Valuing Risk Reduction: The Example of Nitrates in Drinking Water

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Consumers make choices about the food and drink they consume based on a number of factors, including price and convenience. Quality, as perceived through appearance, texture, smell, and product information is a major influence. All products have particular attributes that give an indication of product quality, as with evidence of spoilage, poor appearance, or discoloration for meat and poultry or with cloudiness or unpleasant odor for drinking water.

However, sometimes quality is not immediately or easily noticeable. Bacteria or chemicals invisible to the naked eye may be present in food and drinking water. In such cases, consumers would not be able to determine the level of risk of illness posed by consuming products containing these impurities. And, they would not be able to make choices as to which risks to avoid and which they are willing to accept. In this situation, purchase decisions are not based on these risks, and regulators do not know the benefits of risk reduction—how much "safer" food and water is worth to consumers.

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To estimate consumers' willingness to pay for safer water, we used a survey technique where consumers were asked how much they would pay for a filter that removes nitrates from their drinking water. Information on the value consumers place on reducing health risks is one component needed to design cost-effective regulations for food safety.

Nitrates in Drinking Water May Pose a Health Risk

Ground water is an important source of drinking water in the United States, especially in rural areas. Over the past 15 years, a considerable amount of public interest has arisen about contamination of the Nation's ground water resources with pesticides, fertilizers, and other agricultural chemicals. Concern about ground water contamination is driven by fears that exposure to agricultural chemicals in drinking water may pose human health risks.

Discovery of nitrates and pesticides in ground water during the late 1970's and early 1980's dispelled a commonly held view that ground water was protected from these chemicals by layers of rock, soil, and clay. (Nitrates are molecules of nitrogen and oxygen that are formed when fertilizer reacts with soil.)

In 1990, the U.S. Environmental Protection Agency (EPA) released results from a nationwide survey of drinking water wells conducted over a 5-year period. The survey showed that while at least half of the Nation's drinking water wells contained detectable amounts of nitrates, only about 1.2 percent of community water systems and 2.4 percent of private rural wells contained nitrates at levels higher than EPA's recognized safe level of 10 milligrams per liter. The Environmental Working Group, a public-interest group, estimated that 2 million people drank water from community water systems that violated the EPA nitrate standard at least once between 1986 and 1995, and that an additional 3.8 million people drank water from private wells with nitrate levels above the 10 milligram per liter standard.

The extent to which drinking water contamination from agricultural chemicals poses a risk to human health is unclear. A well-documented human health concern from nitrate contamination at levels above 10 milligrams per liter is infant methemoglobinemia, a condition brought on when nitrates impair the ability of an infant's blood to carry oxygen. Nitrates in water and other foods (such as hot dogs) have also been suggested as possible sources of cancer risk by the Environmental Working Group and the National Research Council. However, the health risk associated

with ingesting water containing nitrates at levels below those in which human health is considered endangered is poorly understood.

Consumers, faced with uncertainty about the danger posed by drinking water containing low levels of nitrates, may be willing to pay for increased safety in their drinking water supplies beyond levels considered acceptable by EPA.

Consumers Willing To Pay For Nitrate Reduction...

To estimate the benefits of reducing nitrates in drinking water, we conducted an experiment as part of the National Survey of Recreation and the Environment, administered by the Survey Research Institute at the University of Georgia. Researchers asked several questions in this survey in a contingent valuation method (CVM) experiment to find out how much consumers might be willing to pay to reduce nitrates in their drinking water (see box). This telephone survey was conducted in two parts in 1994 and covered four geographic areas—the White River region of Indiana, Central Nebraska, Lower Susquehanna in Pennsylvania, and Mid-Columbia Basin in Washington State (see fig.1). About half of those contacted responded to the survey.

After a set of questions on water-based recreational activities, respondents were asked a series of questions regarding drinking water quality and how much they would pay for a special filter to reduce or eliminate nitrates. Respondents were asked to consider a hypothetical situation where they were told that their tap water contained nitrates at a level 50 percent greater than EPA maximum standards. (Nitrates were described to respondents as "chemical substances hazardous to human health if taken in large quantities.") Then, the respondents were asked whether they would pay a randomly chosen dollar amount between $4 and $90 to have a filter installed that would reduce nitrate levels to an EPA-established safe level. Respondents were then asked whether they would pay a randomly chosen dollar amount between $5 and $110 for a more powerful filter that would completely eliminate nitrates from the home's tap water.

A statistical analysis of the survey results found that people were willing to pay between $45 and $60 per household per month for a water filter that reduced nitrates to "safe" levels, for an average of about $53 for all four regions taken together (table 1). Differences in willingness to pay stemmed from differences in demographics and other socioeconomic factors across the regions.

Figure 1
Location of Survey Sites

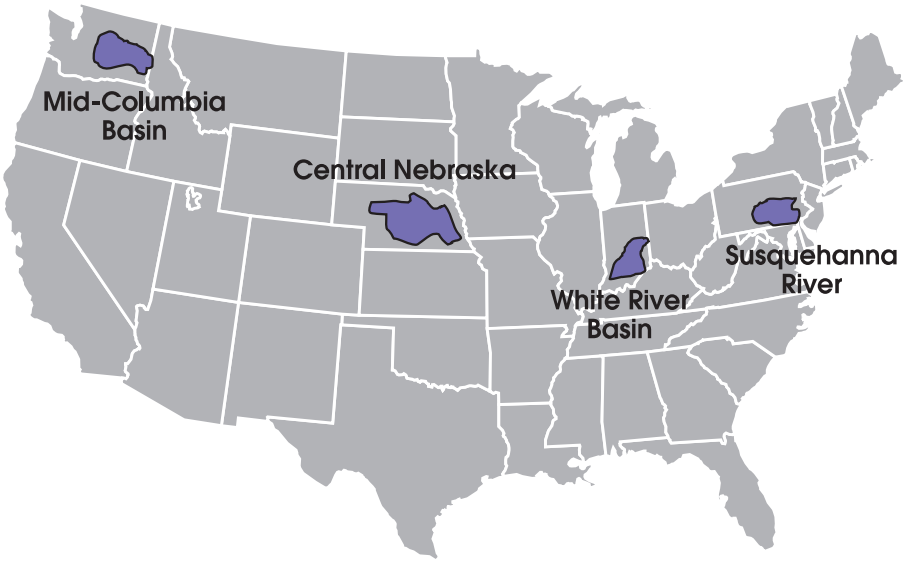

Table 1
Willingness To Pay for Reduced Nitrates in Drinking Water Varies by Region

Location of survey respondents	Consumers reported how much they were willing to pay to improve drinking water quality–		
	Reduce nitrates to the maximum EPA standard	Completely eliminate nitrates	Difference
	Dollars per month		
White River	45.42	48.26	2.84
Central Nebraska	51.39	56.66	5.27
Lower Susquehanna	60.76	60.85	.09
Mid-Columbia Basin	55.16	65.11	9.95
Average for all regions	52.89	54.50	1.61

Valuing Consumer Preferences for Reduced Risks

Economists have developed several ways of estimating the value consumers place on possible reductions in health risks associated with the products they consume. These include values revealed by market prices, values measured by expenditures on related goods or services, and values obtained directly from consumers through surveys.

Market Prices

In situations where products are sold with verifiable safety attributes, market prices can provide information about the value consumers place on those attributes. When making product choices, consumers are assumed to balance the value they place on products felt to be "safer" with the increased costs they might have to pay for this extra measure of safety. This "willingness to pay" would be revealed by the price differences seen in the market between products with different levels of safety.

For example, foods labeled "organic" may be viewed by some consumers as posing a lower risk from chemical residues. The value of the extra safety consumers may perceive in consuming organic foods would be reflected by the price premiums charged for such products. Although estimates vary, organic foods enjoy a price premium in some markets of as much as 15 percent over foods produced with conventional pesticides and synthetic fertilizers. Although consumers may choose to purchase organic foods for many reasons (such as perceptions of higher nutritional value, environmental concern, or farm worker safety), some of this price premium may be attributed to consumers' willingness to pay for reduced health risk from chemical residues on the foods they eat.

Expenditures on Related Goods and Services

When consumers cannot directly observe safety attributes of food and drinking water, market prices cannot guide us in assessing the value of safer food. However, expenditures on related goods and services may provide insight into how consumers value reduction of health risks in food and drinking water. When consumers undertake defensive actions to protect themselves from foodborne health risks, the costs incurred by those actions can represent the value of reducing these risks. For example, we can measure the value of safer drinking water by looking at the expenditures on less risky substitutes, such as bottled water—assuming that we know that the consumer is buying the substitute for safety reasons. Note that what is important from the valuation standpoint is the consumer's perceived safety benefits, and not the actual safety benefits.

Consumers may also take other actions that involve costs to protect themselves from health risks. For example, they may spend more time preparing foods to minimize health risks, such as washing and peeling vegetables and taking more time preparing meat and poultry dishes. They may also have their drinking water wells tested for hazardous chemicals.

Estimating the costs of such actions is an indirect way to value the worth consumers place on reducing these risks. In a 1988 survey conducted by the University of Florida in cooperation with USDA's Economic Research Service, nearly one-third of the respondents said they were willing to spend up to 20 additional minutes preparing chicken and cleaning up afterwards to reduce the chance of foodborne illness. Valuing these 20 minutes at the minimum wage in that year implied a willingness to pay for pathogen control of about 56 cents per pound, assuming 2 pounds of chicken were prepared on each occasion.

Consumer Surveys

We can also use consumer surveys to identify values people place on reducing health risks. The most widely used technique is the contingent valuation method (CVM), where respondents are presented with information about a safety concern or health risk. Respondents are then asked to tell how much a given change in food safety, water quality, or some other safety concern would be worth to them. CVM surveys ask people how much they are willing to pay for a change in the level or condition of some attribute that does not have a market price, such as pathogen- or pesticide-free. The respondent may be asked for an actual dollar amount, such as "how much would you be willing to pay for grapefruit certified to be free of pesticide residues?"

A problem with this method is that respondents may have trouble formulating a response to questions like these. One approach is to specify a given amount and ask them to indicate whether they would be willing to pay this amount—"Would you be willing to pay 50 cents extra for a pesticide-free grapefruit?" This technique is called the referendum, or dichotomous choice CVM approach, since the respondent must "vote" with a yes or no answer. Doing so, however, raises another problem in choosing the appropriate value to give to consumers. A recent refinement of the referendum CVM approach is to offer respondents a dollar amount randomly drawn from a range of values, and then a follow-up dollar amount whose level is contingent on the response to the first offer, so a wide variety of possible values can be given to different respondents. We used this type of referendum CVM survey to determine the value consumers place on reducing health risks from nitrates in drinking water.

As expected, the estimated willingness to pay for a filter that removed all nitrates was higher than for a filter that reduced nitrates to the EPA-recommended level, but not by much. For each region, respondents were willing to pay more for the higher level of protection. For the four regions taken together, the premium placed on the more effective filter came to about 3 percent over the standard filter, or about $1.61 per month. Multiplying the monthly willingness to pay estimates for the filters by 12 gives an estimate of the annual willingness to pay of $540 to $780 per year.

... But Not for Complete Safety

Like all CVM studies, this one is subject to some cautionary notes. We were somewhat surprised by the relatively small difference in values between the first question and the second. Other studies where questions have been asked in order to determine consumers' preferences for risk reduction showed a greater willingness to pay for marginal changes in risk. For example, economists at the University of Kentucky conducted a CVM study of willingness to pay for grapefruit with two different levels of pesticide residues. One group of consumers was asked how much more they would pay for a 50-percent reduction in residue-related health risk (achieved by switching to grapefruit treated with a safer chemical). A second group of consumers was asked how much they would pay for a 99+ percent reduction in health risk. The consumers who participated in the survey were willing to spend up to 5 cents per grapefruit for a 99+ percent reduction in risk—22 percent more than for a 50-percent reduction in risk.

Two explanations are possible. First, it may be that our respondents truly felt that the safe levels of nitrates were acceptable, and that there was little reason to pay more for a water filter that completely eliminated nitrates. It may also be the case that the respondents may have overstated their willingness to pay on the first question. Ordering of questions is important in multistage CVM experiments. Perhaps splitting the survey so that respondents were asked about their willingness to pay for either partial nitrate reduction or total elimination, but not both, would have yielded different results. However, a split of this sort would entail significantly larger survey costs.

One criticism of CVM studies is that this approach only requires consumers to make hypothetical decisions about hypothetical purchases. As an alternative, other researchers have constructed experiments where respondents are asked to allocate a set budget across goods with varying attributes. For example, researchers at Iowa State University created experimental auction markets where participants were given money and asked to purchase sandwiches with different levels of food safety. The objective in this type of experiment is to derive willingness-to-pay measures which are based on actual preferences revealed through purchases rather than on hypothetical responses. Researchers found that participants in the study would pay an additional 45 to 93 cents for a chicken sandwich free from contamination by *Salmonella*.

Estimates of the value consumers place on reducing health risks are important, because they can help policymakers evaluate the overall benefits of policies intended to enhance safety. These benefit estimates, when compared to estimates of the costs of efforts to improve the safety of food and drinking water, can support the development of efficient and cost-effective programs and policies to protect public health.

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