Published in final edited form as:

JAMA Intern Med. 2013 August 12; 173(15): 1395–1396. doi:10.1001/jamainternmed.2013.6405.

Public Health Responses to Arsenic in Rice and Other Foods

Ana Navas-Acien, MD, PhD and

Department of Environmental Health Sciences, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, and Department of Epidemiology, Welch Center for Prevention, Epidemiology, and Clinical Research, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland

Keeve E. Nachman, PhD, MHS

Department of Environmental Health Sciences, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, Department of Health Policy and Management, Johns Hopkins Center for Livable Future, Johns Hopkins Bloomberg School of Public Health, Baltimore, and Department of Oncology, Johns Hopkins School of Medicine, Baltimore

Inorganic arsenic and its methylated metabolites are powerful toxicants and carcinogens.¹ Arsenic has always been present at varying levels in drinking water and various foods. Recently, however, there has been heightened concern about rice, fruit juices, and chicken as sources of dietary arsenic.^{2–5} There are many questions about the appropriate public health responses.

In the United States, most drinking water has less than 10 µg of arsenic per liter, the current Environmental Protection Agency (EPA) safety standard. Because the levels of arsenic in most drinking water in the United States are low, the major source of arsenic exposure is diet. Inorganic and methylated arsenic species are present in food for different reasons, including natural contamination of soils and water with inorganic arsenic, soil contamination due to past or current use of arsenic pesticides (eg, lead arsenate, banned in 1988 in the United States, and dimethylarsinate, also known as cacodylic acid and still in use), and the use of arsenic-based drugs in poultry production. Roxarsone and nitarsone are approved to treat coccidiosis (a common parasitic disease in poultry) and to facilitate faster growth. Organic arsenicals (arsenobetaine, arsenosugars, and arsenolipids), which are believed to be nontoxic or have low toxicity, are found in seafood.⁶

The presence of inorganic arsenic and dimethylarsinate in rice and other grains is well established.^{2,7} Rice produced in some parts of the United States is particularly high in arsenic owing to soil contamination by arsenic pesticides and the development of arsenic-tolerant rice breeds. Apple, grape, and pear juices have also been recognized as sources of inorganic arsenic,^{3,4} sometimes at concentrations that exceed the drinking water standard. Inorganic arsenic from arsenic-based drugs has recently been found in chicken meat,

Corresponding Author: Dr Navas-Acien, Departments of Environmental Health Sciences and Epidemiology, Johns Hopkins Bloomberg School of Public Health, 615 N Wolfe St, Room W7513D, Baltimore, MD 21205 (anavas@jhsph.edu).

Conflict of Interest Disclosures: None reported.

especially after cooking,⁵ indicating that consuming poultry may contribute to dietary arsenic exposure.

Chronic, high-level exposure to inorganic arsenic (eg, >100 µg/L in occupational settings and in drinking water) causes cancers of the lung, bladder, and skin. (To convert arsenic to micromoles per liter, multiply by 0.0133.) It probably also causes cardiovascular disease, respiratory disease, and diabetes mellitus, and affects neurodevelopment.¹ At lower levels in drinking water (<50 µg/L), some, but inconsistent, evidence supports the role of arsenic in the development of cancer, cardiovascular disease, and diabetes mellitus.¹ Additional evidence is needed to reach firm conclusions. Epidemiologic studies using high-quality exposure and outcome assessment and careful evaluation of dose-response relationships are needed to understand the health effects of low-to-moderate arsenic exposure from food, water, and air.

At present, there are few federal efforts to characterize arsenic content and species in food. Two monitoring programs, the US Food and Drug Administration (FDA) Total Diet Study and the US Department of Agriculture National Residue Program, collect data on total arsenic levels in foods but do not collect data on arsenic species. The Total Diet Study examines a wide array of foods in a small number of samples intending to mimic the diet in the United States; the National Residue Program evaluates selected animal products (such as chicken, turkey, and hog meat and livers) in greater depth. These efforts provide some information on dietary arsenic exposure, but understanding the public health importance is challenging without data on arsenic species. The reason is that the species profile of arsenic in foods can vary substantially.

In response to recent public concern, the FDA has initiated focused analyses of arsenic in specific foods, such as rice and fruit juices. Arsenic monitoring data, including speciation, coupled with food consumption data, are needed to characterize arsenic dietary burdens, conduct risk assessment at the population level, and identify interventions to minimize arsenic-based risks. A better understanding of dietary exposures could also facilitate the development of arsenic standards for specific foods. Such standards are lacking for most foods, except for certain animal products. For instance, the standards for chicken muscle and liver are 0.5 and 2.0 ppm of total arsenic, respectively. These standards, however, are decades old, focused exclusively on cancer risk, and do not reflect recent epidemiologic findings at relevant exposure levels.

Physicians should inform their patients about sources of arsenic exposure and prevention strategies. People who obtain water from private wells should be advised to test their water systems, and individuals should diversify their diets. Dietary guidance, however, may be difficult to follow, especially for people who frequently eat rice. Rice and rice-based products, for instance, are important for people with celiac disease and for infants who are lactose intolerant. Rice cereals are also among the first solid foods introduced for children. Pediatricians should recommend that parents diversify solid foods to avoid the exclusive use of rice or products that are based on brown rice syrup or rice milk. In the absence of federal regulation of arsenic levels in food, medical organizations could develop guidelines and recommend diverse diets to minimize arsenic exposure. In situations of concern (eg, high

arsenic in drinking water or a rice-based diet), measurement of urine total arsenic is a relatively easy and inexpensive (<\$100) biomarker of exposure. Interpretation of the results, however, can be complicated by organic arsenicals from eating seafood.⁶ Before arsenic biomonitoring, seafood must be avoided for at least 5 to 7 days. If high levels of arsenic are found in urine, the sources can be investigated and dietary changes made as appropriate.

Although physicians can help patients reduce their dietary arsenic exposure, regulatory agencies, food producers, and legislative bodies have the most important roles. The FDA should prioritize foods based on arsenic content and dietary patterns, and set arsenic standards. With standards in place, the FDA should establish a rigorous monitoring and enforcement program, including the removal from the market of products that do not meet the standards. The FDA standards would also help the food industry evaluate the safety of its products. Given the protracted nature of the federal regulatory process, however, food producers should not wait for the FDA to act. Companies that produce and market foods that are a cause for concern should examine and implement interventions to minimize their arsenic content. Interventions might include sourcing low-arsenic commodities for use as food ingredients or engineering controls to remove arsenic from foods.

A separate but related issue is the deliberate use of arsenic-based drugs in animal production. The consequences are the presence of inorganic arsenic in chicken meat,⁵ and the potential environmental contamination of soils and water by animal waste. Poultry research, however, has shown no differences in most indices of meat production following the use of arsenic-based drugs.⁸ Given the insufficient evidence on the benefits of arsenic-based drugs in chicken production⁸ and the concerns regarding human exposure to inorganic arsenic,¹ the FDA should consider limiting or banning their use in animal production.

Absent voluntary measures from food producers or regulatory initiatives by the FDA, federal or state legislation addressing dietary arsenic should be considered. Bills that are pending in Congress would require the FDA to set arsenic standards for rice and juice. In 2013, Maryland became the first state to ban most arsenic-based drugs from poultry production.⁹ Maryland's ban is important but insufficient. For reasons that are not clear, nitarsonsone was exempted from the Maryland law, although roxarsone, a very similar drug, was banned. And arsenic based-drugs are not banned in other states or countries.

Protecting the public from exposure to dietary arsenic requires many coordinated measures. Adequate surveillance systems for arsenic species in food are required, as are safety standards for rice, fruit juices, and other relevant foods. In addition, food production systems should minimize the presence of inorganic arsenic and its methylated metabolites. Raising public awareness is a first step toward long-term solutions that prevent dietary arsenic exposure.

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