ASSESSING WHETHER THERE IS A CANCER PREMIUM FOR THE VALUE OF A STATISTICAL LIFE†

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ABSTRACT

This article estimates whether there is a cancer risk premium for the value of a statistical life using stated preference valuations of cancer risks for a large, nationally representative US sample. The present value of an expected cancer case that occurs after a one decade latency period is $10.85m, consistent with a cancer premium that is 21% greater than the median value of a statistical life estimates for acute fatalities. This cancer premium is smaller than the premium proposed for policy analyses in the UK and the USA. There is also a greater premium for policies that reduce cancer risks to zero and for risk reductions affecting those who perceive themselves to have a greater than average probability of having cancer.

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KEY WORDS: cancer; value of a statistical life (VSL); stated preference; risk

1. INTRODUCTION

The economic valuation of risks of death establishes the unit price for the benefits of policies that affect mortality risks. A frequent approach to valuing mortality risks in the US regulatory contexts is to use estimates of the value of a statistical life (VSL) based on labor market estimates of the wage premium for acute accident risks. These estimates, which are reviewed in the meta-analysis by Viscusi and Aldy (2003), find a median VSL in current (2011) US dollars of $9m.1 Stated preference approaches to estimating the VSL are also frequently used in policy contexts, such as for valuation of transport safety risks in the UK.2 The morbidity effects associated with other causes of death may differ, consequently producing a different value for risks to life depending on how one dies. Deaths from cancer involve loss of life but often entail substantial, longer term morbidity effects. Cancer is also considered a ‘dread disease’, in that it generates a fear that is greater than would be justified by its objective risk probabilities.3 This article explores the valuation of cancer risks and the possible premium for cancer risk reductions using a stated preference approach. We are not making any normative judgments but instead are ascertaining how individuals value their cancer risks.

Although there is increasing recognition that the benefits transfer assumption of applying the VSL based on accidents to cancer risks may not be appropriate, there is little agreement regarding whether there should be a

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†Supporting information may be found in the online version of this article.
1More recent evidence in Kniesner et al. (2012) using panel data yields very similar estimates.
2See, for example, Chilton et al. (2006) and Mason et al. (2009), and the references contained therein. A large class of stated preference studies falls under the general heading of ‘contingent valuation,’ but the evolution of survey approaches has been accompanied by a change in nomenclature.
3For an exploration of the valuation of dread risks in the domain of accidents, see Chilton et al. (2006).
cancer premium or its magnitude. The procedure adopted by the UK Health and Safety Executive (2001) and the UK HM Treasury (2011) is to value cancer risks at twice the value of accidents. This doubling factor is a judgmental valuation not based on empirical estimates. The US Environmental Protection Agency (EPA) (2010) is also considering a cancer premium for policy valuations and has recommended a 50% premium for cancer as a placeholder value until the appropriate magnitude of any cancer premium is resolved. Accurate evaluation of a cancer risk premium is also pertinent to broader health policy assessments, such as estimating the value of the war on cancer (Lakdawalla et al., 2010) or cancer treatments.4

Several stated preference studies have yielded estimates of the VSL for cancer either in absolute VSL terms or relative to the VSL for accidents. Magat et al. (1996) used a survey approach based on a risk–risk tradeoff between acute automobile deaths and terminal lymph cancer but did not include factors related to the presence of a latency period (i.e., the amount of time between the time of the risk exposure until the time when the symptoms of the disease are present). They found that an expected cancer death had a mean value equivalent to 1.5 automobile accident deaths. Van Houtven et al. (2008) used a similar risk–risk tradeoff survey approach for stomach, liver, and brain cancer and found that the cancer VSL commanded a premium that varied with the latency period. With a 5 year latency period, cancer has a value three times as great as fatal accidents, with a relative VSL ratio of 1.5 when the latency period is 25 years. In a stated preference study in Taiwan, Hammitt and Liu (2004) found that fatal cases of lung or liver cancer were valued one-third more than similar chronic diseases. However, a subsequent US stated preference study by Hammitt and Haninger (2010) found no significant difference in the VSL for risks of death from motor-vehicle accidents, noncancer disease, or cancer (brain, bladder, liver, or lymphocytes). The contingent valuation and choice experiment survey of bladder cancer risks in Adamowicz et al. (2011) did not indicate a specific cancer latency period but undertook a sensitivity analysis to explore the implications of the empirical estimates of the VSL for cancer assuming different latency periods.

Our study uses a stated preference approach in which we elicit risk–money tradeoffs for fatal bladder cancer risks from arsenic in drinking water. Regulation of arsenic has been a contentious issue in the USA since environmental regulations were issued in 2001. The arsenic regulation was challenged in court and did not take effect until 2006.5 The focus of this article is on the valuation of fatal cancer risks, using hazards from arsenic in drinking water as the survey context. With a large, nationally representative sample, we estimate the VSL for cancer risks with a one decade latency period specified in the survey. We find the cancer VSL estimates are roughly comparable with VSL estimates for acute accident risks but are higher once we appropriately adjust for the 10-year latency period.

How people value cancer risks may depend not only on the risk change but also on the risk level. Interventions that reduce the risk to zero may command an additional ‘certainty premium’ compared with risk changes of comparable magnitude from a higher baseline risk amount (Tversky and Kahneman, 1992). The existence of a premium for the elimination of a risk has been observed for minor morbidity risks (Viscusi et al., 1987). A certainty premium may arise because eliminating a risk removes the anxiety, worry, and dread that may be associated with a nonzero probability of an adverse outcome. Reducing a risk to zero also eliminates that risk category as something that a person needs to think about in terms of possible hazards. This article reports the first evidence of a certainty premium for elimination of the risk of cancer. Eliminating fatal bladder cancer risks from arsenic adds about $1m to the VSL, a 14% premium relative to values based on risk reductions that do not completely eliminate the risk.

Our examination of the valuation of cancer risks also explores whether risk reference points influence valuations. The VSL for cancer may depend on whether the person perceives their own risks as being greater or less than some reference point, in this case, the national average risk. Perceiving oneself as being exposed to an abnormal risk level may affect one’s valuation of changes in risk to the extent that there are reference point

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4If, however, the individual is already under treatment for cancer, then a different approach is warranted, as in Lang et al. (2012).
5Burnett and Hahn (2001) provide a critique of the economic merits of the regulation.
effects for probabilities in much the same way as there are for income levels. The reference point effects may be asymmetric in magnitude, where the prospect of a risk that is greater than the national average is more motivating than one that is less risky.

We do not take any normative position with respect to whether certainty premiums or reference risk effects should be recognized as legitimate aspects of risk valuations or as forms of irrationality. Such matters are beyond the scope of this article.

2. SURVEY STRUCTURE AND THE SAMPLE

Our examination of estimates of VSL for cancer risks utilizes a stated preference survey in which respondents indicate their willingness to incur costs for policies that reduce their risk of cancer. In our implementation, the survey focuses on risks of bladder cancer from drinking water due to arsenic exposure by eliciting a series of responses regarding respondents’ willingness to pay for various policies that would reduce their drinking water cancer risk. These responses form the basis for obtaining estimates of the VSL for fatality risks from cancer.

The computer-based survey uses an iterative choice approach involving a series of up to three decisions. This approach is well suited to eliciting the distribution of valuations across the population and is in the same general family as earlier contingent valuation studies. The additional questions gradually increase tradeoff values in an effort to determine the respondent’s indifference point, allowing individuals with strong preferences to express the magnitude of their values while allowing those with more moderate values a chance to express them in a tightly bounded range.

2.1. Cancer risk survey structure

The initial portions of the survey inquired about the respondent’s experiences with drinking water and knowledge of water-related illnesses. In addition, the survey included a segment that provided respondents with some background in thinking about probabilities using risk ladders and a grid with colored squares. After obtaining this background, respondents considered the cancer valuation portion of the survey. The cancer scenario involved a well-defined set of symptoms and outcomes so that respondents could value the risks of a specific fatal cancer risk outcome.

Figure 1 provides an example of the information that respondents were provided about the bladder cancer risk from exposure to arsenic in their drinking water. The description of the gastrointestinal symptoms was comprehensive but brief, thus avoiding the problems noted by Smith (2008) that can arise if a narrative is too extensive. First, panel 1 of Figure 1 informs them that drinking water can contain arsenic, which is known to pose a risk of bladder cancer. All respondents received the same information in panel 1 about the disease symptoms and a cancer latency period of 10 years. To reinforce the respondent’s attention to these symptoms, the survey asked which of the nonfatal symptoms in Figure 1 would be most upsetting to them.

Panel 2 in Figure 1 provides the risk information, which the survey presented in a frequency format with a population denominator. To accommodate differences in small probabilities across various survey questions, the survey characterized incidence levels in terms of the number of cancer victims out of populations of 100,000. The survey made this number more concrete by linking it to the number of people in a large stadium or a small city. Neuroscience evidence indicates that presenting risks in terms of a frequency format with a specific population denominator is more readily understood as a means of conveying information pertaining to probabilities than the use of a probability format approach (Coaster et al., 2011).

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6National Research Council (2001) notes that bladder cancer incidence can have both short-term (6–8 years) and long-term (20 years or more) latency, or time between risk exposure and disease onset. We chose a value between those levels to make the length of the latency period easy for respondents to understand while also preserving relevance to actual conditions.
The third panel in Figure 1 presents the risk probability information and the choice task. The structure of the choice task follows a format introduced in Magat et al. (2000) and used in subsequent iterative choice studies. This format simplifies the estimation of a value for an unfamiliar good by breaking it into a series of binary choices. This format is easier for respondents to understand than asking them to directly declare how much they value the improvement in a point blank contingent valuation question. The online Appendix 2 analyzes the implications of the initial choice using a random utility model, but the iterative choice permits respondents at the extremes to express their heterogeneous preferences more directly. Slightly different survey versions were required depending on respondent characteristics. For example, the first question scenario differs for respondents using well water, because they do not have treated water delivered to them by a municipality, but instead have to personally intervene to improve water quality. As will be shown in the succeeding text, the well/municipal water supply distinction had minimal effect on VSL.

The focal choice task that is shown in panel 3 elicits a tradeoff between cancer risk and money to reduce that risk. The surveys differed across households with respect to the assumptions about baseline risk level (either two or four chances in 100,000 per year of exposure), risk reduction amount (reduced by four, three, or two chances), and the cost of reducing that risk (between $50 and $300 per year). In some instances, the new
Panel 3:

For respondents on a municipal water supply:

Assume for a moment that you have a A out of 100,000 chance each year to eventually get bladder cancer and die due to arsenic in your drinking water. We are asking you to assume this because arsenic exists at different levels in drinking water depending upon the region of the country.

What if your water treatment system could use a new treatment to reduce that risk to B out of 100,000 chance each year?

If you learned that this treatment increased your annual water bill by $Dollars, what would you think of the new treatment?

1. I would be in favor of the new treatment and the increased water bill.
2. I would be opposed to the new treatment.
3. I have no preference for whether the new treatment is used or not.

For respondents using well water:

Assume for a moment that you have a A out of 100,000 chance each year to eventually get bladder cancer and die due to arsenic in your drinking water. We are asking you to assume this because arsenic exists at different levels in drinking water depending upon the region of the country.

What if you could purchase a filter that would reduce that risk to B out of 100,000 chance each year?

If you learned that you could purchase such a filter at a cost of $Dollars per year, what would you think?

1. I would be in favor of using such a filter.
2. I would prefer not to use such a filter.
3. I have no preference for whether or not I would use such a filter.

Panel 4:

Compared to the 2 out of 1,000 average lifetime risk for the country overall, do you think that arsenic risk of your tap water is:

<table>
<thead>
<tr>
<th>Much Lower Risk</th>
<th>Lower Risk</th>
<th>About the Same Risk</th>
<th>Higher Risk</th>
<th>Much Higher Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

Figure 1. (Continued)

treatment reduces the risk to zero. The risk levels reflect the magnitude of risks associated with the EPA maximum contaminant limit for arsenic before and after the proposed rule change from 50 parts per billion to 10 parts per billion for public water systems. Adjusting risks from lifetime risks into yearly totals and accounting for bladder cancer’s estimated 20–29% share of arsenic-related cancers, the rule change generates a cancer risk of between 2.6 to 3.7 out of 100,000 under the old rule to 0.5 to 0.75 out of 100,000 under the new rule.

After deciding whether to incur the new treatment cost, respondents encounter an iterative choice task designed to more accurately ascertain their value of reducing cancer risks. Respondents who are in favor of...
the new treatment are offered the same hypothetical choice but at a higher cost. Respondents who are opposed to the new treatment are offered the same choice but at a lower cost. The process ends if the respondent expresses ‘no preference’ at any stage. Figure 2 illustrates a representative decision tree for the situation in which the new treatment involves a risk reduction of 2 in 100,000 and an initial cost of $200 per year.

Across different starting configurations, there were 1008 respondents who indicated indifference at the initial choice. For subjects expressing a preference for the new treatment policy, as 1397 respondents did, the subsequent choices increase the cost of the new treatment. Conversely, for the 1025 respondents who initially decline the treatment, the subsequent treatment choices entail a lower cost. The process continues for up to three choices until the respondent switches their water treatment preference in response to a new cost level or reaches a point of indifference. This iterative choice processes generates three categories of respondents. First, for respondents who indicate indifference, the ratio of the accepted cost to the change in risk generates a point estimate of their VSL. Second, respondents who indicate a preference for the high (low) cost option and subsequently switch to the low (high) cost option on the subsequent choice have values bounded in

![Decision Tree Diagram](Image)

**Example of the Survey Decision Tree**

**New Treatment**

- **Starting Annual Risk:**
  - 4 in 100,000 chance

- **Annual Risk After Treatment:**
  - 2 in 100,000 chance

- **Cost:**
  - $200 per year

- 1397 yes
- 1008 no preference
- 1025 no

**New Cost:**

- **$400 per year**
  - 788 yes
  - 214 no preference
  - 395 no

- **$100 per year**
  - 264 yes
  - 66 no preference
  - 695 no

**New Cost:**

- **$800 per year**
  - 395 yes
  - 102 no preference
  - 291 no

- **$300 per year**
  - 86 yes
  - 38 no preference
  - 271 no

- **$150 per year**
  - 66 yes
  - 21 no preference
  - 177 no

- **$50 per year**
  - 213 yes
  - 41 no preference
  - 441 no

*a Note: The numbers breaking down how many respondents picked each possible choice in this figure reflect all respondents, not merely those who faced an initial 2 in 100,000 chance risk reduction at a $200 cost.*

Figure 2. Example of the survey decision tree

the cost–risk tradeoff range given by these choices. The final category is for respondents who continue to indicate a consistent preference for lower cost–risk tradeoff rates on the right branch of the decision tree or higher cost–risk tradeoffs on the left branch of the decision tree. The valuations for these respondents are bounded on one side at the extreme amounts permitted by the tree but unbounded on the other. By design, all individual choices are consistent, because the sequences of choices along paths in Figure 2 do not permit reversals in preferences.

In addition to completing the valuation task, respondents also indicated whether they think that their arsenic risk of cancer from tap water is above or below the national average. Panel 4 of Figure 1 presents this question. Our survey represents an advance over previous surveys in that the responses to this question provide a basis for controlling for the effect of respondents believing their risks are not consistent with average exposure amounts.

2.2. Sample description

The data for the study are based on a survey of valuations of health risks from drinking water undertaken in 2008 and 2009. Over 60% of the respondents completed the survey in December 2008, with the remainder in 2009. The sample of 3430 respondents was drawn from the Knowledge Networks panel, a 50,000 member nationally representative Web-based sample of US adults aged 18 or older constructed using probability sampling of the adult US population. The Knowledge Networks panel provides a Web panel representative of adults in the USA. To achieve broad representation, Knowledge Networks provides its panelists with computers and internet access when needed. The characteristics of the sample reasonably follow the distribution of the US adult population in terms of gender, age, education, race, marital status, and income. Table I summarizes the means and standard deviations of the variables used in our analysis.

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Table I. Means and standard deviations of variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income/$10,000</td>
<td>$6.358</td>
<td>$4.388</td>
</tr>
<tr>
<td>Top income category ($175,000+)</td>
<td>2.7%</td>
<td>16.1%</td>
</tr>
<tr>
<td>Years of education</td>
<td>13.8</td>
<td>2.6</td>
</tr>
<tr>
<td>Age</td>
<td>48.7</td>
<td>16.1</td>
</tr>
<tr>
<td>Considers self environmentalist</td>
<td>42.4%</td>
<td>49.4%</td>
</tr>
<tr>
<td>Female</td>
<td>52.0%</td>
<td>50.0%</td>
</tr>
<tr>
<td>Race: Black</td>
<td>10.5%</td>
<td>30.7%</td>
</tr>
<tr>
<td>Ethnicity: Hispanic</td>
<td>10.3%</td>
<td>30.4%</td>
</tr>
<tr>
<td>Metropolitan Statistical Area</td>
<td>84.0%</td>
<td>36.6%</td>
</tr>
<tr>
<td>Region: northeast</td>
<td>18.2%</td>
<td>38.6%</td>
</tr>
<tr>
<td>Region: south</td>
<td>34.8%</td>
<td>47.7%</td>
</tr>
<tr>
<td>Region: west</td>
<td>22.5%</td>
<td>41.8%</td>
</tr>
<tr>
<td>Well user</td>
<td>18.5%</td>
<td>38.8%</td>
</tr>
<tr>
<td>Considers own cancer risk high</td>
<td>5.2%</td>
<td>22.2%</td>
</tr>
<tr>
<td>Considers own cancer risk low</td>
<td>50.1%</td>
<td>50.0%</td>
</tr>
<tr>
<td>Respondent answered yes to first question</td>
<td>57.7%</td>
<td>49.4%</td>
</tr>
</tbody>
</table>

N = 3430.

The average arsenic-related bladder cancer risk is estimated to be between 2.6 and 3.7 chances out of 100,000 under the previous EPA rule. Respondents either received a national average of 2 or 4 out of 100,000.

See Table A1 in online Appendix 1. For additional information on the Knowledge Networks panel, see http://www.knowledgenetworks.com/knpanel/docs/KnowledgePanel%28R%29-Design-Summary-Description.pdf.
3. INTERVAL REGRESSION ANALYSIS OF ITERATIVE CHOICE PREFERENCES

On the initial choice, the respondent faces a pairwise choice defined in terms of the change in the cancer risk level \( r \) and change in cost \( c \). The utility \( u_{ni} \) for policy \( i \) \((i=1, 2)\) and respondent \( n \) is given by

\[
u_{ni} = \alpha r_{ni} + \beta c_{ni} + \epsilon_{ni},\]

where \( \epsilon_{ni} \) is a random error term. One can view this formulation as a first-order Taylor series approximation to changes in utility functions with respect to changes in cost and changes in risk. Choices depend on the difference in utility levels between two options.

The empirical analysis is framed in terms of a discrete choice in which policy option \( i \) designates the new treatment that has a lower risk and higher cost, and policy option \( j \) designates the higher risk current treatment. The choices thus can be framed in terms of the risk change variable, which we designate by \( r \) and is the decrease in risk levels associated with the new treatment. The second component of the choice is the increased cost of treatment, which we will term \( c \). If \( r = r_{ni} - r_{nj} = 0 \) and \( c = c_{ni} - c_{nj} = 0 \), then the policy options are identical, and the respondent should be indifferent between the two options. Respondent \( n \) indicating no preference between new treatment \( i \) and current treatment \( j \) has a tradeoff \( v_n \) between cost and risk given by

\[
\frac{(c_{ni} - c_{nj})}{(r_{nj} - r_{ni})}.
\]

Those who reach indifference in this manner consequently have a revealed cost–risk tradeoff for the associated interval in which the tradeoff is reached.

The survey procedure generates information that can be used to estimate the cost–risk tradeoff rate but not always explicitly. For respondents who reach a no preference option, the indicated tradeoff is their VSL. For respondents who switch from a higher (lower) to lower (higher) cost–risk tradeoff, the survey bounds the VSL. Although one could use the midpoint of the range as the estimate, doing so imposes an assumption regarding where preferences shifted. For respondents who hit the low (high) value corner solutions, their valuation amounts are censored so that using the expressed value at the corner will overstate (understate) their tradeoff value. An ideal econometric solution is to address the censoring issue and also to estimate the pertinent switch point in the interval.

The appropriate econometric technique that accounts for the three categories of respondents uses interval regression.\(^{11}\) The interval regression treats the response indicating indifference to a tradeoff level as in Equation 2 as having a value in the interval \((v_{ni}, v_{nj})\). Respondents who switch their preferences between new treatment with tradeoff rate \( v_2 \) and the current treatment with tradeoff rate \( v_1 \) do not indicate their point of indifference but have revealed that their indifference point is located somewhere in the interval \((v_{n1}, v_{n2})\) between the two tradeoff rates. The interval regression estimates this tradeoff value in the interval \((v_{n1}, v_{n2})\). The lowest permitted tradeoff rate for the respondents’ choices is \( v_1 \) and the highest is \( v_{n2} \). Respondents who decline the new treatment option in every available choice involving progressively lower cost–risk tradeoff rates have unbounded responses at the low end. Such responses are in the interval \((-\infty, v_{n2})\). Those respondents who always select the new treatment in each question, even after its cost is increased, lie in the interval \((v_{n2}, \infty)\). Thus, the use of interval regression addresses both the unbounded and interval aspects of the data.

One of the advantages of the iterative choice procedure and the interval regressions is that they make it possible to compare results at each stage of the iterative choice procedure. The coefficients are directly interpretable in terms of dollar differences in units of $100,000. The three sets of interval regression results reported in Table II demonstrate that the additional choices allow respondents to refine their value estimates. After the initial question, the effects of significant respondent characteristics fall into two broad categories. First, there are those whose effects mostly stabilize after two questions and do not greatly increase thereafter such as respondents who consider their own risk low, income, age, and gender. Other characteristics, however,

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\(^{11}\)See Wooldridge (2010), pp. 783–785 for further discussion.
exhibit more of the magnitude of their effects on values with a third question, such as those who consider their own risk high, environmentalists, and minorities.

Individual beliefs regarding the relative risk of cancer from drinking water have large and economically reasonable effects on valuations. We focus on the results after three questions. Although only 5% of the sample believes that they are incurring above average cancer risks from arsenic, their choices indicate an increase in VSL for cancer by $4.97m. The downward influence of the more common belief that their risk is below average has a smaller effect on VSL estimates, lowering the VSL for cancer by $864,000. This asymmetry in the effect is consistent with the behavioral hypothesis that upward deviations in beliefs about risk relative to the national norm are much more consequential than deviations where the belief is that one is safer than average.

The role of the demographic variables in influencing willingness to pay for lower cancer risk at each level accords with usual economic predictions, thus providing additional validity checks. We focus on the results after three questions. Although only 5% of the sample believes that they are incurring above average cancer risks from arsenic, their choices indicate an increase in VSL for cancer by $4.97m. The downward influence of the more common belief that their risk is below average has a smaller effect on VSL estimates, lowering the VSL for cancer by $864,000. This asymmetry in the effect is consistent with the behavioral hypothesis that upward deviations in beliefs about risk relative to the national norm are much more consequential than deviations where the belief is that one is safer than average.

The role of the demographic variables in influencing willingness to pay for lower cancer risk at each level accords with usual economic predictions, thus providing additional validity checks. Respondents who have higher income are more likely to pick the new treatment option, consistent with the established positive income elasticity of the valuation of risks to health. Given the risk units in terms of cancer deaths per 100,000, a $10,000 increase in income increases the VSL by $106,000, or an income elasticity of 0.08. The relatively low net income elasticity may arise because of the survey context that only required modest expenditures for small risk reductions. Further, this estimate reflects the incremental influence of income controlling for factors correlated with income, such as education and age. Finally, we see that those

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12 These tests often come under headings such as behavioral scope tests. Passing such tests does not ensure survey validity but is an essential hurdle that a survey must pass to be valid.
who describe themselves as environmentalists are more likely to pick the new treatment option, which involves higher costs and lower risks, which is consistent with higher value on environmental quality. Being an environmentalist is associated with a $2.20m greater VSL.

Three other demographic variables have significant effects. Age has a positive effect, perhaps capturing the greater incidence of cancer in older age groups as well as life-cycle income and health status effects. In addition, our VSL is specific to the specific disease, cancer, making a benefit transfer in this context more pertinent than use of VSL for accidental deaths. Female respondents have a higher valuation, consistent with evidence of greater risk aversion by women. Respondents who are Black or Hispanic also have a higher valuation, which accords with evidence that those groups are exposed to greater hazards from poor water quality than non-Hispanic Whites. For example, Black and Hispanic groups are more likely to live in rental housing, which tends to have lower water quality. Moreover, within housing types, they are more likely to report that their water quality is poor, which also should make them more supportive of the new treatment option. The corresponding marginal increase in VSL amounts is $3.02m for Blacks and $2.26m for Hispanics.

Table III summarizes the VSL estimates and their distribution at each level of depth within the iterative choice procedure. This analysis comes from sample enumeration from the results from Table II assigning appropriate characteristics to each respondent and then aggregating. The mean value limited to answers to the first question is $6.62m, which is in the lower range of the estimates. The iterative procedure yields a higher value at each level of refinement because the sequence of choices provides more information on values at the tails of the distribution, and the upper tail of relatively high values has a greater upwards effect on the mean than the lower tail’s downwards effect. The VSL estimate using two questions is $7.56m, and if the answers to all three possible questions are considered, the estimate is $8.67m. The difference between the number of questions applied to the interval regression provides a measure of the sensitivity of the method through which the stated preferences are assessed.

As a robustness check, the online Appendix 2 provides an analysis using random utility model estimates based on the initial choice. That analysis drops the indifferent judgments in the first round, whereas the interval regression for one choice uses all the information the choice tasks. The probit analysis used in the sensitivity analysis yields estimates that are very similar to those implied by the interval regression estimates based on the first two questions. That analysis also provides a scope test for valuations, demonstrating that respondents are averse to increases in cost and favor decreases in risk.

Table III. Calculations of the distribution of the value of a statistical life derived from interval regression estimates

<table>
<thead>
<tr>
<th></th>
<th>One Question</th>
<th>Two Questions</th>
<th>Three Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>$6.62m</td>
<td>$7.56m</td>
<td>$8.67m</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>$3.22m</td>
<td>$3.06m</td>
<td>$3.71m</td>
</tr>
<tr>
<td>Percentiles:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10%</td>
<td>$2.17m</td>
<td>$3.53m</td>
<td>$3.92m</td>
</tr>
<tr>
<td>25%</td>
<td>$4.12m</td>
<td>$5.34m</td>
<td>$6.02m</td>
</tr>
<tr>
<td>50%</td>
<td>$6.30m</td>
<td>$7.58m</td>
<td>$8.58m</td>
</tr>
<tr>
<td>75%</td>
<td>$9.22m</td>
<td>$9.66m</td>
<td>$11.09m</td>
</tr>
<tr>
<td>90%</td>
<td>$10.57m</td>
<td>$11.66m</td>
<td>$13.55m</td>
</tr>
</tbody>
</table>

aN = 3430 for all regressions. All figures are in 2011 dollars.

13Studies suggest, for example, that perception of risks may be strongly influenced by the incidence of these risks among one’s age cohort. See Benjamin et al. (2001).
14Eckel and Grossman (2008) provide a review.
15These and other calculations in this paragraph are based on data in Tables 3, 4 and 4–4 of the US Department of Housing and Urban Development (2011). See also Wescoat et al. (2007) for the relation of water quality to poverty.
Using the estimates from Table II and summarized in Table III, it is possible to estimate the heterogeneity of the VSL across individuals. Focusing again on information from all three iterative choices, for a risk change that does not involve a risk reduction to zero, the VSL is $8.10m, with a 95% confidence interval ($7.97, $8.22). Risk changes that reduce the risk to zero lead to corresponding VSL of $9.24m and a confidence interval ($9.11, $9.36). The predicted VSL and associated confidence intervals for those who consider their own cancer risk high is $12.47m ($12.35, $12.59), whereas for those who consider their own cancer risk low, the values are $6.63m ($6.51, $6.75).

The choice task in our survey explicitly includes a decade latency period. Given a 3% discount rate used for US regulatory analyses, we can convert the value of a deferred case of cancer to the value of an immediate case of cancer. That discounting increases VSL to 1.34 times the survey amount. Thus, the VSL for an immediate cancer risk that is not reduced to zero is $10.85m. This amount is 21% greater than the comparable VSL for acute accidents. The boost in VSL is much greater for those who consider their cancer risk to be above the national average, as their premium relative to the VSL for intermediate risk changes. The VSL of $16.71m for those at high risk implies a VSL premium of 54% for being in a high risk area. Reducing the risk to zero is also associated with an additional VSL premium, although more modest at 14%.

The existence of a cancer premium would boost the desirability of arsenic regulations but does not ensure that benefits exceeded costs. In its analysis for revising the maximum arsenic level in drinking water, the EPA used a VSL of $6.1m for an immediate cancer death risk, whereas our results indicate a 40% larger VSL of $8.54m (in 2001 dollars, as used by the EPA analysis). On the basis of the work of Burnett and Hahn (2001), the VSL must be at least $7.5m (2001 dollars) to pass a benefit–cost test if the regulation prevented cancer cases with no latency period. With a latency period of a decade, the break-even VSL would be $10.05m, and the regulation would fall short on benefit–cost grounds.

4. CONCLUSION

There is evidence of several factors affecting the premium for cancer VSL. In addition to the premium for the morbidity effects of cancer, there are also influences related to the risk reduction. Whether an intervention reduces the cancer risk to zero has a value above and beyond the magnitude of the risk change. We find a VSL certainty premium of about $1.5m for eliminating a cancer risk. Eliminating worry about a potential source of cancer may be of real economic value that could be considered in any valuation amount.

Individuals who believe that they are exposed to risks above the national average have a VSL that is 54% greater than that of the typical VSL. The role of the risk reference point has greater impact than the contrast between cancer risks and acute accidents or the influence of certainty effects accompanying reductions in the risk to zero. Whether reference point effects should affect the VSL that is applied in policy assessments depends on whether one views such influences as a rational choice or a behavioral anomaly.

There is evidence of a cancer premium above the VSL associated with acute accidents. Our estimate of the VSL for an immediate risk of cancer is $10.85m, excepting any premium associated with the certainty of completely avoiding all risk. This VSL is about $2m more, or 21% greater, than US estimates for acute accidents. If the pertinent discount rate is higher than the 3% discount rate used in our present value calculation, then converting the value of a deferred case of cancer to be comparable with an immediate risk will lead to higher VSL levels. The cancer risk premium of 100% recommended for policy assessments in the UK and

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16 If actual individual discount rates are greater than 3%, the value of an immediate decrease in cancer risk rises. A 7% discount rate is also permitted to be used under government guidelines, leading to a benefit increase factor of 1.97 rather than 1.34. We set aside issues such as higher personal discount rates, such as those embodying hyperbolic discounting, as they may reflect a form of individual irrationality and often times inconsistency. See the US Office of Management and Budget, Circular A-4 at http://www.whitehouse.gov/omb/circulars_a004_a-4.

17 Viscusi et al. (1987) found evidence that people are willing to pay a premium to reduce health risks to zero.
the 50% premium proposed for use in the US exceed the more modest premium for the fatal bladder cancer risks examined in this study.

CONFLICT OF INTEREST

The authors have no conflict of interest.

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REFERENCES


