OREGON PSR PHYSICIANS FOR SOCIAL RESPONSIBILITY

Arsenic
& Public Health

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BACKGROUND

Arsenic exposure is a world-wide public health problem. We present here a summary that includes recent reviews of scientific evidence on arsenic's adverse health impacts. [Bailey et al, 2016; Dangleben et al, 2013; Nachman et al, 2013; Naujokas et al, 2013; and others] Arsenic is a naturally occurring element that is found in rocks, at levels that vary by geographic region, and that leaches into groundwater and soil. Arsenic can also be swept into the air and attach to very small airborne particulate matter, allowing it to travel long distances. [Goossens et al, 2015; Chung et al, 2014; Csavina et al, 2014]

Arsenic is used industrially in mining operations, insecticides, herbicides, wood water-proofing, medicine, electronics, pigments for coloring glass, and other manufacturing. [Goossens et al, 2015; Chung et al, 2014; Csavina et al, 2014] Agriculturally, it is used as a pesticide, and up until the end of 2015, was used in commercial poultry to enhance growth and as an antibiotic. [Nachman et al, 2013; FDA, 2015] Arsenic is emitted into the air during the mining and combustion of coal, and during mining and smelting in mineral extraction industries. [Martin et al, 2014]

Arsenic in drinking water is a health threat in many parts of the world. Photo courtesy of National Resource Centre.

Naturally occurring, industrial, and agricultural arsenic exist in a variety of forms that make it more or less bio-available; in other words, different forms of arsenic vary in their ability to be absorbed by and affect humans and other life-forms. [Carlin et al, 2015; Chung et al, 2014] The US EPA lowered the allowable level of inorganic arsenic in drinking water to 10 ppm from 50 ppm in 2002, as evidence built that arsenic is toxic at lower levels than previously thought. [NAS, 2014]

HOW DO WE COME INTO CONTACT WITH ARSENIC?

The presence of arsenic in water, air, and soil, whether naturally occurring or intentionally added in agricultural and industrial activities, means that arsenic exposure can come from contaminated drinking water, food, and inhalable dust. [Carlin et al, 2015] Human exposure to arsenic is through two main pathways: ingestion (of food and water and soils), and inhalation (of dust and particulate matter).

In the US, the average person is exposed to more arsenic through food than through drinking water. [Davis et all, 2012, Xue et al, 2010] Potentially contaminated food includes: rice, organic rice syrup,

fruits, juices, and other grains. [Naujokas et al, 2013] Arsenic has been found as a contaminant of rice likely due to its growth on soils and in waters with naturally occurring arsenic. Rice plants take up arsenic in the soil through the silicon transport system because arsenous acid in flooded rice paddies is indistinguishable from silicic acid to the rice plant. [Davis et al, 2012] This means that arsenic is actually contained in the rice — it cannot be washed off.

Arsenic is also present in cigarettes [Afridi et al, 2015] and in cosmetic products. [Bocca et al, 2014]

Air exposure is a particularly important pathway in occupational settings [Chung et al, 2014] and can also be an important pathway in residential settings when located near industrial or manufacturing activities. Arsenic is absorbed through the lungs when inhaled. Small particulate matter, acting as a sponge, transports the arsenic compounds and other soluble metals into the smallest chambers of the lung where they can be directly absorbed into the bloodstream. [Martin et al, 2014]

HOW DOES ARSENIC AFFECT PEOPLE?

Arsenic is a toxin affecting every system in the body. High dose effects have been studied for decades; low dose effects are more recently understood. Recent, short-term exposure to arsenic is measured in urine as it does not rapidly accumulate in the body. However, arsenic may accumulate in the long-term and can be measured in hair and nails. [Martin et al. 2014]

Symptoms of high dose arsenic toxicity can include muscle pain and weakness, changes in skin pigmentation, and excessive perspiration. More advanced symptoms include reduced sensation in the hands and feet, skin changes on the palms and soles, and circulation, liver, and kidney effects. High arsenic exposure has been linked to cancer of the skin, lung, bladder, kidney, and liver, [Naujokas et al, 2016 – review paper] cardiovascular and respiratory disorders, and diabetes. [Bailey et al, 2016; James et al, 2013] For a complete list of symptoms of exposure to high levels of arsenic, see the US Agency for Toxic Substances & Disease Registry (ATSDR) arsenic page. [ATSDR, 2007]

Recent studies suggest that arsenic may be harmful at lower levels than previously thought. [Carlin et al, 2015; Kapaj et al, 2006] There is increasing evidence that prolonged low levels of exposure over time can produce effects similar to a one time high level of exposure. [Gilbert, 2014] Risks incurred by exposure may be persistent for up to 20-30 years. [Dauphine et al, 2011]

Worldwide studies of exposures to arsenic in drinking water greater than the US and WHO standard of 10 micrograms/liter of water show increased risks of cancers, cardiovascular and respiratory disorders, immune disorders, and diabetes. [Bailey et al, 2016; James et al, 2013] Recent studies also confirm linkages with low dose effects. A few of these include evidence of:

- **Cardiovascular effects**: From a population in Colorado, one study shows increased risk of cardiovascular disease with total lifetime arsenic exposure. [James et al, 2015] A study of low level arsenic exposure in Texas shows increased coronary artery disease and hypertension. [Gong, 2012]

- **Increased incidence of metabolic disorders, including diabetes**: An Oklahoma study shows arsenic effects on maternal glucose tolerance. [Ettinger et al, 2009 and 2016] Another study shows increased diabetes in an area of low levels of arsenic in water in Serbia. [Jovanovic et al, 2012] A Colorado study shows increases in diabetes associated with increased arsenic exposure. [James et al, 2013]

- **Decreased lung function**: One study shows a long latency period after exposure and lung disease. [Dauphine et al, 2011]
- **Impaired immune functions and increased infections**: [Dangleben et al, 2013]

Evidence is accumulating to explain the effects of arsenic as a generalized neurotoxicant. [Grandjean and Landrigan, 2014] Effects on the developing fetus, infants, and children at very low exposure levels point to arsenic's role in epigenetic changes in the programming of fetal development [Flora 2011] and later neurodevelopment. There is also evidence for an endocrine disruption mechanism. [Bailey et al, 2016] Early life exposures increase risk for:

- **Later development of cancer of the liver, skin, bladder and lung:** This risk is greater than that of exposure to arsenic as an adult. [Bailey et al, 2016; Naujokas et al, 2013]
- **Decreased cognitive ability (IQ):** [Wasserman et al, 2004 and 2007] A 2014 study correlated soil arsenic in North Carolina with decreases in IQ. The combination with high levels of lead was particularly damaging. [McDermott et al, 2014]
- **Birth effects, low birth weight, higher infant mortality:** [Rahman et al, 2010] and **decreased fetal growth**. [Henn et al, 2016; Gilbert-Diamond et al 2016] A study in New Hampshire demonstrates a link between arsenic exposure and decreased birth weight.
- **Increased risk of infection in infants:** [Rahman et al, 2011] A study in Bangladesh demonstrated a link between arsenic exposure and increased influenza and diarrhia in infants.
- **Other impaired immune response issues:** [Bailey et al, 2016; Naujokas et al, 2013]
- **Neurobehavioral effects:** a systematic meta-analysis showed 13/18 studies suggested that arsenic affects the development of behavioral disorders. [Rodriguez-Barranco et al, 2013]

Occupational exposures to arsenic are associated with significant cancer risks. Lung cancer and skin cancer are serious long-term concerns in cases of chronic arsenic exposure. [IARC, 2012; ATSDR, 2007]

WHAT ARE CURRENT ISSUES IN THE NORTHWEST?

Arsenic has been detected in some well-waters in Oregon. Most recently, certain art glass fabrication in Portland has become well known for the release of airborne arsenic. An ongoing issue is fossil fuel transport: coal transport releases arsenic in coal dust into the air, and crude oil transfer from trains to holding tanks involves the release of arsenic into the air. [Corvin, 2013] Airborne particulate matter absorbs arsenic from the air and carries it to the lungs, soil, and water.

US, EU, AND WHO POSITIONS ON ARSENIC AND HEALTH

The US Agency for Toxic Substances & Disease Registry (ATSDR) states that arsenic is known to be a human carcinogen, and arsenic is the ATSDR's top chemical of concern. [ATSDR, 2007] The European Chemical Agency states that arsenic is: "toxic if swallowed, is toxic if inhaled, is very toxic to aquatic life and is very toxic to aquatic life with long lasting effects." Its uses are restricted by REACH (EU Registration, Evaluation, Authorisation and Restriction of Chemicals). [ECHA, 2016] Arsenic is one of the WHO's (World Health Organization's) 10 chemicals of major public health concern. [WHO, 2016]

WHAT YOU CAN DO TO PROTECT YOUR FAMILY AND COMMUNITY

Given the multiple sources of arsenic exposure, and its many adverse health impacts, efforts to reduce arsenic exposure are necessary. This is particularly important for pregnant women and children.

Arsenic can be metabolized after absorption into the body to make it less toxic. People differ in their ability to metabolize arsenic, which makes it difficult to predict individual vulnerability to its effects. [Hall and Gamble, 2012] Folate or folic acid is required for the metabolization process and thus consuming enough folate can help protect against arsenic impacts. A healthy diet including selenium (nuts, whole grains), iron (enriched cereals, meat, beans), calcium (milk products, leafy greens) and folate (beans, spinach, avocado) may mitigate toxicity from metals. [DEQ et al, 2016]

Limiting overall exposure to heavy metals and polycyclic aromatic hydrocarbons (PAHs) found in air pollution and charred food can also help.

Arsenic clings to dust particles and can be found in soil. Therefore, minimizing dust and soil in your home can reduce your exposure to arsenic. Some ways to do this include:

- Remove shoes when entering the house.
- Brush pets often to minimize the dust and dirt they bring into the house.
- Wipe down surfaces with a wet mop or cloth.

Other effective actions you can take to reduce your exposure to arsenic include:

- If you smoke cigarettes, stop. Avoid exposure to second-hand smoke as much as possible.
- Test your water, especially if you drink well-water. Filter the water or take other actions if necessary. The arsenic content of groundwater varies considerably from place to place, and high arsenic concentrations have been measured in well waters in the US as well as other parts of the world. Well waters in Oregon have been found to contain arsenic at concentrations greater than 10 ug/l, the EPA drinking water standard.
- Wash your hands and your food before eating.
- Garden in raised beds if you suspect your soil may be contaminated with arsenic. Use raised beds deep enough to contain crop roots and maintain them with clean soil and fresh compost that is free of pesticides or other hazardous chemicals. Keep the beds away from roof “drip lines” to avoid rainwater that may have picked up contaminants from roofing material. Make sure raised beds are not made with chemically treated wood—especially wood treated with heavy metals. [Grossman, 2016]
- Use a portable air filter in your home.
- Wash hands and face and those of children after playing outside and before eating.
- Keep children’s toys and play areas clean and discourage eating dirt.
- Eat organic vegetables as much as possible.
- Wear gloves and masks if digging or excavating.
- Wear gloves when handling chemically-treated wood, and never burn it.

Since a large part of the diet for infants and children is made up of rice and rice products, including baby formula and cereals, [Bailey et al, 2016] reducing the quantity of rice products consumed will reduce exposures from this source, but this may be difficult for large segments of the population. Putting pressure on producers and growers to test for and potentially reduce the arsenic content of foods is one way to reduce exposures over the long term.

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