Arsenic in drinking water

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Research, doi:10.1136/bmj.d2431

Increases mortality from cardiovascular disease

Arsenic has more effects on health than any other toxicant, and the list continues to grow, along with evidence that exposure is widespread throughout the world. Ingestion of inorganic arsenic in drinking water causes cancer of the skin, bladder, lung, liver, and kidney.[(1) (2)] Mounting evidence suggests that arsenic is also a cause of chronic respiratory disease,[(3) (4)] and adverse effects on reproductive outcomes and child development have also been reported.[(5) (6)] In the linked cohort study (doi:10.1136/bmj.d2431), Yu Chen and colleagues add to the evidence that arsenic in water increases mortality from cardiovascular disease with the findings of their prospective cohort study in Bangladesh.[(7)]

The first evidence of a link between cardiovascular disease and arsenic in drinking water came in 1980 from Antofagasta, Chile, with a report of 17 deaths from myocardial infarction in people under the age of 40.[(8)] Later, a comprehensive body of evidence from a series of studies in Taiwan starting in 1988 found that arsenic in water was associated with increased mortality from cardiovascular disease.[(9)] In 2007, cardiac effects including QT prolongation were shown to be associated with arsenic in drinking water in China.[(10)] In 2008, a 50 year study in Chile showed that mortality from acute myocardial infarction was the main initial cause of death attributable to arsenic in drinking water. This effect started about a year after exposure commenced and peaked at a mortality rate ratio of 1.48 for men (P<0.001) and 1.26 for women (P<0.001).[(8)] Increased mortality from myocardial infarction gradually decreased after exposure ceased, after which lung and bladder cancers became the main long term causes of death as a result of arsenic. In 2009, a prospective cohort study in Bangladesh of more than 115<thin>000 people reported a clear dose-response trend between increased concentrations of arsenic in water and increased mortality from cardiovascular disease.[(11)] For drinking water concentrations under 10 µg/L, 10-49 µg/L, 50-149 µg/L, 150-299 µg/L, and 300 µg/L or more, the mortality rate ratios were 1, 1.03, 1.16, 1.23, and 1.37, respectively (test for trend P=0.026).

Chen and colleagues' study adds important new evidence that arsenic increases mortality from ischaemic heart disease. In a prospective cohort study of 11<thin>746 people, they report a clear dose-response trend for mortality between ischaemic heart disease and arsenic concentrations in water—rate ratios were 1 in the reference group, but increased to 1.22, 1.35, and 1.92 as water concentrations increased (test for trend P=0.002).[7] They found a similar association with urine arsenic concentrations, making this the first study to use this biological marker to confirm exposure. This is also the first study to find evidence of synergy between smoking and arsenic. Non-smokers in the group who had high arsenic exposure had a rate ratio of 1.53 for mortality from cardiovascular disease (an imprecise estimate because of the small numbers), but for smokers the rate ratio was significantly increased to 3.45 (95% confidence interval 1.32 to 8.98).

Does all this matter? After all, the relative risk estimates reported here are moderate compared with those associated with outcomes such as bladder cancer and lung cancer, which often exceed 5. However, cardiovascular disease is the most common cause of death worldwide, so moderately increased relative risks mean very large numbers of excess cases. Also, exposure in utero and in children has a major effect on mortality in young adulthood,[6] including mortality from myocardial infarction.[8] More research is needed on the impact of early life exposure, and on the mechanisms that make arsenic so toxic.

In the meantime there is enough evidence to highlight a serious public health concern because exposure to groundwater containing arsenic is widespread throughout the world. Early research into the health effects of arsenic was largely limited to populations in Taiwan, Argentina, Mexico, and Chile and to areas with private wells in the United States. Many more countries can now be added to that list, which continues to grow. And arsenic poses far higher health risks than any other known environmental exposure, with about one in 10 people dying because of high concentrations of arsenic in water.[8]

Water contaminated with arsenic is tasteless, looks crystal clear, and boiling the water only concentrates the arsenic in it. In all parts of the world where groundwater is used for drinking, clinicians should therefore ask their patients where they obtain their drinking water. If it comes from a well, the next question should be whether the water has been tested for arsenic. If not, the patient should be urged to have it tested. It is too late to identify exposure after diseases caused by arsenic have been diagnosed, because many are fatal.

Competing interests: All authors have completed the Unified Competing Interest form at http://www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial

relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Provenance and peer review: Commissioned; not externally peer reviewed.

1 International Agency for Research on Cancer. *Some drinking-water disinfectants and contaminants, including arsenic*. WHO, 2004.

2 Yuan Y, Marshall G, Ferreccio C, Steinmaus C, Selvin S, Liaw J, et al. Kidney cancer mortality: fifty-year latency patterns related to arsenic exposure. *Epidemiology* 2010;21:103-8.

3 Smith AH, Marshall G, Yuan Y, Ferreccio C, Liaw J, von Ehrenstein O, et al. Increased mortality from lung cancer and bronchiectasis in young adults after exposure to arsenic in utero and in early childhood. *Environ Health Perspect* 2006;114:1293-6.

4 Von Ehrenstein OS, Mazumder DN, Yuan Y, Samanta S, Balmes J, Sil A, et al. Decrements in lung function related to arsenic in drinking water in West Bengal, India. *Am J Epidemiol* 2005;162:533-41.

5 Smith AH, Steinmaus CM. Health effects of arsenic and chromium in drinking water: recent human findings. *Annu Rev Public Health* 2009;30:107-22.

6 Vahter M. Effects of arsenic on maternal and fetal health. *Annu Rev Nutr* 2009;29:381-99.

7 Chen Y, Graziano JH, Parvez F, Liu M, Slavkovich V, Kalra T, et al. Arsenic exposure from drinking water and mortality from cardiovascular disease in Bangladesh: prospective cohort study. *BMJ* 2011;362:d2431.

8 Yuan Y, Marshall G, Ferreccio C, Steinmaus C, Selvin S, Liaw J, et al. Acute myocardial infarction mortality in comparison with lung and bladder cancer mortality in arsenic-exposed region II of Chile from 1950 to 2000. *Am J Epidemiol* 2007;166:1381-91.

9 Chen CJ, Wu MM, Lee SS, Wang JD, Cheng SH, Wu HY. Atherogenicity and carcinogenicity of high-arsenic artesian well water. Multiple risk factors and related malignant neoplasms of blackfoot disease. *Arteriosclerosis* 1988;8:452-60.

10 Mumford JL, Wu K, Xia Y, Kwok R, Yang Z, Foster J, et al. Chronic arsenic exposure and cardiac repolarization abnormalities with QT interval prolongation in a population-based study. *Environ Health Perspect* 2007;115:690-4.

11 Sohel N, Persson LA, Rahman M, Streatfield PK, Yunus M, Ekstrom EC, et al. Arsenic in drinking water and adult mortality: a population-based cohort study in rural Bangladesh. *Epidemiology* 2009;20:824-30.

Cite this as: *BMJ* 2011;342:d2248