April Article of the Month

Maternal arsenic exposure and gestational diabetes and glucose intolerance in the New Hampshire birth cohort study

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ABSTRACT

Background:

Women who do not have diabetes and become pregnant may develop *gestational diabetes* (GDM) which is a condition that only develops during pregnancy. Some factors increase the chances of a woman developing the disorder, such as being overweight or having a family history of diabetes. [1] The development of GDM can put both the mother and child at risk of certain short-term and long-term health problems. A woman diagnosed with GDM is at higher risk for pregnancy complications and an increased risk of developing Type-2 diabetes. [2] Children born to women with GDM are more likely to become obese, develop glucose intolerance or Type-2 diabetes later in life. [3]

Arsenic is a naturally occurring element in the environment but it has been found to be associated with various long term health effects including infertility and miscarriage. Please see CEHN's *Arsenic Factsheet* for more information. GDM has been estimated to have increased almost 50% between 1990 and 2009. [4] Scientists suspect exposure to environmental contaminants like toxic metals may be a contributing factor to this rise. Previous studies have explored the connection between arsenic exposure and diabetes. Thus examining the possible associations between this toxic chemical and GDM in pregnant women is of interest.

Drinking water is an important potential source of human exposure to arsenic. Public Water Systems (PWS), which provide drinking water to the majority of the U.S. population, are regulated by the U.S. Environmental Protection Agency (EPA); however, private wells are not, and arsenic can seep into private well water. According to the Centers for Disease Control, "over 15 million U.S. households rely on private, household wells for drinking water". Thus, pregnant women in these households (and their unborn children) may have greater risk of exposure to harmful levels of water contaminants, including arsenic, if the wells are not regularly monitored and mitigated as needed. [5] Whereas 3 studies have investigated the association of arsenic with GDM via blood or urine samples, no prior research team investigated this relationship while also assessing arsenic exposure levels in study participants' drinking water.

Objective:

The study assessed the relationship between gestational diabetes mellitus (GDM) and glucose intolerance with exposure to arsenic in pregnant women without a history of diabetes, by examining arsenic levels in their drinking water, in their urine, and in their toenail samples.

Methods:

Women who were 6 to 7 months pregnant and between 18 to 45 years old were recruited from the New Hampshire Birth Cohort Study. Women were only enrolled in the study if they reported using water from a private well at home and had no plans of relocating before giving birth. Upon enrollment, the women provided a urine sample for analysis, as well as a home tap water sample. After giving birth, their toenail clippings were collected, and their medical records were reviewed for diagnoses and diagnostic test results associated with GDM. Based on the medical records review, women were categorized as either normal, glucose intolerant, or GDM for study analysis. Of those who enrolled, 1,151 women were part of the study analysis.

The toenail clippings, urine, and tap water samples were tested for elements of arsenic. Relationships of the levels of arsenic found in these samples to evidence of glucose intolerance were then examined, as were the relationships of the arsenic levels to GDM diagnoses. The researchers were careful to account for other factors which could influence glucose intolerance, such as pre-pregnancy body mass index (BMI), smoking and exposure to secondhand smoke during pregnancy, education, and time of glucose testing.

Results:

Notable results include the extent of exposure among the women in the study. Arsenic was found in 90% of the toenail and 84.4% of the tap water samples. Around 56% of women had detectable levels in their urine. Almost 1 in 10 homes in the study had tap water arsenic levels above EPA's maximum contamination limit (10 µg/L).

There was some correlation between the presence of arsenic in the women's tap water and the presence of arsenic in the women's bodies, as measured in the urine and toenail samples. Tap water arsenic measuring above 1 µg/L (1 microgram of arsenic per liter of water) was found to have a positive relationship with arsenic detected in urine and toenail samples.

Correlations between measures of arsenic exposure and health outcomes were mixed. A significant positive relationship between toenail arsenic and GDM diagnoses was observed. However, the positive relationship found between tap water arsenic levels and GDM diagnoses was not statistically significant. Interesting, this association was largely limited to obese women. There was no relationship found between any of the exposure measures and glucose intolerance (apart from GDM diagnosis).

Conclusion:

This study found that levels of arsenic in tap water were (at levels above 1 µg/L) positively associated with arsenic levels as measured in women's bodies (during pregnancy and postpartum), indicating that drinking water is a potential source of arsenic exposure to pregnant women, and thus, their unborn children. Higher levels of arsenic in tap water was also correlated with increased risk for GDM, primarily among obese women, indicating that this association is potentially modified by body composition. Lastly, women's cumulative arsenic burden, as measured from toenail clippings, was significantly associated with GDM. Water may not be the only source of exposure to As for pregnant women, but it is an important source, and one where simple interventions can reduce risk.

POLICY IMPLICATIONS

This study found that increases in levels of arsenic in home well water were associated with increased odds of GDM. This was not a statistically significant finding; however, exposure to arsenic in drinking water has been associated with various negative health effects in humans, including a strong and significant association with cancer. Strong regulations on arsenic in drinking water are imperative. Currently the U.S. Environmental Protection Agency's (EPA) safety standard is 10 micro-grams of arsenic per liter of drinking water [6]. It is not a pure health-based standard. Rather, it was based on maximizing risk reduction while minimizing costs. Lowering this standard and ensuring that drinking water systems could comply with the stricter regulation would provide improved protection, especially to vulnerable populations such as children and pregnant women.

In addition, whereas municipal water suppliers in the United States (US) are required to meet EPA's safety standard for arsenic in drinking water, no such regulation exists for private wells. Approximately 13 million people, nationwide, get drinking water from private wells with arsenic levels above the federal standard[7] . Increased support for public health campaigns to educate the general public, especially in the areas of the country with high levels of bedrock arsenic and with high percentages of the population using private wells, is important.

This study found a statistically significant association between the level of arsenic in a mother's toenail clippings (obtained within 2 weeks after giving birth) and the odds of GDM. This indicates the importance of a mother's cumulative arsenic body burden with regard to risk. Drinking water contributes to this cumulative burden, but so do exposures from certain work settings, contaminated food, and air contaminated from the burning of arsenic-containing fossil fuels and pesticide manufacturing facilities.

Occupational exposures to arsenic are usually via breathing in contaminated air. The Occupational Safety and Health Administration (OSHA) has the responsibility to protect workers, especially pregnant women, due to their vulnerability, and thus has set a permissible exposure limit (PEL) of 10 micrograms of arsenic per cubic meter of workplace air (10 µg/m3) for 8 hour shifts and 40 hour work weeks[8].

However, despite its designation as a "hazardous air pollutant", there is currently no national standard for arsenic levels in ambient (outdoor) air. Instead, EPA sets arsenic emissions standards for copper smelters and certain manufacturing plants known to emit arsenic into the air.

Certain foods and beverages, especially rice and rice-products and apple juice, contain arsenic, yet there is currently no legally enforceable arsenic concentration limit for food in the U.S The U.S. Food and Drug Administration (FDA) issued draft guidance to industry, recommending an arsenic "action level" of 100 parts per billion for infant rice cereal and also for apple juice[9]. Also, the FDA has provided advice regarding rice consumption for vulnerable groups such as infants and pregnant women. While this guidance is helpful, what is needed to best safeguard children's health are legally enforceable standards, or limits on the amount of arsenic in foods.

Other efforts that would help to reduce arsenic exposure from food: EPA has begun to phase out arsenic-containing pesticides; the U.S. Department of Agriculture (USDA) and EPA should cease the use of arsenic-containing manure as fertilizer; and the FDA should ban the use of all arsenic containing drugs for food animals.

A comprehensive approach to reducing arsenic exposure and cumulative body burdens would best protect children, including those yet to be born.

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