High-Risk Economics:
Gambling on Cost-Benefit Analysis for Arsenic Standards

Dr. Frank Ackerman[1]

The Global Development And Environment Institute at Tufts University filed the following public comment on the Environmental Protection Agency Report "National Primary Drinking Water Regulations; Arsenic and Clarifications to Compliance and New Source Contaminants Monitoring; Proposed Rule" released on June 22, 2000. This report came as a result of the findings of the National Research Council, published in an EPA-commissioned study, which stated that the current permissible levels of arsenic in drinking water were too high. The NRC said that the known health effects of arsenic justified the adoption of a new standard. EPA's proposed new arsenic standard is currently being reviewed before a final rule is proposed. The regulations are being contested by a number of organizations, including the Natural Resources Defense Council.

A recent law required EPA to perform a cost-benefit analysis of the proposed new regulation. The law stated that the agency may (but is not required to) use that analysis as the basis for setting new standards. Both supporters and opponents view the arsenic study as a test case for the broader use of cost-benefit analysis in environmental regulation. The following comment addresses the misuse of cost-benefit analysis in this and similar cases.

Under the 1996 Safe Drinking Water Act (SDWA) Amendments, EPA was legally required to perform a cost-benefit analysis of the proposed regulations for arsenic in drinking water. In view of the quality of the analysis that was performed, it is fortunate that EPA is *not* required to use it in setting its arsenic standard. The law says EPA "may" adopt a standard less stringent than what is feasible if it finds the less stringent level "maximizes the health risk reduction benefits at a cost that is justified by the benefits." (See SDWA §1412(b)(6)(A)). The agency is free to say - and should say - that although there are enormous health benefits, many of them cannot be quantified with certainty and therefore the cost-benefit analysis does not provide a basis for weakening the standard below what is economically and technologically feasible.

A multitude of problems, primarily in the incomplete and unreliable estimates of benefits, make the EPA's arsenic cost-benefit calculations meaningless and misleading. If cost-benefit analysis is to be used, a different approach would produce a more direct, less ambiguous estimate of benefits.

---

[1] Research Director, Global Development and Environment Institute, Tufts University, Medford MA 02155, e-mail fackerma@tufts.edu. Thanks to Eliza Waters for research assistance in preparing these comments.

However, cost-benefit analysis is not required for coherent, rational regulation. Traditional regulatory approaches based on the technologically feasible levels of health risk minimization—as embodied in the SDWA for over 25 years—provide a sound guide to decision-making in this case. The lowest feasible level (3 ppb) can be achieved at moderate cost on an aggregate basis; the principal obstacle is the distribution of the cost burden, particularly its impact on smaller communities. This distributional problem should not drive the outcome of the regulatory process.

When is Cost-Benefit Analysis Appropriate?

Cost-benefit analysis is an attempt to extend the efficiency of private markets to a broad class of public decisions. In a private-sector market transaction, the benefits to the buyer are automatically compared to the costs to the seller; no sale takes place unless the buyer's valuation of the benefits is at least as great as the seller's valuation of the costs. No statistical studies, planning, or regulation are required; decentralized trading based on market prices is all that is involved. In an idealized, perfectly competitive economy with no environmental or social problems, private market transactions would ensure that every resource is used where it produces the greatest social benefit, and every worker is employed in the most valuable, best-paid occupation for which he/she is qualified.

In reality, many public sector decisions involve costs or benefits that are not normally valued by the market. Cost-benefit analysis attempts to "fill in the blanks", producing monetary values for each of the costs and benefits of a project or policy. Then a market-like decision can be made: carry out the project if the total benefits are at least as great as the total costs, but not otherwise. An aura of neutral objectivity surrounds the process: who could object to proceeding if benefits are greater than costs, or to canceling a project if the costs are greater?

Nonetheless, there are important objections to the process, as a review of the arsenic cost-benefit analysis will make clear. In general terms, there are three categories of problems that limit the applicability of cost-benefit analysis.

First, some decisions are not appropriately made on the basis of weighing costs and benefits. Suppose that studies showed that the benefits exceeded the costs for child labor, or for selling the national parks to developers, or for selling votes on election day. It is not only that these activities are illegal; if they were up for debate, few people would propose that cost-benefit analysis was the right way to make the decisions about such issues. That is, there are matters of rights and morality that are not subject to cost-benefit analysis, nor to market decisions.

The delineation of the respective spheres of morality and of markets is itself a contentious issue. For example, do people have the right to be free of involuntary, preventable exposure to carcinogens such as arsenic? Or is the control of carcinogens a market-like decision, appropriately governed by cost-benefit analysis?

Second, cost-benefit analysis presumes that it is possible to develop comparable, complete estimates of both the costs and the benefits. Yet the situation is often asymmetrical. The costs of environmental protection consist largely of well-documented, market prices of pollution control hardware, infrastructure investment, and the like. The benefits frequently include improvements in human health and the natural environment, which are intrinsically unpriced. Efforts to construct artificial market prices for health and environmental benefits are not always successful, as seen in the arsenic analysis.

Particularly problematical are the attempts to deduce a universal monetary value for life and death - the "value of a statistical life" - and for major, chronic illnesses. These outcomes are nothing like marketed commodities; they do not have meaningful prices independent of the context in which they occur. In practice, the unsuccessful pursuit of universal values for life and health means that some benefits are priced by wild guesses and extrapolations that do not withstand scrutiny. Other benefits are simply omitted from the analysis, effectively pricing them at zero. The result is that cost estimates are "hard" numbers and relatively complete, while benefit estimates are soft and quite incomplete. Comparing the two is, if not apples and oranges, perhaps apples and applesauce.

Since the costs are more likely to be complete than the benefit estimates, reliance on cost-benefit analysis will create a bias toward rejection of proposals for environmental protection. If complete benefit calculations were available, who knows how many more proposals would be accepted? The errors in the process are not randomly distributed, but consistently tilt toward understatement of benefits, and consequently lend exaggerated support to reduction in regulation.

Third, the comparison of total costs and total benefits implicitly assumes that there are no problems of distribution. The economic theory underlying cost-benefit analysis relies on the idea that if the benefits of a project exceed the costs, the winners could potentially compensate the losers and make everyone better off. Yet as critics have often pointed out, this is of little comfort to the losers unless the compensation actually occurs. A project that made the rich much richer and the poor a little poorer might pass the cost-benefit test - but if the rich then decide not to compensate the poor for their losses, are we sure that the project is desirable?

The distributional issue that arises in the arsenic analysis concerns the unequal burden of costs on the affected communities. In the smallest rural systems the annual costs per household are more than 100 times greater than in the largest metropolitan areas. How much arsenic reduction is affordable? The answer depends entirely on the distribution of the costs, as discussed in more detail in the next section.

Costs of Arsenic Reduction

The costs of reduction from the current standard of 50 ppb to four different levels of arsenic - 20, 10, 5, and 3 ppb - are calculated in impressive detail. Many different technologies are examined, and cost estimates are developed for application of each technology to water systems of varying sizes. There is no problem of economic valuation here; water purification technologies are matters of buying, installing, and operating equipment that has well-defined market prices.

In the aggregate the costs are quite modest: the annual costs of achieving the lowest feasible level are $643 - $751 million, or roughly $2.35 - $2.75 per capita nationwide. The incremental cost of moving from the EPA's recommended 5 ppb to the lowest feasible level, 3 ppb, are $266 - $311 million, or about $0.95 - $1.15 per capita.

It is difficult to imagine that costs of this magnitude represent an economic burden. In a country as wealthy as the U.S., especially one with a budget surplus and an active debate about how large the next tax cuts should be, there is no question about whether the costs of arsenic reduction are affordable. If it were a line item in the federal budget, the nationwide cost of achieving the lowest feasible level of arsenic would barely be noticed. Much more has often been spent on programs with much less important benefits.

No new federal expenditure on arsenic reduction, however, is being proposed. (Several existing programs already provide loans and grants to help communities with water treatment upgrades.) The costs of arsenic reduction appear large enough to worry about only because they are assumed to be the local responsibility of the affected communities.

Costs are steeply graduated by size of water systems: the very biggest metropolitan systems affected by new standards, namely Los Angeles, Phoenix, and Houston, face per capita costs similar to or lower than the national averages cited above. At the other extreme, water systems with 500 or fewer customers face much higher costs: at 3 ppb there are 460,000 affected households in such systems, with annual costs of $280 per household. At 5 ppb there are only 288,000 households facing similar costs. (Stricter standards are more expensive primarily because more systems are affected; the cost per affected household varies only slightly with the level of the arsenic standard.)

The small systems include only a tiny fraction of the affected population: at 3 ppb, there are more than 11 million affected households in systems of up to one million customers, plus another 7 million people in the Los Angeles, Phoenix, and Houston water systems. And the potentially burdensome small-system costs are a tiny fraction of the total. At 3 ppb, if the federal government picked up the tab for all costs in all systems in excess of $100 per household, the total federal expenditure would be a mere $85 million, or 30 cents per capita nationwide.

EPA has determined that the smallest systems do not quite qualify for waivers; a cost of $500 per household is suggested as a point at which waivers would be considered. Even in the smallest systems, with under 100 customers, the costs only reach $368 per household at 3 ppb. However, detailed reporting of the costs for small systems creates the impression that arsenic reduction imposes a significant economic burden - which it does not for metropolitan areas, or for the nation as a whole.

There are several possible public policy responses to this set of facts:

A) Perhaps federal funding is needed for all arsenic reduction, or (for a truly minimal expenditure) just for the excess above a threshold cost per household in small systems.

B) Perhaps the EPA's threshold of $500 per household for waivers is too high, and the very smallest water systems need waivers from new arsenic regulations.

C) Perhaps the health benefits justify a requirement that forces the smallest water systems to spend $300 or more per household. As the arsenic reduction costs show, there are real diseconomies in operating such small systems, and they could often save money by consolidating with neighboring systems.

The least sensible response is unfortunately the one that is pursued in the cost-benefit analysis:

D) Perhaps the well-defined costs of arsenic reduction should be compared to incomplete and insubstantial estimates of the value of the health benefits, to find out how much arsenic reduction is worth paying for.

Arsenic Reduction Benefits

A lower level of arsenic in drinking water means that fewer people will die from cancer and other diseases, and fewer people will suffer through years of painful, incapacitating illnesses. This is the great benefit of arsenic reduction, the reason why the costs of arsenic control are being incurred. The benefits of reduction are inherently non-monetary, involving the length and quality of human life. Yet the logic of cost-benefit analysis requires a number: how much, in dollars, are the health benefits worth?

Monetizing human life and health is an ethically controversial and technically challenging process at best. Unfortunately, the EPA's arsenic cost-benefit analysis does not rise to the challenge. It falls far short of producing reasonable estimates for policymaking purposes, both in what it includes and in what it excludes. The problem is not primarily in the uncertainty regarding the incidence of disease and death, a subject which is examined in great quantitative detail. The greater problem is that the scientific uncertainties are compounded by reliance on casually developed, barely justified estimates of the economic value of health impacts.

Specifically, the cost-benefit analysis rests on implausible economic assumptions in three areas : the assignment of dollar values to deaths from bladder and lung cancer, to non-fatal bladder cancers, and to all other health outcomes. These areas are discussed in the next three sections; the final sections then draw conclusions about the state of the analysis and the implications for regulation of arsenic.

Death, Be Not Priced

Life and death are rarely thought of in monetary terms. Protecting human life is a moral and legal obligation; the penalties for murder are not financial. Yet the financial value of death due to polluted drinking water is a crucial component of this cost-benefit analysis. In putting a price on human life, it is difficult to use the technique favored by economists for valuing externalities, namely asking people about their “willingness to pay” (WTP) to avoid damages. “How much would you pay to avoid the death of someone you love?” is a meaningless or hostile question, and would be likely to get meaningless or hostile answers.

Is it logical, in any case, to think that there is a single value for a human life? Despite the common fact of finality, it is not the case that all deaths are equivalent or interchangeable. Death on the job, when a coal mine collapses or a fishing boat sinks, is judged differently from death caused by skiing or other risky, voluntary recreation. Our response to a death may depend on the age and health of the person who dies. And there must be a different meaning to sudden, accidental death during an enjoyable activity, as opposed to agonizing, slow deterioration surrounded by medical equipment.

The deaths at issue in this case, as in many environmental regulations, result from involuntary exposure to a pollutant that cannot be detected without laboratory equipment. They are likely to be slow, painful deaths, accompanied by substantial dread and physical and emotional suffering on the part of the afflicted person and their family, and controlled and surrounded by medical bureaucracies. These factors should raise the valuation: if there is a meaningful monetary price of life and death, it should be higher for involuntary and painful deaths. On the other hand, the people affected are often (not always) older, which some economists might argue should lower the valuation (an argument that essentially holds that old peoples' lives are less valuable than young peoples' lives, an approach that we and others would consider morally repugnant).

The valuation of life used for the arsenic cost-benefit analysis is not based on deaths due to pollution of any sort. Rather, it rests largely on inferences about the wage differentials required to attract workers to risky jobs. A 1992 review of 26 “mortality valuation estimates” (Viscusi 1992) produced an average guess at the value of life; updated for inflation, it was used in an extensive cost-benefit analysis of the Clean Air Act (EPA 1997). The same estimate, further updated for inflation, amounts to $6.1 million in 1999 dollars, the figure used in the arsenic analysis.

Use of this particular estimate is problematical on several levels. Of the 26 studies, 21 were labor market, or wage-risk studies. Such studies look at the wages paid for similar jobs with slightly different risks of death on the job. If jobs A and B are comparable in all other ways, but the risk of death is 1 in 1000 greater for A than for B, then the value of a life is said to be 1000 times the wage difference between A and B. Under a series of unrealistic economics textbook assumptions, wage-risk estimates are conceivably applicable to other causes of death, such as cancer due to arsenic.

A fundamental problem is that wage-risk studies extrapolate from small changes in the probability of death to the value of an actual death. Yet as the economist Thomas Schelling said,

> A difficulty about death, especially a minor risk of death, is that people have to deal with a minute probability of an awesome event, and may be poor at finding a way - by intellect, imagination, or analogy - to explore what the saving is worth to them. (Schelling 1993)

Even if people could reliably estimate the value of small risks, there is no firm logical basis for extrapolation from these risks to the value of a death, as E.J. Mishan observed in a classic text on cost-benefit analysis:

> The implied assumption of linearity, which has it that a man who accepts $100,000 for an assignment offering him a four to one chance of survival will agree to go to certain death for $500,000, is implausible to say the least... [I]t would not surprise us to discover that, in ordinary circumstances, no sum of money is large enough to compensate a man for the loss of his life. (Mishan 1988, pp. 335, 337)

Mishan argued that there is no meaning to the value of a statistical life, divorced from the particular policy that increases or decreases risk. In his opinion, cost-benefit analysis should be based on direct measures of the public's willingness to pay for specific projects and policies, not on indirect inferences about the monetary value of life and health. This option is discussed further in a later section, below.

Wage-risk analysis relies on more specific assumptions as well. It makes the unlikely assumption that workers are perfectly informed about the relative risks of different jobs and choose jobs rationally on that basis, weighing wage gains against safety concerns. Wage-risk analysis also assumes that the workers considering dangerous occupations, largely blue-collar men, are typical of the population as a whole in their valuation of risk and safety. On the contrary, those who enter the most risky occupations are likely to have a higher than average tolerance of risk - implying that the rest of us might place a greater value than they do on reducing the risk of death.

The use of increasingly dated wage-risk analyses assumes that the value of life does not change, except for keeping up with inflation, over the course of decades. The latest of the 26 individual studies was published in 1991, and the earliest in 1974; most are based on wages and job choices in the 1970s and 1980s, when economic conditions were distinctly different and many workers were worried about losing their jobs. These labor market conditions would tend to depress the premium required for risky jobs. There is no reason to think that the same wage-risk studies would produce the same answers, simply corrected for inflation, if they were repeated today. Under the current conditions of very low unemployment, would a much larger wage differential be required to draw workers into dangerous jobs? If so, does the value of a life rise every time the unemployment rate falls, and vice versa? It would be more sensible to conclude that wage-risk analysis fail to produce a stable, reasonable estimate of the value of a life.

In short, the crucial figure of $6.1 million per life is a dated (though inflation-adjusted) estimate of what was once required to attract workers into dangerous occupations. This number is applicable to the cost-benefit analysis of arsenic regulation only if we assume that the workers in question were perfectly informed, economically rational, and typical of the whole population, and that nothing has changed in the last twenty years except inflation, and that deaths on the job and cancer deaths caused by arsenic should be valued identically. And, of course, we have to assume that it is ethically acceptable and logically meaningful to place a single monetary value on human life and death, based on extrapolation from responses to small changes in risk.

There are numerous grounds, in other words, for questioning the relevance of the $6.1 million estimate of the value of a life. Assuming for the moment that there is a meaningful and morally acceptable way to calculate the value of a statistical life (and the pain and suffering that accompanies its end), EPA's estimate is a substantial underestimate of the value that most people would place on avoiding a slow and painful death of cancer caused by involuntary exposure to arsenic. This is particularly so when involuntary exposure of one's children to this toxin is considered.

New Diseases For Old

In addition to deaths, there are important non-fatal health effects of arsenic. Bladder cancer, the best-documented health effect of arsenic exposure, has a mortality rate of 26%, implying that about three-fourths of bladder cancer victims will survive. The valuation of serious, non-fatal illnesses such as bladder cancer is therefore a key part of the cost-benefit analysis.

Unfortunately, economists have not directly addressed the valuation of non-fatal bladder cancer, nor any other non-fatal cancers. In the absence of any appropriate studies, the cost-benefit analysis adopts an estimate that was developed for a very different disease. The only argument offered for this procedure is that it has been used before, and that nothing better was available.

A research team led by Kip Viscusi, the same economist who estimated the value of a life, published an estimate of the value of a case of chronic bronchitis, based on interviews in a shopping mall in Greensboro, North Carolina in 1990 (Viscusi et al. 1991). It is a study of the willingness to pay (WTP) to avoid bronchitis, based on indirect inferences about WTP. Such inferences were considered necessary because the researchers considered it unlikely that most people could meaningfully answer the question, "How much would you be willing to pay to avoid a case of bronchitis?" Instead, survey respondents were asked to weigh small increases in income against small increases in the risk of a serious case of bronchitis, with the symptoms described in detail.

However, it is still not obvious that people can give meaningful answers to such questions. Outside of the economics profession, the "contingent valuation" survey technique for valuing nonmonetary health and environmental impacts, used by Viscusi et al., remains controversial. A *Harvard Law Review* editorial on the subject was titled, "Ask a Silly Question..." (Harvard Law Review 1992)

The possibility that economists may have asked a silly question is suggested by the extraordinarily wide range of responses that they receive. As often happens in WTP surveys, Viscusi et al. received many answers which they considered too extreme to be relevant. (No serious consideration is given to the alternative possibility, that a significant number of people understand and dislike the questions, and actually hold extreme views on the answers.) The standard deviation of the individual valuations was greater than the mean, reflecting a rather complete lack of consensus. An average valuation of bronchitis was, nonetheless, extracted from this field of disagreement.

What we know, therefore, is that among several hundred people at a mall in Greensboro in 1990, there was a wide range of opinions about the valuation of chronic bronchitis, as inferred from their responses to small trade-offs of income vs. health risk. We know nothing about whether Greensboro is typical of the nation as a whole in its valuations, whether valuations have changed since 1990 (other than to keep up with inflation), or whether people in Greensboro or anywhere else consider the symptoms of bladder cancer to be more or less serious than the very different symptoms of bronchitis.

Use of the 1990 Greensboro bronchitis valuation to represent bladder cancer nationwide in 2000 and beyond can charitably be described as grasping at straws. It is not remotely close to the level of scientific rigor that is seen throughout the natural science, engineering, and public health portions of the arsenic analysis. No public policy decisions should be based on such flimsy and inappropriate valuations.

Out of Price, Out of Mind?

No one has suggested that bladder cancer is the only serious health effect of arsenic. Regulation of arsenic levels is important because arsenic can cause a wide range of cancers and other diseases. Yet the cost-benefit analysis comes close to dismissing all effects other than bladder cancer. No other effects are valued in detail. Of the other effects, only lung cancer receives any monetary valuation, and it is expressed in a tentative, "what-if" manner, with upper bounds more than ten times the lower bounds. (Since lung cancer is almost always fatal, the valuation is directly derived from the value of a life.)

Even worse than the uncertainty surrounding the valuation of lung cancer is the treatment of other health impacts. They are simply ignored in the cost-benefit calculations, in effect giving them a valuation of zero. They are acknowledged in the text only by frequent reminders to the reader that the cost-benefit analysis is incomplete because it fails to value all the known health problems that result from arsenic. Needless to say, such reminders, if taken seriously, limit the value of the entire cost-benefit exercise.

How strong is the evidence for the other health effects? Of ten key studies of the effects of arsenic, nine found evidence of bladder cancer, seven for lung cancer, and five for kidney cancer and liver cancer (NRC 1999). Thus the argument for including estimates for kidney and liver cancers is almost as strong as for lung cancer. Non-cancer health problems associated with arsenic include several types of cardiovascular, pulmonary, immunological, and neurological effects. There is very little data on the magnitude of these effects, especially at low levels of arsenic. However, it seems unlikely that zero is the correct valuation for kidney cancer, liver cancer, and all the non-cancer health effects.

The cumulative effect of the various health problems could be quite significant. As the introduction to the NRC report says, "Because some studies have shown that excess lung cancer deaths attributed to arsenic are 2-5 fold greater than the excess bladder cancer deaths, a similar approach for all cancers could easily result in a combined cancer risk on the order of 1 in 100." (NRC 1999: 8). This is far in excess of EPA's standard accepted risk range of 1 in 10^{-4} to 1 in 10^{-6}. A cost-benefit analysis that ignores some forms of cancer tends to hide this crucial conclusion, and thereby downplays the health risks that are at stake.

Is There an Alternative?

It is possible, though difficult, to do a better job of cost-benefit analysis, even within the same methodological framework. The EPA's analysis of the costs and benefits of the Clean Air Act (EPA 1997) goes into much greater detail, identifying several categories of measurable benefits and applying several types of evidence in the attempt to monetize the gains from clean air.

That analysis, however, was a massive undertaking, with substantial time and budget requirements. Even so, it failed to resolve the crucial dilemmas about the valuation of life and health. At the end of its review of the estimated value of a life, the Clean Air Act analysis observes that there are two major sources of uncertainty for the monetary benefits. The first is "uncertainty about the avoided incidence of health and welfare effects" deriving from air pollution, and the second is "uncertainty about the economic value of each quantified health and welfare effect." (EPA 1997) That is to say, first, we don't know with certainty how many health problems are avoided by clean air; and second, we don't know how much each avoided health problem is worth. The benefit valuations are the products of these two uncertain numbers, and as a result have a wider range of uncertainty than either number by itself. (The uncertainties discussed here are relevant because the estimated value of a life in the arsenic analysis was taken directly from EPA 1997, updated only for inflation.)

One might reasonably object that regulators will rarely get the time and budget required for a study on the scale of the Clean Air Act analysis - especially since crucial uncertainties still plague even a study of that magnitude. Cost-benefit analysis done under ordinary budget pressures will inevitably lead to cutting corners and sometimes using out-of-date or inappropriate approximations, in the style of the arsenic study. But this is no defense of the methodology; rather, it is a reason to reconsider the commitment to the use of cost-benefit analysis for regulatory purposes.

Imagine that an engineer involved in building pollution controls - items on the cost side of the analysis - reported that he could not find the current prices of several needed pieces of equipment. Instead, he planned to estimate the price of a pump as being equal to the price for which a different style of electric motors was selling ten years ago in one small city in another region (adjusted for ten years of inflation, of course). Meanwhile, the price of filters was so uncertain that he felt it was more prudent to leave it out of the budget entirely. This would be ludicrously unacceptable as an approach to construction costs, yet it is exactly what has been done in the valuation of the benefits of arsenic reduction.

One of the great strengths of a market economy is that it provides information about the current prices of goods and services, in a decentralized, constantly updated manner, with almost no information costs. If you need to know the price of a pump, there is no need to contrive estimates based on ten-year-old scraps of information about a different kind of equipment; pump manufacturers will be happy to tell you today's price. Decisions made on the basis of such prices are typically well-informed and efficient, as least as regards the use of resources that have market prices.

Cost-benefit analysis holds out the hope of extending that efficiency and precision to decisions that affect unpriced health and environmental benefits. Its advocates hope that it could simplify regulatory debate through the application of a clear, consistent, market-like standard. All that is needed, it appears, is an estimate of the market value of health and environmental impacts. But that information is not available on a costless, constantly updated basis. No one is in the business of telling you the current value of a life, nor even the value of a case of bronchitis or bladder cancer.

As we have seen, there are good reasons to doubt the existence of a single value of a life, independent of the context in which that life is lost or saved. And there are no good reasons to think that all chronic diseases are the same, or that bladder cancer is equivalent to bronchitis. Lacking meaningful numbers for the value of life and health, there will be a constant temptation to use inappropriate estimates in order to speed up and simplify the analytical process.

If cost-benefit analysis is to be used in setting environmental standards, a different approach is needed. As suggested by E. J. Mishan, a direct, project-specific analysis might avoid many of the problems: why not describe the expected health benefits of arsenic reduction and ask a representative sample of people how much they are willing to pay (or have the federal government pay) for those benefits? Such a survey would still need to be performed and analyzed with care, but it would eliminate the troubling step of forcing everyone's answers into the ill-fitting mold of consistent values for death and for chronic disease.

While this methodology would be an improvement, cost-benefit analysis is not an indispensable ingredient in the process of setting health and environmental standards. Traditional methods of regulatory decision-making, based on comparison of estimated levels of risk and technically feasible levels of control, involve much less uncertainty. Any analysis of proposed regulations requires estimates of the health and environmental impacts that will be avoided, involving some inescapable scientific uncertainty. However, cost-benefit analysis also involves the economic uncertainties and controversies surrounding monetary valuation of life, health, and the environment. Far from introducing quantitative, market-like precision and certainty, cost-benefit analysis is often a step backward into more intractable controversy and confusion.

Conclusions

1. The lowest feasible level of arsenic – 3 ppb – should be adopted as the standard for drinking water. That standard will prevent a significant number of painful deaths and disabilities, at an estimated annual cost of about $2.50 per capita nationwide. The incremental cost of moving from EPA's recommended 5 ppb standard to the preferable 3 ppb standard is around $1.00 per capita. It is ludicrous to suggest that the United States cannot afford such minor expenditures. It is morally offensive to suggest that some of us should suffer involuntary, fatal exposure to a known carcinogen in order to save pocket change for the rest of us.

2. The only potentially serious problem about the costs of arsenic reduction concerns the impact on the smallest affected communities. There may be a need for further discussion of cost sharing or other alternatives for small water systems, but this discussion should not delay adoption of the 3 ppb standard.

3. The cost-benefit analysis of arsenic regulation is fundamentally incomplete and misleading in its valuation of benefits. It depends on ethically controversial, logically flawed, and empirically dated estimates of the value of a life. It adopts inappropriate and dated estimates for the wrong disease in its sole attempt to value nonfatal health impacts. It simply omits many known health impacts, effectively valuing them at zero. The only solid conclusion that can be drawn from the benefits analysis is that economists have not come close to placing a meaningful dollar value on the benefits of arsenic reduction.

4. The problems encountered in the valuation of benefits are not unique to arsenic reduction. The same problems are likely to appear in cost-benefit analyses of any environmental regulations that prevent death or disability. Until solutions to these problems are found, cost-benefit analysis should play little or no role in decision-making about environmental regulations.

References

EPA (Environmental Protection Agency). 1997. *Benefits and Costs of the Clean Air Act, 1970-1990*, EPA 410-R-97-002. Office of Air and Radiation.

Harvard Law Review. 1992. "'Ask a Silly Question...': Contingent Valuation of Natural Resource Damages", editors' comment, *Harvard Law Review* 105, 1981-2000.

Mishan, E. J. 1988. *Cost-Benefit Analysis: An Informal Introduction*, fourth edition (London: Routledge).

NRC (National Research Council). 1999. *Arsenic in Drinking Water* (Washington: National Academy Press).

Schelling, Thomas C. 1993. "The Life You Save May Be Your Own", in *Economics of the Environment: Selected Readings*, Dorfman and Dorfman, eds., third edition (New York: Norton).

Viscusi, W. Kip, Wesley A. Magat and Joel Huber. 1991. "Pricing Environmental Health Risks: Survey Assessments of Risk-Risk and Risk-Dollar Trade-Offs for Chronic Bronchitis", *Journal of Environmental Economics and Management* 21, 32-51.

Viscusi, W Kip. 1992. *Fatal Tradeoffs: Public and Private Responsibilities for Risk* (Oxford: Oxford University Press).