Morbidity and Mortality: How Do We Value the Risk of Illness and Death?

PROCEEDINGS OF SESSION VI: VALUING MORBIDITY AND MORTALITY: DRINKING WATER

A WORKSHOP SPONSORED BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY'S NATIONAL CENTER FOR ENVIRONMENTAL ECONOMICS AND NATIONAL CENTER FOR ENVIRONMENTAL RESEARCH

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DISCLAIMER

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Combining Psychological and Economic Methods to Improve Understanding of Factors Determining Adults' Valuation of Children's Health: The Case of Nitrates and Infants

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May 11, 2006

Abstract

The objective of this research is to evaluate the gain in explanatory power from adding independent variables from the a psychology model of predicting behavior, the Theory of Planned Behavior (TPB) to an economic model, conjoint analysis for determining adults' willingness to pay (WTP) to protect children's health, with the method to be adapted for policy-making. For the development of this method, nitrate in drinking water will serve as the risk factor because it only affects children's health. A questionnaire is used to assess knowledge, attitudes, beliefs, norms, and perceived control with respect to the risk factor, as well as the components of TPB. Respondents also complete a choice task for a conjoint analysis to assess their preferred choices of behavior for averting this risk. One half of the groups are told the choice is hypothetical. The other group is told that one of their four choices will be binding and they will actually buy the amount of bottled water using the money given to them at the beginning of the experiment. We test whether the behavioral responses of these two groups are equivalent or not. The majority of the data collected to date have been in the English-speaking (88%) and hypothetical (76%) treatments.

There was a statistically significant difference in the real/cash cost coefficient and when the costs were hypothetical. The real/cash cost coefficient was far more negative (price sensitive) than the hypothetical cost coefficient, although the hypothetical cost coefficient was still negative.

A household would pay $2.64 in the real cash treatment and $18 in the hypothetical treatment for bottled water that would result in a .0001 (1 in a thousand) reduction in the chances of an infant going into shock from nitrate in water. A household would pay $5.25 in the real cash treatment and $36 in the hypothetical treatment for bottled water that would result in a .0001 (1 in a thousand) reduction in the chances of an infant experiencing permanent brain damage from nitrate in water.

Dividing the coefficient on infants present in the household by the cost coefficients allows us to calculate to investigate the extent of altruism of households without children in terms of their willingness to pay to buy bottled water for households with infants. While willingness to pay (WTP) rises by $49 with real money and $332 for hypothetical payment for households with infants at risk, WTP is still positive for households without an infant. This suggests there is some measure of altruism reflected in our WTP results.

The Theory of Planned Behavior (TPB) variables were only significant at between the .14 and .19 levels and added about 2.5% to the explanatory power of the logistic regression model. Of the variables in the TPB, *attitudes* about infant health issues were not significant p = .48, *health perceived control* (one can protect an infant from environmental contaminants) was significant at p = .19, *water perceived control* (one can control the quality of one's drinking water) was

significant at $p = .14$, and *water norms* (subjective norms for being concerned about drinking water quality) was significant at $p = .15$. The results indicate that perhaps perceived control and community norms would be most useful for a policy maker.

Legal Background

Increasingly federal agencies are being called upon to explicitly factor children's health into their regulatory decisions and benefit cost analyses. For example Executive Order 13045 issued by President Clinton on April 21, 1997 required making children's health a high priority in federal agency decision making. In that same year, EPA established the Office of Child Health Protection to give increased emphasis on children health in the agency's many programs. See U.S.E.P.A. (2003) for more details on the Executive Order.

Study Objective

There are two basic issues when valuing children's health. One is selecting the appropriate risk-reducing policies and actions and the other is the value of reducing these risks. Although it is important to economically put a value on the reduction of an environmental health risk to a child, doing so does not necessarily give public and private stakeholders the information they really need to decide upon the appropriate policies or actions.

The kind of information that is most useful to these stakeholders would not necessarily be a dollar figure. It may be an understanding of how and if knowledge, education, belief systems, cultural or societal norms and general attitudes actually lead to the decisions each individual makes when they put a value on a child's health.

To that end, the objective of the proposed research is to test a combining of the explanatory variables from the Theory of Planned Behavior (TPB) with conjoint analysis for determining adults' willingness to pay (WTP) to protect children's health, with the method to be adapted for policy-making.

Study Design

The overall study design focuses on:

(a) Deriving adults' willingness to pay to reduce their infants' risk of shock, brain damage and death from nitrate in drinking water during their first year of life;
(b) Deriving these values using a choice experiment, which involves a hypothetical WTP for bottled water.
(c) Using a consequential treatment in which adults will be asked to pay real money for the bottled water, with a pre-paid coupon for the bottled water provided to those agreeing to pay.
(d) Using the Theory of Planned Behavior to see if attitudes, beliefs, knowledge, norms, and perceived control increase the predictability of adults' WTP choices.
(e) Testing for whether there is altruism toward children's health by testing whether people without infants at risk would pay for bottled water for other households with infants at risk.

Hypotheses:

1. In tests of the internal validity of the choice experiment, adults' demand for children's health will be reduced at higher prices (i.e., negative own price), and positive with respective to the amount of risk reduction.
2. In tests of the external validity of the experiment, marginal value for risk reduction i from the traditional hypothetical choice experiment ($MV_i(h)$) will equal the marginal value for risk reduction i from the consequential (real money) choice experiment ($MV_i(c)$).
3. In tests of the predictive power of the Theory of Planned Behavior, regression analyses of WTP for bottled water as a function of risk reduction and cost will show increased predictability by adding beliefs, attitudes, knowledge, subjective norms, and perceived control as predictors and which of those predictors may be more relevant to stakeholders and policy-makers as they make decisions around education or potential mitigation.

Literature Review

Agee and Crocker provide an evaluation of the available methods for valuing children's health. They suggest that stated preference methods such contingent valuation are one of two methods that are most theoretically tenable and analytically tractable. Stated preference methods are not only able to measure parents' willingness to pay for their children, but may also allow elicitation of community public good values toward children's health as well.

While there is a rising demand for children's health information, there have been very few primary valuation studies of children's health issues using stated preference methods. One of the first was Viscusi, et al. (1987) where adults are asked their WTP to reduce adverse health effects to children (in this case pesticide poisonings). Dickie and Messman (2004) perform a very thorough stated preference study of parents' WTP to reduce their own acute illnesses versus those of their children. They used WTP for a medicine that would treat the acute respiratory symptoms such as cough, chest pain, shortness of breath, fever and the untreated duration of these symptoms. For severe acute illness parents are WTP about $217 to reduce one symptom day (Dickie and Messman, 2004: 1167). The values for younger children (age three) is nearly double that of children ages 12 to 17.

WTP of parents to reduce latent skin cancer chances were studied by Dickie and Gerking based on parents WTP for a sunscreen product. Liu, et al. (2000) studied mother's WTP to reduce their own and their child's multiple day, multiple symptom episodes of colds in Taiwan. Converting WTP into U.S. dollars average WTP was $71, and upwards of $121 if adjustments made for differences in income levels and a mid-range income elasticity of WTP.

Valuation Methodology

The methodological approach used in this study is based on the conjoint or choice experiment approach (Holmes & Adamowicz, 2003). This is a stated preference method, in which a respondent makes a series of contingent choices. These choices are contingent upon the characteristics in the choice set. Our choice set has cost as one attribute, and risk of the child going into shock, risk of the child suffering brain damage and risk of death as the key variables we wish to value. By dividing the attribute coefficient by the cost coefficient the marginal value of a one unit change is monetized.

Following theoretical foundation of Hanemann (1984) on utility difference from random utility models and Roe et al. (1996)'s application to conjoint, we make the first choice a "no action" or baseline risk level associated with no cost. Then the action alternative that reduces the three health risks to the child is offered at a one time cost of X, that varies across the sample. We do this in pairwise fashion, whereby each choice task or choice set is a no action and a single action alternative. As Carson et al. suggest, having just two choices increases the likelihood that the choice will be incentive compatible (even in the hypothetical treatment).

The probability a respondent will choose the action alternative should be related to the expected gain in the parents' well being obtained from their infant receiving the health risk reduction, over and above the satisfaction lost due to paying higher cost. To be more specific, a state-dependent utility function is posited focusing just on the risk of death, to keep the notation simple. Thus UL and UD is the utility to the parent when the child is alive and dead, respectively. Further let PD be the baseline probability of the child dying with and without the risk reduction intervention (e.g.., bottled water). Baseline expected utility (EU) to the parent can be defined as:

$$EU = PD[UD(I)] + (1-PD)[UL(I)] ,$$

where I is income.

The parents' purchase of bottled water reduces the probability of premature death from PD to P'D, but at a proposed cost to the respondent of \$X each year. If the reduction in the probability of premature death from PD to P'D yields more expected utility than the loss of \$X in income, the parent will select the action alternative in the choice question. Specifically, the expected utility difference (EUD) is given by:

$$EUD= \{P'D[UD(I-\$X)]+ (1-P'D)[UL(I-\$X)]\} - \{PD[UD(I)]+ \quad (1-PD)[UL(I)]\}$$

If this expected utility difference is linear in its arguments, and if the associated additive random error term is distributed logistically, then the probability a respondent will select the action alternative to a question asking him or her to pay \$X for the bottled water that would reduce the risk of the child's death from PD to P'D is:

$$\text{Probability of buying bottled water} = P(Y) = 1 - [\ 1 + e^{Bo-B1(\$X)}]^{-1}$$

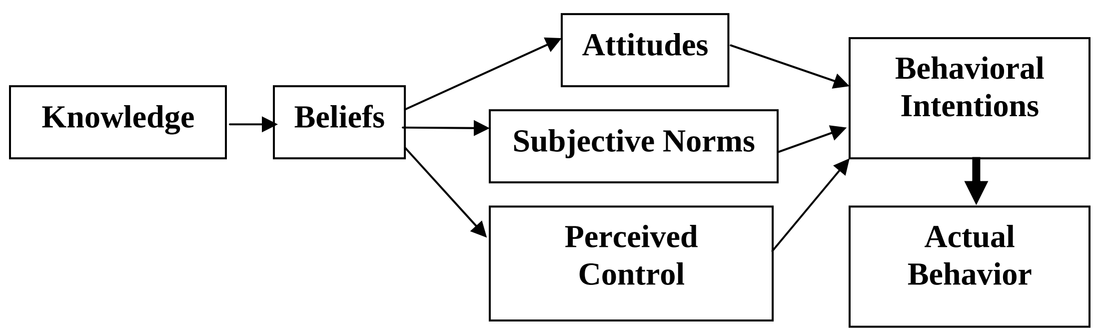
Maximum likelihood statistical routines such as logistic regression can be used to estimate a transformation of this equation in the form of:

$$\text{Log } \{P(Y)/[1-P(Y)]\} = Bo - B1(\$X) +B2 \text{ (Reduction in Risk of Death)}$$

The marginal value to the parent of reducing a child's risk of death (or parental WTP) is: B2/B1.

Theory of Planned Behavior
Besides deriving the adults' value of each type of risk reduction, we wish to explore whether the Theory of Planned Behavior (TPB) adds explanatory power to this model.
According to TPB, there are certain factors that influence behavior. Attitudes toward behavior, knowledge, subjective norms (beliefs about whether the behavior is appropriate), and perceived control have a combined influence on behavioral intentions (whether the individual intends to engage in the behavior or not). In this study, the choices made in the contingent valuation task served as a measure of behavioral intentions. Attitudes, beliefs, knowledge, and perceived control were measured via a questionnaire.

Theory of Planned Behavior



Some sample items are: "I am not aware of any potential negative health effects for children caused by drinking water contaminated with nitrate" (knowledge); "Overall, the children in my community are healthy" (beliefs); "Children's health is an important issue" (attitudes); "Most of the people I know would take steps to ensure that their drinking water is safe" (subjective norms); and "I can ensure that my children are healthy" (perceived control). Behavioral intentions will be assessed via a contingent valuation task. Actual Behavior will be assessed in the experimental conditions via a consequential choice treatment in which the participants will be instructed that the decision they make on one of the choice tasks will be binding.

Choice Experiment Design
The choice experiment involves four attributes (cost, risk of shock, risk of brain damage and risk of death). There were four levels of the risk attributes and seven levels of the cost attribute. We utilized a main effects design to develop an orthogonal choice set with ten different survey versions.

Peer Review of Study Design
The overall study design evolved with numerous discussions with water quality specialists and economists. Several versions of the survey were reviewed by economists that were experts in the area of contingent valuation and choice experiments.

Key Elements of the Survey Design
The key elements of the choice task involves the information provided the respondent and the nature of the alternatives before them.

Figure 1. Key Elements of the Choice Task Given in the Survey

<u>Section 5</u> → This section contains a choice task for you to complete. We have listed below some important information, which you may or may not be aware of, about nitrate in water. Please read this information before you continue.

- ✓ Your community is one of many in Colorado that is at risk for nitrate contamination of its drinking water.
- ✓ Both public water supplies and private wells can be affected.
- ✓ Because infants do not have fully developed digestive systems, drinking nitrate contaminated water can have negative effects on infants' health, but it will not affect adults.
- ✓ Consuming nitrate contaminated drinking water places infants at risk for a condition called "blue baby syndrome" that is caused by depleting the oxygen in the blood.
- ✓ Symptoms of "blue baby syndrome" include a bluish tint to the infant's skin, shortness of breath, shock, brain damage, coma, and death.
- ✓ Using bottled water or water that has had the nitrate removed to prepare formula will eliminate negative health effects caused by nitrate contaminated drinking water for infants, but will not reduce risks from other sources.

What follows is some information concerning different choices you have to reduce health risks to infants associated with exposure to nitrate contamination of drinking water. Please read through the following information and for each pair of options, choose the option that you feel is best.

Options for Preparing Infant Formula

<u>Option A</u>	**<u>Option B</u>**
Use tap water	Use bottled water

**Option B may have other potential benefits in addition to reducing exposure to nitrate.*

Effects of Over-exposure to Nitrate Contaminated Drinking Water

<u>Cost</u>	<u>Risk of Temporary Shock</u>	<u>Risk of Permanent Brain Damage</u>	<u>Risk of Death</u>
Total, one-time cost of the option in dollars	Risk of infant experiencing decrease in blood pressure and a weak, rapid pulse	Risk of infant experiencing damage to the brain	Risk of infant dying

Adults with infants were told the following in the Non Consequential Treatment:

In the next part of the survey you will be asked whether you would purchase or not purchase various amounts of bottled water. This water would help to reduce your infant's exposure to water with excessive levels of nitrate.

If you purchased the water, the health risks to your child from nitrate contaminated drinking water (as well as other potential drinking water contaminants) would be reduced. The amount by which these risks would go down for a given amount of water is presented on the sheet for each choice. Purchasing the bottled water would not reduce risks to your child to zero because she would still face all of the normal risks that do not come from drinking contaminated water.

If you would not purchase the water, your child would continue to face the risks associated with drinking contaminated water (either by drinking the water by itself or by drinking formula that was prepared with contaminated water). The total risk that your child would face if you chose not to purchase the water is also presented on the sheet for each choice. You will be asked to make 4 choices in total.

Households without children were told the following in order to allow for investigation into altruism:

In the next part of the survey you will be asked to imagine (pretend) that you have to choose between purchasing or not purchasing various amounts of bottled water for a needy family in your community to help reduce their infant's exposure to water that may contain excessive levels of nitrate.

If you purchased the water, the health risks to the infant from nitrate contaminated drinking water (as well as other potential drinking water contaminants) would be reduced. The amount by which these risks would go down for a given amount of water is presented on the sheet for each choice.

If you chose not to purchase the water, the infant would continue to face the risks associated with drinking contaminated water (either by drinking the water by itself or by drinking formula that was prepared with contaminated water). The total risk that the infant would face if you chose not to purchase the water is also presented on the sheet for each choice. You will be asked to make 4 choices in total.

CONSEQUENTIAL SURVEY TREATMENT

Adults with infants were told the following in the consequential survey treatment.

In the packet containing this survey, you were also given a voucher for $_____. In the next part of the survey you will be asked whether you would purchase or not purchase various amounts of bottled water. This water would help to reduce your infant's exposure to water with excessive levels of nitrate.

If you purchased the water, the health risks to your child from nitrate contaminated drinking water (as well as other potential drinking water contaminants) would be reduced. The amount by which these risks would go down for a given amount of water is presented on the sheet for each choice. Purchasing the bottled water would not reduce risks to your child to zero because she would still face all of the normal risks that do not come from drinking contaminated water.

If you would not purchase the water, your child would continue to face the risks associated with drinking contaminated water (either by drinking the water by itself or by drinking formula that was prepared with contaminated water). The total risk that your child would face if you chose not to purchase the water is also presented on the sheet for each choice.

You will be asked to make 4 choices in total. Choosing between Option A and Option B will allow you to either: actually purchase bottled water for your infant using money provided by Colorado State University or keep the money that it would take to purchase the water.

*At this time, look over the voucher that was attached to your survey. You will see that it is good for a dollar amount that matches the highest cost given for bottled water on the four choice tasks. Once you have completed the survey, send the completed survey along with the signed voucher back to us in the self-addressed postage-paid envelope that we have provided. Once we have received the surveys and vouchers back, we will randomly select one of your four choices between A and B in Section 5. If on that particular task you chose "Do Nothing," you will receive a check for the full amount listed on the voucher. If, on the other hand, you chose "Purchase Bottled Water," you will receive a pre-paid punch-card to obtain the bottled water from a local grocery store. If the value of the punch-card is **less** than the dollar amount given on the voucher, you will be sent a check for the difference.*

Adults without infants were told the following in the consequential survey treatment.

In the packet containing this survey, you were also given a voucher for $_____. In the next part of the survey you will be asked whether you would purchase or not purchase various amounts of bottled water. This water would go to a needy family to help to reduce their infant's exposure to water with excessive levels of nitrate.

If you purchased the water, the health risks to the child from nitrate contaminated drinking water (as well as other potential drinking water contaminants) would be reduced. The amount by which these risks would go down for a given amount of water is presented on the sheet for each choice. Purchasing the bottled water would not reduce risks to the child to zero because she would still face all of the normal risks that do not come from drinking contaminated water.

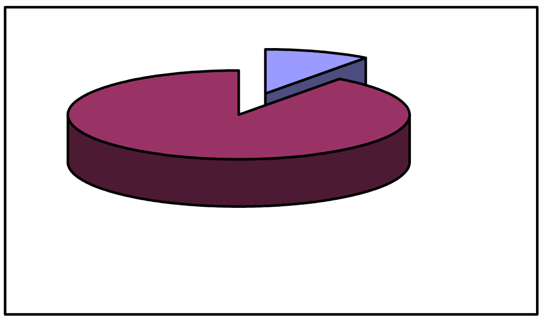
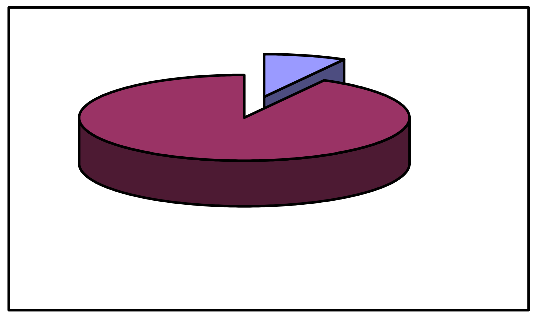
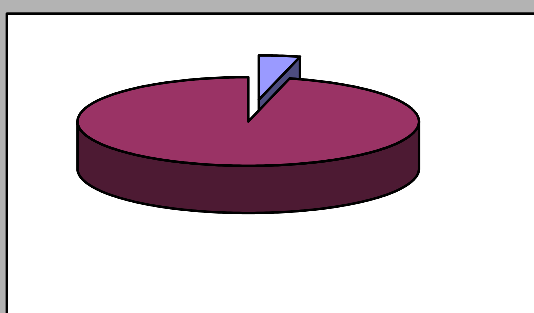
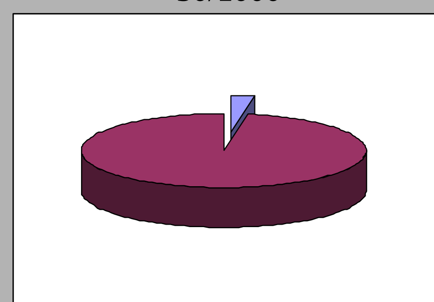
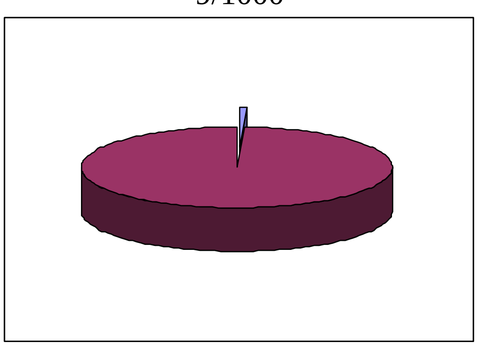
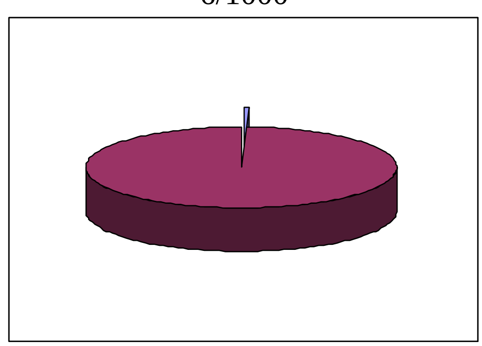
If you would not purchase the water, the child would continue to face the risks associated with drinking contaminated water (either by drinking the water by itself or by drinking formula that was prepared with contaminated water). The total risk that the child would face if you chose not to purchase the water is also presented on the sheet for each choice.

You will be asked to make 4 choices in total. Choosing between Option A and Option B will allow you to either: actually purchase bottled water for an infant in a needy family using money provided by Colorado State University or keep the money that it would take to purchase the water.

At this time, look over the voucher that was attached to your survey. You will see that it is good for a dollar amount that matches the highest cost given for bottled water on the four choice tasks. Once you have completed the survey, send the completed survey along with the signed voucher back to us in the self-addressed postage-paid envelope that we have provided. Once we have received the surveys and vouchers back, we will randomly select one of your four choices between A and B in Section 5. If on that particular task you chose "Do Nothing," you will receive a check for the full amount listed on the voucher. If, on the other hand, you chose "Purchase Bottled Water," a needy family with an infant will receive a pre-paid punch-card to obtain the bottled water from a local grocery store. If the value of the punch-card is ***less*** *than the dollar amount given on the voucher, you will be sent a check for the difference.*

ACTUAL CHOICE TASK

*For this task, we want you to compare Option A to Option B and choose the option you would actually pick if you had to pay the cost shown. *Risk information is presented in the number of infants in your community out of 1,000 who will be affected.*

Effects	**Option A** **Do Nothing**	**Option B** **Buy Bottled Water for an Infant in Your Household**
Cost	$0	$300
Risk of Temporary Shock*	100/1000 	80/1000 
Risk of Permanent Brain Damage*	40/1000 	30/1000 
Risk of Death*	9/1000 	6/1000 

Which option do you choose? _____

Data Collection
The survey was pilot tested with two groups, one English-speaking and one Spanish-speaking, in the San Luis Valley area of Colorado. Due to pilot results, the survey was revised to decrease its length and to improve clarity. Data collection was to take place through in-person sessions with participants conducted at various recruitment sites (day care, childbirth classes, etc.). However both participants and sites proved reluctant to participate in this manner. As a result, the data collection methods were altered to include a mail survey mode and "hosted sessions," as well as recruiting from a broader range of areas in Colorado.

For the mail surveys, the survey packets were sent to five early childhood sites, such as Head Start, family centers, or preschools. The packets include a self-addressed stamped envelope for the participants to return the survey. From the time the surveys were mailed to the sites to the time the first participants picked up surveys was approximately three weeks. Participants complete a contact sheet when they pick a packet up at the site and the contact sheets are sent back to the experimenters. Participants are asked to date the slips so that the experimenters know when to begin the reminder phone calls. Using this survey tracking method, the experimenters call participants who have not returned the survey within two weeks and remind them to mail back the survey or send them a new one if necessary. If respondents have simply forgotten to return the survey, they are reminded to do so. If they have lost the survey and are still interested in participating, they are mailed another. In another two weeks they are contacted by phone again and if they don't return the survey, they are counted as a non-respondent and dropped from the study.

To date, information on hosting a session has been disseminated via word of mouth. Starting May 15th, fliers for hosted sessions will be given to individuals who attend in person sessions. For the "hosted" sessions, individuals who are interested in being a host set up a time when they can meet with any friends, family, or acquaintances who are in the demographic groups of interest. An experimenter attends and conducts an in-person session with the guests. Individuals participating in an in-person session received $25 for their participation and those completing the survey via mail receive $15. In the case of "hosted" sessions, participants receive $25 and the host receives $5 for each completed survey.

The target number of participants is 280 (see Table 1). To date, data have been collected from 92 individuals. About one third of them in the adults with infants or expecting category and most have been non-consequential (Non).

Table 1

	Expecting		Child(ren) under 1		Child(ren) 1 to 3		No Children	
English-Speaking	Non 2	Con 0	Non 20	Con 4	Non 27	Con 6	Non 21	Con 1
Spanish-Speaking	Non 0	Con 0	Non 0	Con 5	Non 0	Con 4	Non 0	Con 2

RESPONSE RATE

Over the last two months 216 survey packets have been sent to five sites and at least one survey has been returned from each site for a 100% recruiting site response rate. Of the 216 surveys sent to the five sites, 55 participants (25%) have completed a contact card. Of those 55, 23 or 42%, have returned a survey. In addition to the mail recruitment, there have been 2 hosted sessions and 19 surveys have been completed there. There have also been two in-person sessions, both at family centers in southern Colorado.

Response rates to health surveys tend be lower than other types of valuation surveys. For example, Dickie and Messman (2004) who did a parental health survey regarding themselves and their children obtained response of 7.5% of eligible households (those with children). This is on a par with other health valuation surveys such as Johnson, et al. (1997) obtained about 8.8%. So our response rate to date is on a par with these other surveys.

ECONOMIC MODEL RESULTS

Table 2 provides the basic economic model that focuses primarily on the cost and risk reduction variables.

Table 2 Logistic Regression of the Binary Choice Model

Dependent Variable: YESPAY
Method: ML - Binary Logit (Quadratic hill climbing)
Date: 05/08/06 Time: 21:03
Sample(adjusted): 3 370
Included observations: 363

Variable	Coefficient	Std. Error	z-Statistic	Prob.
CONSTANT	-0.610367	0.503933	-1.211206	0.2258
COST	-0.010853	0.002351	-4.616077	0.0000
HYPCOSTDUM	0.009256	0.001889	4.899394	0.0000
SHOCK RISK REDUC	0.028697	0.010585	2.711134	0.0067
BRAIN DAM RR	0.056937	0.024426	2.331006	0.0198
DEATH RISK REDUC	0.026172	0.081679	0.320430	0.7486
INFANT	0.530914	0.271195	1.957684	0.0503

Mean dependent var	0.707989	S.D. dependent var	0.455315
S.E. of regression	0.431550	McFadden R-squared	0.094395
Sum squared resid	66.29976		
Log likelihood	-198.5367	LR statistic (6 df)	41.38877
Restr. log likelihood	-219.2311	Probability(LR stat)	2.43E-07
Obs with Dep=0	106	Total obs	363
Obs with Dep=1	257		

Where:
Cost is the one time cost to you.

HypCostDum is whether the survey is hypothetical-consequential dummy variable (Hypothetical equals 1) times the one time Cost.
Shock Risk Reduc is the reduction in risk of shock to your child
BrainDamRR is the reduction in risk of brain damage
Death Risk Reduc is the reduction in risk of death to your child
Infant is whether the respondent has an infant (ages 0-1) that would be at risk from drinking water with nitrates in it.

Note that the one time cost is negative and statistically significant at the 1% level. However, the HypCostDum is positive and significant. Thus, when the cost is hypothetical (not actual or consequential), then the net or overall price coefficient becomes much less price sensitive, although still negative suggesting that the higher the price the less likely households are to purchase the risk reduction through bottled water. The difference in the real cash cost coefficient and the hypothetical cost coefficient, provides results of our hypothesis test regarding whether there is a statistical difference in responses of people facing a hypothetical cost and an actual cost. There is quite a difference, with households facing the hypothetical cost being much less sensitive to the cost than households that face an actual monetary opportunity cost. For purposes of comparing marginal values calculated using the actual monetary cost versus the hypothetical cost treatment, we set the HypCostDum to one for hypothetical and adding its coefficient to the Cost coefficient results in a net Cost coefficient of -.001597. Thus to calculate marginal values for the real cost, we divide the attribute coefficient by Cost variable of -.010853, while for the hypothetical cost we use the -.001597.

The positive signs on Brain Damage Risk Reduction, Shock Risk Reduction and Death Risk Reduction make sense. People are willing to pay more the greater the reduction in risk of shock and brain damage is provided by using bottled drinking water. However, the Death Risk Reduction coefficient is not statistically significant and therefore we will not calculate marginal values for this coefficient.

The coefficient on Infant is positive and statistically significant, indicating individuals with an infant in their household are more likely to pay, than those without.

Calculating Marginal Values of Risk Reduction
Marginal Value is Shock or Brain damage risk reduction coefficient divided by the absolute value of the cost coefficient. It is the willingness to pay to reduce shock or brain damage by 1 per 1000 infants. Performing such calculations with our data yields the following results.

A household would pay $2.64 in the real cash treatment and $18 in the hypothetical treatment for bottled water that would result in a .0001 (1 in a thousand) reduction in the chances of an infant going into **shock** from nitrate in water. A household would pay $5.25 in the real cash treatment and $36 in the hypothetical treatment for bottled water that would result in a .0001 (1 in a thousand) reduction in the chances of an infant experiencing **permanent brain damage** from nitrate in water.

Dividing the coefficient on Infant by the cost coefficients allows us to calculate to investigate the extent of altruism of households without children in terms of their willingness to pay to buy bottled water for households with infants. While WTP rises by $49 with real money and $332 for hypothetical payment for households with infants at risk, WTP is still positive for households without an infant. This suggests there is some measure of altruism reflected in our WTP results.

Comparison of Economic Results to Results with the Theory of Planned Behavior

Table 3. Logistic Regression of the Binary Choice Model with Theory of Planned Behavior Variables.

Dependent Variable: YESPAY
Method: ML - Binary Logit (Quadratic hill climbing)
Date: 05/08/06 Time: 21:05
Sample(adjusted): 3 370
Included observations: 343

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-2.204187	1.452501	-1.517511	0.1291
COST	-0.012265	0.002641	-4.644250	0.0000
HYPCOSTDUM	0.010640	0.002184	4.870890	0.0000
SHOCKRISKREDUC	0.022966	0.011058	2.076906	0.0378
BRAINDAMRR	0.038686	0.026311	1.470324	0.1415
DEATHRISKREDUC	0.015765	0.085622	0.184118	0.8539
INFANT	0.749895	0.301004	2.491310	0.0127
HEALTH ATTITUDES	0.149765	0.212629	0.704350	0.4812
HEALTH PERCEIVED CTRL	0.263524	0.199599	1.320263	0.1867
WATER PERCEIVED CTRL	0.461788	0.312784	1.476383	0.1398
WATER NORMS	-0.240546	0.167906	-1.432628	0.1520

Mean dependent var	0.720117	S.D. dependent var	0.449598
S.E. of regression	0.420073	McFadden R-squared	0.121784
Sum squared resid	58.58504		
Log likelihood	-178.5810	LR statistic (10 df)	49.52848
Restr. log likelihood	-203.3452	Probability(LR stat)	3.26E-07
Obs with Dep=0	96	Total obs	343
Obs with Dep=1	247		

Health Attitudes is positive or negative evaluation of health-related behaviors.
Health Perceived Control is perceived control over means of reducing risks to infant health.
Water Perceived Control is perceived control over drinking water safety.
Water Norms is subjective norms for being concerned about drinking water quality.

Evaluation of the Contribution of the Theory of Planned Behavior Variables

Comparison of the McFadden R square of the standard economic model at .094 and the .12 McFadden R square of the full model with the inclusion of the Theory of Planned Behavior suggests these Planned Behavior variables add a small amount of explanatory power (roughly 2.5%). Health Attitudes variable was not significant (p=.48) and Health Perceived Control is significant at the 19% level. The Water Perceived Control and Water Norms were significant at the 14% and 15% levels, respectively.

The Health Attitudes items were scored so that a high score indicates an orientation toward viewing infant health issues as a community problem. Health Perceived Control items were scored so that a high score indicates a strong feeling that one has control over keeping infants free from harm caused by environmental contaminants. Water Perceived Control items were scored such that a high score indicates a strong feeling of personal control over drinking water quality. Water Norms items were scored such that high score indicates a strong subjective norms for being concerned about drinking water quality.

Conclusions

The results support the first hypothesis, indicating that respondents' WTP was negatively correlated with one time cost for bottled water and positively correlated with risk reduction. The second hypothesis was not supported, with respondents in the consequential treatment being more cost sensitive than respondents in the hypothetical treatment. The third hypothesis was partially supported with TPB components accounting for a very small amount of the variance.

The fact that respondents were willing to pay more in the hypothetical treatment than in the consequential treatment makes sense and indicates that for such choices there is a hypothetical bias. The data indicate that individuals who believe infant health is a community issue and have a high degree of perceived control over both infant health issues and water quality issues are more likely to choose to purchase the bottled water, which makes intuitive sense. On the other hand, individuals who perceive strong subjective norms for being concerned about water quality were less likely to choose the bottled water option. It is possible that such individuals feel that the norms are extreme and to a certain extent are reacting against them.

It is hoped that with a complete data set the TPB components will have better explanatory power. A complete data set will also allow more in-depth analyses, including testing for differences between English-speaking and Spanish-speaking participants and a more detailed test of the differences between the different demographic groups (expecting parents, parents of infants, parents of children 1-3 years old, and adults with grown children or no children). The difficulties initially encountered with participant recruitment are informative. Despite the offer of compensation, both sites and participants were generally unwilling to participate in in-person data collection sessions. Sites were much more receptive to distributing mail surveys and the response rate for this targeted quasi-mail was much higher than that obtained in previous research on this topic.

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APPENDIX A – Sample Mail Survey

Valuation of Infant Health Survey Directions

The survey you are going to be completing contains questions concerning water quality, infant health, nitrate, environmental attitudes, and some demographic questions such as age and gender. Part of the survey will also ask you to make a series of choices between two different options for averting risks to infant health that are associated with unsafe levels of nitrate in drinking water.

Please answer all the questions honestly. There are no right or wrong answers to any of the questions. We are only interested in your opinion and attitudes. Your responses will be completely confidential. Even though we have your names, they will not be associated with your responses in any way.

Please feel free to contact Helen Cooney at (970) 491-2119 if you have any questions. Your participation is voluntary and you may quit at any time without any negative consequences.

Please remember to return a signed copy of our informed consent form along with your survey.

Thank you for your participation!

<u>Section 1</u> → This section asks some general questions about you and your drinking water.
Note: "Tap water" means water that comes out of the faucet in you kitchen.

1) How long have you lived in ________________County, Colorado?_______________

2) a) Overall, how would you rate the taste of your tap water?
   ○ Poor ○ Below Average ○ Average ○ Above Average ○ Excellent

   b) Overall, how would you rate the smell of your tap water?
   ○ Strong unpleasant smell ○ Somewhat unpleasant smell ○ Noticeable smell ○ No smell

   c) Overall, how would you rate the appearance of your tap water?
   ○ Colored (brown, red, yellow) ○ Very Cloudy ○ Cloudy ○ Slightly cloudy ○ Clear

   d) Overall, how would you rate the safety of your tap water?
   ○ Poor ○ Below Average ○ Average ○ Above Average ○ Excellent ○ Don't Know

3) List any problems that you think your tap water has.

____

____

____

4) Do you use a water filter system at home to purify your tap water?
○ Always ○ Often ○ Sometimes ○ Never (Go to question 5)
   If you use a filter system in your home, what type is it?
   ○ Filter Pitcher ○ Faucet Mounted ○ Under-sink ○ Refrigerator

5) How much money do you spend on each of the following over the course of a typical month?
   Bottled Water (for use at home only)
   ○ None ○ $1-$10 ○ $11-24 ○ $25-$49 ○ $50 or more
   Filter System at home (maintenance or replacement filters)
   ○ No System ○ Less than $25 ○ More than $25

6) Does the water in your home come from a well on your property?
   ○ Yes ○ No (if "No" skip to question 7)
   6a) Do you have your well water tested?
   ○ Yes ○ No (if "No" skip to question 7)
   6b) How often do you have your well-water tested?
   ○ Once a year ○ Once every two years ○ Every five years
   6c) Does your well water meet standards when tested?
   ○ Yes ○ No

7) Check any of the items below that you think can be a source of nitrate contamination in drinking water.

○ Fertilizer Runoff ○ Natural Deposits ○ Decaying Plant Matter

○ Fossil Fuels ○ Sewage ○ Landfill Runoff

○ Steel Factories ○ Discharge from Coal-burning Factories

○ Leaching from Ore-processing Sites ○ Leaching from Septic Tanks

8) Check any of the items that you think can help you avoid drinking water with high levels of nitrate.

○ Under-sink Filter ○ Faucet-mounted Filter ○ Filter Pitcher (e.g., Brita™ filters)

○ Bottled Water ○ Boiling Tap Water

9) Have you heard about the quality of your community's drinking water?

○ Yes ○ No

10) Do you read the water quality information included in your water bill?

○ Always ○ Sometimes ○ Never ○ Don't receive a water bill

11) Do you prepare formula for an infant (a child under one year old)?

○ Yes ○ No (if "No" skip to question 12)

11a) How old is the infant?________________

11b) Do you use bottled water to prepare infant formula?

○ Always ○ Often ○ Sometimes ○ Never

12) Have you or a woman in your household been pregnant in the last three years?

○ Yes ○ No (if "No" skip to question 13)

12a) While pregnant, how often did you or a woman in your household buy bottled water to drink at home?

○ Always ○ Often ○ Sometimes ○ Never

12b) While nursing, how often did you or a woman in your household buy bottled water to drink at home?

○ Always ○ Often ○ Sometimes ○ Never ○ Didn't Nurse

13) Do you have health insurance?

○ Yes ○ No (If no, skip to question 14)

13a) Does your insurance cover emergency room care?

○ Yes ○ No

13b) Is your family (spouse and/or children) covered?

○ Yes ○ No

14) If you have children, how much does a visit to the doctor for your child usually cost you?

○ $0 ○ $5 - $20 ○ $21 - $30 ○ $31 - $50 ○ $51 - $70

○ $71 - $90 ○ $91 - $100 ○ $100 +

14a) Does an adult in your household have to miss work in order to take a child to the doctor or hospital?

○ Yes ○ No

<u>Section 2</u> → This section asks about your beliefs regarding infants' health (consider infants to be children under 1 year of age).

Please check the box corresponding to your responses for questions 1 through 17.

	Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
1) If drinking water is safe for adults, it is also safe for infants.	○	○	○	○	○
2) If infants consume water contaminated with nitrate, it can be harmful to their health.	○	○	○	○	○
3) If adults consume water contaminated with nitrate, it can be harmful to their health.	○	○	○	○	○
4) It is natural for infants to become ill more often than adults.	○	○	○	○	○
5) The infants in my community are never ill due to pollution.	○	○	○	○	○
6) My friends and family are concerned with infants' health issues.	○	○	○	○	○
7) The parents I know are worried about the health of their infants.	○	○	○	○	○
8) It is possible to reduce the exposure infants have to pollution.	○	○	○	○	○
9) It is possible to prevent infants from becoming seriously ill due to environmentally caused illnesses.	○	○	○	○	○
10) Only people with infants living in their home need to be concerned about pollution.	○	○	○	○	○
11) Parents, not the public, have the sole responsibility for protecting their infants from harm.	○	○	○	○	○
12) More state and community resources need to be devoted to infant health issues.	○	○	○	○	○
13) There is too much emphasis placed on issues regarding infants' health.	○	○	○	○	○
If you are NOT currently caring for an infant, skip to question 1 of Section 3.					
14) My infant(s) are not exposed to dangerous environmental contaminants.	○	○	○	○	○
15) I can ensure that my infant(s) do not become ill due to environmental contaminants.	○	○	○	○	○
16) I can afford to take my infant(s) to the doctor when they are ill.	○	○	○	○	○

	Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
17) I can prevent my infant(s) from becoming seriously ill.	○	○	○	○	○

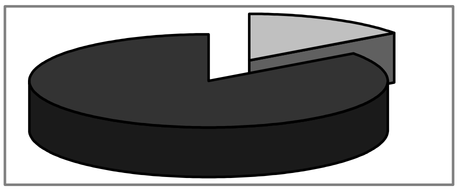
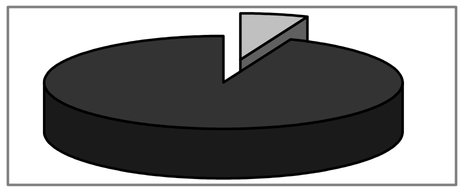
<u>Section 3</u> → This section asks what you think about the quality of your drinking water. Please fill in the bubble corresponding to your responses for questions 1 through 7.

	Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
1) My community has safe drinking water.	○	○	○	○	○
2) My home's drinking water (straight from the faucet) does not have unsafe levels of nitrate.	○	○	○	○	○
3) My friends and family are worried about our drinking water.	○	○	○	○	○
4) Most of the people I know would take steps to ensure that their drinking water is safe.	○	○	○	○	○
5) Nitrate in drinking water is an unavoidable occurrence.	○	○	○	○	○
6) It is important to me to test the quality of my home's drinking water.	○	○	○	○	○
7) It is the government's responsibility to ensure that my drinking water is safe.	○	○	○	○	○

<u>Section 4</u> → We are now going illustrate some risk information for you to help you get used to the way in which risk information is presented as pie charts. Please read the information and then choose which chart represents the greatest risk.

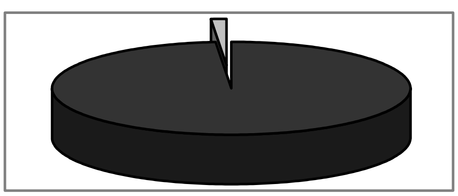
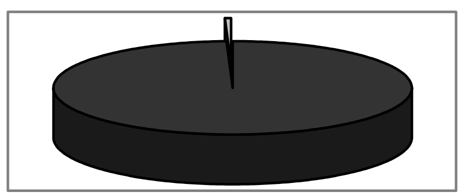
In the first example, the gray pie wedge represents the fraction or proportion of 1000 accidents which involve Car A and Car B. The larger the gray slice, the greater the risk. As long as the bottom numbers in the fractions (as in this case, 1000) are the same, the larger the top number, the larger the risk.

1) The following charts represent the risk (in number of accidents out of 1000) of being involved in a fatal car crash in two different types of car.

Car A	**Car B**
150/1000 	**60/1000** 

Which car poses the greatest risk? ____________________

2) The following charts represent the risk (in number of park visitors out of 1000) of being attacked by a mountain lion in two different national parks.

Park A	**Park B**
15/1000 	**6/1000** 

Which park poses the greater risk? ________________

1) **<u>The correct answer is A. The top number for A (150) is greater than the top number for B (60).</u>**
2) **<u>The correct answer is A. The top number for A (15) is greater than the top number for B (6).</u>**

<u>Section 5</u> → This section contains a choice task for you to complete. We have listed below some important information, which you may or may not be aware of, about nitrate in water. Please read this information before you continue.

- ✓ Your community is one of many in Colorado that is at risk for nitrate contamination of its drinking water.
- ✓ Both public water supplies and private wells can be affected.
- ✓ Because infants do not have fully developed digestive systems, drinking nitrate contaminated water can have negative effects on infants' health, but it will not affect adults.
- ✓ Consuming nitrate contaminated drinking water places infants at risk for a condition called "blue baby syndrome" that is caused by depleting the oxygen in the blood.
- ✓ Symptoms of "blue baby syndrome" include a bluish tint to the infant's skin, shortness of breath, shock, brain damage, coma, and death.
- ✓ Using bottled water or water that has had the nitrate removed to prepare formula will eliminate negative health effects caused by nitrate contaminated drinking water for infants, but will not reduce risks from other sources.

What follows is some information concerning different choices you have to reduce health risks to infants associated with exposure to nitrate contamination of drinking water. Please read through the following information and for each pair of options, choose the option that you feel is best.

Options for Preparing Infant Formula

<u>Option A</u>	**<u>Option B</u>**
Use tap water	Use bottled water

**Option B may have other potential benefits in addition to reducing exposure to nitrate.*

Effects of Over-exposure to Nitrate Contaminated Drinking Water

<u>Cost</u>	<u>Risk of Temporary Shock</u>	<u>Risk of Permanent Brain Damage</u>	<u>Risk of Death</u>
Total, one-time cost of the option in dollars	Risk of infant experiencing decrease in blood pressure and a weak, rapid pulse	Risk of infant experiencing damage to the brain	Risk of infant dying

CR

In the packet containing this survey, you were also given a voucher for $_____. In the next part of the survey you will be asked whether you would purchase or not purchase various amounts of bottled water. This water would help to reduce your infant's exposure to water with excessive levels of nitrate.

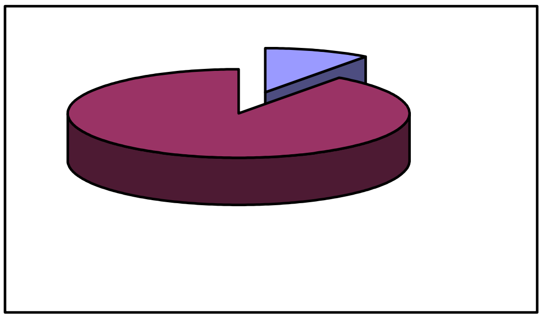
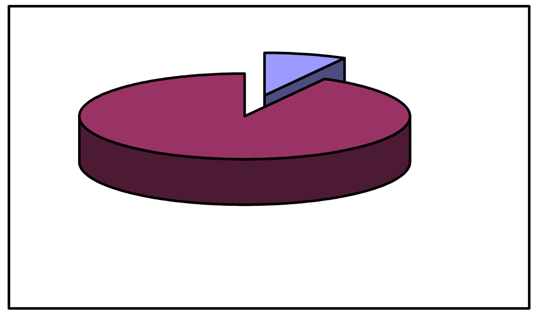
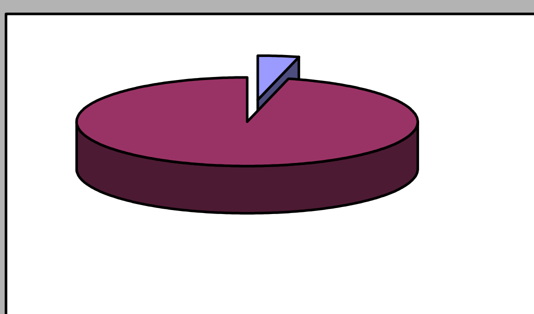
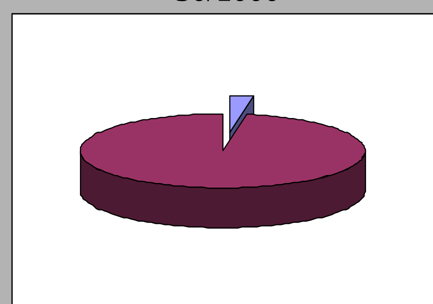
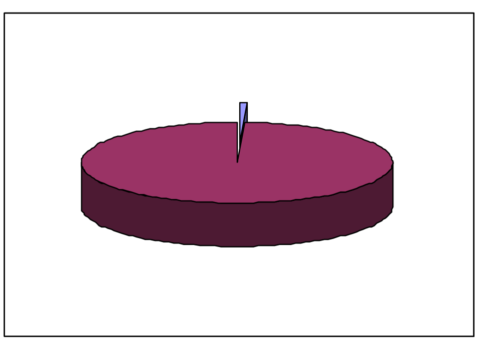
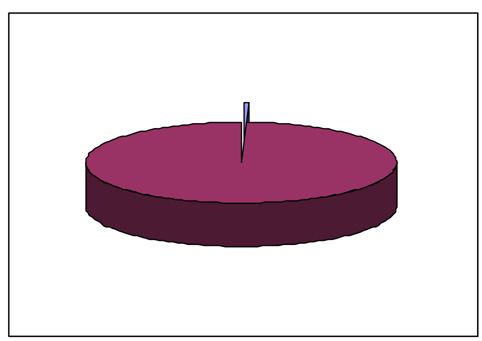
If you purchased the water, the health risks to your child from nitrate contaminated drinking water (as well as other potential drinking water contaminants) would be reduced. The amount by which these risks would go down for a given amount of water is presented on the sheet for each choice. Purchasing the bottled water would not reduce risks to your child to zero because she would still face all of the normal risks that do not come from drinking contaminated water.

If you would not purchase the water, your child would continue to face the risks associated with drinking contaminated water (either by drinking the water by itself or by drinking formula that was prepared with contaminated water). The total risk that your child would face if you chose not to purchase the water is also presented on the sheet for each choice.

You will be asked to make 4 choices in total. Choosing between Option A and Option B will allow you to either: actually purchase bottled water for your infant using money provided by Colorado State University or keep the money that it would take to purchase the water.

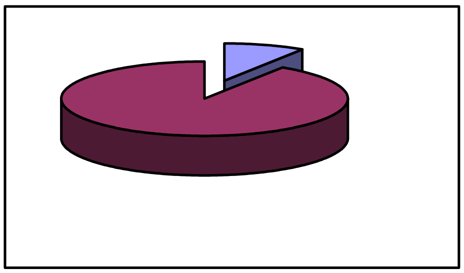
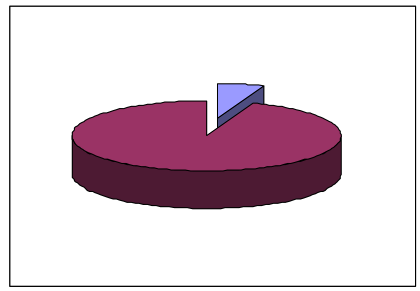
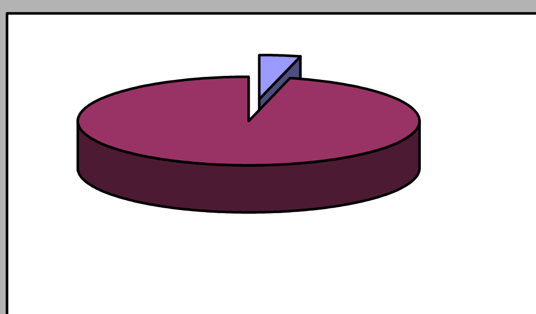
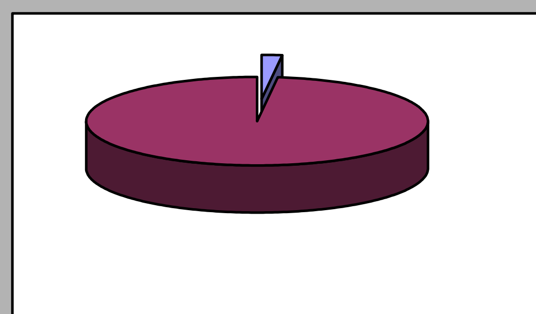
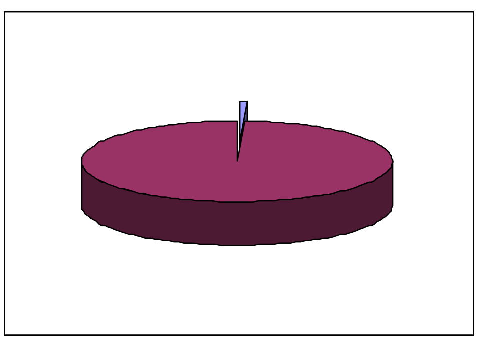
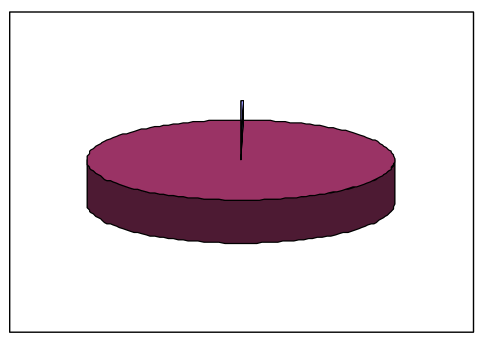
At this time, look over the voucher that was attached to your survey. You will see that it is good for a dollar amount that matches the highest cost given for bottled water on the four choice tasks. Once you have completed the survey, send the completed survey along with the signed voucher back to us in the self-addressed postage-paid envelope that we have provided. Once we have received the surveys and vouchers back, we will randomly select one of your four choices between A and B in Section 5. If on that particular task you chose "Do Nothing," you will receive a check for the full amount listed on the voucher. If, on the other hand, you chose "Purchase Bottled Water," you will receive a pre-paid punch-card to obtain the bottled water from a local grocery store. If the value of the punch-card is **less** than the dollar amount given on the voucher, you will be sent a check for the difference.

For this task, we want you to compare Option A to Option B and choose the option you would actually pick if you had to pay the cost shown.
*Risk information is presented in the number of infants in your community out of 1,000 who will be affected.

Effects	**Option A** **Do Nothing**	**Option B** **Buy Bottled Water for an Infant in Your Household**
Cost	$0	$300
Risk of Temporary Shock*	100/1000 	80/1000 
Risk of Permanent Brain Damage*	40/1000 	30/1000 
Risk of Death*	9/1000 	6/1000 

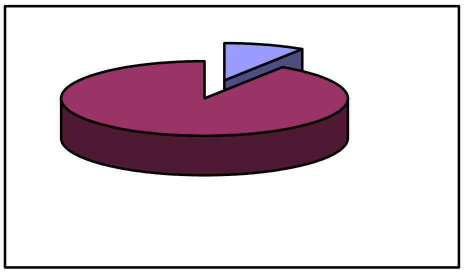
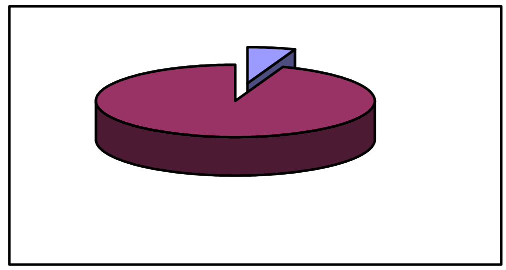
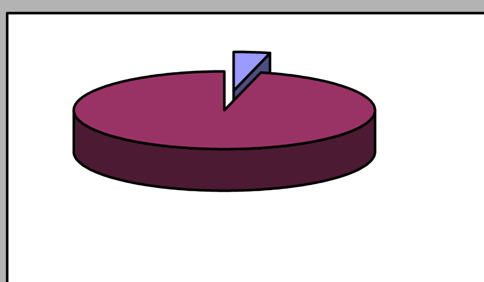
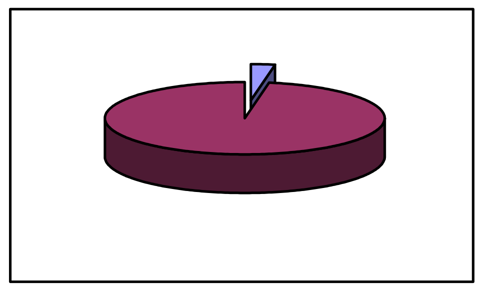
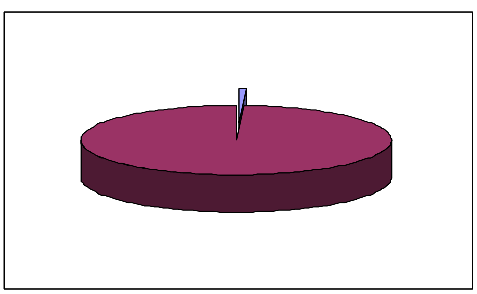
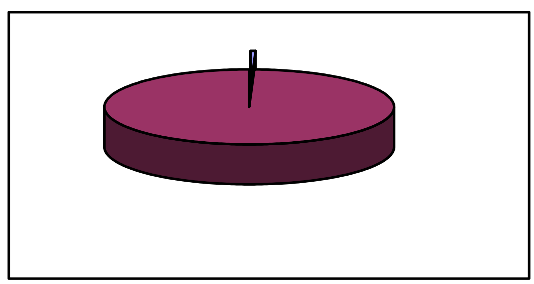
Which option do you choose? ______
Why did you choose that option?

For this task, we want you to compare Option A to Option B and choose the option you would actually pick if you had to pay the cost shown.
*Risk information is presented in the number of children in your community out of 1,000 who will be affected.

Effects	**Option A** **Do Nothing**	**Option B** **Buy Bottled Water for an in Your Household**
Cost	$0	$450
Risk of Temporary Shock*	100/1000 	60/1000 
Risk of Permanent Brain Damage*	40/1000 	20/1000 
Risk of Death*	9/1000 	3/1000 

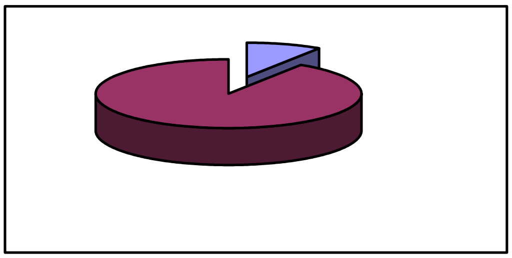
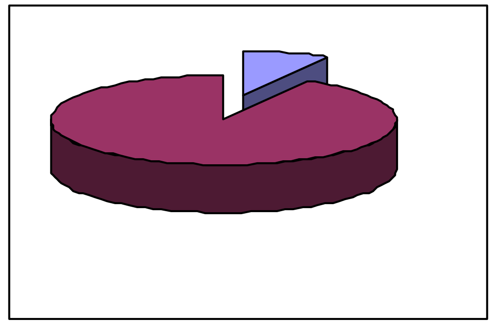
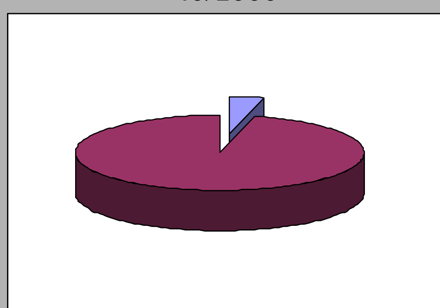
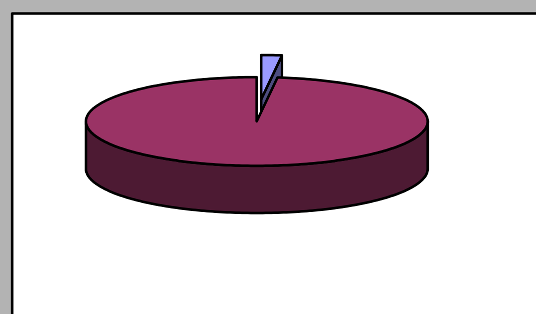
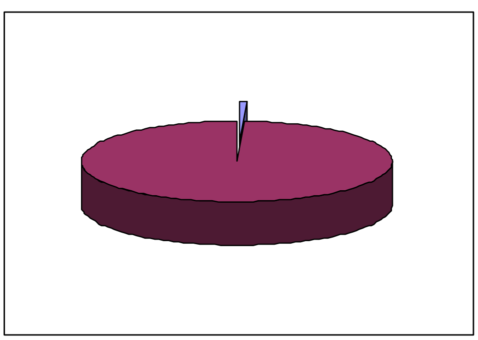
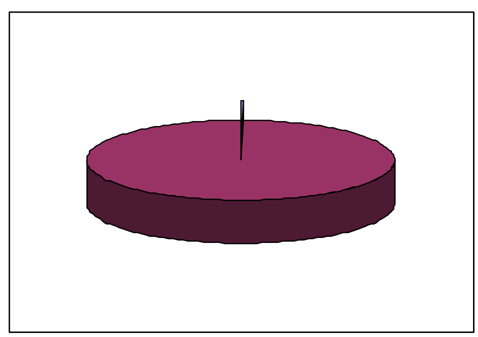
Which option do you choose? _____
Why did you choose that option?

For this task, we want you to compare Option A to Option B and choose the option you would actually pick if you had to pay the cost shown.
*Risk information is presented in the number of children in your community out of 1,000 who will be affected.

Effects	**Option A** **Do Nothing**	**Option B** **Buy Bottled Water for an Infant in Your Household**
Cost	$0	$400
Risk of Temporary Shock*	100/1000 	60/1000 
Risk of Permanent Brain Damage*	40/1000 	30/1000 
Risk of Death*	9/1000 	6/1000 

Which option do you choose? _____
Why did you choose that option?

For this task, we want you to compare Option A to Option B and choose the option you would actually pick if you had to pay the cost shown.
*Risk information is presented in the number of children in your community out of 1,000 who will be affected.

Effects	**Option A** **Do Nothing**	**Option B** **Buy Bottled Water for an Infant in Your Household**
Cost	$0	$500
Risk of Temporary Shock*	100/1000 	80/1000 
Risk of Permanent Brain Damage*	40/1000 	20/1000 
Risk of Death*	9/1000 	3/1000 

Which option do you choose? _____
Why did you choose that option?

<u>Section 6</u> → This section asks for some general demographic information. Your responses will be confidential. No information about your identity (name, SSN, etc.) will be associated with your data. Only researchers on this project will have access to your data.

1) Age _____

2) What is your gender? ○ Male ○ Female

3) Occupation ______________________________

4) Number of Years of Schooling:________________

5) Ethnicity (Check all that apply)

○ African American

○ American Indian

○ Asian American

○ European American

○ Hispanic/Latino

○ Native Hawaiian/Pacific Islander

○ Other (___________________)

6) Do any of your children (under the age of 18) live in your community?

○ Yes ○ No ○ I have no children.

7) Do any of your grandchildren (under the age of 18) live in your community?

○ Yes ○ No ○ I have no grandchildren.

8) Do any of your nieces or nephews (under the age of 18) live in your community?

○ Yes ○ No ○ I have no nieces or nephews.

9) Yearly Household Income from all Sources

○ $0 - $10,000 ○ $10,001 - $20,000 ○ $20,001 - $30,000 ○ $30,001 - $40,000

○ $40,001 - $50,000 ○ $50,001 +

Appendix B – Sample Risk Group Voucher

Colorado State University
Family and Youth Institute Study on Valuation of Infant Health
Voucher

$250

Sign this voucher where indicated and return with your completed survey. Once the choice has been randomly selected, **you will be sent one of three things**:

--A check for the full amount of this voucher (you chose "Do Nothing" on the selected choice)

--A pre-paid punch-card for bottled water worth the dollar amount listed as the cost for the choice (you chose "Purchase Bottled Water" and the randomly selected choice was the one with the highest dollar amount)

--A pre-paid punch-card for bottled water worth the dollar amount listed as the cost for that choice **and** a check to make up the difference between the worth of the punch card and the amount listed on this voucher (you chose "Purchase Bottled Water" and the randomly selected choice was not the one with the highest dollar amount)

______________________________	______________________________
Staff Signature	Participant Signature



Economic Valuation of Avoiding Exposure to Arsenic in Drinking Water

Kathleen P. Bell1
University of Maine
Kevin J. Boyle
Virginia Polytechnic Institute

U.S. EPA Morbidity and Mortality Workshop
April 10-12, 2006

Research Team

- **Kelly Maguire (US EPA)**
- **Andrew E. Smith (Maine Bureau of Health)**
- **Laura Taylor (Georgia State University); Tom Crocker (University of Wyoming); Anna Alberini (University of Maryland)**

Research Objectives

- Economic Valuation of Avoiding Exposure
  - Scrutinize behavioral response of households to information regarding levels of arsenic in private wells
    - private actions at home
    - transactions of residential properties
  - Examine public support for government programs aimed at reducing arsenic levels in drinking water
    - coverage (public and private water supplies)
    - level of reduction

Central Research Questions

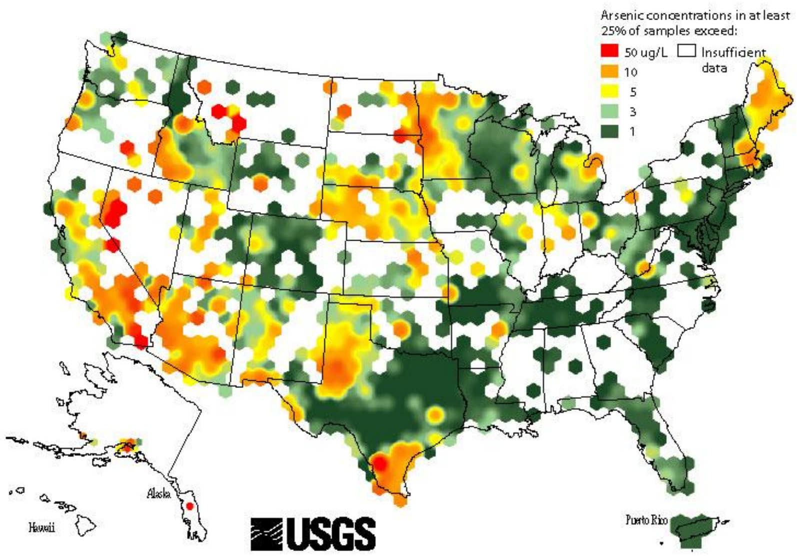
- What will be the relationships among valuation estimates derived using different valuation methods?
  - averting behavior
  - hedonic property value
  - hybrid conjoint / contingent valuation
- Do household composition and location factors influence behavioral responses?
  - children, age, gender, health status
  - household location – proximity to arsenic "cluster" areas

Multiple Valuation Methods

- **Revealed Preference**
  - **Hedonic Property Value**
  - **Averting Behavior**
- **Stated Preference**
  - **Hybrid Conjoint / Contingent Valuation**

Study Area: Maine

- **Upwards of 50 % of Maine Households Rely on Private Wells for Drinking Water**
- **Assessment of Risks (Loiselle, Marvinney, and Smith 2001)**
  - **10% exceed 10 micrograms per liter**
  - **6% exceed 20 micrograms per liter**
  - **2% exceed 50 micrograms per liter**



Source: Citation--
Ryker, S.J., Nov. 2001, Mapping arsenic in groundwater: Geotimes v.46 no.11, p.34-36.
Accessible at:: http://webserver.cr.usgs.gov/trace/arsenic/.

Sample Selection

- **Town Sample**
  - 1,000 randomly selected households from arsenic "cluster" towns
    - Buxton, Hollis, Northport, Standish
- **State Sample**
  - 1,000 randomly selected households
    - split – general population (500) versus private well / prior arsenic test (500)
- **Property Sample**
  - Sales data from arsenic "cluster" towns

Comparative Approach

- Samples
  - Town Sample
    - averting behavior
    - hybrid conjoint / contingent valuation
  - State Sample
    - hybrid conjoint / contingent valuation
  - Property Sample
    - hedonic property value
- Permits joint estimation
- Facilitates comparison and contrast of valuation estimates

Relevant Literature

- Hedonic Property Value Studies
  - Contamination of Private Wells (McCormick 1997; Malone and Barrows 1990)
  - Health Risks/Stigmas (Gayer et al., 2000; Gayer et al. 2002; McCluskey and Rausser 2001; Kiel 1995; Kiel and McClain 1995)
- Conjoint and CV Studies of WTP for State Programs
  - Safe Drinking Water Supplies (Boyle et al. 1994; Edwards 1986; Bergstrom et al. 2001; Poe et al. 2001)
- Averting Behavior
  - Gerking and Stanely 1976; Dickie and Girkie 1991; Shogren and Crocker 1999; Abdalla 1994; Abdalla et al. 1992; Bartik 1998

Relevant Literature (continued)

- Health and Risk Communication
  - Lead in Tap Water (Griffin and Dunwoody 2000)
  - Risk Communication (Fischhoff 1995; Slovic 1987; NRC 1989; Covello et al. 1989)
- Environmental and Health Economics
  - Hazardous Waste Sites (Gayer, Hamilton, and Viscusi 2002; Gayer, Hamilton, and Viscusi 2000)
  - Smokers (Smith et al. 2001)
  - Radon (Smith and Johnson 1988; Smith and Desvousges 2001)
  - Chemical Industry Workplace (Viscusi and O'Connor 1984)

Hedonic Property Value Study

- Objective
  - Examine evidence of impacts on property values of arsenic levels
    - "elevated"
    - spatial spillovers
- Valuation estimates
  - Marginal WTP to avoid exposure

Averting Behavior Study

- Objective
  - Examine evidence of relationships between averting expenditures/decisions and potential causal factors
    - household composition
    - household location
    - arsenic level in drinking water
- Valuation estimates
  - WTP to avoid exposure
  - Value of a statistical life
  - Value of a statistical cancer

Hybrid Conjoint / Contingent Valuation Study

- Objective
  - Examine evidence of relationships between support for State Programs and potential causal factors
    - household composition
    - household location
    - arsenic level in drinking water
    - household drinking water source
    - program coverage
      - private wells, public supplies, both private and public
    - program scope (level of protection)
- Valuation estimates
  - WTP for State Programs

Progress

- Hedonic Property Value Study √
- Averting Behavior Study
  - Focus Group √
  - Survey Design / Approval √
  - Survey Implementation
  - Analysis
- Hybrid Conjoint / Contingent Valuation Study
  - Survey Design / Approval √
  - Survey Implementation
  - Analysis
- * Risk Communication Study √

Results

- Hedonic Property Value Study
  - Devanney (2005)
- Risk Communication - Aggregate Analysis of Household Testing Decisions
  - Huang (2005)
- Focus Group Research on Averting Behavior

Hedonic Results (Devanney 2005)

- Sample
  - Buxton and Hollis
  - 1991 to 2003
  - 2,212 transactions
- Arsenic level
- Other explanatory variables
  - acreage, structures (age, sqft), time

Measurement of Arsenic

- continuous or discrete
  - elevated levels (> 50 ppb)
- property and test
  - 1 to 1 correspondence
  - "closest" test
  - average test result within a radius of ¼ mile, ½ mile, or 1 mile

Estimated Parameters (Arsenic Variables)

- 1 to 1 correspondence
  - insignificant (Buxton)
  - significant (0.1) and negative (Hollis)
- Closest test result > 50 ppb
  - significant and negative (Buxton)
  - insignificant (Hollis)
- Average test result in buffer
  - ¼ mile
    - significant and negative (Buxton)
    - insignificant (Hollis)
  - ½ and 1 mile
    - insignificant

Marginal WTP (Devanney 2005)

Table 4.6. Estimated implicit prices of arsenic concentrations in groundwater.

Variable	Buxton		Hollis	
	Marginal implicit price ($)			
	ML	OLS	ML	OLS
ASHETL	-254.15	-334.03	**-1,497.37***	-1,134.41
AS50	**-400.73****	**-337.67***	-62.92	-26.60
AS50AVGQT	**-216.76***	**-195.68****	-200.91	-125.83
AS50AVGHALF	-31.08	-36.25	-91.63	29.61
AS50AVGONE	-16.07	-19.19	-158.39	-278.37

Notes: ***,**,* denotes significance at the 0.01, 0.05, and 0.1 level, respectively. Arsenic concentrations are measured in parts per billion (ppb).

Sales Price Effects (Devanney 2005)

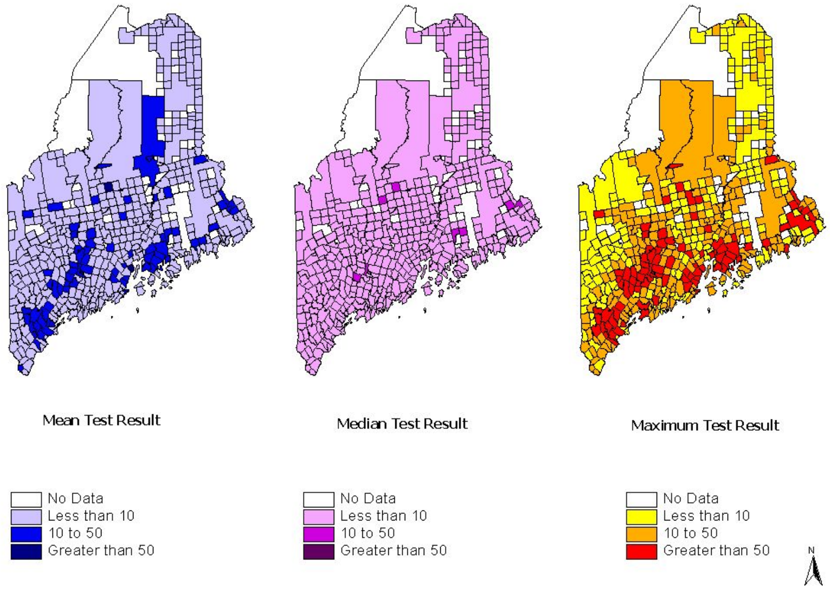
Table 4.7. Sales price effect of arsenic contamination of groundwater.

Variable	Δ in Arsenic concentration (ppb)	Buxton		Hollis	
		Sales price effect ($)			
		ML	OLS	ML	OLS
ASHETL	90 to 50	6,318.21	7,715.17	15,764.57	15,422.50
	50 to 10	7,064.88	8,935.10	29,131.23	24,557.76
AS50	90 to 50	9,049.29	7,430.47	1,664.40	732.56
	50 to 10	10,791.36	8,619.16	1,707.89	740.58
AS50AVGQT	90 to 50	5,508.58	5,044.03	5,403.47	3,479.40
	50 to 10	6,059.81	5,497.01	5,867.52	3,663.66
AS50AVGHALF	90 to 50	887.21	1,029.54	2,695.11	-936.61
	50 to 10	900.06	1,046.06	2,797.57	-925.32
AS50AVGONE	90 to 50	465.32	550.42	4,264.64	3,315.02
	50 to 10	469.29	555.75	4,550.82	3,482.20

Risk Communication Study (Huang 2005)

- **Panel Count Regression Model of Annual Arsenic Test Requests by “town”**
  - **Household-level Data on Tests**
    - **Maine State Testing Lab (HETL)**
    - **1990 – 2003**
    - **Final sample size of 16,854 tests(private residential) over 520 towns**

Descriptive Statistics -Private Residential Tests (1990-2003)



Explanatory Variables

- **Demographic Characteristics**
  - **Census of Population and Housing (1990 and 2000)**
    - **WELLS, GENDER, CHILDREN, EDUCATION, INCOME**
- **Newspaper Coverage of Arsenic in Drinking Water**
  - **Number of total articles**
  - **“town” referenced in articles**

Results (Huang 2005)

- Newspaper coverage (general and town-specific)
  - positive and significant
- Household Composition (at "town" level)
  - education, gender, and income
    - positive and significant
  - proportion of town under age 3 and age 17
    - negative (?) and significant

Focus Group (Averting Behavior)

- Joint Production
- Uncertainty / Misinformation
  - treatment methods in place
- Share Information with Neighbors

Reflections on Current Results

- Hedonic Property Value Analysis
  - further exploration of measurement of arsenic concentration
  - past mitigation
  - timing of sample
- Household test decisions
  - role of test
  - sample selection
  - perverse incentive - disclosure

EXTRA / BACKGROUND SLIDES

Background - Arsenic in Drinking Water: Federal Policy

- 1976 SDWA
  - MCL of 50 micrograms per liter (1942)
- 1999 NRC Report
  - Proposed MCL of 5 micrograms per liter (5 ppb)
    - Evaluated 3, 5, 10, and 20
- 2001 SDWA
  - MCL of 10 micrograms per liter (10 ppb)
  - Public Water Supply Systems Must Comply by 2006

Health Effects (NRC 2001)

- Cancer effects
    - skin, bladder, lung
- Non-cancer effects
    - diabetes, high blood pressure
    - * adverse reproductive outcomes, respiratory effects

Variation in Exposure to Arsenic in Drinking Water

- Ground water sources of drinking water
  - Public Water Supply Systems
    - 100 million persons (2000)
  - Private Wells*
    - 40 million persons (2000)

U.S. EPA NCER/NCEE Workshop
Morbidity and Mortality: How Do We Value the Risk of Illness and Death?

Washington, DC
April 10-12, 2006

Session VI: Valuing Morbidity and Mortality: Drinking Water

"Perceived Mortality Risks and Arsenic in Drinking Water: Preliminary Research"
Presenter: Douglass Shaw, Texas A&M University

Dr. Shaw opened by stating that he had "*way* too much to say and was going to just launch right in." He went on to put a disclaimer on the upcoming discussant comments, admitting that what he was about to present had evolved since the submission of the paper and, therefore, there might be little correlation between the two. In anticipation of "running out of time" and perhaps not getting to his scripted wrap-up to the presentation, he set out the following summary in advance.

"Here's what we're trying to do—I think it's way different than anything you've heard at this conference. There's been a little talk about what to do with people who look like they're irrational, or what do you do with people who don't get the probabilities, and that kind of thing. There's a sense that you either ignore that and you don't know about it at all or that you throw those people out [of your study]. We're not going to do either one of those things. What we're trying to do is to really bridge the gap between what the decision theorists and the psychologists have been saying about risk and uncertainty for the last 25 or 30 years, but which economists, to some extent, are ignoring—and I don't mean the theoretical economists. The theoretical economists are *loaded* with that stuff—they all know it. If you ask theorists in risk and uncertainty what they think about the expected utility model, they'll say, "It doesn't work, and we have 6 billion experiments to show that it doesn't work."

Now, our task then is to determine how we adopt a more-general framework in an empirical setting. Can we do something to bring some of what they're telling us is true into an empirical model? So, our agenda is to try and develop an empirical model of one of the non-expected utility models, make it work with survey data, *and* derive a formal derivation of an [unintelligible word] welfare measure that's consistent with that generalized or non-expected utility model.

So, if this sounds like mumbo jumbo, take a look at the paper that we have coming out in the *Journal of Risk and Uncertainty*, technically coming out this month although it probably won't be. That one's on nuclear waste. We're going to try to do it better when we do this with arsenic in drinking water. So, I won't talk a lot about arsenic in drinking water, but I'm going to talk more about the *theory*, and I'll hope you're awake enough to catch it, because I think a lot of this is important.

So, let me jump to the important things. First of all, what we're interested in is called "ambiguity," and ambiguity goes back a long way. Daniel Ellsberg thought of this in 1961 and talked about how when he did experiments, people were averse to ambiguity. So, what is ambiguity? Ambiguity is *uncertainty about the risks.* So, if you think that you know the risks but people say, "I heard what you said, and I saw all your visuals and everything you communicated to me, and I still don't get it—I still am not certain about these risks"—that's ambiguity. In a lot of conventional settings, you'd say that we can't do anything with ambiguity. Well, we *can*, so that's what we're trying to do.

When you introduce ambiguity, what happens is that the conventional expected utility model is not going to be that useful. It's going to provide a benchmark, so we're not going to throw it out—we're going to try and use it—but we're going to try to expand on that and let it provide a benchmark for us. So, Kathleen [Bell] told you all about arsenic risks, but let me get a little bit of the nitty-gritty of where the problem is [he refers to slides.] If you go to the reports that were done for the arsenic rule, it's as Kathleen said: there were some thresholds. The old threshold was, of course, 50 parts per billion (ppb); the new one is 10. What do we know about 50? Well, that in itself the experts don't agree on. Even one of the members of the Science Advisory Board for arsenic said, when I asked him if 10 was safe, "Well . . . we didn't all agree about that." When I asked then why they set it at 10, he responded, "Cost—the cost of compliance. If you go below 10, it's going to be a real problem, particularly for rural areas."

So, is 10 safe? Well, we're going to *say* that 10 is safe, but the reality is if we tell people that 10 ppb is safe (which may or may not be true, but let's assume for now that it is), the *real* problem for people, as Kathleen suggested, is between the 10 and wherever they are. So, if someone is at 22 ppb, and they're wondering if they're safe, what *exactly* are the health risks? We know some things from the Science Advisory Board. For instance, we're looking at 30-to-60 times higher than baseline risk for the incidence of lung and bladder cancers. That's good that we know that, but we have no exact credible relationship that's been mapped out between 0 and 10, or 0 and 22, or 0 and 50. Now, there was extrapolation done in the EPA report that looks pretty good, but a lot of the physical scientists are arguing and disputing with that—there are some papers out in some of the science journals that say it was just an extrapolation and if we apply a different approach, we get different results.

So, this is a perfect setting to allow for ambiguity, because if the experts don't even know what the risks are, then how can we expect the respondents to know what the risks are? Then we add to that that you've got all of these complicating factors. It matters *hugely* in a drinking water setting that risk is completely endogenous. It can be completely controlled by averting behavior, either through your drinking water behavior itself or adopting a treatment—you can solve the arsenic problem pretty quickly if people are willing to install a reverse osmosis or distillation treatment method in their homes or if they're willing to support a program that brings the public drinking water system into compliance. But, that means that the risk is endogenous and there is going to be a lot of averting behavior that we have to watch out for.

Okay, I'll tell you what I know so far about arsenic, and then I'll try to do a little more of the theory to give you an idea about where we're going with this. We did a pilot study for USDA. If you want the papers, there are two of them out that are already published—you can ask me about those—I have a couple of copies of them. Here's the bottom line, and I think Kathleen suggested that they're finding the same thing. Drinking water behavior is very complicated. When we started the pilot study for USDA, we thought it was really simple. We thought that all you have to do is ask people, "Do you drink tap water?" Wrong! What we found out in the pilot study is when you ask people this question, a whole bunch of them say, "No." Then when you follow that up and ask what they do, they might say they drink bottled water. Then when you ask them if they use bottled water in all their cooking and to make tea and to fill up the ice trays and all those kinds of things, they say, "Oh no, we don't do that. We drink bottled water if we're at work, and then when we're at home we use the tap water . . ." They said, "No," but the reality, and what the published studies report, is that they *do* use tap water. So, you have to ask them very detailed questions about what their drinking water behavior is. People who live in two-story houses will ask whether you mean in the kitchen or whether you're asking about the glass of water they drink when they get up in the middle of the night. If you're really going to get a detailed report on drinking water, you have to ask all of that.

[Again, referring to slides, he continued] People don't treat because of cost. We have a relationship in the data that we have, where we were looking at a rural area of Nevada. They were completely aware of the arsenic in the drinking water of the rural area community that we studied. They had been studied to death—the CDC had come in there—Hillary Clinton had gone there—everybody had gone there—they had a very well publicized cancer cluster—they were all very aware, and they're still drinking it. We have people in this rural area who are drinking water with arsenic at 100 ppb—we have some with 500 ppb—the risks are very, very high. We were astonished to see that. So, when you ask them why they're doing that, they say, "Well, you know, the government doesn't know what they're talking about. This stuff is safe—I've lived here all my life, and I don't have cancer." That's a common response that we received. So, we learned a lot from that. We learned that we have to expand the surveys that we are doing to substantially rethink and rework the kinds of questions about tap water that we're going to ask.

Trudy [Cameron] has a paper that I don't think many people know about. It's in the *Journal of Risk and Uncertainty* the year before ours. It's very different from our paper, but she does have a measure of ambiguity, and she finds that it is important in explaining behavior.

Here's another way to think about ambiguity that might be useful. The decision theorists say that you can view a lot of complex problems as a two-stage lottery. In normal expected-utility frameworks, we think that everybody can take a compound lottery and they can do the multiplication and they can reduce that to an easy single-lottery problem. That's called the "reduction of compound lottery axiom," and that's something you would adhere to and believe in if you believe in expected-utility theory. With ambiguity, that's not so. What we think, in fact, is that under ambiguity, people cannot do that. In experiment after experiment after experiment—many of these get reported on in the *Journal of Management Science*, which is a big decision theory journal, and some other ones—people can't do it. *And*, in conjunction with Reed's comments this morning, [F. Reed Johnson] they are much better able to do it in the context of financial gambles because when you talk about flipping a quarter and getting a head or a tail, they can figure that out. So, if you say there's going to be an expected outcome, they'll say, "Oh yeah, I get that. I know what an expected outcome is"—because it's simple. What we've found in the work that we're doing is that they can't do the same thing when you talk about mortality. It's emotional, and it's very difficult for them to do.

So, what does the utility function look like with ambiguity in it? [again, referring to a slide] There's one right there. They're complicated. You can put in two different probabilities, and you can put in what's called an "absolute risk aversion coefficient." In empirical work, we don't want to *assume* that people are averse to ambiguity—we want to test for it in an empirical model and see if it turns out to be true. In that utility function there [referring to a slide], there are two states, and in state 1, the person doesn't know—the probability could be equally likely to be very small or very large. We see that in behavioral experiments all the time.

So why do people do this? They do this for a lot of reasons. One, psychologists think they do this because they get confused. You give them too many sources of information, and those sources conflict with one another. For instance, in climate change, gee, it might get hotter or it might get cooler—it might get wetter or it might get drier. So their perception is that the questioners don't even know, so they get totally confused and that creates ambiguity. It's more pronounced when they're not confident and, if it can be overcome, if they're quite confident. Chip Heath and Amos Tversky have a paper on that.

[referring to a slide] Here's the mess that you get into: If you allow for ambiguity, then the probabilities that you're dealing with may not do the things that you're hoping they'll do. We all think, for example, that probabilities are supposed to sum to 1 if we've given people a complete space of probabilities. With ambiguity they may not, and the decision theory people are well aware of that. David Schmeidler has this whole new mathematical technique called [unintelligible word] integration which allows for that. You can also have violations of stochastic dominance—and then something I'm working on as a side paper to all of this: What is the welfare measure in all of this? The decision theory people don't care about welfare measures. If we went to them right now and we told them that we're running around estimating willingness to pay for this and that kind of risk reduction, they'd wonder what we're talking about. They'd say, "Do you mean like Pratt's Risk Premium?"—because that's the only thing they know about. And if we say "option price"—some of us in this room know that if you send out a paper to a journal and you say "option price" they send it to a finance person because they think you're talking about pricing financial options. So, there's sort of a gap between them and us on all of that.

Okay, here's the key thing: In all of the alternatives to the expected utility model, the heart, foundation, and soul of these approaches is a probability-weighting function. What we know from observed behavior is that people can over-weight very low probabilities and they can under-weight high ones, and each person can do something different. So, that weighting function there has an inverse-S shape—that's the one that Kahneman and Tversky thought that we would most often observe when we observe behavior. So, for everybody in the sample that we're going to try to go after, we're going to try to get their probability weighting function. The question is "How do you get it?"—and that turns out to be very hard to answer. So, in the focus groups we have been trying to uncover this probability weighting function. Again, the risk and decision theory people have done this in experimental settings, but they've primarily done it with incentive-compatible financial gambles. They'll tell people, "We'll give you $100 to participate in this experiment—we're going to try to do these things on your probability weighting function—if you get it right, you can win a whole bunch of money"—and people try very, very hard to get it right. This is where a lot of this stuff about the trade-offs comes from, so when you talk to people about doing kinds of risk/risk trade-offs or life trade-offs, this is really coming from Peter Fokker's work on whether we want to ask people about the difference between a certainty equivalent and risk measures or whether we want to ask them about something different than that. That led people to wonder, "Gee, could we do this with mortality risks?"

So, that's what we've been up to for the past six months—running experiments and doing focus groups to try to see if we could get at this probability weighting function. We're not having much luck, unfortunately. It's turning out to be quite hard. There is one paper in the entire literature that I know of (and I'm probably wrong—somebody's probably got another one somewhere) where they did it for mortality risks and they were convinced that it was right.

The last little bit that I wanted to talk about is this willingness to pay issue. It has come up time and time again over the past two days, and I wanted to put this slide up about what is this welfare measure that we're trying to get? I want to remind people: We're trying to get the option price. The reason we're trying to get the option price is because Daniel Graham and all that work that he did was trying to help all those great people (Rich Bishop among them) who had struggled with trying to figure out "What do we want?—Do we want an option value?—Do we want an option price?—Can we use the expected surplus?—and all of those kinds of things.

The bottom line is that it's a state-dependent concept. We have two states. We've got the balance of the left-hand side with the right-hand side. What I wanted to make a plug for is that if you look at Trudy's [Cameron] paper in the *Journal of Public Economics* last year and you look at ours that's coming out, you'll see that we're very careful about the derivation of that option price. In ours it's even more complicated because we have ambiguity in the model and we derive the "quasi-" option price—because I don't know for sure what it is yet. But, we take the expected utility difference, and when you solve an equation like this one [referring to a slide], and you set it equal to zero in the top, the expected utility difference, and you solve for some sort of *payment* that balances these two things, that's how you're going to get the formal expression for what the willingness to pay is. What I'm interested in finding out is whether a lot of the really good people who have been here the last couple of days are doing that.

Okay, that's kind of the theoretical stuff that I wanted to talk about, and if I lost you, I'll be happy to talk about it afterwards. Here's what we're thinking, and it sounds as if we're thinking a lot of what Kathleen [Bell] and them are thinking: With public systems, we're trying to do both public and private wells—the private wells are not regulated by the federal government, whereas the public systems are. What we have figured out from our focus group work so far is that with public systems people can certainly choose to treat within their own homes, and many people often do because they don't like the taste of the drinking water that comes out of the public system. For example, in the town that I live in the water is considered by EPA to be perfectly safe, yet thousands of households have water treatment systems because they can't stand the taste. If you've ever been to Texas, you know that the tap water has a lot of salt in it and tastes terrible. Another interesting health issue is whether people's blood pressure is going up because of drinking the tap water down there, so people are working on that down there too.

Now, their rates may increase if they're on the public system, or they may have already, to pay for getting into compliance, and if it was an [unintelligible word] framework before it happened, of course we would want to find out whether they'd support that rate increase. We're going to also be trying to tackle the child vs. adult health issue, so thank you for all those great papers—I've learned a lot on that, because we haven't been sure how we're going to deal with that. We're going to try to allow for ambiguity for the public system. For the private, we have to ask them if they treat. And remember, when you ask this, it is a very complicated question, because in our focus groups and in the pilot study we did for USDA people say they don't know what is meant by that. So, you have to explain to them very carefully what treatment you mean and which types of treatment that they can adopt actually get rid of arsenic. I never thought in a million years to ask this or to explain this to people, but we've been asked in every focus group so far: What about our refrigerator—is the water that comes out of the door dispenser treated? They do actually put a little filter on the back of many refrigerators to filter the drinking water, but as it turns out, it's a charcoal filter and it's not the kind that actually gets rid of arsenic. But when you tell people that they need a reverse osmosis filter, they don't know what that is. Or, they may respond that they treat, but it turns out to be a Brita water pitcher, which doesn't do anything to get rid of arsenic.

Now, we were thinking of doing complete private welfare measures for those on private wells and then we thought: These people could have a public-goods-related welfare measure. So, again, similarly to what Kathleen and them are doing, we also are going to try to take advantage of different valuations approaches. So, we can have a revealed preference value that comes out of adopting a treatment method, which is going to be averting behavior and can reveal their value for protecting themselves, but there's no reason to think that those people in private homes don't also have some sort of value for a public good. If we can get both out of the same household, we'll be able to cross-validate and look at the preference functions in both cases, which would be really nice. That's one of the things that—those of you who have never cared about recreation demand modeling, you missed a good thing. The good thing is that those guys figured out that you can use stated preference and a revealed preference in the same model and then do preference restriction tests, which are quite nice, actually.

So, we're going to tackle trying to get all of that—both a public and a private value—out of the people on private wells, and we'll try to get the averting behavior if they've done it.

I'll only share one of the focus groups so far and what came of that. [again, referring to slides] For this group, which was on a public system—this was Eagle Mountain, Utah—we knew that their drinking water was 26 ppb arsenic, so they're not in compliance with the new arsenic rule. We did two focus groups there, and we thought that in the first one we would not tell them. Well, in the first five minutes, when they started to figure out that it was all about arsenic in drinking water, they began to demand that we tell them what their level was. We realized that once you open this door, you have to tell them pretty quickly what their arsenic level is. That's going to be a challenge for our survey team. We're using a risk ladder, and J.R. [DeShazo] and I had a really good discussion on the phone one day about risk ladders vs. grids. We have tested both risk ladders and grids. Surprisingly, our folks are doing a lot better with the risk ladder than they are with the grid, even though some people are saying that that grid is the way to go now. It *may* be that you want to do baseline risks with the ladder and changes with the grid. But then that raises the issue of "Are you overloading them with two different kinds of risk communication devices?" In all of the risk experiments that we've done so far, when we communicate to them that we think the risks are different for children and that they're probably higher, they get that. So, when they come back with subjective risks, we let them mark on the ladder what they think the risks are after we tell them what the experts think the risks are. When they come back and mark them on the ladder, they mark very different points than the experts did, but they get that relative difference between an adult's and a child's risk.

[referring to slides] Here are some summary results from this particular focus group: There were eleven subjects in the focus group and all but one said that the child's risks were much higher. On the risk ladder, they all say very different orders of magnitude from what we told them, which is interesting. That's borne out in the paper on nuclear waste that's coming out in the JRU. Jim Hammitt was talking about having very, very low risks of 1 in 100,000. *Ours for nuclear waste were 2 in 10,000,000!* There is no way that people can understand what 2 in 10,000,000 means—they just cannot do it. So, when we get their subjective risks in that study, and we were looking at people that live along the proposed transportation corridor for shipments to Yucca Mountain, they come back with risks *thousands* of times higher than the DOE says that those risks will be. I told that to Paul Slovik a couple of years ago and he laughed and said, "I told them that. I've been telling DOE that for 20 years and they won't listen to me." But, again, if you have very low risks, in the scheme of things all of this becomes much more important.

So, that's good enough—I'll stop there. Thanks.

Willingness to Pay to Reduce Community Health Risks from Municipal Drinking Water: A Stated Preference Study

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ABSTRACT

This paper examines the value of health risk reductions to Canadians in the context of clean and safe drinking water. The health risks we examine pertain both to microbial illnesses and/or deaths and bladder cancer illnesses and/or deaths. The cancer risks arise because chlorine, the most common disinfectant used to remove microbial contaminants, has been implicated in the production of Trihalomethanes (a disinfection by-product) that are linked to increases in bladder cancer cases. We evaluate results from an panel-based Internet survey of 1,600 Canadians conducted in the summer of 2004. The survey included text and graphical information regarding risk changes and employed contingent valuation and attribute-based stated choice benefit valuation techniques. The valuation questions were designed to elicit consumer preferences for public programs to reduce health risks associated with improved tap water. Our analysis of the stated preferences of consumers reveals several types of values that are of interest to policy makers. These include: the value of mortality risk reduction and the value of morbidity risk reductions for both microbial contaminants and cancer. In addition, the value of reducing cancer risks versus microbial risks in a public context is revealed. Our results suggest that reducing mortality risks from microbial illness has greater value than reducing mortality risks from cancer. Similarly, overall microbial risk reductions programs (mortality and morbidity) have higher value than cancer risk reduction programs in this context. In addition, we provide separate estimates of the value of statistical life associated with cancer and microbial risks, and the value of statistical illness cases associated with these two risks. The results also include a host of

comparisons between contingent valuation and attribute-based methods, as well as different formats within each of these classes of methods. The values estimated in this study can be used to evaluate investment decisions associated with water treatment, or as estimates of mortality and morbidity value in benefit transfer cases.

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Background

Ninety percent of Canadians receive their tap water from public water systems (Environment Canada, 2004). With assistance and scientific input from Health Canada, the Federal-Provincial Subcommittee on Drinking Water (DWS) has developed a set of national drinking water guidelines. The publication *Guidelines for Canadian Drinking Water Quality* lists substances found in drinking water that are known or suspected to be harmful. The most recent summary was published in 2004 (Federal-Provincial-Territorial Committee on Drinking Water, 2004). Substances include both pathogens (microbes such as E. coli, cryptosporidium, giardia, etc.) and potentially carcinogenic chemical by-products (such as Trihalomethanes or THMs). These are formed when chlorine – used for disinfecting water to destroy bacterial and viral contaminants – reacts with other chemicals present in the water.

Provincial regulations require municipal water utilities to provide tap water that is as free as possible from pathogenic micro-organisms called microbes. While many people are familiar with the harm caused by the bacteria, E.coli O157:H7 in Walkerton, it is not the only microbe of concern. Over the last 10 years communities all across Canada have experienced problems with other microbes including: cryptosporidium and giardia. Microbes are generally transported into surface water through agricultural runoff. While most municipalities employ both primary and secondary disinfection technologies - typically chlorine-based - to remove microbes, recent work shows that some microbes are present, even in disinfected tap water (Payment, Berte, Prévost, Ménard, and Barbeau, 2000).

Concern has been expressed about the predominant use of chlorine for disinfection (Carson and Mitchell, 2000). It is implicated in the production of a number of disinfection by-products commonly called Trihalomethanes.[1] These are considered to be potentially carcinogenic. Health Canada convened an expert workshop in 2000 to look into the health risks of drinking water chlorination by-products (Mills, Bull, Cantor, Reif, Hrudey, and Huston, 2000). After reviewing the available evidence, the experts noted that, five epidemiological studies show a statistically significant positive association of chlorinated by-product exposure with risk of bladder cancer. The expert panel concluded "… that it was possible (60% of the group) to probable (40%) that chlorination by-products pose a significant risk to the development of cancer, particularly bladder cancer." Furthermore, they stated that "… this is a moderately important public health problem."

For each substance, the Guidelines establish the maximum acceptable concentration (MAC) permitted in tap water used. A change in any MAC level generally means that water suppliers must improve disinfection techniques in order to meet more stringent requirements. In general, these new methods are more expensive than the traditional chlorine-based methods. While they may or may not be as effective at removing microbial contaminants, they are generally considered to produce fewer THMs. Thus, it is possible that there is a tradeoff between reducing THMs and reducing microbial contaminants.

To inform such tradeoffs, public preferences towards reducing bladder cancer from THMs and microbial disease from pathogens in water must be gauged. Thus, the main research question examined in this paper is how much Canadians are willing to pay on their municipal water bills in order to reduce these types of health risks from drinking tap water in their community. To our knowledge, ours is the first effort to elicit tradeoffs from individuals between reducing microbial risks and reducing cancer risks within the context of publicly supplied water quality. From a methodological perspective, ours is also one of the few attempts to ask for mortality risk and morbidity risk preferences in the same survey (see Cameron and DeShazo for another example), albeit in a public goods, rather than private goods context. In addition, our study examines the performance of two stated preference techniques within the same basic survey, i.e., contingent valuation and choice experiments. While there have been several comparisons between CVM with ABSCM (see e.g. Adamowicz et al 1998 or Hanley et al, 2001 for a survey) our comparison includes controls for various context factors including information provision, number of alternatives presented, and a referendum approach.

Using data from an Internet-based survey conducted across Canada during the summer of 2004, the paper presents estimates of the value of reducing one more death or one more illness in the overall population. Values such as these can be used to actually inform choices of technologies for treating drinking water at the plant level and may also be used to help evaluate policy options at the Provincial or Federal level. For instance, on the one hand, the status quo disinfection technology implies a set of baseline risks for microbial illnesses and deaths and cancer illnesses and deaths. On the other hand, alternative disinfection programs using ozone or ultra-violet light are expected to reduce the health risks associated with cancer illnesses and deaths and with microbial illnesses and deaths. However, these programs are more costly to the household (US EPA, 1999). From the point of view of the public, the decision problem is whether it is worth the additional cost to have reduced risks of both morbidity and mortality effects and whether effort should be focused more on microbial illness reduction versus reductions in cancer cases.

The next section discusses a number of methodological issues addressed in the surveys. This is followed by a description of the survey versions employed in this study. Survey administration and a brief description of the data are presented next. After this, the models and empirical results, along with a number of statistical tests, are described in detail. A discussion of how these results can be useful in a policy context follows. Conclusions and suggestions for future research directions complete the paper

Methodology

Our goal is to obtain information about consumer preferences and tradeoffs relating to household water bill increases and the morbidity and mortality health risks associated with the consumption of tap water. Given the inefficient pricing structure adopted by water utilities and the absence of competitive markets for the sale of tap water, virtually no information exists that yields the value of potable water to Canadians, or indicates which aspects of water are subject to potential tradeoffs according to preferences. In order to obtain this information we constructed a hypothetical market, which allows respondents to express their preferences. We discuss below in detail some important aspects of what we did: preference elicitation methods, presentation of health risks, and public versus private risks.

Preference Elicitation Methods

We employ two non-market valuation methods for eliciting information about consumer preferences for the public good "tap water" -- contingent valuation methods (CVM) and the

Attribute Based Stated Choice Method (ABSCM) (Adamowicz, Louviere, and Swait, 1998). CVM requires the researcher to describe in detail the characteristics of the good to be valued (scenario). Respondents then answer choice questions (we used a double-bounded dichotomous choice format) about whether they would be willing to pay for the described good in its entirety at a stated price. The researcher constructs the willingness-to-pay for the good, where the expressed WTP is for the good in its entirety as described in the scenario, from the pattern of responses. In the ABSCM framework a good is described expressly as a bundle of characteristics or attributes. Each attribute provides valuable services to the consumer. While the individual attributes have value, they cannot be purchased separately but are acquired by the consumer at some stated price for the entire good. With this approach, then, the price paid for a particular bundle of characteristics becomes itself an attribute. In contrast to the CVM method, which provides an overall willingness-to-pay for the bundle of attributes, the ABSCM approach permits us to determine separate willingness-to-pay values for each identified attribute, as well as to examine tradeoffs between individual attributes. For the purposes of this project, the relevant tap water attributes are household water costs and morbidity and mortality health risks from microbial and bladder cancer.

Describing the Health Risks

In presenting the program choices to survey participants we need information about the health effects (a description of each health risk in terms of the symptoms) and baseline risk levels (the likelihood of contracting the disease and or dying from it), as well as changes in risk levels and costs of different programs. A range of reasonable program cost increases was estimated from information on alternative disinfection technologies (US EPA, 1999). These were presented as dollar increases per year in one's household water bill effective January 2005. Information describing symptoms of microbial and bladder cancer illnesses is readily available from a number of sources including Health Canada and the United States Centers for Disease Control. (See Appendix 1 for descriptions used in the survey.)

Baseline information for the number of microbial illnesses and deaths attributable to waterborne microbes is needed for our survey but difficult to ascertain. While outbreak data are collected by regional health officials, they are generally considered to be lower bound estimates of endemic health risks (Mead et al. 1999). This is for three reasons. First, some people become ill prior to general knowledge of an outbreak and are not tested by the doctor for the presence of the microbe, so these cases are not counted. Second, symptoms are often attributed to another cause such as food poisoning or flu. Third, some microbial illnesses are not considered "notifiable" diseases, so doctors are not required to report cases. A second source of data for water-based microbial illnesses is from medical practice cases, which are generally considered to better present the endemic risks (Wheeler et al. 1999; De Wit et al. 2001). A third source of data, which presents the highest estimates of health risks from microbial illnesses, is from microbiological studies examining water supplies for presence of pathogenic micro-organisms.[2] These represent the high end because they assume a dose-response model that links the number of organisms to the number of affected persons (Payment and Riley, 2002). Data on the number of deaths attribute to waterborne microbes are even scarcer. However, Ronchi and Wald (1999), writing in the OECD Observer, claim that "in the United States about 900,000 cases of illnesses and 900 deaths occur every year as a result of microbial contamination of drinking water".

Determination of the baseline risks of becoming ill and/or dying from bladder cancer from consuming water that contains elevated levels of THMs also poses problems. While there is some disagreement in the scientific/medical literature about the relationship between chlorine in water and the incidence of bladder cancer, there are a number of studies that show an association. Recent work under the auspices of Health Canada reports on a study of individuals living around the Great Lakes. The research shows a link between the presence of THMs in drinking water and increased cases of bladder cancer. These results suggest that long-term exposure (on the order of 20-35 years or more) to THMs in water may cause between 14-16 % of all bladder cancer cases in Canada (King and Marrett, 1996). Similar numbers from the United States EPA are between 2-17 % (Mills, Bull, Cantor, Reif, Hrudey, and Huston, 2000). Cancer statistics are available from Health Canada (Cancer Surveillance on-line) by site. Status quo bladder cancer cases attributed to water consumption can be estimated by applying the attribution rates to all bladder cancer cases. Mortality rates are also presented on the Health Canada Cancer Surveillance web site.

With our baseline numbers established (See Appendix 1), we review the engineering and microbiological literature for estimates of anticipated reductions in microbes and/or THMs associated with improvements to water disinfection systems. Numbers from US EPA (1999), Havelaar et al. (2000) and Barbeau et al. (2000) form the basis for our estimates of changes in baseline risks presented to survey respondents (See Appendix 1).

Appendix 1 shows three pages of health risk information presented to our survey respondents. They review this information prior to answering the preference elicitation questions. The first page describes potential health effects associated with using chlorine for water treatment. In particular, it describes symptoms of bladder cancer and clearly identifies the potential tradeoff between the beneficial aspects of reducing microbial contaminants and the potential adverse effects in terms of enhanced risks of contracting bladder cancer. The second page places the baseline microbial and cancer risks together and shows typical linkages between illnesses and deaths for each health condition. In addition, it puts health risks from tap water consumption into a more general perspective. It is important to present the contextual setting to respondents, so that tap water health problems are not viewed in isolation from other health risks. The third page summarizes the baseline health risks from the four health outcomes: microbial illness, death from microbial illness, bladder cancer illness, and death from bladder cancer. Again, the magnitude of health risks from tap water consumption are contrasted with all health risks for each of these health outcomes.

Since we are asking our respondents to assess these health risks, we need to ensure that they are able to evaluate changes in health risks in a meaningful way. Some respondents find numerical representations difficult to interpret. There is a large literature on how best to communicate risk and researchers have used visual aids such as graphs, pie charts, risk ladders, and tables (Jones-Lee et al., 1985; Hammitt, 1990; Corso, Hammitt, and Graham, 2001). We adapt probability communication techniques from Krupnick et al. (2002). After experimenting with a number of options we use what we call our “snake in the sand” design. This begins with a blue rectangle representing a population of 100,000. To this rectangle we add yellow squares representing individuals who get microbial illnesses from drinking tap water and red squares representing individuals who get bladder cancer from drinking tap water. We superimpose black squares onto either the red or yellow squares in order to illustrate the deaths arising from either microbial illnesses or cancer illnesses. An example of this graphic is shown in Appendix 2 for a CVM format question and in Appendix 3 for an ABSCM format question.

After reviewing the background information (in Appendix 1), the survey respondent is presented with a discussion about changes to water disinfection methods that can alter health risks. The respondent is told that he/she will be faced with a series of choices regarding alternative municipal water treatment programs for his/her community. Each choice includes a status quo (do nothing) option. Alternative programs presented generally lower the health risks and involve an annual increase in the existing water bill for the household. A given respondent answers questions either in the CVM format (example in Appendix 2) or the ABSCM format (example in Appendix 3).

Private versus Public Risks

An issue arising from the approach adopted in this research is whether this particular problem should be treated as an individual (private) decision or a social (public) decision. The private decision context would readily yield individual specific measures of value (e.g. values of statistical life or VSLs) that could be compared to other private good estimates (e.g. Krupnick et al, 2002). A public context, however, is more realistic in this setting since drinking water is consumed by an individual at home as well as at other places (office, school, etc.) and most people view drinking water treatment as a municipal or public responsibility. Therefore, the decision context chosen for this case is a public or social decision. Carson and Mitchell (2000) make the same choice in their open ended CVM survey to obtain willingness to pay for carbon filtration to reduce the risks associated with trihalomethanes,

Thus, with our approach respondents are asked to indicate their preference for one program for drinking water improvement over another (or the status quo). A potential drawback of this approach, however, is that the resulting estimates of the willingness to pay for water quality improvement and for the specific attributes of reduced microbial and cancer risks may contain elements of altruism. That is, when individuals make their choices they may be thinking about their family members, friends, and others in the affected community who will benefit from this program in addition to themselves. Thus, we elicit the individual's preferences including, at once, that for their own health and for the rest of their community. While, in principle, we would like to have these "total social values" to make policy decisions, summing altruistic values from all individuals can introduce an unknown, possibly large degree of double-counting, as opposed to the summing of individuals' values for their own risk reductions, where the latter provides, perhaps, a reasonable lower bound to social value. While this is a challenge, it may also provide us with important and interesting information. Since so many individuals in certain provinces and areas of Canada rely on tap water substitutes, and thus may believe the benefits of such programs will be enjoyed wholly by others, ultimately we hope to be able to sort out altruistic and individual values. This is a topic for future papers.

Outline of Survey Versions

We developed two versions employing the CVM format and 6 versions employing the ABSCM format. In this paper, only four versions of the ABSCM format are referenced. Details of each version follow. Table 1 describes some of the key features of these different versions.

Versions 1 and 2: Contingent Valuation Methodology Format (CVM)

The CVM format (example shown in Appendix 2) presents the respondent with the option to choose status quo (no increase in water bill, no reduction in health risks) or a new municipal water treatment program (increase in water bill, reduction in some or all health risks). Regardless of the versions, each respondent was presented with three separate double-bounded dichotomous choice questions. For Version 1, when compared with the status quo, the first question presented a reduction in bladder cancer illness (from 100 to 50) and a proportional reduction in the risk of death (from 20 to 10), holding constant microbial illness and death risks at their status quo levels. For the second question, respondents were asked to consider a reduction in microbial illnesses from 23,000 to 7,500 and a proportional reduction in the risk of death from 15 to 5, holding constant cancer illness and death risks at their status quo levels. For the third question, the reductions in health risks pertained to all four risks and were the same as those in questions one and two. The payment vehicle was additional costs to the household water bill. Payment levels ranged between $25 per year to $350 per year.[3]

For Version 2 the ordering of the first and second WTP questions was reversed; however, the risk reduction and payment levels are the same as those in Version 1. The third question was identical to that in Version 1.

Versions 3 to 6: Attribute Based Stated Choice Format (ABSCM)

The ABSCM approach begins with the determination of a number of attributes that characterize the good to be valued, along with the setting of the number of separate levels of those attributes. For each choice task the respondent compares a status quo option of no change (risks or household water bills) with either one (Versions 3 and 6) or two (Versions 4 and 5) alternative municipal water treatment programs, where attribute levels for these programs are varied systematically according to the experimental design. Each combination of attributes/levels represents a unique bundle of the good to be valued (Cochran and Cox, 1957). A fractional factorial experimental design procedure is needed to identify those combinations that best reveal the underlying consumer preferences (Louviere, J., D. Hensher and J. Swait, 2000). We identify 32 combinations and divide these into 8 blocks of four questions each. In order to avoid respondent fatigue, each respondent is randomly chosen to face a particular block of 4 choice tasks only. Appendix 3 presents an example of one of the choice tasks faced by survey respondents who received the ABSCM format of the questionnaire.

In order to facilitate a direct comparison of the results from Versions 1 and 2 with the ABSCM format, Versions 3 and 6 present respondents with a status quo option, along with a single alternative program choice. Programs describe three attributes: cancer cases, microbial cases and household water bill. Cancer and microbial cases are each defined to have four levels of attributes, while household water bill has five levels (including a status quo level of zero increase in a water bill). These values are the same as those used in the CVM questions. We maintain the fixed proportions ratio between morbidity and mortality effects.

One problem with assuming a fixed proportions relationship between illnesses and deaths is that it does not permit us to disentangle the willingness to pay for cancer or microbial morbidity risk reduction from that for cancer or microbial mortality risk reduction. While we could have created a large number of sub-samples of CVM questions using varied proportions, this approach would have been costly since it would have required at least 100 respondents per sample in order to have confidence in the statistical properties of the estimates. A solution is to employ a desirable feature of the alternative ABSCM format to obtain separate WTP values for each of the health risks of interest.

Versions 5 and 6 relax the assumption of proportionality between morbidity and mortality health effects. This requires us to specify five attributes: cancer illnesses, cancer deaths, microbial illnesses, microbial deaths and household water bill. Version 5 presents the respondent with a status quo option, along with two alternative programs. Version 6 is similar to versions 3 in that the respondent may choose only between status quo and one alternative program.

Regardless of the version the ABSCM formats share a common framework. Each respondent provides us with four separate choices across a number of different levels of each attribute.

These choices are pooled and added to choices made by other respondents in order to obtain WTP estimates for the various attributes, along with the tradeoffs between these attributes.

We identify results from the 6 versions as follows. We call results from Versions 1 and 2 our CVM results. We call results from Versions 3 and 4 our Proportional (ABSCM) results and we call results from Versions 5 and 6 our Non-Proportional (ABSCM) results. In all cases we first estimate separate models using data from each version without covariates and follow this with estimates that include covariates. Furthermore, we estimate all models using firstly the full sample of data and secondly a reduced sample of data that removes individuals whose responses identified them as "yea-sayers." (See discussion in next section of how these individuals were identified.) Finally, we also estimate pooled versions of the models: CVM (using data from versions 1 and 2), Proportional ABSCM (using data from versions 3 and 4) and Non-Proportional ABSCM (using data from versions 5 and 6). We also perform series of statistical tests to determine whether these data can be pooled.

- The CVM results are used to obtain a willingness to pay estimate for reductions in cancer risks, a willingness to pay for reductions in microbial risks, and a willingness to pay for reductions in both types of risks together. In the discussion of the empirical results we examine the role played by question order upon these willingness to pay values. We also examine whether the results support both a weak adding-up test (the willingness to pay from question 3 is greater than either the willingness to pay from question 1 or question 2) and a stronger form of the same test (the sum of the individual willingness to pay values from questions 1 and 2 is equal to the willingness to pay value obtained for both items in question 3). We also examine the effects of screening out for yea-saying responses and, finding such effects, do most of our analyses with these respondents removed.

- The Proportional ABSCM results are used to calculate both an overall willingness to pay for the same health risk reductions as described in the CVM scenario for the three items (microbial risk reduction alone, cancer risk reduction alone, and combined cancer and microbial risk reduction). In addition, we present results on the marginal willingness to pay for a one unit reduction in either of these items. As for the CV analysis, we remove respondents who answered questions leading to categorizing their answers as "yea-saying."
- We compare the results from the CVM approach with those using the Proportional ASBCM format in order to determine whether question format has an impact upon the estimated willingness to pay values.
- The Non-Proportional ABSCM results are used to calculate overall willingness to pay values for the same health risk reductions described in the CVM scenario. However, we can now separate out the WTP for the cancer deaths from that associated with cancer illnesses. Similarly, we calculate the WTP for reductions in microbial deaths, as separate from the WTP for microbial illness risk reductions.
- We compare results from the Proportional ABSCM and Non-Proportions ABSCM versions to determine whether a relaxation of the fixed proportions assumption of deaths to illnesses has an impact upon the estimated WTP.

Survey Administration and Data Description

Survey Administration

We employed Ipsos-Reid, a marketing and public research agency to administer and put the survey onto a secure on-line website. Respondents were solicited from amongst a panel of Internet users maintained by Ipsos-Reid. The panel consists of over 100,000 members and reflects an accurate, balanced representation of Internet-enabled Canadians, recognizing that this does not necessarily mean that the panel is representative of all Canadians. These households have been recruited primarily to the panel over the telephone using random digit dialing. After focus groups and pilot testing to refine the survey, we implemented the final version in two waves during the summer of 2004. The waves are only important because they gave us an opportunity to make “mid-course corrections” to the survey, of which there were virtually none. As, after analyzing the data, we have found no reason to distinguish responses by wave, we drop this distinction from here on out. On our behalf Ipsos sent out 4,563 email invitations to its panel of Internet users, of which 2,520 respondents began the survey. Of these 1,633 completed the survey and 419 individuals quit the survey before completion. Additionally, 466 were dropped because they did not obtain any of their tap water from a local municipal water supplier. Finally, 2 responses were deleted after errors arose when the Ipsos server went down in the middle of completing a survey. Assuming that ineligibles are found in the same proportions to those contacted as to those responding (466/2520 = 18.5%), the overall response rate is 46% (1,633/3,536). As we utilize only six of the 8 versions of the survey in this paper, the sample size is 1219.

Table 2 presents summary statistics from the data for all the variables used in this paper, both for the full samples (by stated preference approach -- CVM or ABSCM) and samples that remove “yea-saying” observations. (See below for discussion of how this was done). The Table also reports 2001 Census average statistics for the Canadian population. For most characteristics, average values for survey respondents are virtually the same as these average values. The only socio-demographic characteristic that differs in any appreciable way from that of the general Canadian population is the percentage of individuals educated beyond high school. The 2001 Census estimate is 55 per cent, while the corresponding value for our sample, collected in 2004, is 79.1 per cent. In the previous five years, the percentage of people educated beyond high school increased 5 points. So, the 2004 percentage is likely to exceed 55 percent.

The most important implication of our overeducated sample is in the implication for non-response bias because of the Internet nature of the panel. Statistics Canada (2004) notes that two thirds of Canada’s 12.3 million households have at least one family member who regularly used the Internet in 2003. Thus the degree of bias suggested by the education level in our sample may not be very large.

Beyond the issue of sample representativeness is the issue of what is called in the stated preference literature “warm glow” (see, for instance, Kahneman and Knetsch, 1992, “Valuing Public Goods: The Purchase of Moral Satisfaction,” JEEM **22** 57-70; and Andreoni, J. 1989. “Giving with Impure Altruism: Applications to charity and Ricardian Equivalence,” *Journal of Political Economy* **97**(6), 1447-1458) and “yea-saying” (see, for instance, R. K. Blamey, J. W.

Bennett, M. D. Morrison. (BBM) 1999. “Yea-Saying in Contingent Valuation Surveys,” *Land Economics*, Vol. 75, No. 1 (Feb.) , pp. 126-141), the former being a more narrowly defined phenomenon than the latter. The warm glow issue is that, when asked to value a public good, people may derive satisfaction, and be willing to pay something, just from the act of giving. The latter is defined by BBM as “the tendency to subordinate outcome-based or ‘true’ economic preferences in favor of expressive motivations….” (pg. 126). There are two implications for our results. First, we might expect that people’s responses to either CV or CE questions will be insensitive to the commodities or attributes being put up for purchase, and that, therefore, if present in large numbers in the sample, such responses will make it less likely for various tests of sensitivity to scope to be passed. Second, such people are likely to be insensitive to the money – health tradeoffs being posed and are therefore likely to drive WTP estimates inappropriately upwards. We will use the term “yea-saying” to describe this phenomenon.

To address these issues, we used responses to one or two questions to remove “yea-saying” respondents. For the CV analysis, we removed people who said that they would pay anything for health risk reductions and who answered Yes-Yes (YY) to all three dichotomous choice questions with follow-up posed to them. This amounted to 44 respondents (11% of the sample of 407). Interestingly, 10 people who said they would pay anything actually did not answer YY to all three WTP questions. For the ABSCM analysis, we could not use the “YY to all three WTP questions” condition because in a choice experiment set-up there is no equivalent to the YY condition. Even if we had identified those respondents choosing the alternative with the largest health improvement all six times, we would still not necessarily be removing yea-saying effects since attributes are able to differ across programs. Thus,, in very few cases are there clear and unambiguous “yea-saying” answers. Therefore, we used only the first criterion (a statement that the respondent was willing to pay anything for health risk reductions) to screen out respondents. This amounted to dropping 86 respondents out of 812 (10.6 %). The remaining respondents are distributed among 4 ABSCM versions, 361 in the two versions that are directly comparable to the CV approach and 366 in the two approaches that varied morbidity and mortality attributes, permitting separate valuation of these endpoints for both cancer and microbial cases.

As shown in Table 2, the various samples have similar demographic and other characteristics and responses (variables are defined in table 3). The exceptions include URBAN, where a higher percentage of the respondents in Versions 5 and 6 live in urban areas, and ASSETS, where wealthier people were randomly slotted into ABSCM versions (We generally did not use this variable in further analyses because it is missing for too many respondents).

Models

The econometric model used to analyze the CVM survey data is the one appropriate for interval data. We use this model to obtain estimates of WTP

$$\log WTP_i^* = X_i\beta + \varepsilon_i \quad (1)$$

In this equation, *WTP** is the underlying willingness to pay for a selected risk reduction; *X* denotes a vector of age, health, and other attributes; β is a vector of coefficients; and ε is an extreme value Type I error term. Effectively, equation (1) describes a survival time model based on the Weibull distribution. The log-likelihood function for this model is

$$\log L = \sum_{i=1}^{n} \log\{F[(\log WTP_i^H - X_i\beta)/\sigma] - F[(\log WTP_i^L - X_i\beta)/\sigma]\} \quad (2)$$

where *F* is the type I extreme value distribution with scale σ, $WTPi^H$ and $WTPi^L$ are upper and lower bounds for the payments as presented to respondents in the CVM questions, and *X* is a vector of age, health, and other attributes with β as the corresponding coefficients. σ is the scale parameter of ε, as well as the reciprocal of the shape parameter of the Weibull distribution describing WTP. The scale parameter for the Weibull distribution is exp$(X\beta)$. A similar model is also estimated assuming preferences can be described by a lognormal distribution.

A random utility model is used to analyze the responses from the ABSCM format. Random utility theory begins with the assumption that individual consumers choose alternatives that provide them with the greatest utility. It is assumed that an individual's utility is composed of a deterministic component (*V*) and an unobservable or stochastic component (ε), where *V* is an indirect utility function. Respondents may choose amongst a number of alternatives. If the stochastic component or error term is distributed extreme value, McFadden (1981) shows that the conditional choice probability of selecting alternative *i* is:

$$\Pr ob(i) = \exp(\mu\beta_k Z_i) \Big/ \sum_{j \in C} \exp(\mu\beta_k Z_j) \qquad (3)$$

where Z is a vector of attributes of each program, μ is a scale parameter and C is the choice set. Note, however, that μ is confounded with the parameter vector β and cannot be identified. Normally, μ is set equal to 1.0 and the parameters are estimated using maximum likelihood methods.

An individual application of the method involves the generation of a number of bundles of attributes, and these are presented to respondents in series of choice tasks. Thus, the attributes of each alternative offered in a task comprise the Z vector and the sets of alternatives in each task comprise C, the choice set.[4] In our case, respondents are required to answer four choice tasks. In Versions 3 and 6 the choice tasks consist of comparing the status quo and one alternative program and in Versions 4 and 5 the choice tasks consist of comparing the status quo and two alternative programs. The resulting information is viewed as four individual choices from either a binary or a trinary universe. The econometric analysis (maximization of the likelihood employing the probabilities derived from the equation above) provides the estimates of the marginal utilities associated with the attributes and allows for their use in welfare measures.

Empirical Results: Contingent Valuation Method

There are three sets of results in this section. The first presents the most assumption-free results behind the estimates of willingness to pay – the percent of sample voting Yes to the first bid they are given. The second presents estimates of WTP and subjects these estimates to a variety of validity tests. The third presents regression results to examine construct validity and estimate marginal effects of covariates explaining WTP.

% Yes results

Figure 1 shows “percent Yes” responses by bid separately for each of three public goods being valued (cancer risk reductions, microbial risk reductions, and both types of risk reductions together). Note that each bar in the chart refers to a separate subsample. In general, there is concern for ordering effects, in that the answers to the microbial reduction program that follow answers to the cancer reduction program may be different than answers to the microbial reduction program when it appears first in the order. We use a likelihood ratio test to show that the two samples may be combined, therefore, we present only the results of pooling the % Yes responses across versions. Our expectation is that % Yes should fall with the size of the bid, and that % Yes should be greater for the third WTP question (the one that combines cancer and microbial reductions offered in the first two WTP questions) than either the responses to cancer or microbial reductions alone. Figure 1 generally and visually supports these expectations, which are confirmed statistically using a Wald Test in Table 5. The figure also reveals that the % Yes for a microbial risk reduction program are generally larger than for a cancer risk reduction program.

CVM WTP Results

Mean and median WTP results appear in Table 4. They are presented for a variety of combinations of cancer and microbial endpoints and for two assumptions about the underlying error distribution (lognormal and Weibull). Estimates are shown both for the full sample and for the sample that removes yea-saying observations. In addition, we present separately results from the two CVM versions (1 and 2) in order to examine issues related to question ordering. Thus, the mean household willingness to pay from the full sample for a reduction in 50 cancer cases of which 10 would have resulted in death (both over a 35-year period) in a community of 100,000 is $535 Cdn per year taken from the responses to the first WTP question in Version 1. This WTP translates into a VSC (a case being the above mortality/morbidity combination) of $14.4 million.[5]

Because the Weibull outperforms the lognormal distribution in a variety of ways and because we believe the yea-saying observations should be deleted, refer to the last two columns but one of the table. The most reliable comparisons are for Cancer asked first (Cancer V1), Microbial V2 (microbial asked first in Version 2), and Both Cancer and Microbial Pooled. The mean WTP are $182, $200 and $294, respectively. Using the pooled versions for added power, mean WTP for reductions in cancer is $157 per household per year, while that for microbial cases is $211 and that for these changes combined is $294. Median WTP is about half that of the mean.

Are any of these differences statistically significant? Table 5 presents results of both Wald tests and likelihood tests. The tests of whether question order matters, or alternatively, whether the answers to the cancer questions can be pooled (and the same for microbial questions and "both" questions) show that they can be pooled by both types of tests. The next relevant comparison is whether the WTP for cancer risk reduction and that for microbial risk reduction are statistically different. Comparing WTP Cancer Pooled to WTP Microbial Pooled we find that the Wald statistics is 3.685, slightly lower than the 95% Chi-squared value of 3.84. Thus, we barely reject the hypothesis that the microbial WTP is larger. Finally, there are two types of "adding up tests" -- what may be termed the weak and the strong adding up tests. The weak test asks whether the WTP for both risk reductions when asked together (in Question 3) is greater than that for either risk reduction separately. Comparing the Cancer Pooled to Both Pooled, we see that mean WTP value for both risk reduction changes exceeds that for cancer alone. However, comparing Microbial Pooled to Both Pooled, we reject this symmetric finding (barely). However, if we compare the more reliable WTP for microbial risk reduction, i.e., when it is the first question asked, to the WTP for the third question (Both) pooled, we find that the Wald statistic exceeds the target value and that therefore the WTP for both changes exceeds that for microbial risk reductions alone.

The strong test asks whether there is a summation relationship, i.e., whether the sum of the risk reductions for cancer (pooled) and microbial disease (pooled) is significantly the same as the combined risk reductions asked in Question 3 (pooled). In fact, this hypothesis cannot be rejected. In an absolute sense, however, the sum of mean WTPs ($157 + $211) exceeds the WTP for both risk reductions ($294), which could indicate declining marginal utility of health improvements.

CVM Regression Results

Table 6 presents regression results assuming a Weibull distribution (the lognormal results are similar) explaining variables affecting the pooled responses to the cancer risk reduction question, the microbial risk reduction question and the question with both reductions. These results are representative of results with many other specifications and with many variables tried. In all regressions, whether respondents believe in the health information we give them is a robust variable, where those who believe are willing to pay more than those who do not. Household income is *negative and significant for cancer*, but positive and insignificant in the other regressions. This result is somewhat surprising and may arise from correlation between income and other factors in the model, including education and/or belief in the scientific information. Those from larger households and who are older, who have a college education, and who live in more rural areas (but are served by municipal water supplies) are willing to pay more. Interestingly, those who do not engage in averting behaviour are willing to pay *less* than those who do not. This variable could be hypothesized to take either sign. On the one hand, those who do not engage in averting behaviour may feel tap water has few risks, so might be willing to pay less. On the other hand, those who do not engage in averting behavior may have stronger preferences for good water quality, so would be more willing to pay for improvements. The former hypothesis is the one that appears to be closer to the mark.

Finally, for cancer only, there appears to be an ordering effect, where those who answered the cancer question first were willing to pay more than those who answered the cancer question second. This is shown by the significant coefficient on the variable V1Q1 in Table 6. This is a dummy variable coded 1 for respondents who answered Version 1 questions (cancer risk reduction followed by microbial risk reduction). This is in contrast to the findings in table 5 using the Wald and Likelihood tests. However, the other two comparisons show no difference in responses across versions. The insignificant coefficient on V2Q1 (dummy for version two responses where microbial risk reduction is asked first) indicates no ordering effect for microbials. Similarly, the insignificant coefficient for the dummy variable V1Q3 indicates that there is no significant difference in responses to the third question (microbial plus cancer risk reductions) in either Version 1 or Version 2 responses. Other variables, such as for health status, were not significant.

Empirical Results: ABSCM Method

We estimated six models from the Proportional data (versions 3 and 4), each version independently, and a pooled model, for each of a full sample and a smaller sample that removed yea-saying observations. The parameter estimates are presented in Table 7. These models include only the attributes and status quo constant. All parameters are highly significant and of the expected sign. There are significant status quo effects as illustrated by the positive status quo constant. Tests of pooling Versions 3 and 4 (likelihood ratio tests) indicate that these versions can be pooled and the joint model used for further analysis.

Table 8 provides estimates of the WTP for Microbial Deaths and Illnesses, Cancer Deaths and Illnesses, and the sum of these two WTP values. Since these are proportional models a single WTP amount is presented for both the mortality and morbidity reduction similar to the presentation of the CVM cases. The removal of yea-saying observations generally reduces the size of WTP. For example, a reduction in microbial risks in the full sample pooled model are valued at $219 while, for the yea-saying removed sample, they are valued at $175. Overall the yea-saying removed sample exhibits WTP reductions of approximately 20 to 35% relative to the full sample. Table 8 also illustrates the effect of the status quo parameter. When excluded the WTP measures are significantly higher (on the order of 50%). Welfare measures with the status quo effect excluded rely on the attributes in the model to capture all of the welfare effect of the change while welfare measures with the status quo included discount changes from the status quo (or changes in attribute levels) by the amount of the status quo preference parameter. There is little guidance in the literature on how to treat this difference, thus we present both measures. If a more conservative measure is desired the WTP with status quo effect included is appropriate. A further finding in Table 8 is that the microbial programs appear to be more highly valued than the cancer programs. This is a finding similar to that obtained in the CVM responses. This policy relevant result carries through many of our findings.

Table 9 presents the parameter estimates for the Non-Proportional versions. As in the Proportional case the parameters are highly significant and the signs are as expected. In this case, however, the test of pooling is rejected. The version with one alternative (Version 6) is statistically different than the version with two alternatives (Version 5). The most significant difference can be seen in the size of the status quo effect. A much lower proportion of respondents chose the status quo in the two alternative version. The reason for this difference is unclear, but shows up in other work by the authors and is a topic for further research. The inability to pool results from these Non-Proportional versions results in our conducting many of the tests discussed below on Version 5 and 6 individually, as well as on the joint version for comparison.

Willingness to pay measures for the Non-Proportional versions are presented in Table 10. Values are provided for microbial deaths and illness reduction programs (jointly) and cancer deaths and illness reduction programs (jointly) to parallel the Proportional versions and the CVM analysis. In addition, the marginal values per cancer and microbial death and illness case are presented. Separate measures of the mortality and morbidity values are made possible by the Non-Proportional design. In Table 10, the yea-saying removed results are generally lower than the full sample results for the programs, but the difference is not as pronounced as in the Proportional versions. For example, the WTP for microbial deaths and illnesses, with the status quo effect, in Versions 5 is $306 in the full sample and $288 in the removed sample. The cancer program provides values of $110 for the full sample and $80 for the yea-saying removed sample for this same version. The status quo effect, however, is of the same magnitude as in the Proportional case. The difference between status quo included and excluded for a microbial program is $443 versus $306 in Version 5, and $336 versus $163 for Version 6. WTP amounts from Version 6 are generally smaller than those from version 5, although the size of the difference varies. The two alternative version provides smaller WTP values, regardless of whether the status quo effect is included or not. Table 11 provides Wald test statistics examining the differences in the WTP measures in the Proportional and Non-Proportional models. Examining the tests of differences within versions we find that in the Proportional version there is no significant difference between cancer and microbial WTP, but there are differences between WTP for other programs (the critical value for a 5% level of significant is approximately 5). Examining the Non-Proportional versions, only in Version 6 is the difference between Cancer and Microbial WTP not significantly different. In all cases the WTP values between Cancer and Both are significantly different. The differences between Microbial and Both, however, are generally not statistically different, although they are close to the critical value.

The middle panel of Table 11 tests difference across versions. Interestingly the tests of WTP across version are all insignificant. That is, the WTP value for the Cancer and Microbial programs are not different across the Proportional and the Non-Proportional versions. This is a very powerful result suggesting that the different elicitation strategies do not generate widely different WTP values.

Finally, the bottom panel of 11 provides tests of the adding-up of deaths and illness WTP in the Non-Proportional version (where these two effects are separated) against the WTP in the Proportional version. In all cases the null hypothesis is accepted, indicated that response format did not significantly alter WTP.

Table 12 presents measures of the value of statistical life (VSL) and the value of statistical illness (VSI) for cancer and microbial deaths and illnesses. This summary table is based on the Non-Proportional versions. Several pieces of information emerge from the table. First, in most cases VSLs for microbial mortality are higher than for cancer mortality. This is particularly the case when we use data that has removed yea-saying observations. Second, the VSL values themselves are “high” relative to those in the published literature, however, they are not too far outside the range of accepted values. Recall that these are values for public reductions in mortality and thus one would expect them to be larger that private WTP values.

The values of statistical cases of cancer are in the \$2M to \$4M per case range, and range between 20% to 50% of the value of cancer mortality reduction. The value of a statistical case of microbial disease is in the vicinity of \$20,000, which is the product of an estimated WTP of \$0.018 per case per household and 100,000 people (38,500 households) in the community over 35 years. The value per case appears to be quite high and in our view results from the inability of respondents to register preferences in a choice format that would lead to WTP estimates of a fraction of a cent.

To provide an analysis of the effect of demographic factors on WTP, Table 14 presents two sample sets of parameter estimates that included interactions with demographic factors. These are examples of similar models for the various versions of the Proportional and Non-Proportional models. In general the most robust findings are significant impacts of income (higher income respondents are more likely to choose an alternative program to the status quo and higher income respondents are less sensitive to cancer), Male (less likely to choose a program), Urban (less likely to choose program), and those who believe scientists (are more sensitive to cancer deaths).

Comparison of Results from Two Formats

Results from statistical tests on selected WTP values from the ABSCM and CVM versions of the survey are shown in Table 13. The joint models from the choice experiment are compared to the CVM WTP distributions. The tests of the joint Proportional model reject the hypothesis of equality with the CVM values except for the case of the microbial program and the status quo effect included. However, the values of the Wald tests are not that much above the critical value. The tests comparing the Non-Proportional WTP with CVM are accepted for cancer with the status quo effect excluded, and rejected for all other cases. Recall that the WTP measures with the status quo effect included are considerably lower that with the effect excluded. The WTP from the models with status quo effects includes tended to be lower than the CVM values while the WTP from the models with the status quo effects excluded tended to be higher than the CVM models. Thus, the choice experiment results appear to bracket the CVM results or provide an upper and lower bound.

Using Results to Assist in Policy Making

The values calculated using the approaches discussed in this paper can be used to inform decisions regarding drinking water infrastructure renewal and enhancement, as well as being useful for cost-benefit analysis of drinking water rulemaking. In addition, it is possible that the WTP and regression estimates can be used in various kinds of benefit transfers, to the extent that such values are insensitive to the cause of the health effects (in this case drinking water and its treatment).

The WTP estimates from the non-proportional versions of the survey can be used to derive estimates of the value of statistical life (VSL) or value of a statistical illness (VSI) both for cancer and microbial disease. These values were reported in Table 12. In order to put these results into context, Viscusi and Aldy (2003) examine a number of studies that have produced estimates for the VSL. They report that the range of values is fairly broad between \$3.9 - \$21.7 million US dollars (2000). While our estimates fall within the upper range of these values, we must note that the majority of studies that calculate a VSL do so using a WTP for a reduction in the risk of death to oneself (that is, a private mortality risk). In contrast, our VSL estimates are based on the WTP to avoid public mortality risks. We would expect that altruistic WTP values might be higher than private WTP values since the former would include the willingness-to-pay to avoid the deaths of members of one’s community (including family members). Further, our estimates are for deaths from two specific causes. The fact that the VSL for deaths from microbial disease is somewhat greater than that for cancer is a big surprise. This may be related to previous experience with contamination of municipal water systems in Walkerton, Ontario, and North Battleford, Saskatchewan by microbial contaminants in 2000 and 2001, respectively. More research on this point is needed to verify if this is an artifact of our survey or a true representation of preferences.

In a similar fashion we can calculate the Value of a Statistical Illness as presented in Table 12. Previously, cancer morbidity costs have typically been expressed using costs of illness. Our estimates express costs for cancer in welfare terms.

In addition, we can use the estimated willingness-to-pay values from either the CVM or the ABSCM formats to obtain estimates for the composite value of a statistical case of illness, which includes deaths for a small proportion of cases. Such estimates actually integrate morbidity and mortality in one number so may prove even more useful for policy analysis than the VSLs or VSIs if the policy reduces the source of cases (such as a pollution reduction policy) rather than alters the ratio of illness to death (such as would occur with a health care policy).

Conclusions and Future Directions

This report presents findings from an Internet-based survey designed to elicit preferences relating to tap water quality and health risks. These values show that Canadians are willing to pay in order to reduce the public risks for a number of different water-related health conditions and that they may have a mild preference for reducing microbial contamination over cancer cases. The numbers pertaining to cancer appear reasonable and accord with prior work; however, there are no comparable estimates available for microbial illnesses. We would argue that respondents appear to have trouble with the large number of illnesses presented in the microbial case. This results in small values per illness per respondent ($0.02), but large values per illness when added up over the community. This is clearly an area requiring future study.

A few caveats are in order. Firstly, the numbers in this report, while typical of what we have found, are first round estimates. We are still working to incorporate respondent heterogeneity and to adopt non-linear indirect utility functions. These are the next steps. Secondly, our results show how difficult it is to collect values based on very small probability changes. This is future work. Finally, values collected in this fashion are for public goods, rather than private goods.

.With few studies of this nature and with concerns about double-counting when one adds up public values in the presence of altruism, caution is in order.   Attempts to purge our estimates of altruism effects are in our plans for future research.

Table 1: Key Features of 6 Versions of Survey

Version	Question Format	Number of Questions/Tasks Per Respondent	Question Ordering	Number of programs (status quo included)	Relationship between mortality and morbidity
1	CVM	3	Cancer, microbial, both	2	Proportional
2	CVM	3	Microbial, cancer, both	2	Proportional
3	ABSCM	4	Na	2	Proportional
4	ABSCM	4	Na	3	Proportional
5	ABSCM	4	Na	3	Non-Proportional
6	ABSCM	4	Na	2	Non-Proportional

Table 2: Descriptive Statistics by Version and Sub-sample

Variables	Canadian Population Values	CVM and ABSCM (V1,2,3,5,6,7) full sample	CVM (V1 and V2) full sample	CVM (V1 and V2) yea-saying observations removed	ABSCM (V3, 5, 6, 7) full sample	ABSCM (V3, 5) yea-saying observations removed	ABSCM (V6) yea-saying observations removed	ABSCM (V7) yea-saying observations removed
INCOME	**58360**	**57458.52** (35650.89)	**58734.17** (35562.79)	**58080.27** (35501.41)	**56819.12** (35699.68)	**54743.30** (35012.21)	**57796.83** (35865.36)	**60289.60** (37069.08)
MALE	**49.9%**	**52.75%** (0.50)	**54.55%** (0.50)	**54.96%** (0.50)	**51.85%** (0.50)	**49.86%** (0.50)	**50.81%** (0.50)	**56.35%** (0.49)
AGE	**45.8**	**46.55** (15.02)	**44.93** (15.02)	**44.18** (15.25)	**47.36** (14.97)	**47.58** (15.07)	**46.15** (15.30)	**47.42** (14.31)
HHSIZE	**2.6**	**2.59** (1.31)	**2.63** (1.26)	**2.61** (1.26)	**2.57** (1.34)	**2.65** (1.35)	**2.52** (1.37)	**2.53** (1.25)
EDUCATION	**55 %**	**61.77%** (0.49)	**61.18%** (0.49)	**62.04%** (0.49)	**62.07%** (0.49)	**61.77%** (0.49)	**64.86%** (0.48)	**62.98%** (0.49)
ENGLISH	**73%**	**76.13%** (0.43)	**75.92%** (0.43)	**75.64%** (0.43)	**76.23%** (0.43)	**76.73%** (0.42)	**75.68%** (0.43)	**74.03%** (0.44)
URBAN	**80%** [d]	**65.14%** (0.48)	**61.67%** (0.49)	**63.17%** (0.48)	**66.87%** (0.47)	**64.82%** (0.48)	**70.27%** (0.46)	**71.27%** (0.45)
ASSETS	**na**	**89417.54** (82906.93)	**79677.19** (74853.48)	**79464.06** (75809.54)	**94483.83** (86427.92)	**93916.12** (85986.44)	**94999.78** (85166.08)	**93749.79** (90464.05)
BELIEFMS	**na**	**74.82%** (0.43)	**73.96%** (0.44)	**71.39%** (0.45)	**75.25%** (0.43)	**72.85%** (0.45)	**80.00%** (0.40)	**70.17%** (0.46)
NOAVERT	**na**	**45.37%** (0.50)	**45.95%** (0.50)	**46.46%** (0.50)	**45.07%** (0.50)	**42.38%** (0.49)	**49.19%** (0.5)	**45.86%** (0.50)
N		1219(906*)	407(310*)	353(266*)	812(596*)	361(263*)	185(135*)	181(130*)

Notes: [a] Standard deviations are in brackets.

[b] Yea-saying data is identified in CVM samples when YY for all three CVM questions and respondents indicate are willing to pay anything for health risk reductions. Yea-saying data is identified in CE samples when latter condition is true.

[c]* denotes number of observations for ASSETS.

[d] The Census **definition is more encompassing than ours. It includes an individual as being in a rural area if the population is less than 1000. We used 10,000 to better capture locations with municipally supplied water.**

Table3: Definition of variables

Variables	Definition
INCOME	Average household income in Canadian $
MALE	Percentage of respondents who are men
AGE	Average in years
HHSIZE	Average size of a household
EDUCATION	Percentage of respondents with more than Some Community College/CEGEP/Trade School
ENGLISH	Percentage of respondents whose first language is English (This is indicated by whether respondents completed the survey in their choice of English or French)
URBAN	Percentage of respondents live in a city in which the population is over 10,000
ASSETS	Total value of household's financial assets in Canadian $
BELIEFMS	Percentage of respondents who believe scientists are certain about microbial illnesses arising from drinking tap water. (Highly correlated with other belief variables relating to certainty of scientific community about risks associated with cancer and microbial deaths and cancer illnesses.)
NOAVERT	Percentage of respondents who undertake no averting behavior against drinking water related health risks

Table 4. Mean and Median WTP Estimates by Endpoint, by Assumed Distribution, Full and Clean Sample

	Lognormal				*Weibull*				
	Full Sample		*Yea-saying Observations Removed*		*Full Sample*		*Yea-saying Observations Removed*		*Weibull Mean Test*
	Mean	*Median*	*Mean*	*Median*	*Mean*	*Median*	*Mean*	*Median*	
WTP Cancer V1	**535** (199)	**110** (16)	**289** (82)	**84** (11)	**266** (46)	**119** (44)	**182** (27)	**91** (27)	2.458
WTP Cancer V2	**393** (149)	**72** (11)	**201** (55)	**55** (8)	**200** (33)	**79** (31)	**133** (19)	**60** (19)	3.097
WTP Microbial V1	**1075** (567)	**130** (22)	**532** (220)	**95** (15)	**332** (67)	**137** (61)	**226** (39)	**104** (38)	1.883
WTP Microbial V2	**552** (194)	**118** (17)	**344** (100)	**92** (13)	**265** (43)	**127** (43)	**200** (29)	**101** (30)	1.548
WTP Both Cancer and Microbial V1	**1187** (597)	**198** (35)	**667** (273)	**149** (24)	**404** (86)	**200** (82)	**293** (54)	**156** (55)	1.191
WTP Both Cancer and Microbial V2	**758** (278)	**179** (26)	**514** (162)	**143** (20)	**345** (60)	**186** (60)	**276** (44)	**153** (45)	0.849
WTP Cancer Pooled	**464** (124)	**90** (9)	**244** (48)	**68** (7)	**232** (28)	**97** (27)	**157** (16)	**74** (16)	5.480
WTP Microbial Pooled	**739** (223)	**123** (14)	**416** (101)	**94** (10)	**294** (37)	**132** (36)	**211** (24)	**103** (24)	3.453
WTP Both Cancer and Microbial Pooled	**922** (277)	**187** (21)	**739** (223)	**123** (14)	**370** (50)	**192** (49)	**294** (37)	**132** (36)	1.478

Note: [a] Standard errors in parentheses.

Table 5: Likelihood Test and Wald Tests

	Lognormal				*Weibull*			
	Full Sample		*Yea-saying Observations Removed*		*Full Sample*		*Yea-saying Observations Removed*	
	Mean	*Median*	*Mean*	*Median*	*Mean*	*Median*	*Mean*	*Median*
Likelihood Ratio Tests								
Cancer V1, V2 vs. Cancer Pooled	4.217		4.632		4.205		4.663	
Microbial V1, V2 vs. Microbial Pooled	1.221		0.887		0.662		0.294	
Both V1, V2 vs. Both Pooled	0.552		0.288		0.304		0.059	
Wald Tests								
Cancer V1 vs. V2	**0.327**	**3.815**	**0.787**	**4.325**	**1.362**	**0.555**	**2.232**	**0.894**
Microbial V1 vs. V2	**0.760**	**0.170**	**0.609**	**0.022**	**0.714**	**0.019**	**0.292**	**0.004**
Both V1 vs. V2	**0.426**	**0.192**	**0.234**	**0.041**	**0.316**	**0.018**	**0.059**	**0.002**
Cancer Pooled vs. Microbial Pooled	**1.171**	**4.161**	**2.387**	**4.744**	**1.710**	**0.590**	**3.685**	**0.964**

Internal Consistency Tests

Weak Adding Up Test: Cancer Pooled vs. Both Pooled	**2.290**	**17.812**	**4.727**	**13.398**	**5.697**	**2.861**	**11.269**	**2.138**
Weak Adding Up Test: Microbial Pooled vs. Both Pooled	**0.264**	**6.472**	**1.745**	**3.167**	**1.478**	**0.991**	**3.453**	**0.465**
Microb V2 vs. Both Pooled	**1.198**	**6.510**	**2.627**	**2.790**	**2.499**	**0.996**	**3.897**	**0.434**
Strong Adding Up Test: (Cancer pooled + Microbial pooled) = Both Pooled	**0.558**	**0.938**	**0.102**	**4.592**	**5.161**	**0.309**	**2.507**	**0.971**

Related Tests:

Cancer V1 & Both V1	**1.074**	**5.257**	**1.766**	**6.267**	**1.983**	**0.739**	**3.389**	**1.121**

Cancer V2 & Both V2	**1.337**	**13.907**	**3.315**	**16.818**	**4.451**	**2.482**	**9.032**	**3.635**
Cancer V1 & Both Pooled	**1.288**	**8.340**	**3.603**	**5.071**	**2.312**	**1.211**	**5.879**	**0.803**
Microb V1 & Both V1	**0.019**	**2.726**	**0.149**	**3.661**	**0.434**	**0.373**	**1.001**	**0.605**
Microb V2 & Both V2	**0.367**	**3.750**	**0.796**	**4.605**	**1.149**	**0.639**	**2.086**	**0.927**

External Scope Test

Cancer V1 & Both V2	**0.423**	**4.902**	**1.530**	**6.726**	**1.070**	**0.799**	**3.355**	**1.372**
Microb V2 & Both V1	**1.024**	**4.286**	**1.242**	**4.494**	**2.069**	**0.613**	**2.291**	**0.782**

Table 6: Regression Results – Weibull Distribution (Using Data that Removes Yea-saying Observations)

Variable	Cancer		Microbial		Cancer plus Microbial	
Constant	**4.348**	***	**4.252**	***	**4.564**	***
	(0.394)		(0.398)		(0.379)	
Household Income	**-5.870E-06**	**	**3.640E-06**		**1.600E-06**	
	(2.630E-		(2.770E-		(2.770E-	
Male	**-0.302**	*	**-0.260**		**-0.355**	*
	(0.182)		(0.187)		(0.190)	
Household Size	**0.135**	*	**0.108**		**0.070**	
	(0.074)		(0.078)		(0.075)	
Age 65 or Older	**0.514**	*	**0.256**		**0.061**	
	(0.272)		(0.267)		(0.264)	
English	**0.302**		**0.143**		**0.248**	
	(0.204)		(0.209)		(0.206)	
College	**0.164**		**0.540**	***	**0.525**	***
	(0.182)		(0.188)		(0.188)	
Urban	**-0.407**	**	**-0.397**	**	**-0.189**	
	(0.186)		(0.191)		(0.190)	
BelieveInformation	**0.577**	***	**0.710**	***	**0.774**	***
	(0.196)		(0.199)		(0.196)	
Do Not Avoid Tap Water	**-0.285**		**-0.337**	*	**-0.266**	
	(0.180)		(0.184)		(0.185)	
V1Q1	**0.380**	**				
	(0.176)					
V2Q1			**-0.132**			
			(0.180)			
V1Q3					**0.051**	
					(0.180)	
Scale	**1.343**		**1.330**		**1.232**	
	(0.096)		(0.095)		(0.092)	
N	363		363		363	
Log Likelihood	-432.83		-460.80		-440.59	

Notes: [a] Standard errors in parentheses.
[b] * = significant at 10% level, ** is 5% and *** is 1%.

Table 7: ABSCM: Estimated Parameters Proportional Versions

	Full Sample			*Yea-saying Observations Removed*		
Variable	***Version 3 (proportional)***	***Version 4 (proportional)***	***Pooled Version 3 and 4***	***Version 3 (proportional)***	***Version 4 (proportional)***	***Pooled Version 3 and 4***
Status Quo Constant	0.837* (.175)	0.618 (.129)	0.720* (.102)	0.850* (.190)	0.664* (.136)	0.759 (.109)
Microbial deaths	-0.163* (.020)	-0.156 (.013)	-0.159* (.011)	-0.154* (.022)	-0.164* (.014)	-0.163 (.012)
Cancer deaths	-0.125* (.017)	-0.122 (.013)	-0.121* (.010)	-0.121* (.018)	-0.122* (.014)	-0.120 (.011)
Program cost	-0.004* (.001)	-0.004 (.001)	-0.004* (.000)	-0.005* (.001)	-0.005* (.001)	-0.005 (.001)
Observations (choice sets)	824	800	1624	712	732	1444
Log-likelihood	-507.22	-780.19	-1288.76	-428.70	-700.68	-1131.35

Notes

[a] Microbial deaths and illnesses are proportional, statistics are reported for deaths in the model. Similarly, cancer deaths and illnesses are proportional.

[b] Standard errors in parentheses. Asterisk indicates significance at the.01 level.

[c] Test of pooling version 3 and 4, chi-squared 2.70, critical value 11.07.

[d] Test of pooling version 3 and 4, chi-squared 3.95, critical value 11.07.

Table 8: ABSCM: Estimated Mean Willingness to Pay Values

	Full Sample			Yea-saying Observations Removed		
Variable	***Version 3 (proportional)***	***Version 4 (proportional)***	***Pooled Version 3 and 4***	***Version 3 (proportional)***	***Version 4 (proportional)***	***Pooled Version 3 and 4***
Microbial deaths and illnesses (including SQ effect)[a]	202.420 (40.69)	237.820 (29.63)	219.270 (21.48)	142.580 (31.59)	196.830 (21.89)	175.400 (17.17)
Cancer deaths and illnesses (including SQ effect)[a]	101.720 (26.90)	149.290 (26.03)	123.550 (18.26)	69.401 (26.66)	113.150 (22.16)	88.427 (16.31)
Microbial deaths and illnesses (excluding SQ effect)[b]	429.660 (107.29)	396.310 (65.87)	404.230 (53.59)	321.090 (75.18)	334.740 (51.75)	332.590 (38.44)
Cancer deaths and illnesses (excluding SQ effect)[b]	326.080 (81.03)	309.800 (51.36)	306.920 (40.33)	250.300 (58.21)	247.690 (38.87)	244.150 (29.07)
Cancer deaths and illnesses (including SQ effect)[a]	528.350 (99.03)	548.450 (68.81)	524.760 (53.677)	393.590 (64.87)	445.430 (47.296)	419.130 (36.612)
Microbial and cancer deaths and illnesses (excluding SQ effect)[b]	752.56 (176.13)	709.80 (111.14)	707.100 (92.11)	575.20 (123.89)	580.88 (81.14)	574.22 (65.40)

Notes:
[a] Welfare calculations include consideration of the status quo constant.
[b] Welfare calculations do not include consideration of the status quo constant.
[c] Standard errors in parentheses, based on Krinsky Robb simulation using 1000 draws.

Table 9: ABSCM: Estimated Parameters Proportional Versions

	Full Sample			Yea-saying Observations Removed		
Variable	***Version 5 (non-proportional)***	***Version 6 (non-proportional)***	***Pooled Version 5 and 6***	***Version 5 (non-proportional)***	***Version 6 (non-proportional)***	***Pooled Version 5 and 6***
Status Quo Constant	0.523* (.123)	1.067* (.172)	0.728* (.097)	0.528* (.127)	1.132* (.183)	0.753* (.102)
Microbial deaths	-0.054* (.011)	-0.074* (.017)	-0.056* (.009)	-0.053* (.011)	-0.081* (.018)	-0.058* (.009)
Microbial illness	-7.621E-05* (.000)	-8.662E-05* (.000)	-8.040E-05* (.000)	-7.552E-05* (.000)	-8.769E-05* (.000)	-7.974E-05* (.000)
Cancer deaths	-0.058* (.011)	-0.046* (.015)	-0.055* (.009)	-0.048* (.011)	-0.041* (.016)	-0.045* (.009)
Cancer illness	-0.008* (.002)	-0.022* (.003)	-0.011* (.002)	-0.008* (.002)	-0.020* (.004)	-0.010* (.002)
Program cost	-0.004* (.001)	-0.006* (.001)	-0.004* (.000)	-0.004* (.001)	-0.006* (.001)	-0.005* (.001)
Observations (choice sets)	812	812	1624	740	724	1464
Log-likelihood	-786.502	-458.291	-1262.62	-716.16	-398.46	-1130.95

Notes:

[a] Microbial and cancer deaths and illnesses are non-proportional.
[b] Standard errors in parentheses. Asterisk indicates significance at the.01 level.
[c] Test of pooling version 3 and 4, chi-squared 32.62, critical value 14.45.
[d] Test of pooling version 3 and 4, chi-squared 35.65, critical value 14.45.

Table 10: ABSCM: Estimated Willingness to Pay – Non-Proportional Models

	Full Sample			Yea-saying Observations Removed		
Variable	***Version 5 (non-proportional)***	***Version 6 (non-proportional)***	***Pooled Version 5 and 6***	***Version 5 (non-proportional)***	***Version 6 (non-proportional)***	***Pooled Version 5 and 6***
Microbial deaths and illnesses (including SQ effect)[a]	306.180 (44.14)	163.870 (31.53)	246.110 (27.46)	288.190 (41.81)	161.780 (31.36)	237.190 (26.88)
Cancer deaths and illnesses (including SQ effect)[a]	110.440 (37.30)	81.127 (20.21)	81.927 (20.13)	80.136 (38.35)	43.977 (23.89)	40.421 (24.30)
Microbial and cancer deaths and illnesses (including SQ effect)[b]	554.580 (74.78)	422.660 (52.42)	496.570 (47.02)	501.150 (67.49)	386.240 (49.83)	447.040 (44.43)
Microbial deaths and illnesses (excluding SQ effect)[b]	443.490 (73.25)	336.750 (55.28)	415.200 (51.24)	426.580 (70.95)	343.660 (58.59)	404.61 (53.58)
Cancer deaths and illnesses (excluding SQ effect)[b]	246.539 (52.26)	255.637 (42.25)	248.650 (35.31)	214.596 (47.99)	226.663 (43.86)	209.57 (33.82)
Microbial and cancer deaths and illnesses (excluding SQ effect)[b]	690.029 (111.04)	592.387 (89.77)	663.850 (79.21)	641.176 (103.50)	570.323 (94.22)	614.180 (78.96)
Marginal value of microbial death	13.616 (3.37)	11.789 (2.99)	12.659 (2.44)	12.940 (3.32)	12.601 (3.17)	12.825 (2.50)
Marginal value of microbial illness	0.019 (0.00)	0.014 (0.00)	0.018 (0.00)	0.018 (0.00)	0.014 (0.00)	0.018 (.002)
Marginal value of cancer death	14.661 (3.02)	7.403 (2.38)	12.525 (2.10)	11.763 (2.86)	6.354 (2.46)	10.011 (2.06)
Marginal value of cancer illness	1.944 (0.62)	3.581 (0.69)	2.442 (0.47)	1.864 (0.62)	3.170 (0.68)	2.176 (0.47)

Notes:

[a] Welfare calculations include consideration of the status quo constant. Welfare measure for 10 fewer cases MICD and CAND, and 15500 cases fewer MICI, and 50 cases fewer CANI)

[b] Welfare calculations do not include consideration of the status quo constant. Welfare measure for 10 fewer cases MICD and CAND, and 15500 cases fewer MICI, and 50 cases fewer CANI).

[c] Standard errors in parentheses, based on Krinsky Robb simulation using 1000 draws.

Table 11: Wald Tests of Differences in Willingness to Pay In ABSCM Models

	Tests of Difference within Version		
	Cancer vs Microbial	***Cancer vs Both***	***Microbial vs Both***
Joint Proportional (JP)	3.367	34.924	15.687
Joint Non-Proportional (JNP)	9.47	22.19	4.82
Version 5 (V5)	6.12	13.98	2.92
Version 6 (V6)	2.55	10.93	4.17
	Tests of Difference Across Versions		
	JP vs JNP	JP vs V5	JP vs V6
Cancer	0.601	0.277	0.110
Microbial	1.193	1.357	0.025
Both	0.152	0.299	0.001
	Test of Non-proportional version sum of death and illness vs Proportional effect		
	Including status quo effect	***Excluding status quo effect***	
Microbial	3.750934	1.193	
Cancer	2.691023	0.601	

Note: Using willingness to pay measures that remove yea-saying observations and exclude status quo effects unless otherwise noted.

Table 12: Value of Statistical Life and Case Calculations from Non-Proportional Versions Based on Marginal Values (no status quo effect)

	Full Sample			Yea-saying Excluded		
	Version 5 (non-proportional)	Version 6 (non-proportional)	Pooled Version 5 and 6	Version 5 (non-proportional)	Version 6 (non-proportional)	Pooled Version 5 and 6
Microbial death	18,887,000 (4,684,700)	16,352,000 (4,198,300)	17,359,000 (3,326,200)	17,498,000 (4,510,100)	17,135,000 (4,333,800)	17,634,000 (3,585,000)
Microbial illness	26,567 (4,519)	19,103 (3,404)	24,815 (3,036)	25,188 (4,291)	18,591 (3,322)	24,013 (3,124)
Cancer death	20,157,000 (4,281,100)	10,092,000 (3,334,200)	16,980,000 (2,917,000)	16,021,000 (4,057,400)	8,538,000 (3,261,100)	13,559,000 (2,785,800)
Cancer illness	2,676,000 (876,650)	4,933,000 (992,250)	3,335,000 (652,050)	2,539,900 (903,860)	4,330,900 (943,830)	2,952,400 (624,130)

Note: Standard deviations are in brackets. Results are generated using 1,000 draws in a Krinsky-Robb procedure.

Table 13: Wald Tests of Differences in Willingness to Pay

	Tests of Difference CVM versus ABSCM			
	JP – SQ excluded vs CVM Pooled	***JP – SQ included vs CVM Pooled***	***JNP – SQ excluded vs CVM Pooled***	***JNP – SQ included vs CVM Pooled***
Cancer	6.92	9.01	1.97	16.05
Microbial	7.20	1.45	10.87	14.45

Note: Weibull distribution forms used. All measures use data with yea-saying observations removed.

Table 14: Sample Models with Demographic Interactions and Attributes

	Non-Proportional, Pooled Version 5 and 6 Yea-saying Observations Removed		***Non-Proportional, Pooled Version 5 and 6 Full Sample***	
Variable	***Coefficient***	***Coefficient/St.Er.***	***Coefficient***	***Coefficient/St.Er.***
SQ	0.301	0.725	0.290	0.727
MICD	-0.026	-0.605	-0.026	-0.631
MICI	-7.017E-05	-2.388	-6.232E-05	-2.215
CAND	-0.022	-0.550	-0.030	-0.757
CANI	-0.028	-3.247	-0.025	-2.971
SQ*INCM	-5.284E-06	-1.949	-5.852E-06	-2.238
MD*INCM	-2.002E-07	-0.674	7.512E-08	0.266
MI*INCM	5.286E-11	0.261	-5.176E-11	-0.269
CD*INCM	1.855E-07	0.691	1.838E-07	0.720
CI*INCM	1.141E-07	1.997	1.075E-07	1.982
SQ*MALE	0.528	2.766	0.542	2.972
MD*MALE	0.027	1.336	0.025	1.316
MI*MALE	-1.264E-06	-0.092	-4.300E-06	-0.334
CD*MALE	0.003	0.158	-0.005	-0.287
CI*MALE	-0.002	-0.434	-0.001	-0.377
SQ*HHSZ	0.086	1.074	0.110	1.479
MD*HHSZ	-0.007	-0.814	-0.011	-1.409
MI*HHSZ	-5.894E-06	-1.023	-8.080E-06	-1.523
CD*HHSZ	-0.010	-1.351	-0.005	-0.727
CI*HHSZ	0.002	1.365	0.001	0.977
SQ*ENGL	-0.233	-1.003	-0.188	-0.836
MD*ENGL	0.009	0.370	0.015	0.618
MI*ENGL	2.083E-05	1.237	2.193E-05	1.355
CD*ENGL	0.019	0.845	0.010	0.452
CI*ENGL	0.003	0.643	0.000	0.089
SQ*EDU	0.094	0.460	0.237	1.222
MD*EDU	0.023	1.055	0.006	0.313
MI*EDU	7.282E-06	0.493	4.903E-06	0.355
CD*EDU	0.013	0.684	0.007	0.368
CI*EDU	0.006	1.510	0.005	1.342
SQ*ILL	-0.018	-0.322	-0.038	-0.714

MD*ILL	-0.003	-0.519	-0.003	-0.543
MI*ILL	4.375E-06	1.099	5.065E-06	1.368
CD*ILL	0.002	0.347	0.004	0.763
CI*ILL	3.477E-04	0.301	5.473E-04	0.509
SQ*URBAN	0.443	2.144	0.385	1.966
MD*URBAN	-0.032	-1.454	-0.029	-1.376
MI*URBAN	-1.757E-05	-1.185	-1.370E-05	-0.986
CD*URBAN	-0.002	-0.083	0.003	0.139
CI*URBAN	0.005	1.178	0.005	1.290
SQ*BLIEF	0.131	0.578	-0.007	-0.029
MD*BLIEF	-0.018	-0.743	-0.018	-0.783
MI*BLIEF	-3.107E-05	-1.887	-2.753E-05	-1.732
CD*BLIEF	-0.038	-1.706	-0.049	-2.290
CI*BLIEF	-0.004	-0.845	-0.003	-0.676
SQ*AVERT	0.116	0.595	0.156	0.839
MD*AVERT	-0.008	-0.397	-0.006	-0.297
MI*AVERT	1.565E-05	1.123	1.308E-05	0.990
CD*AVERT	-0.014	-0.724	-0.012	-0.690
CI*AVERT	-0.001	-0.326	-0.003	-0.840
SQ*AGE65	-0.278	-0.963	-0.342	-1.246
MD*AGE65	0.025	0.812	0.026	0.902
MI*AGE65	0.000	-0.349	0.000	-0.131
CD*AGE65	-0.010	-0.350	0.004	0.157
CI*AGE65	-0.005	-0.718	-0.004	-0.676
BILL	-0.005	-9.068	-0.005	-9.313
Number of observations	1464		1624	
Log likelihood	-1082.634		-1206.9	

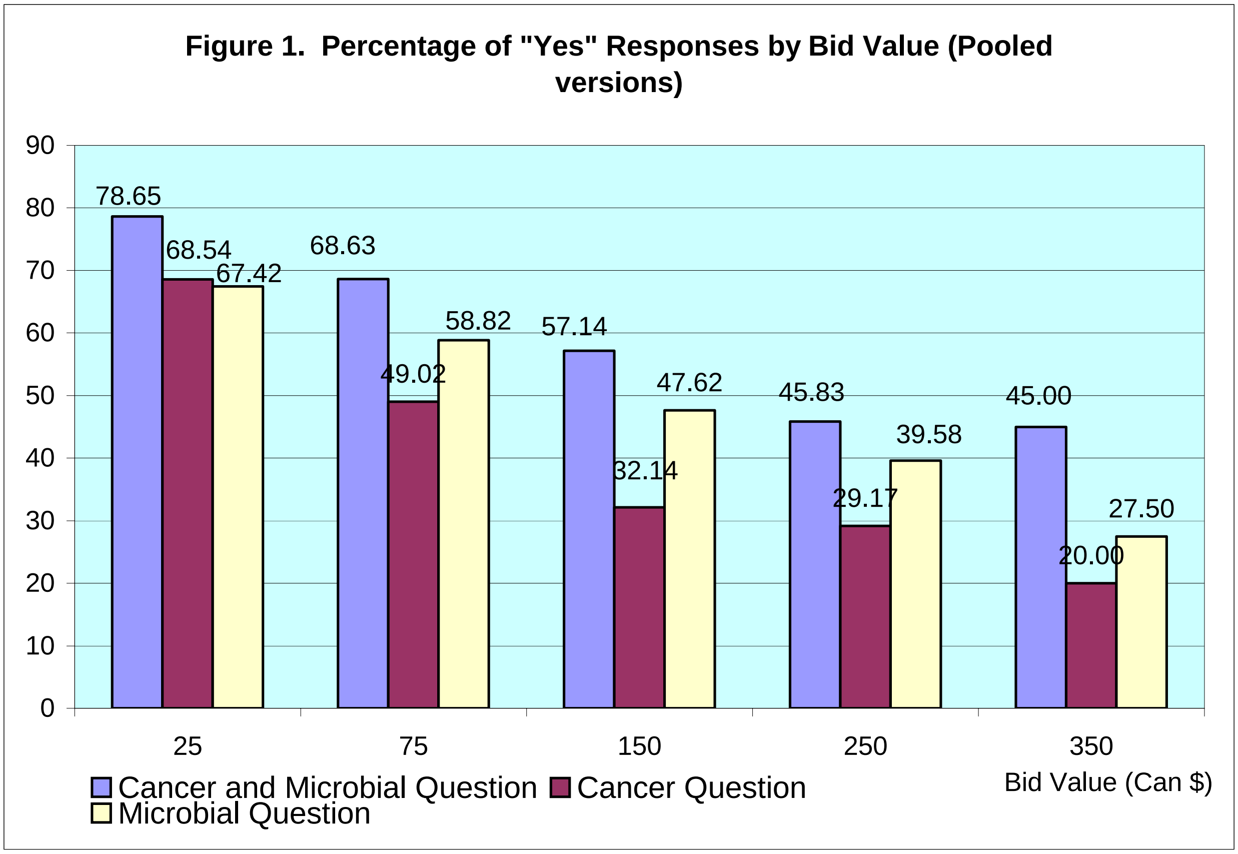
Figure 1. Percentage of "Yes" Responses by Bid Value (Pooled versions)
90
80
70
60
50
40
30
20
10
0
78.65
68.54
67.42
68.63
49.02
58.82
57.14
32.14
47.62
45.83
29.17
39.58
45.00
20.00
27.50
25
75
150
250
350
Bid Value (Can $)
Cancer and Microbial Question
Cancer Question
Microbial Question

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Appendix 1

Below are the descriptions of the health effects from microbial illnesses and bladder cancer illnesses relating to the drinking of tap water presented in the survey.

Ipsos i-Say

E-mail: questions@i-say.com Phone: 1-866-893-1188

Health Effects of Chlorine

When tap water is disinfected with chlorine, various by-products including Trihalomethanes (THMs) are produced. Scientists believe that THMs are an indicator for substances in the tap water that are linked to increased cases of bladder cancer when water is consumed over long periods of time.

- Symptoms of bladder cancer:
  - Urgent and frequent need to urinate, blood in your urine, pain during urination, and pain from the tumour.
  - Symptoms for this cancer do not occur immediately after drinking tap water, rather they take years to show since it takes years for this cancer to develop.
  - For about one in five cases, death occurs **within five years** from diagnosis.
- Medical Treatment of Illness:
  - Surgery, radiation, and chemotherapy are used to treat bladder cancer.
  - Side effects from surgery may include a long recuperation period and the need for colostomy (bag for body wastes).
  - Side effects of chemotherapy include loss of hair, change in taste or smell, mouth sores, possible loss of fertility, fatigue and less ability to deal with infections.
- Sensitive Groups:
  - Occurs most frequently in male smokers over the age of 70, but other older people can also get this cancer.
- Tap Water Treatment:
  - Providers of tap water can lower the chlorine levels in the water supply.
  - Less chlorine lowers cancer risks but raises microbial risks.
  - More expensive water treatment technologies are available to reduce both cancer risks and microbial risks

E-mail: questions@i-say.com Phone: 1-866-893-1188

Health Effects of Microbes and THMs in Tap Water

You won't need to remember these numbers. We just want to give you some idea of the risks people face.

First we list effects from all causes, then we list effects from drinking tap water only.

Microbial Health Effects in Numbers	Cancer Health Effects in Numbers
From all causes of microbial disease	**From all causes of cancer**
• Scientists estimate that for every 100,000 people: - Over a 35-year period, microbes from all sources (food, tap water and direct contact such as swimming), lead to 2.5 million cases of microbial infection. This means that a person may likely suffer multiple episodes of microbial illness over this period. - Over a 35-year period, about 100 deaths occur from microbes from all sources.	• Scientists estimate that for every 100,000 people: - Over a 35-year period, 27,000 people will contract cancer of all types. - Of these 27,000 people, 7,000 deaths are due to cancer of all types.
From drinking tap water	**From drinking tap water**
• Scientists estimate that for every 100,000 people drinking tap water: - Over a 35-year period, 23,000 people will get some sort of microbial infection. - Of those infected, 15 will die over the 35-year period. Death often occurs soon after infection.	• Scientists estimate that for every 100,000 people drinking tap water: - Over a 35-year period, 100 people will contract bladder cancer. - Of these, approximately 20 persons will die within 5 years as a direct consequence of the cancer. - Out of the 80 who do not die, some will be fully cured; others will experience cancer symptoms, and require medical interventions and drugs over their remaining lifetime.

This information is summarized in the following screen.

Sources for Health Effects Estimates

<< >>

Ipsos i-Say

E-mail: questions@i-say.com Phone: 1-866-893-1188

For a community of 100,000 people, over a 35-year period, illnesses and deaths from microbial disease and cancer will be approximately...

	MICROBIAL DISEASE		CANCER	
	Illnesses	**Deaths**	**Illnesses**	**Deaths**
From all Causes	2,500,000	100	27,000	7,000
	↓	↓	↓	↓
From Drinking Tap Water	23,000	15	100	20

On the next two screens, this situation is shown with pictures.

<< >>

Appendix 2: Example of CVM Question Format (Version 2)

Ipsos i-Say

E-mail: questions@i-say.com   Phone: 1-866-893-1188

Here's the first program we want you to vote on.

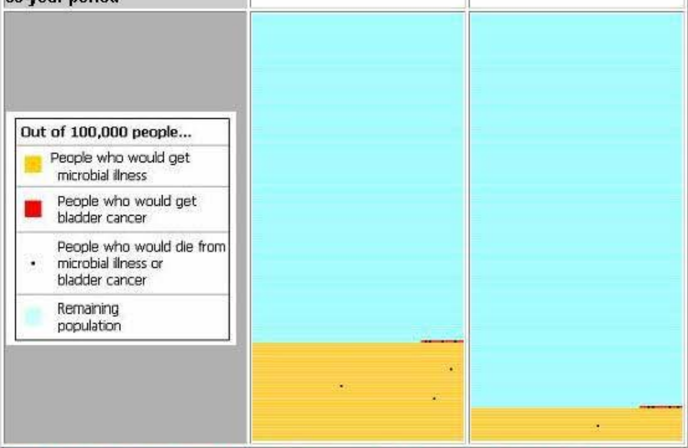
THE BENEFITS OF MUNICIPAL WATER TREATMENT PROGRAM A

Based on current water drinking patterns in your community this program would have the following benefits to every 100,000 people:

- 15,500 fewer people will develop microbial illness over a 35-year period. Another way to say this is that the average person in a community of 100,000 people will see their risk of getting microbial illness from drinking the water fall from 23,000 in 100,000 to 7,500 in 100,000
- With fewer people developing microbial illness, 10 fewer people will die from getting the disease. Another way to say this is that the average person in this community will see their risk of dying from microbial illness reduced from 15 in 100,000 to 5 in 100,000
- Bladder cancer illness and deaths will not be affected by the program

Here is a table showing these benefits:

For every 100,000 people, the NUMBER who would...	CURRENT SITUATION	PROPOSED PROGRAM A
Get **sick** from **microbial illness** in a **35-year** period	23,000	7,500
Die from **microbial illness** in a **35-year period**	15	5
Get **sick** from **bladder cancer** in a **35-year** period	100	100
Die from **bladder cancer** in a **35-year period**	20	20



THE COST OF THE MUNICIPAL WATER TREATMENT PROGRAM A

If the majority of voters support this program your household will share in the cost starting January 2005 by paying an additional amount on your household water bill.

PLEASE VOTE NOW:

CVM21 If the estimated addition to your household's water bill was **$25 per year ($2.08 per month)** starting in January 2005, and a vote were held today, would you vote **FOR** or **AGAINST** the proposal?

- FOR
- AGAINST

<< >>

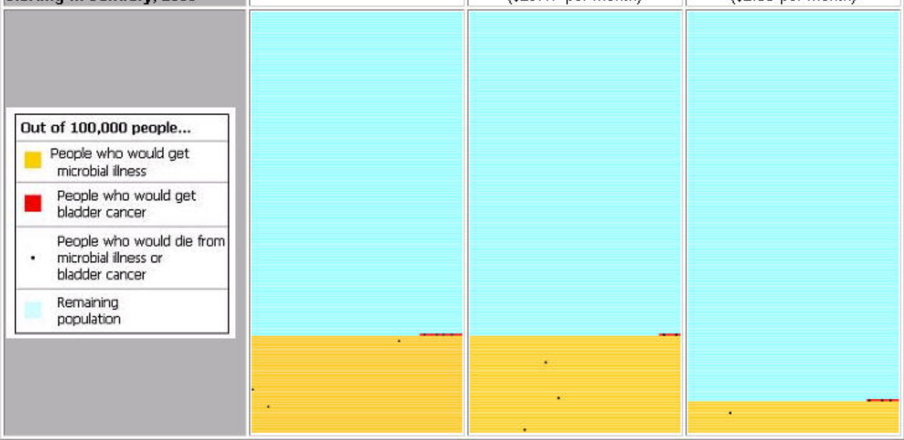
Appendix 3: Example of ABSCM Question Format (Version 5)

Ipsos i-Say

E-mail: questions@i-say.com   Phone: 1-866-893-1188

This is the second scenario we want you to vote on.

For every 100,000 people, the NUMBER who would...	CURRENT SITUATION	PROPOSED PROGRAM A	PROPOSED PROGRAM B
Get **sick** from **microbial illness** in a **35-year** period	23,000	23,000	7,500
Die from **microbial illness** in a **35-year** period	15	15	5
Get **sick** from **bladder cancer** in a **35-year** period	100	50	75
Die from **bladder cancer** in a **35-year** period	20	10	15
Change to your water bill starting in January, 2005	No Change	Increase $350 per year ($29.17 per month)	Increase $25 per year ($2.08 per month)



DC1 If there were a referendum, I would vote for...

CHECK ONE ONLY

- ○ Current Situation
- ◉ Proposed Program A
- ○ Proposed Program B

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Endnotes

[1] The chlorine demand of the water is defined as: the amount of chlorine that reacts with the other chemicals in the water plus the amount required to achieve disinfection. In addition, however, utilities add extra chlorine added to the water to account for length of time in the distribution network. This is called free chlorine and is the culprit in the production of disinfection by-products such as Trihalomethanes.

[2] Two epidemiological studies suggest that drinking water from water treatment plants following standard treatment processes could be responsible for half of the cases of gastrointestinal illnesses in the receiving population (Payment et al. 1991, 1997).

[3] The typical range of annual household water bills in Canada is between $300 and $500.

[4] Attribute levels for microbial illnesses were 7500, 15000, 23000 and 30000. Attribute levels for microbial deaths were 5,10,15 and 20. Attribute levels for cancer illnesses were 50,75,100 and 125. Attribute levels for cancer deaths were 10,15,20 and 25. All were defined for a population of 100.000 and over a 35 year period. Annual increases to household water bills ranged between $25 and $350.

[5] $14.4 million = $535/50 cases*100,000*35 years/2.6 persons per household.

Trish Hall's Discussant Comments for
Session IV: Valuing Morbidity and Mortality: Drinking Water

- **Policy Implications: Adamowicz, Dupont, Krupnick**
  - Preliminary Conclusion:
    - Higher VSL values for microbial illness
    - Significant value for illness avoided
    - Altruism: results can't be used at this point
  - Interpretation:
    - Canadians more aware of waterborne disease outbreaks?
      - Was also surprise by this result but agreed with the authors that Walkerton etc… may have had an impact
      - Impacts on kids/sensitive sub-populations
        - Did folks know from outbreaks that these groups are more adversely impacted by microbial illness?
      - Bladder cancer description
        - Average age of onset described as 70 years old
    - WTP values for illness very useful
      - WTP for Mircrobial illness was significant but did not seem unreasonable but will be heavily scrutinized if we were to use
    - Combined case avoided valuations could also be beneficial
      - Combined value for per case avoided would avoid the need to estimate mortalities and also severities
    - Altruism: Can it be sorted out
      - But how to tease out…almost everyone drinks from a public supply at some point so how do we figure this out (Shaw brings this up)
  - Points to Consider
    - Canada vs. USA
      - Make sure tables and text clearly indicate CAD $
      - Benefit transfer issues
    - Description on TTHM impacts could perhaps change results
      - Would results be different with these additional descriptors?
        - Routes of exposure: dermal and inhalation
        - Other health impacts: other cancers and repro and developmental
        - Exposure varies through out distribution system
      - However, it could make it more difficult to conduct benefit transfer to other contaminant where this is not the case (such as arsenic).
    - Latency vs. Cessation lag (I will talk about this at the end)

- **Policy Implications: Shaw et al.**
    - Conclusion: None yet but…
        - Potentially useful for understanding this issues…even if valuation proves elusive
    - Potential implications
        - Averting behavior: does it also correlate with greater WTP?
            - Averting behavior:? If valuation can be obtained, do the results match those in the Adamowicz paper?
              -Do folks who take averting action also have higher WTPs?
        - Altruism vs. self-interest: benefits from transient water supply regulation for chronic contaminants
            - Currently, the Safe Drinking Water Act exempts transient water supplies (e.g. restaurants, truck stops) from chronic contaminant regulation (such as arsenic). Are folks concerned about these outside the home exposures even if they have their own well?
        - How can we improve risk communication?
            - Focus group shows that we need to work on putting risk in context
        - Potential valuation estimates
            - Would always be welcome

- **Points to Consider: Shaw et al.**
    - Addressing ambiguity in risk
        - Some Clarity: Do you use tap water? --very good that researchers clarified uses for cooking, making ice, etc… many people don't realize how much they actually ingest.
        - BTW: fountain sodas are also made with tap water!
    - Lots of new arsenic risk information that could address some ambiguity
        - Arsenic inhibits DNA repair
            - Arsenic may be a "promoter" of cancer and prevent the body from making repairs to damaged DNA
            - Would describing this process help people understand the risk?
        - *In utero* Arsenic exposure and lung disease
            - UC Berkeley: Arsenic Health Effects Research Program (in utero study)
    - Sources of data
        - Would not recommend using Burnett/Hahn report for benefit estimates or risk data
            - many inaccuracies regarding the Arsenic Rule
    - Latency vs. Cessation Lag
        - Same issue as with the Adamowicz paper
        - Agency prefers cessation concept
        - Some examples of it use can be found here:

- See SAB report and Stage 2 DBPR EA for more information
- http://www.epa.gov/sab/pdf/ec01008.pdf
- http://www.epa.gov/OGWDW/disinfection/stage2/regulations.html
- I'll briefly describe the differences between latency and cessation next

- **Note about Cessation Lag**
  - Outlined in EPA's Science Advisory Board's Arsenic Rule Benefits Review Panel
    - Benefits analysis based only on latency greatly underestimates actual benefits
    - A good example of this is smoking:
      - Latency: initial exposure and increase in lung cancer risk is ~ 20 years
      - Cessation: risk of lung cancer declines quickly with reduced exposure
      - Smoking probably both imitator and promoter of carcinogenic effects.
        - Promoters should see more rapid decline in risk (i.e. late stage actor not the one that started the problem)
        - Arsenic seems to be a promoter
          - Perhaps does not cause DNA damage but inhabits DNA repair
      - The Final Stage 2 DBPR expands on the work of the SAB and includes cessation models for: smoking/lung cancer, smoking/bladder cancer, and arsenic/bladder cancer.

Valuing Reductions in Health Risks from Drinking Water: Discussion

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It is a distinct pleasure to participate in this workshop, and to have the opportunity to focus my attention on a group of research efforts directed toward exploring methods of conceptualizing and measuring the economic benefits of reducing health risks from drinking water. Individually and collectively the presentations in this session meet what I view to be the objective of EPA, and more specifically EPA STAR, funded research and collaboration: to make methodological contributions while remaining policy informative.

While I enjoyed and learned from each of the four presentations in this session, and appreciate that they are at varying levels of completion, I have been asked to center my present discussion on the presentation by Vic Adamowicz, Diane Dupont, and Alan Krupnick (hereafter ADK). Of the four research efforts comprising this session, the work by this research group is the furthest along and the only one in a position to provide a manuscript to accompany the oral presentation.

Although it is not funded through the STAR program, the ADK research is clearly in the spirit of EPA STAR objectives ascribed above. ADK does offer a methodological contribution to a contemporary debate in non-market valuation by comparing willingness-to-pay value estimates obtained from a contingent valuation (CV) study with those obtained from an Attribute Based Stated Choice Method (ABSCM). More colloquially this latter method is referred to a choice modeling or a variant of conjoint analysis. Although the research was conducted in Canada, ADK's findings are relevant to water quality policy in the United States. The tradeoff between microbial contamination and the cancer risks associated with byproducts of chlorination (i.e., Trihalomethanes) are fundamental to the Surface Water Treatment Rule, the Disinfectant/Disinfection Byproducts Rule, and the Groundwater Rule (http://www.epa.gov/safewater/dwa/electronic/ematerials.html#npdwr). The apparent high quality of this research suggests to me that KDM will make a notable and lasting contribution to both the literature on research methods and applied policy analysis.

The remainder of my comments is organized around central themes raised in ADK. With an eye toward addressing ADK's (p. 33) expressed concern that the value of statistical lives (VSL) that they find in their research "falls in the upper range of [previously estimate VSL] value," and the "fact that VSL for deaths from microbial disease is somewhat greater than that for cancer is a big surprise", the following sections discuss issues related to risk communication, the valuation of private versions public risks, and ADK's design and comparisons of stated preference methods.

Risk Communication:

Communicating drinking water risks in a manner that induces reasonable protective behavior when appropriate and reasonable inaction when exposure levels are well within safety levels is not a simple task. For instance, a recent arsenic risk communication study that endeavored to bring together concepts "of information processing, mental models and health behavior" into a single model of health behavior theory identified 45 possible variables in the path from arsenic exposure level to protective behavior (Severtson, Baumann, and Brown).

Economists, however, are more parsimonious in their characterization of risk updating with respect to new information. One such model treats an individual's subjective posterior risk assessment (R_P) as a function of prior risk perceptions (R_0) and the subjective risk associated with the information message (R_I) (see Smith and Johnson). A simple form of this relationship, which is consistent with many updating models, is a weighted linear average:

$$R_p = w_0 R_0 + (1- w_0)R_I$$

where w_0 is the weight placed on the prior risk perceptions. In turn 'I' contains general information about contaminants and their effects and exposure information. Past research using this simple updating framework has demonstrated that in making informed risk assessment, individuals place significant weight on both prior perceptions and new information for various health risks (e.g. radon, Smith and Johnson; chemical labeling, Viscusi and O-Connor; nitrates in groundwater, Poe and Bishop).

The above relationship has implications for ADK's analysis and conclusion. Of overarching importance, it implies that $R_p \neq R_I$. Related to this is the supposition that individuals likely have, and place weight on, prior perceptions of exposure and health risks from drinking water in characterizing their reference risk. Hence the respondents' subjective assessment of how the proposed program would affect the risk that they (individually or collectively) face will typically not align with the "objective" change presented (and modeled) in the research.

I posit that these implications shed light on ADK's "upper range" VSL finding indicated previously. Specifically, prior perceptions of health effects may be artificially large because of high profile microbial contamination events in Walkerton Ontario and North Beettleford, Saskatchewan (p. 3, p. 33, ADK). If R_p is elevated relative to the exposure and risk information provided by the researchers, and supposing that respondents take the target exposure level at face value, then respondents will be valuing a larger change than indicated. Dividing this larger value by the smaller change in "objective" risk conveyed in the survey materials would engender upwardly biased VSL estimates.

Whilst I find it innovative, I worry too that the "snake in the sand" communication approach that presents both microbial and cancer risks in the same diagram could lead to disproportional focus on the change in microbial risk relative to that associated with cancer. In examining the question formats in Appendices 2 and 3, I was taken by the fact that microbial exposure risks were, in essence, represented by an area, and cancer risks by a line. Although the changes in risks are proportional, to me the change in area associated with microbial risks loomed much larger. Should this optical "illusion" carry over to respondents, it would cause a further deviation between the change in objective risks communicated in the survey and the subjective risks utilized by the respondents.

In identifying these issues of subjective and prior risks, I do not mean to imply that ADK somehow failed in their efforts to communicate risk and risk changes. Indeed, I would argue the opposite. I am genuinely impressed with ADK's efforts to accurately understand and communicate the risks facing individuals, and would rate their work quite high relative to previous valuation work in groundwater risks. Nevertheless, I do believe that more could (can still?) be done with respect to understanding the subjective risks that individuals used as a base for formulating their willingness-to-pay values. Enhanced understanding of subjective risk, perhaps gleaned from a much smaller, shorter follow up survey or other auxiliary information, would provide an informative step toward better understanding the reported values and their relationship to prior work on groundwater and more general VSL studies. It is in this area of understanding what the respondents are valuing that I particularly commend the preliminary work presented by Douglass Shaw in this same session.

Altruism and Public Values:

ADK are correct in highlighting the fundamental difference between private and public valuation exercises and its impact on how we are to interpret value estimates, particularly with respect to comparisons with VSL estimates. Whereas groundwater quality is a public good, "best" estimates of the value of a statistical life derive largely from individual choices made in wage or market place studies (although CV and averting behavior studies have also been conducted and utilized in VSL estimates). As one moves from the private to public arena, other-regarding preferences enter into an individual's valuation equation, leading, potentially, to incomparable value estimates between public and private risk valuation exercises.

While fairness, reciprocity and other concerns are key elements of the set of other-regarding behaviors, ADK limit their concerns to "elements of altruism". That altruistic preferences are a concern in the valuation of safety is made evident in Viscusi, Magat and Forrest's work which compared willingness-to-pay values for personal risk reductions with willingness-to-pay values for programs that reduce the risk to others. They report that the sum of altruistic values for the risk reductions of other individuals are as high as six to seven times the value of reduction placed on an equivalent reduction in individual personal risk.

Economists have classified at least three types of altruistic preferences, each with a differing economic-theoretic role in benefit-cost analysis. The first is deemed "pure" altruism, reflecting the fact that I care for the well being or utility of others (Bergstrom, 2006). A second form is paternalistic altruism, which refers to the fact that I derive utility from how you consume (eat your peas! and don't take drugs!) and derive your utility (Jones-Lee, 1992). The third is Andreoni's "impure" altruism (or warm glow giving) in which I derive egoistic utility simply from the act of giving, independent of the particular good in question (Andreoni). ADK's paper implies that they interpret economic-theoretic benefit discussions of the role of the various forms of altruism in welfare assessments to imply that it is appropriate to "purge our estimates" (p. 35) of impure and pure altruistic motives[1]. But to the extent that altruistic preferences are paternalistic or safety oriented, they should be accounted for in benefit-cost analyses of risk reductions. I concur with this assessment.[2]

I do, however, dispute ADK's interpretation that pure altruism necessarily inflates values relative to private values. As Bergstrom (2006) reminds us "we should not forget… to count sympathetic losses each bears from the share of its costs paid by the other" (p. 339). The potential for such costs is of particular concern in the discrete choice framework employed in the stated preference elicitation formats utilized in ADK. Johannesson *et al*. argue that the coercive nature of voting and taxation raises the possibility that some people who are pure altruists will vote "no" on a project that would provide them private net benefits for risk reduction, narrowly defined, because they desire not to impose costs on others for whom costs exceed the benefits.

> Let us assume that [an individual] is willing to pay $t for a ceteris paribus increase in his own safety. His total WTP for a uniform public risk reduction of the same magnitude will fall short of $t if he believes that others are willing to pay less than $t but will still be forced to pay that amount ($t) for the project. This is because other individuals, for whom he cares will experience a lower utility if the program is implemented. In turn, this decrease in the utility of others reduces the pure altruist's WTP for the public safety project. (p. 264)

In other words, purely altruistic behavior may in some instances *lower* the proportion of affirmative votes relative to a self-interested model. Johanneson *et*

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[1] There is continuing debate in the economic literature regarding the role of pure altruism in benefit-cost analyses. Conventional economic wisdom suggests that the optimal provision of public goods should be based solely on selfish preferences (Bergstrom, 1982; Jones-Lee, 1991, 1992; Milgrom; Johansson) in social benefit-cost analyses for small projects evaluated close to a social welfare optimum. However, as Flores notes, public projects are rarely, if ever, financed under such conditions: most typically the funding for specific public projects imposes coercive costs that result in utility gains and losses. Moreover, projects evaluated tend to be discrete, and the initial allocation of public goods is inefficient. Under these conditions the extrapolation of Bergstrom's (1982)result for marginal changes at the optimum do not carry over to the "more modest problem [of benefit-cost analysis], determining whether a specific project can lead to a Pareto improvement" (Flores, p. 304). While Bergstrom (2006) does not dispute Flores' argument he concludes that "for a broad class of economies, a comparison of the sum of private values to the cost of a project is the appropriate test for determining whether it can lead to a Pareto Improvement" (p. 348).

[2] In the spirit of full disclosure, I should not that Professor Richard C. Bishop, an attendee at this conference, Professor Emeritus at the University of Wisconsin, longstanding leader in non-market valuation research, and the Chair of my dissertation committee indicated, after my presentation, disagreement with the exclusion of warm glow giving from benefit-cost analyses. At the time of this writing we have not yet had the opportunity to determine our point of departure on this issue.

al. demonstrate this outcome in a dichotomous choice contingent valuation study of safety. In an experimental study of willingness to pay for protection against financial risks in coercive tax settings, Messer, Poe and Schulze further demonstrate this result.

With respect to warm glow, I agree with ADK that warm glow should be removed from value estimates for use in benefit-cost analyses, but disagree with their method of doing so. To isolate warm glow respondents in the CV format, ADK "removed people who said that they would pay anything for health risk reductions and who answered Yes-Yes" (p. 20: for ABSCM they simply removed individuals who said that they would pay anything). These types of people are best categorized as yea- sayers, not warm glow respondents. Warm glow need not be large. And it could be a small or large element of every respondent's values. Hence, it appears the removal of selected yea-sayers from the data set bears little relation to removing warm glow values from the entire data set of respondents.

In sum, I concur with the intent of the last sentence in ADK's paper, "Attempts to purge our estimates of altruism effects are in our plans for future research," and heartily urge the authors to undertake this effort. In doing so, however, they must take care to do so in a manner consistent with the underlying economic-theoretic construct.

The CV and ABSCM studies:

Overall the survey implementation and the analyses seem to be, as already suggested, of high quality (as I would expect from this set of co-authors). My comments on the survey design tend to be of a more specific rather than general nature, and hence, I shall rely on a bulleted format to convey my impressions.

- Both modes: The 46% response rate is relatively low by contemporary stated preference standards for established methods of survey research such as mail, telephone or in-person contacts. Web-based survey research is still fairly nascent and it is not clear at this time what response rate expectations and non-response implications for this mode. Nevertheless, it is a concern for any policy research when the response rate falls below 50%.
- CV format:
    - Valid comparisons of adding up should account for the likely positive correlation in DC-CV responses (or more specifically error terms) across risk scenarios. Failing to account for this difference will lead to biased estimates of the significance of the difference between the parameters being compared (see Poe, Welsh and Champ)
    - There appears to be a "fat tails" problem at upper bids (45% yes to the joint treatment of Cancer and Microbial) which should be accounted for/addressed in estimating the mean WTP values.

- ABSCM format:
  - As ADK note, a fundamental question arises with the observation that the inclusion/exclusion of the status quo (a difference on the order of 50%). This is a concern, in part, because the authors provide little guidance about which of the two measures is appropriate.
- Comparing CV and ABSCM:
  - ADK note that the "WTP measures from the [ABSCM] models with the status quo effect included tended to be lower that the CVM values while the WTP form the models with the status quo effects excluded tended to be higher than the CVM models" (p. 32). Either result is of interest as well as of concern. The former result is of interest because it is not consistent with previous comparisons of CVM and ABSCM that have found that ABSCM values are not significantly different or are statistically higher than CVM (see Boyle, Morrison and Taylor). In contrast the latter results are consistent with the previous literature, but that is a concern. Here, ADK use a dichotomous choice CV format, which has been demonstrated to engender the highest deviations between hypothetical and actual values in simulated market studies (e.g., Brown *et al*.). It would thus be disappointing to find that ABSCM provides higher values than the most upwardly biased CV format.

Concluding Thoughts:

My sense is that ADK have designed a study that provides one of the fairest and competent comparisons of CV and ABSCM. I believe that this research will make a notable contribution to the stated preference literature. The research also has high potential for informing policy. As I see it the only shortcoming of this research is that, I suspect, the present statistical analyses are far from final and that there are several issues, some of which I have raised above, that merit closer consideration as this research is brought to completion. I do look forward to reading revised and updated analyses of this work, and maintain that the EPA and the other agencies that have funded this research have made a solid investment that will, in time, make a lasting contribution to the dual objective of policy and methods in the valuation of drinking water risks.

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Questions and Discussion section was not conducted for Session VI