

Arsenic

DISCLAIMER: the following is not meant to treat anyone with advice or tell you what you should do, such as relative to use of medication, exercise, or changing your diet. The information in this handout is merely offering what has been published in the research literature, as well as based on my professional experience. Talk to a doctor or other appropriate professionals as to what is best for your own specific needs.

It should also be appreciated that everyone has their own perspective on how to improve health. Nutritionists do it through food. Physicians do it through medicine. Psychologists do it through changing thoughts, feelings, and behaviors. Consequently, what is offered here is a reflection of my own bias and perspective.

Arsenic is one of the most toxic metals found in nature. There is an agency of the federal government, (Agency for Toxic Substances and Disease Registry, ATSDR) that ranks 275 toxic substances as to which poses the greatest threat to human health based on frequency, toxicity, and potential for exposure to people. Arsenic is #1 (as of 2022).

It has been used as a poison for rats, roaches and other unwanted pests, and in chemical warfare. Chronic arsenic exposure is said to impact 200 million people worldwide, and is often comorbid with zinc deficiency.

Arsenic can be divided into organic vs. inorganic forms. Organic contains carbon. Inorganic contains something other than carbon, such as oxygen. Inorganic forms are more serious for human health. It can inactivate up to 200 enzymes especially those involved with cellular energy and DNA synthesis and repair.

Arsenic is what is known as a non-threshold carcinogen, meaning there is no safe amount to consume, and any that is ingested carries some risk. Consequently, what is called ALARA (as low as reasonably achievable) may be considered a wise approach to take toward it.

More specifically, chronic exposure to inorganic arsenic has been associated with cancer of the skin, bladder and lungs. It may also cause liver, kidney, digestive, lymphatic system and prostate cancers too. Short-term exposure to large amounts of inorganic arsenic can lead to nausea, vomiting, bruising, numbness or burning feelings in the hands or feet. It can also contribute to cardiovascular disease, and mood problems like depression.

Diabetes is also linked to arsenic in both lower and higher levels of it. One meta-analysis of seventeen studies with over 2 million participants found that arsenic in drinking water was associated with diabetes. There was a 13% increase in risk for every 100 mcg/L of it in drinking water (Journal of Epidemiology & Community Health, "Association of inorganic arsenic exposure with type 2 diabetes mellitus: a meta-analysis" W. Wang et al, Feb. 2014). There are at least four mechanisms by which arsenic may do damage. They include

- ❖ reducing the uptake of glucose by insulin
- ❖ pancreatic beta-cell damage
- ❖ pancreatic beta-cell dysfunction
- ❖ stimulation of liver gluconeogenesis

Exposure to arsenic early in life also increases the risk of developing diabetes (along with cancer, cardiovascular disease, and non-alcoholic fatty liver disease). One study found that maternal exposure levels were associated with diabetes in their children 15-20 years later. Arsenic exposure is also associated with metabolic syndrome and that is associated with type 2 diabetes. Koreans with metabolic syndrome had higher levels of arsenic and lead in their hair than those without metabolic syndrome (Biological Trace Element Research, "Relationships of hair mineral concentrations with insulin resistance in metabolic syndrome" Whan-Seok Choi et al, June 2014). There is also evidence that arsenic exposure increases the risk of gestational diabetes.

Arsenic also can lead to reproductive problems such as premature delivery, spontaneous abortion, birth defects, decreased birth weight, and stillbirth. Fetuses and young kids exposed to inorganic arsenic are associated with reduced intellectual development. Other impacts on a fetus may vary depending on the trimester of exposure. It can also cause neurobehavioral problems in kids and especially so if lead is present because they are synergistic with each other.

One study from 2018 done in New Hampshire looked at 204 infants who were 6 weeks old. Well water consumed by the mothers ranged from undetectable levels of arsenic to 57 mcg/l. Findings from the research were that gut microbiome health of formula fed boys was worse, but not for breastfed or formula-fed girls.

Other effects include that peripheral neuropathy can develop leading to pain, muscle weakness or atrophy. A Mexican study of children found that urinary arsenic concentration was inversely associated with verbal IQ and long-term memory. It can also impact the immune system.

Arsenic accumulates in the brain with the largest amount in the pituitary.

Arsenic is a natural element. Sources of it can include smoking tobacco products, living near industrialized areas, being exposed to landfill or waste sites, or breathing in smoke or dust from pressure treated wood that contains arsenic.

But it also gets into farmland from insecticides, as well as arsenic-containing animal feed that is used to prevent disease and cause more growth of the animal. Rice is probably best known as a crop containing arsenic, but it actually is ranked at only #3. Vegetables are #1 and contribute 24% of inorganic arsenic dietary exposure, and #2 are fruits and their juices at 18%. A European study found that cereal products contributed over half of the dietary exposure to inorganic arsenic mostly because of rice.

Poultry is another source of arsenic because it has been in drugs fed to them to prevent disease. Their manure then contains it (a half million pounds of pure arsenic per year), and that can then

get into groundwater. Plus, it can then be used as a fertilizer such as for mushroom growing. The level of arsenic in mushrooms is said to rival that of rice, but people usually eat more of the latter.

There was a study done by a non-profit group, Moms Across America, and they looked at the Top 20 fast-food restaurants in the country. The primary finding: Of all the samples purchased at 21 locations nationwide, 100% were contaminated with lead and cadmium. Arsenic was found in 17% of the fast food samples. The highest amount was in Panda Express' orange chicken and white rice, which had 362% more than the EPA allows in drinking water. They also noted that "Arsenic has been detected in chicken feed at such high levels that hazmat licenses may be required to transport the grains." (https://www.momsacrossamerica.com/fast_food_heavy_metals)

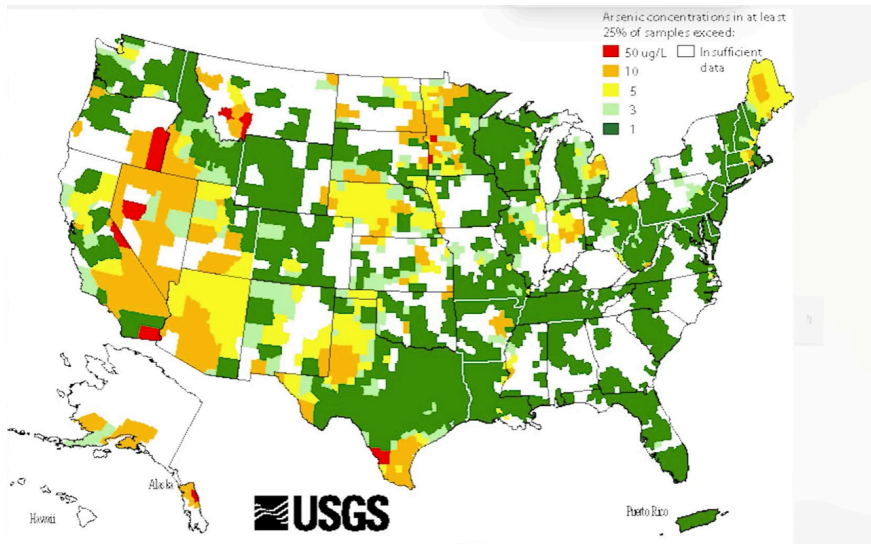
Yet other food sources that can be contaminated with arsenic include wine and beer. A study done in New Hampshire found that women having 5-6 glasses of wine per week had at least 20% more arsenic in their system than those who did not drink at all. As to which type of wine (red, white, or rose) had the most, different studies have come up with different results, at least partially due to where it was conducted such as wines from different states or countries.

One study (Journal of Environmental Health, "Arsenic content in American wine" Denise Wilson, Oct. 2015) looked at 65 wines from the top four wine-producing states (California, Oregon, Washington, and NY). All of them exceeded the 10 ppb for drinking water and the average was 23.3 ppb. (Lead was found in 58% of the samples.) Having 2 ½ beers/day may leave you with an arsenic level 30% higher than non-drinkers. It may be coming from the water, or it could be from various ingredients or brewing equipment. Brussels sprouts and other cruciferous veggies are another potential source of arsenic as to picking it up from the farm soil. Some seafood (e.g. salmon, tuna, octopus, mackerel, sardines – which had the highest concentration, bluefish, swordfish) are another source with the fish getting it from the water. Arsenic levels were about 7% higher in people eating such fish once a week compared to those eating them less than once a month. Veal, chicken, lamb and pork also contain arsenic.

There is also hijiki seaweed which has about 100 times more arsenic than rice. Canada, the UK, the rest of Europe, Australia, New Zealand and China have told their public not to eat it. Japan which grows it advises moderate consumption.

Another source of arsenic exposure is drinking water and it is recognized as a global concern. It is one of the most significant environmental causes of cancer in the world according to the EPA. It can get into water through erosion and leaching of geological formations which is a particular problem in the western US where some areas have arsenic as high as 31 ppm in drinking water, about 300 times higher than is recommended. It can get into water from industrial use such as uranium and gold mining, metal processing, and application of fertilizers and pesticides. Arsenic naturally occurs in ground water in a number of states including Alaska, Arizona, California, Idaho, Indiana, Missouri, New Hampshire, Nevada, Ohio, and Washington.

The map below is from the US Geological Survey.



A study done by the U. of Arizona in 2014 (Journal of Exposure Science and Environmental Epidemiology, “Contribution of diet to aggregate arsenic exposure – an analysis across populations” Margaret Kurzius-Spencer) found that with arsenic in water at a level above 10 ppb water becomes the dominant source of exposure. When the level in water is below 10 ppb food becomes the main source of arsenic.

A study was done on national data (NHANES, 2003-2010) looking at 3,633 people over the age of 6 years. Analysis found that those who ate one rice food item the prior day had urinary arsenic levels 44% greater than those who did not. Two or more rice items consumed in the prior 24 hours had arsenic levels 70% higher than those who did not. Consumption of apple or grape juice led to average arsenic levels about 20% higher than those people who did not drink them.

Another study (Environmental Health Perspectives, “Rice consumption and urinary arsenic concentrations in U.S. children” Matthew Davis et al, Oct. 2012) found that total urinary arsenic concentration increased about 14% for each quarter cup of daily cooked rice consumption. The average daily consumption in the US is about a half cup of cooked rice. But rice consumption comes in other forms, such as Rice Krispies cereal. Organic brown rice syrup is a sweetener used in organic products which is another source of arsenic into one’s diet. Rice milk has widely varying amounts of arsenic across brands with one study finding anywhere from 3-46 ppb in it.

The EPA assumes there is no safe level of inorganic arsenic exposure. The FDA has issued guidance to industry to not have more inorganic arsenic than

- ❖ 100 ppb in infant rice cereal. Consumer Reports (<https://www.consumerreports.org/baby-food/why-you-should-consider-alternatives-to-infant-rice-cereal-a8571897937/>) noted that two brands (Gerber and Earth’s Best) lowered their level of arsenic in these cereals into the low 60’s ppb range. However, the lower level is still above what is considered safe by some experts, and much higher than in other grain cereals like oatmeal (with arsenic in the 7-30 ppb range). Consumer’s says that the 100 ppb limit was based on long-term

exposure leading to a higher risk of cancer, but not taking into account research finding that lower levels can cause neurological damage.

- ❖ 10 ppb in apple juice and drinking water (10 mcg/liter). EPA analysis showed that this level could potentially cause up to 600 cases of cancer per 1 million people who drink arsenic-contaminated water for a lifetime.
- ❖ there is no federal standard for arsenic in other foods, such as rice.

Consumer Reports magazine did some testing in 2012 of rice and rice-containing products and their results can be found here. www.consumerreports.org/cro/magazine/2012/11/arsenic-in-your-food/index.htm#recommendations. One recommendation they make in the above site is for adults to limit servings of actual rice to no more than two per week, and this is based on having just a single rice product per day (e.g. rice, rice milk, rice crackers, rice cakes, etc.).

Consumer Reports also did some testing on fruit juices. Out of 45 popular fruit juices sold nationally, heavy metals like arsenic were found in almost half of them. “In some cases, drinking just 4 ounces a day is enough to raise concern” they say. (www.consumerreports.org/food-safety/arsenic-and-lead-are-in-your-fruit-juice-what-you-need-to-know/#chart)

One way to look at such numbers is to realize that the usual level of acceptable risk for carcinogenic substances is one chance in a million of developing cancer over a lifetime. The FDA has offered that eating the most common type of rice, long grain white, once a day would cause 136 cancers per million people. Plus, there are the non-cancer risks of cardiovascular, diabetes, etc. that arsenic can cause.

The National Research Council has said that the current standard of 10 ppb in water may be associated with a risk of excess cancer as high as 1:300 people, which would be about 3,000 times greater than the commonly accepted standard of 1:1 million. To reach the million to one standard would require a water standard of 0.02 ppb. But the technology to get levels that low are not practical or possible. What is considered technologically feasible is a level around 3 ppb for water. Why is the limit set at 10 ppb? Mainly money, it would be too expensive.

Another study ([Journal of Pediatrics](#), “Arsenic and rice: translating research to address health care providers’ needs” Pui Lai et al, October 2015) found that for every one gram of increased rice intake was associated with a 1% increase in urinary total arsenic. And eating a little over a half cup of cooked rice would equal drinking a liter a day of water at the current standard for arsenic contamination.

Chronic exposure at low levels of arsenic contaminated water has been correlated with lower scores for language, visual-spatial skills, and executive functioning, along with global cognition, processing speed, and immediate memory. One study ([Journal of Environmental Health](#), “Low-level groundwater arsenic exposure impacts cognition: a project FRONTIER study” G. Gong et al, 2011) found that those consuming water with arsenic at 10.6 mcg/l did significantly worse on measures of global cognition compared to those exposed to 6.5 mcg/l.

California's Office of Environmental Health Hazard Assessment has a public health goal of 0.004 ppb (4 parts per trillion) which is a level where arsenic is seen as not posing a significant health risk (a cancer risk of 1 per million). The current governmental standard is 2,500 times higher.

A 2004 study in the U.S. looking at a wide range of locations found that low levels of arsenic in water at the rate of 2-10 mcg/l had a significant association with worse mental health and especially depression. Exposure to those levels for more than 20 years were significantly more likely to show depressive symptoms compared to those exposed to under 2 mcg/l. Those having more than 10 mcg/l exposure were also more likely to have cardiac bypass surgery, high blood pressure, and circulatory problems compared to those with exposure levels below 2 mcg/l (American Journal of Public Health, "Prevalence of chronic diseases in adults exposed to arsenic-contaminated drinking water" KM Zierold et al, 2004).

Another study (Journal of the National Cancer Institute, "Elevated bladder cancer in northern New England" Dalso Baris, 2016) of people drinking from private wells in the northeast found elevated bladder cancer rates even when arsenic levels were below the legal limit. i.e. The government's standard of 10 mcg/l is being seen as inadequate to prevent such problems, and it needs to be lowered.

Ways to reduce arsenic exposure from one's diet includes use of rice alternatives such as quinoa, barley, polenta, couscous, teff, amaranth, buckwheat, oats, flax, or bulgur wheat. Other grains such as these have about one-tenth the arsenic of rice and consequently lower disease risk. Boiling brown or white in a lot of water as if it were pasta and then draining it can lower arsenic levels by roughly 50-65%. How much of the nutrition is lost by discarding the cooking water? White rice is processed as to stripping away some nutrients and then iron and some B vitamins are sprayed back on to enrich it. Discarding the excess cooking water will wash away such nutrients by something like 50-75%. Brown rice is not processed, and its nutrients are locked up inside the grain and so discarding the water has only a slight impact on some of its nutrition, such as a 5% reduction in the iron. The B vitamins take about a 50% hit with discarding water for brown rice. White rice had almost no B vitamins left. What does this accomplish as to reducing cancer risk? According to one study the risk would be cut in about half, going from 165 cases per million down to 66 cases, for brown rice measured over a 50 year time span.

Other ways to reduce arsenic exposure include use of non-rice baby cereals such as oatmeal or mixed grain. Avoid using rice milk, rice based crackers or flour, rice syrup, and limit fruit juices to a half to one cup/day are other approaches to lowering exposure to arsenic.

Arsenic in well water can be treated through reverse osmosis, ultra-filtration, distillation, or ion exchange. Carbon-based water filters do not remove arsenic. You may want to test your well water regularly to make sure the problem is controlled. Bathing and showering in water with arsenic is considered safe at least up to 500 ppb. Arsenic is said not to be absorbed through the skin or evaporate into the air.

Treatment options for arsenic exposure are considered limited. Two drugs that have been used are DMSA and DMPS. One study found DMSA did not improve the health status of patients. DMPS led to significant improvement in symptoms but more research is considered needed. Other research suggest that eating proteins from food may increase the elimination of inorganic arsenic.

A different approach to treating arsenic exposure is to consider what it does to the human body, namely creating free radicals that cause oxidation which leads to cellular damage. Antioxidants are a way to combat them. One study done in India (Human & Experimental Toxicology, "Curcumin protects DNA damage in a chronically arsenic-exposed population of West Bengal" Jaydip Biswas, et al, 2010) used curcumin combined with black pepper in capsules, and another group got placebos. Within a month the curcumin group had significantly less DNA damage, and after three months they were no worse than people never exposed to the arsenic. The placebo group remained unchanged over time. The researchers also found that it prevented damage and also helped perform repairs. One issue to be aware of is that a lot of turmeric is contaminated with lead be it grown in India or the U.S.

Yet another approach to dealing with arsenic may be through beta-carotene. (Cancer Epidemiology, Biomarkers & Prevention, "Serum Beta-carotene level, arsenic methylation capability, and incidence of skin cancer" Yu-ei Hsueh, et al, Aug. 1997) looked at 654 people age 30 or older in Taiwan. Those with low levels of beta carotene were 100 times more likely for developing arsenic-induced cancer compared to those with high levels.

Environmental Working Group has an online database that offers information of contaminants in public water supply by zip code that is free to use. Go to <https://www.ewg.org/tapwater/>.

Dartmouth College also has a website on arsenic in food, water and other sources for the public to use, and it can be found at: <https://sites.dartmouth.edu/arsenicandyou/>