory in Jacksonville, FL.**
- **Urine samples were also tested for creatinine, which indicates how diluted the sample is.**
- **Urine samples that exceeded 30 µg/L (10% of the sample) where tested again to determine how much of the total arsenic was organic and how much was inorganic.**
- **The study team verified that all households with water arsenic levels that exceeded the MCL had been referred to the safe water restoration program for follow-up.**



- **Results are presented as creatinine corrected total arsenic (total arsenic level including inorganic and organic, corrected for urine sample dilution).**
- **Geometric mean is used instead of the arithmetic mean or average because it minimizes the effects of extreme values.**
- **Participants who reported eating fish or seafood during the three days prior to the urine sample collection date were excluded from the analysis.**

Statistical Analysis

Participants were asked to refrain from eating fish or seafood during the three days prior to the urine sample collection date. For this summary analysis, any participant who reported consuming fish or seafood in the three days prior to the urine sample collection (53 participants) was excluded from the results below. Consumption of fish and seafood can significantly raise organic arsenic levels for several days following consumption and therefore raise total arsenic levels. In addition, one participant from the control group who was found to have water arsenic levels above the MCL was removed from this analysis (as they no longer met the control definition). The final analysis presented in this report represents the 306 participants (165 from case households and 141 from control households) who did not report consuming fish or seafood in the three days prior to the data collection. In Table 1, only participants from case households using POU filters or bottled water (153 participants) are displayed for comparison with participants from control households.

Results are presented as geometric means. The geometric mean is usually slightly lower than the arithmetic mean (i.e. the average). The geometric mean is commonly used to report environmental exposure data because it minimizes the effect of extreme values (3). The geometric means are reported with 95% confidence intervals in Table 1. The means are estimates of the true value, and the confidence interval provides the range of numbers in which the true value will fall 95% of the time.

Data are presented as overall means of the cases compared with the controls and are broken down by key demographic variables and by selected percentiles. In addition, urinary total arsenic data from the National Health and Nutrition Examination Survey (NHANES) are presented for comparison to national levels. The NHANES is a nationwide survey conducted by the U.S. Centers for Disease Control and Prevention that collects information on health status and health risks, including the collection of urine samples to monitor environmental exposures to hazards such as arsenic (3).

Results

Urinary total arsenic levels for creatinine corrected values (Table 1) were similar for participants from case and control households. The arsenic levels in the study population (both the case and control groups) were slightly lower than national data from the 2009-2010 NHANES (4).

We were unable to determine if urine arsenic levels for children were different than adults due to sample size limitations. No children in this study were found to have elevated levels of inorganic arsenic.

The majority of case households either had a POU filter (40.0%) or received bottled water (52.7%) through the DEP's water supply restoration program. Seven case households were identified as not having a POU filter or bottled water from DEP.

These study results suggest that urinary arsenic levels of residents in households with drinking water that exceeds the arsenic MCL that use either a water filter or bottled water to provide safe drinking water (filtered or bottled water) are not at an increased risk for arsenic exposure through other unfiltered household water sources (Table 1).

We asked all participants questions about their main source of water for common behaviors such as drinking, brushing teeth, bathing, and cooking. The response options were: 1) unfiltered well water, 2) filtered

Table 1. Urinary Total Arsenic (Creatinine Corrected)

	Geometric Mean (95% confidence intervals) Number of respondents		
	Cases[1,4]	**Controls[2]**	**NHANES[3]**
Total	7.17 (6.38-8.05) N=153	7.19 (6.35-8.14) N=139	9.90 (9.06-10.8) N=2860
Gender			
Males	6.94 (5.87-8.19) N=75	7.92 (6.70-9.38) N=71	9.21 (8.55-9.93) N=1401
Females	7.39 (6.27-8.72) N=78	6.52 (5.41-7.86) N=67	10.6 (9.36-12.0) N=1459
Age Group			
< 18	6.30 (4.60-8.62) N=23	5.42 (4.32-6.99) N=20	N/A
18-64	7.06 (6.07-8.22) N=80	6.88 (5.75-8.30) N=64	N/A
65+	7.54 (6.02-9.44) N=50	7.94 (6.46-9.77) N=55	N/A

[1] Cases are defined as households using private wells with arsenic levels > 10 µg/L
[2] Controls are defined as households using private wells with arsenic levels < 8 µg/L
[3] National Health and Nutrition Examination Survey
[4] Only cases with a POU filter or bottled water are shown here

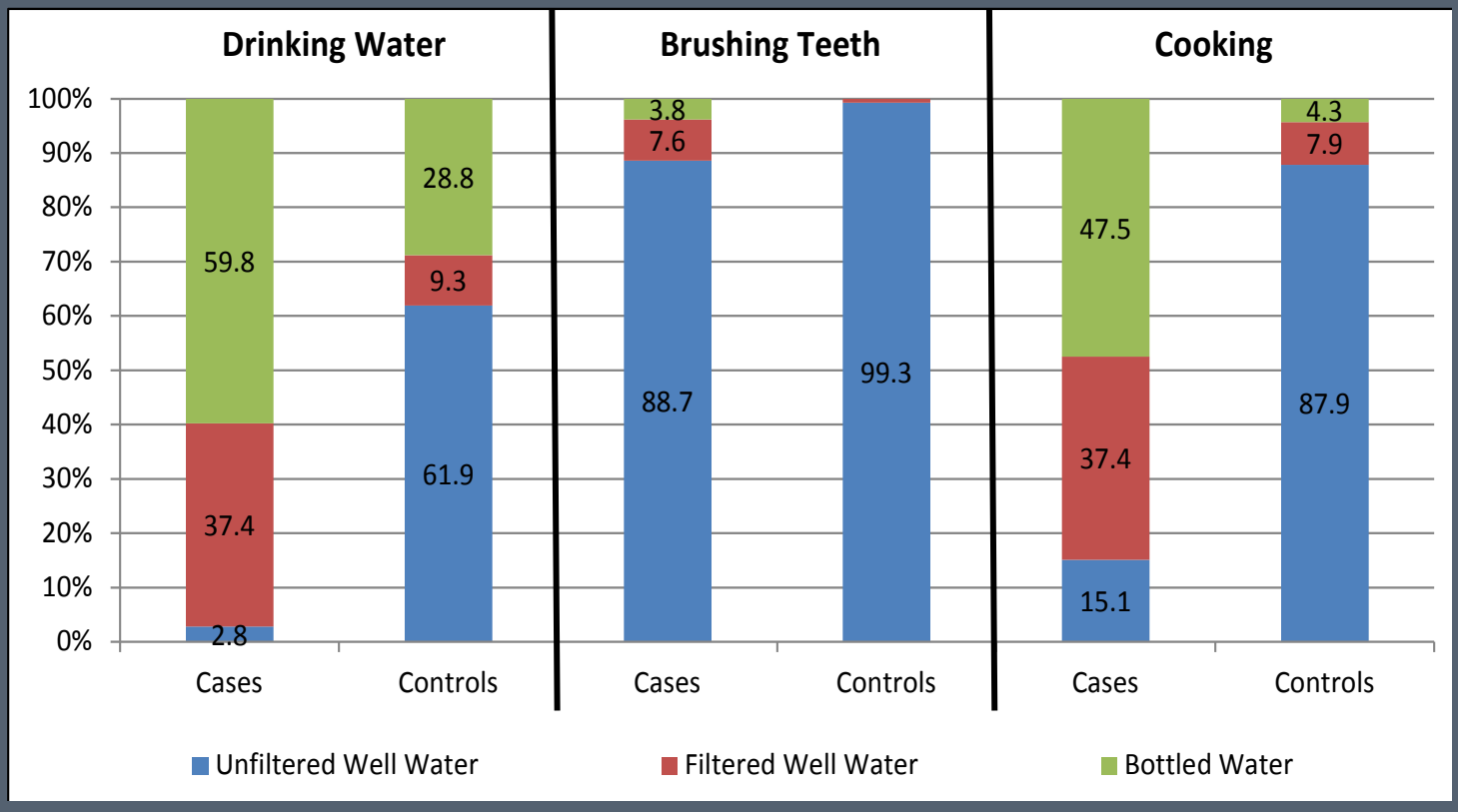
Results (continued)

well water, 3) bottled/vended water, or 4) other.

Figure 1 shows the reported water source most commonly used by participants for drinking, brushing teeth, and cooking. The majority of case households reported bottled water as their most common source of drinking water (59.8%), and 47.5% reported using bottled water for cooking. However, the majority of case households reported using unfiltered well water to brush their teeth (88.7%). Nearly one in three participants from control households (28.8%) reported using bottled water as their main source of drinking water, but very few used bottled water for cooking (4.3%) and no control households reported using bottled water to brush their teeth (0%).

- **Creatinine corrected, urinary total arsenic levels were similar for cases using POU filters or bottled water and controls (7.17 and 7.19, respectively).**
- **Arsenic levels for cases and controls seem to increase with increasing age, but these differences are not statistically significant.**
- **Geometric means for Hernando residents (cases and controls) were lower than national arsenic level estimates.**
- **The majority of case households either had a point of use filter (40%) or received bottled water (52.7%) through the state safe drinking water program.**
- **The majority of case households reported using filtered well water and bottled water for cooking and as the main source of drinking water.**

Figure 1. Main source of water for drinking, brushing teeth, and cooking for cases[1] compared with controls[2]



[1] Cases are defined as households using private wells with arsenic levels > 10 µg/L

[2] Controls are defined as households using private wells with arsenic levels < 8 µg/L

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