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Evaluation of costs and benefits of a lower arsenic MCL—unprecedented high costs for uncertain benefits

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The United States Environmental Protection Agency (US EPA) has recently proposed a reduction in the arsenic maximum contaminant level (MCL; US EPA, 2000) that will affect many United States community water systems. These communities are primarily located in areas of the country with high naturally occurring arsenic in surface and ground water, such as New England and the western states. Because of the expense of removing arsenic and the large number of systems affected, the costs of compliance will range from $55 million to over $2 billion annually, depending on the standard adopted (AWWARF, 2000). Based on an epidemiological study of a poor, undernourished Taiwanese population exposed to much higher levels of arsenic than found in the United States, the EPA estimates that the revised arsenic standard of 10 µg/L (10 ppb) will save between 6.9 and 33 bladder and lung cancer deaths each year (US EPA, 2000).

The EPA agrees that the revised arsenic standard will be expensive. However, they argue that costs of removing arsenic from drinking water are justified by savings from medical treatment and the value of avoiding cancer and premature death. The EPA estimates that each bladder cancer prevented will save $179,000 in health care costs over the duration of the disease (US EPA, 2000). The EPA also estimates that the average American is willing to pay $536,000 to avoid a nonfatal case of bladder cancer (US EPA, 2000). Based on willingness-to-pay models, the EPA estimates that the average American will pay $373,516 in 1999 dollars for each year of life added or year of premature death prevented.

The willingness-to-pay estimates are not constrained by an ability to pay. Furthermore, the estimates of willingness-to-pay for a year of life added have never been validated. In health care and public health, cost-effectiveness of an intervention is based on years of life gained and the costs to achieve that gain. For example, if a $500,000 intervention avoids death for a young person, there are many years of life added to offset the cost. On the other hand, spending the same $500,000 to delay death in an old person will cost more per year of life gained because there are fewer expected years of life remaining. An evaluation of the cost-effectiveness of medical treatment is typically based on the cost of the treatment compared to the expected number of years of life the treatment will add. If the number of years gained is sufficient to offset a cost of $50,000 per year of life gained, then the treatment is recommended (Goldman et al., 1991; O'Brien et al., 1997; Kjekshus and Pedersen, 1997; Maini, 1999; Johannesson et al., 1997; Kerlikowske et al., 1999; Pickin et al., 1999; and Smith and Hillner, 2000).

We evaluated the national cost-effectiveness of the proposed revised arsenic MCL by calculating the costs per year of life gained. We used EPA's estimated benefits of lung and bladder cancer deaths avoided (US EPA, 2000; Table 1) and used cost estimates for water treatment to remove arsenic developed by the American Water

TABLE 1—Incremental annual costs and benefits for revising the arsenic MCL from the present standard of 50 µg/L (50 ppb) to 3 µg/L (3 ppb).

MCL change (µg/L)	Estimates of additional annual costs for the MCL change ($M/yr) (AWWARF estimates)	Additional cancer deaths per year prevented by revising the MCL (EPA estimates)*: Bladder cancer	Lung cancer	Both
50 to 20	$55 M	1.0 to 3.0	2.0 to 15.0	3.0 to 18.0
20 to 10	$550 M	1.3 to 2.5	2.6 to 12.5	3.9 to 15.0
10 to 5	$855 M	1.9 to 3.9	3.8 to 19.5	5.7 to 23.4
5 to 3	$1370 M	1.5	3.0 to 7.5	4.5 to 9.0

*The 10th and 90th percentile of deaths prevented.
AWWARF = American Water Works Association Research Foundation.

TABLE 2—Incremental deaths prevented and cost per death prevented for revising the arsenic MCL.

MCL (µg/L)	Additional bladder and lung cancer deaths prevented	Cost per death prevented for MCL revision (AWWARF cost estimates)†
50 to 20	3.0 to 18.0	$3.1 to 18.3 M
20 to 10	3.9 to 15.0	$36.7 to 141.0 M
10 to 5	5.7 to 23.4	$36.5 to 150.0 M
5 to 3	4.5 to 9.0	$152.2 to 304.4 M

†Estimates of additional annual costs for the MCL change (from Table 1) divided by additional deaths prevented.

TABLE 3—Incremental compliance cost estimates and costs per year of life added from revising the arsenic MCL.

MCL (µg/L)	Medical intervention costs[a]	Water treatment costs minus medical costs[b]	Additional years of life added[c]	Costs per year of life added for this reduction: Lowest[d]	Highest[e]
50 to 20	$6.4 M	$48.6 M	42–252	$192,857	$1,157,143
20 to 10	$5.4 M	$544.6 M	54.7–210	$2,593,333	$9,974,359
10 to 5	$8.4 M	$846.6 M	79.8–327.6	$2,588,991	$10,609,023
5 to 3	$3.2 M	$1366.8 M	63–126	$10,847,619	$21,695,238

a Medical costs averted assuming each cancer death would cost $179,000 to treat for the duration of their illness and that the number of cancer cases is twice the highest number of total estimated arsenic-related cancer deaths for both bladder and lung cancer as reported in Table 1.
b Water treatment compliance costs from Table 1 minus medical treatment costs
c The 10th and 90th percentile of years of life saved for the entire US from the number of bladder cancer deaths that the EPA model predicts would be saved and assuming a range of from 2 to 5 lung cancer deaths for each bladder cancer death and that each death results in 13 yrs of life lost.
d Based on the maximum number of years of life saved divided by the incremental costs in Table 1 minus the savings from averted medical treatment. These results do not reflect discounting over the latency period.
e Based on the minimum number of years of life saved divided by the incremental costs in Table 1 minus the savings from averted medical treatment.

Works Association Research Foundation (AWWARF, 2000; Tables 1, 2, and 3). We used National Cancer Institute data on the average age at death from bladder cancer (i.e. 77 yrs) and lung cancer (i.e. 70 yrs; Ries et al., 2000). We assumed that if the death was avoided, the person would continue to live the life expectancy of the average person their age (i.e. 15 additional years for lung cancer, 11 additional years for bladder cancer; Ries et al., 2000). We subtracted the cost saving from averted medical treatment from the cost of compliance. We then calculated the marginal costs per year of life saved by reducing the MCL from 50 µg/L to 20 µg/L, from 20 µg/L to 10 µg/L, from 10 µg/L to 5 µg/L, and from 5 µg/L to 3 µg/L. For example, we found that the cost per year of life gained from reducing the arsenic MCL from 20 µg/L to 10 µg/L ranges from $2.6 million to $9.9 million (Table 3). The marginal costs for lowering the standard from 10 µg/L to 5 µg/L are similar. These values are considerably higher than the $50,000 standard used for other public-health and medical-treatment interventions.

There are uncertainties associated with both the estimated benefits and the costs. The uncertainties in the cost of water treatment relate to new or undeveloped technology to remove arsenic. Most of the uncertainties in the cost of water treatment, to solve unanticipated problems, will tend to raise rather than lower treatment costs. The uncertainties associated with the benefits relate to the EPA's assessment of the magnitude of cancer risks for the United States. Has the EPA used the correct mathematical model to extrapolate risks to the low levels of waterborne arsenic seen in the United States, and how do nutritional and other differences between United States populations and Taiwanese populations affect the risk assessment? If our evaluation is correct, the benefits are greatly overestimated.

The EPA based their risk estimates on human studies conducted primarily in Taiwan (Tseng et al., 1968) and, to a lesser extent, studies in Argentina (Hopenhayn-Rich et al., 1996) and Chile (Smith et al., 1998). These studies found that chronic ingestion of inorganic arsenic causes bladder and lung cancer as well as skin cancer. However, the National Research Council (NRC) review of the arsenic health effects studies noted that "With minor exception, epidemiological studies for cancer are based on populations exposed to arsenic concentrations in drinking water of at least several hundred µg/L. Few data address the degree of cancer risk at lower concentrations of ingested arsenic" (NRC, 1999). Recent research has increased the level of uncertainty about arsenic-related health risks in United States populations exposed to waterborne arsenic at levels less than 50 µg/L. Studies conducted in the United States and Europe (Lewis et al., 1999; Bates et al., 1995; Burchet and Lison, 1998; and Kurttio et al., 1999) give results that are not consistent with the health risks predicted from the Taiwan and with results of South American studies (Tseng et al., 1968; Hopenhayn-Rich et al., 1996; and Smith et al., 1998). There is currently no evidence of elevated cancer risks in United States or European populations exposed to waterborne arsenic at levels two to four times higher than our current standard.

There are a variety of methods that could be used to extrapolate risks for low dose arsenic exposure, and there are few data to help determine which model is correct. The EPA uses a nearly linear model to estimate the risk at low doses. This means that the risk at 50 µg/L is approximately half that of 100 µg/L. EPA admits that there is uncertainty about which extrapolation model to use. The National Academy of Science panel that reviewed the arsenic standard estimated risks that were approximately ¼ the EPA's risk estimates. EPA noted in their background document that most of the data on modes of action for how arsenic causes cancer suggest that the true risk is likely to be much lower than what their model predicts (US EPA, 2000). We believe that the true risks and benefits from the revised arsenic MCL are likely to be lower than the EPA predicted. If the true risks are only ¼ that of the estimated risks, in the range of the NRC estimate, then the costs per year of life gained by reducing the MCL from 20 µg/L to 10 µg/L could be $738 million. This estimated benefit is scientifically more plausible because it better agrees with the nonlinear relationships between dose and effects seen in laboratory studies (US EPA, 2000).

The EPA assumed that the public-health benefits begin on the day the standard is announced. More likely, the benefits, if any, will be delayed for many years. Using standard economic discounting techniques the cost-effectiveness increases dramatically, by much more than 10 times the original cost estimate. This increases the cost per year of life saved by reducing the MCL from 20 µg/L to 10 µg/L to more than perhaps $7.4 billion. This is about $20 million for each day of life gained or enough to fund more than 400 yrs of life gained from cost-effective medical and public-health interventions.

The justification for spending from $10 million to $7 billion per year of life gained from an uncertain waterborne arsenic risk is unclear. The EPA does not address the large disparity between acceptable costs per year of life gained from the revised arsenic MCL compared to other medical treatment or public-health screening programs. An argument often used is that an environmental risk, such as that possibly posed by a drinking-water contaminant, is involuntary and should be corrected, even though the costs are relatively high. However, most of the risks addressed by public-health and medical treatment are not voluntary. Exposure to many health-risk factors for diseases such as breast cancer or diabetes is typically beyond our control.

Another oft-heard argument is that people are willing to pay more to prevent a premature death from cancer than from heart disease or diabetes. However, acceptable costs for cancer screening and treatment are not different from acceptable costs for heart disease or diabetes screening and treatment. Furthermore, those who have disabilities from premature heart disease or diabetes would likely not agree that a greater emphasis should be placed on cancer prevention and treatment.

We believe that environmental policy makers and scientific panels considering drinking-water regulations should use similar criteria for the quality of evidence as well as the costs per life saved as is used in evaluating medical treatment and screening. Levels of evidence have been formalized to assist practitioners in evaluating the validity of evidence about therapeutic and preventive procedures. In this system, randomized clinical trials are the gold standard. The types of epidemiological studies used to justify the change in the arsenic MCL are generally considered lower levels of evidence. Although a few cohort and case-control studies have been conducted, the EPA has relied primarily on ecological studies that are the least informative about risks. Furthermore, there is a high level of uncertainty about causal inferences for low exposures to waterborne arsenic because studies in United States and European populations with relatively low exposures to waterborne arsenic have not confirmed risks predicted from ecological studies (Smith et al., 1992).

Although the epidemiological evidence is weaker than required for medical interventions, EPA's actions are based on significantly higher costs. The costs per year of life added for the revised arsenic MCL are significantly higher than the costs of other public-health and medical interventions. For medical interventions, the cost-to-benefit criteria of $50,000 per year of life added is often used. Although Americans may be willing to pay more, we may not be able to afford higher pharmacy and medical-treatment costs that would result from raising the criteria. Alternatively, the public may be willing to pay thousands of times more for a year of life gained from revising the waterborne arsenic MCL than they are willing to pay for other medical and public-health interventions. Their willingness-to-pay may not be influenced by the uncertainties of either the risks or the benefits. But, the costs of such interventions can quickly consume a significant fraction of our national income. At a cost of $7 billion per year of life added, the entire gross domestic product of the United States could purchase fewer than 1,300 yrs of life for the nation. The proposed arsenic MCL has raised important public policy issues. How these issues are addressed will have significant economic consequences for the nation and may influence future environmental policy decisions. Before making a costly public-health decision, additional information is needed to improve our confidence in what the benefits will accrue. The public should also have a chance to be informed about the costs and the benefits, as well as the uncertainties about those benefits. If a standard of 10 µg/L is adopted, there are no health data to suggest that this level is more reasonable than 20 µg/L, 5 µg/L, or 3 µg/L, the other alternative standards considered.

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