NBER WORKING PAPER SERIES

PREFERENCES FOR EQUALITY IN ENVIRONMENTAL OUTCOMES

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Working Paper 22644
http://www.nber.org/papers/w22644

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
September 2016

We thank the US Environmental Protection Agency for funding and Chris Dockins, Kelly Maguire, and Glenn Sheriff for their valuable comments. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 22644
September 2016
JEL No. D6,I1

ABSTRACT

Benefit-cost analyses of health regulations traditionally evaluate their economic efficiency—ignoring equity. To help address the importance of equity, we develop a survey to elicit respondents' preferences towards equality in health risks stemming from environmental causes. Survey responses are used to parameterize an Atkinson index over environmental health risks. We compare these results to similar questions in the income context and find that respondents are significantly more averse to inequality in health risks than in income. The mean respondent is willing to accept a 22% increase in average health risk if risks are equally distributed in the population, but willing to accept a decrease of only 5% in average income if incomes are equally distributed in the population. We find that 30% of respondents answer health risk questions lexicographically—always preferring an equal distribution of risks to an unequal distribution, even if the latter makes everyone better off.

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1. Introduction

Benefit-cost analysis judges health and safety regulations according to whether the monetized benefits of risk reductions, as measured by individual WTP, exceed program costs. One way to complement such analyses is to take into account the distributional effects of health and safety policies. If a decision maker has a well-defined social welfare function (SWF) over health risks in a population, the function can be evaluated to see whether the utility of the post-policy distribution of health risks exceeds the pre-policy distribution of health risks.

We argue that the utility of a policy depends on the mean health outcome in a population and on how it is distributed. For individuals who value equality, an uneven distribution will lower their utility. There are many forms that a utility function over the distribution of outcomes might take. Probably the most well-known is the Atkinson SWF (Atkinson 1970). For an Atkinson SWF defined over a good, such as income or survival probability, utility can be written as the product of the mean level of the good and an inequality index. For example, in the case of the Atkinson SWF defined over incomes in a population, utility = mean income*($1-A$), where A is the Atkinson index. Higher values of A indicate greater inequality and reduce the value of higher mean incomes. In the case of health risks (a bad), the Atkinson SWF must be modified: utility, which is decreasing in health risk = mean health risk*($1+A'$), where A' measures how equally health risks are distributed. The modified Atkinson index is higher the more unequally health risks are distributed (Sheriff and Maguire 2013).

Our goal in this paper is to estimate the parameters of individuals' Atkinson SWFs defined over environmental health risks—specifically, risks of cancer and lung disease. We do this by confronting people with choices between environmental programs that result in health risk distributions that differ in both average risk and level of equality. We use the responses to parameterize an Atkinson SWF for cancer risks and a similar function for risks of lung disease. This SWF could be used to evaluate programs that would alter the distribution of environmental health risks in a population. The analysis also produces an Atkinson inequality index, A', for health risks that reflects the preferences of our sample for equality of outcomes.

Our empirical estimates of public preferences for environmental health risk distributions come from an Internet survey, administered in August 2015. The survey asks respondents to choose between environmental programs that result in different mean health risks in a population and different distributions of these risks. Respondents make these choices (a) in a situation in which they (and their families) are not affected by the choices, and (b) in a situation in which they are affected, to see how this alters preferences. We also use "leaky bucket" experiments to elicit respondents' preferences for income inequality and a repeated coin toss question to gauge risk aversion.

The results of our survey suggest that people are willing to accept a program that delivers higher total environmental health risk provided this risk is equally distributed across the population. Specifically, the median respondent is willing to accept a 50 percent increase in mean health risk (e.g., total environmental cancer cases) if these risks are distributed equally in the population. Interestingly, this result is the same whether the respondent and his family are affected by the program or not. When we compare preferences for income equality to preferences for equality in the distribution of health risks, we find that the proportionate sacrifice people are willing to accept in the mean outcome to ensure equality in the distribution of outcomes is greater for health than for income: inequality aversion is higher for health risks than for income.

The remainder of this paper is organized as follows. Section 2 provides a theoretical context for our study. We review the theory of inequality aversion in a welfare framework and briefly discuss how we estimate inequality aversion parameters using our survey. Section 3 provides detailed information about the survey questionnaire. Section 4 summarizes and analyzes survey results. Section 5 concludes.

2. Theory

2.1 The Atkinson Social Welfare Function for Income

To motivate our approach to eliciting preferences, we briefly review the theory of SWFs. We begin with the case of SWFs defined over goods—such as income or survival probability—and then indicate how a SWF must be modified when the argument of the function is a bad, such as risk of cancer.

For concreteness, consider a SWF defined over the incomes $(y_1, y_2, \ldots, y_N)$ of N individuals in a population, where incomes have been ordered from lowest to highest. Define $\omega(i)$ as the welfare weight attached to person i. Blackorby and Donaldson (1980) demonstrate that any social welfare function that obeys the Pareto Principle, maintains the anonymity of individuals, and allows for the possibility that only the welfare of a portion of the population affects social welfare, must be written in the form (1). As in the income inequality literature, we interpret (1) as a cardinal utility function.[1]

$$(1) \qquad W(y_1, y_2, y_3, \ldots, y_N) = \sum_i U(y_i)\omega(i)$$

If $\omega(i)=1$ and $U(y_i) = (1-\varepsilon)^{-1}(y_i)^{1-\varepsilon}$, then the SWF is of the Atkinson form. That is,

$$(2) \qquad W(y_1, y_2, y_3, \ldots, y_N) = \begin{cases} \sum_i (1-\varepsilon)^{-1}(y_i)^{1-\varepsilon}, & \varepsilon \geq 0, \varepsilon \neq 1 \\ \sum_i \ln(y_i), & \varepsilon = 1 \end{cases}$$

[1] An important property of the Atkinson SWF, which we test in our survey, is that it is scale-independent; that is, the rate of substitution between the incomes of persons *i* and *j* depends only on the ratio of their incomes.

The parameter ε captures the decision maker's attitudes toward income inequality. If ε = 0, all that matters is the aggregate (i.e., average) income in the population—how it is distributed is irrelevant. Higher values of ε imply a greater preference for income equality. As ε increases, the decision maker places greater weight on transferring income from a high-income individual to a low-income individual.[2]

This can be seen more clearly by defining the Equally Distributed Equivalent (EDE) income. The EDE is the income that, if equally distributed, would yield the same utility as the existing distribution of income. For the Atkinson SWF, the EDE is given by:

$$(3) \qquad EDE = \begin{cases} \left[\frac{1}{N}\sum_{i=1}^{N}[y_i]^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}, & \varepsilon \geq 0, \varepsilon \neq 1 \\ \prod_{i=1}^{N}[y_i]^{\frac{1}{N}}, & \varepsilon = 1 \end{cases}$$

The higher is ε, the lower is the EDE. As noted above, the EDE may also be written as the product of mean income ($\bar{y}$) and (1-A), where A is the Atkinson index of income inequality,

$$(4) \qquad EDE = \bar{y} * (1 - A).$$

Equation (4) implies that A can be interpreted as the maximum proportion of income that the decision maker is willing to give up if the remainder is equally distributed. The Atkinson inequality index may also be written as a function of ($y_1, y_2, \ldots, y_N$):

$$(5) \qquad A = \begin{cases} 1 - \left[\frac{1}{N}\sum_{i=1}^{N}\left[\frac{y_i}{\bar{y}}\right]^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}, & \varepsilon \geq 0, \varepsilon \neq 1 \\ 1 - \prod_{i=1}^{N}\left[\frac{y_i}{\bar{y}}\right]^{\frac{1}{N}}, & \varepsilon = 1 \end{cases}$$

2.2 Social Welfare Functions for Bads

As Sheriff and Maguire (2013) point out, the desirable properties of the Atkinson SWF no longer hold if the argument of the function is a bad, such as the risk of contracting cancer. Let x_i be person *i*'s risk of contracting cancer. The modified Atkinson SWF is given by:

$$(6) \qquad W(x_1, x_2, x_3, \ldots, x_n) = -\sum_i (1+\alpha)^{-1}(x_i)^{1+\alpha}, \quad \alpha > -1.$$

[2] The Atkinson utility function implies that the marginal rate of substitution between person i's and person j's income = $(y_i/y_j)^{-\varepsilon}$.

Equation (6) is similar to equation (2); however, welfare is decreasing in health risk. The parameter α has a similar interpretation as ε above: higher values of α indicate greater inequality aversion. Analogous to the case of goods, the EDE for health risk (EDE') can be defined as the level of risk the decision maker would accept, if it were to be equally distributed, that would yield the same utility as the current distribution of health risks. For α > 0, the EDE' will be greater than the mean risk ($\bar{x}$). EDE' is given by equation (7):

$$(7) \qquad EDE' = \left[\frac{1}{N}\sum_{i=1}^{N}[x_i]^{1+\alpha}\right]^{\frac{1}{1+\alpha}}$$

Analogous to equation (4), the EDE can be written as the product of mean risk ($\bar{x}$) and (1+A'), where A' is the Atkinson inequality index for health risks:

$$(8) \qquad EDE' = \bar{x} * (1 + A').$$

The modified Atkinson index, A', is the proportionate increase in average risk that the decision maker would accept if risks were equally distributed in the population.

2.3 Estimating Preferences for Inequality

The preceding section suggests that, if we can elicit the respondent's EDE for an unequal distribution of health risks, we can use equation (7) to estimate the parameter α of his SWF and equation (8) to estimate the Atkinson index of inequality aversion. This is the approach we follow in our survey. Initially, we present the respondent with a choice between two programs that will result in equal total health risks; however, one program will result in risks being equally distributed in the population while the other will distribute risks unequally. If a respondent prefers the equal distribution of risks, the average risk of the program delivering equal risks is raised until the individual prefers the program with the lower average risk but unequal distribution of risks. This bounds the respondent's *EDE'* and allows us to solve for A' and α. Similarly, if the respondent initially prefers the program that results in unequal risks, the risks delivered by the other program are reduced until the respondent switches to that program. This likewise bounds the respondent's *EDE'* and allows us to solve for A' and α.

3. Survey

Our survey consists of five sections. In the first two sections, we elicit respondents' inequality aversion in the context of health risks from environmental causes. In the third, we present respondents with a simple series of standard gamble questions using a coin flip to elicit their risk aversion. In the fourth section, we use a leaky bucket experiment to study inequality aversion in the context of income. Finally, we collect relevant demographic and behavioral information from respondents.

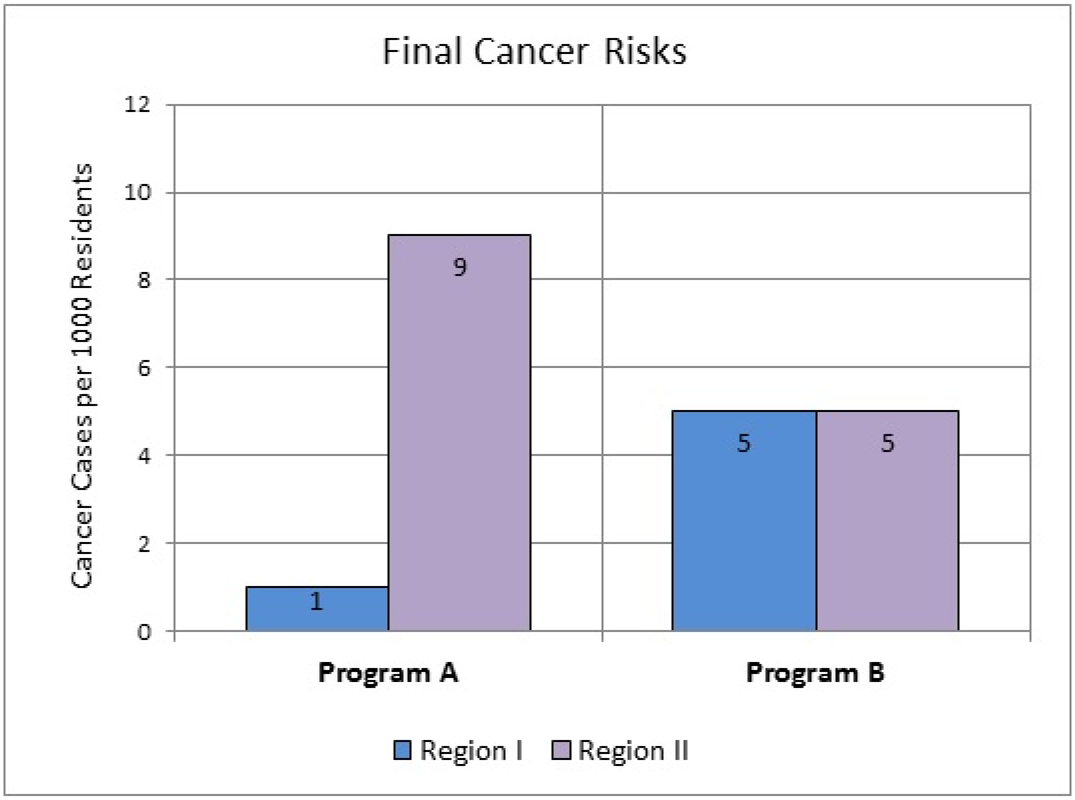
The internet questionnaire was distributed to 913 respondents using SurveyMonkey Audience, a service that distributes surveys to the US population. We are not asserting representativeness but expect these exploratory results inform future work. The following section describes the survey in detail. Appendix II provides further information about survey development.

3.1 Environmental Cleanups

To elicit inequality aversion in the context of health risks, we present respondents with a series of dichotomous choice questions outlining two hypothetical programs aimed at lowering cancer risks in a state. The unidentified state is divided into two identical regions, and pollution sources in the regions are in a “program” to lower cancer risks. We show respondents final risk distributions summarizing the effect of each program on the two regions’ risks of cancer. One program focuses cleanup in one of the two regions, leading to an unequal distribution of health risks. The other program addresses pollution sources in both regions, resulting in an equal distribution of health risks in the state.[3]

We provide respondents with a graph and table to assist in choosing between the programs. The graph and table for the first question are displayed in Figure 1. Respondents are then asked which program they advise the state to choose.

[3] Following a description of the environmental cleanups scenario, respondents are asked to answer four true-or-false comprehension questions related to the script. After answering, they are given the right answers. Our aim is to measure whether respondents understand the questions unaided and then to ensure that respondents fully understand the script and are taking the survey seriously.



	Program A	Program B
Final risk for Region I	1 in 1000	5 in 1000
Final risk for Region II	9 in 1000	5 in 1000
Total cancer cases per 1000 residents	10	10

Figure 1. Environmental Cleanups Example

Initially, as shown in Figure 1, the state's average risk of cancer from environmental causes is equal under both programs. In subsequent questions, the equal distribution of risks in Program B is changed so that respondents must make a new choice between distributions with different mean risks. Inequality-averse respondents—those who chose Program B in the first question—face a new Program B distribution with higher risks for both regions. Respondents who chose Program A in the first question face a new Program B distribution with lower risks for both regions. In both instances, Program A is left unchanged. This process is repeated to elicit each respondent's Equally Distributed Equivalent (EDE) to the Program A distribution.[4]

We present this series of questions to each respondent twice. In the first instance, respondents are told they do not live in the state, nor do they know anyone who lives in the state. Our aim in separating respondents from the programs is to isolate their preferences for equality in health risks—independently of how it might affect them or their friends and family. Removing respondents from the outcome is common in the experimental literature (see Johansson-Stenman et al. 2002; Carlsson et al. 2005). In the second instance, respondents are told that they live in the state; hence the two programs will directly affect their risk of cancer from environmental causes. However, they do not know in which region of the state they live. In this section, responses may also be affected by the respondent's risk aversion.[5] We reverse the order of these scenarios for 235 respondents to test whether the ordering of questions affects their responses.

3.2 Leaky Bucket Experiment

In addition to eliciting inequality aversion in the context of environmental health risks, we use a series of leaky bucket questions to elicit respondents' aversion to income inequality. We do this both to contrast the results with those for health and to compare our results with those of others who have performed leaky bucket experiments. These experiments, initially proposed by Okun (1975), are often employed in the inequality literature to measure attitudes toward inequality (Amiel et al. 1999; Beckman et al. 2004; Pirtillä and Uusitalo 2010). We present respondents with a simplified distribution of income in the United States for the year 2013. To remain consistent with the health risk portion of the survey, we display the income distribution in two bars—one for the bottom 40 percent of households and one for the top 40 percent. Respondents are asked the following question:

Assuming you have the authority, would you be willing to reduce the income of each household in the top 40% by $1000 to increase the income of each household in the bottom 40% by $1000?

[4] A respondent who prefers a 7-7 distribution to a 1-9 distribution but prefers a 1-9 distribution to an 8-8 distribution would have an EDE between 7 and 8.

[5] Focus group feedback indicated that there is substantial heterogeneity among respondents in how much they weigh their own risks versus the risks to society. Individuals who think only about the risks to themselves will offer responses dictated mainly by risk aversion, whereas individuals thinking about society will reveal preferences related to inequality aversion.

Each respondent who answers "yes" is then asked if she would be willing to make the same transfer, but with less money going to the bottom 40 percent.[6] The "leakage" continues to increase until respondents are either unwilling to make the transfer or are willing to accept 90 percent leakage, with $100 going to the bottom 40 percent of households. The maximum tolerable leakage (MTL), used to calculate an inequality aversion parameter, falls between the last accepted transfer and the first rejected transfer.[7] We use the results from the leaky bucket experiment to compare inequality aversion in the health and income contexts. Additionally, we compare our leaky bucket results with similar experiments in the literature.

3.3 Additional Questions

In addition to the environmental cleanups and leaky bucket sections, we present respondents with a series of questions to better understand their attitudes toward and experiences with risk, the environment, health, and altruism. In one set of questions, respondents are asked whether they would prefer a certain amount of money (e.g., $50) to an amount determined by the flip of a coin (e.g., $10 if heads, $90 if tails). By varying the certain amount of money, we are able to elicit respondents' risk preferences for money. Additionally, we ask respondents about their purchases of lottery tickets and trip cancellation insurance for flights. We also ask respondents whether they or their family or friends have experienced cancer.

We include several questions related to altruism in the survey. First, we ask whether respondents belong to or donate money to an environmental organization. Second, we ask respondents whether they have volunteered their time to a community organization in the past year. Finally, we ask respondents how much money they have donated to nonreligious charitable organizations and to which types of charities they have donated money in the past year.

3.4 Treatments

We examine the effect of scale, type of health risk, and the ordering of questions through the use of four additional versions of the survey. In our second version of the survey, we change the health risk from cancer to chronic lung disease, including chronic bronchitis, asthma, and emphysema. Respondents were four times more likely to have no personal, friend, or family

[6] For $1,000 transfers from the top 40 percent of households, subsequent leaky bucket transfers going to the bottom 40 percent are $750, $500, $250, and $100. Focus group feedback helped select this range of transfers. Smaller transfers often didn't seem "worth the trouble."
[7] The inequality aversion parameter (ε) is calculated from the following equation, where MTL is expressed in percentage terms: $MTL = 1 - [(y_{low} / y_{high})^{\varepsilon}]$.

experience with chronic lung disease compared with cancer.[8] Our third version of the survey varies the scale of the risks in the environmental health and leaky bucket questions. In choosing to use the (modified) Atkinson index, we assume that individuals have utility functions that exhibit constant relative aversion to inequality—implying that scale is irrelevant. We test the effect of scale on respondents' inequality aversion by decreasing all risks by a factor of 1,000.[9] All transfers in the leaky bucket questions are decreased by a factor of 10.

In the fourth version of the survey we reverse the order of the local and nonlocal environmental cleanups for roughly a fifth of the sample (hereafter, version Order A). In the fifth version of the questionnaire we present the leaky bucket questions before questions on health risks (hereafter, version Order B). Exact sample sizes for each of the treatment groups are displayed in Table 1.

4. Results

4.1 Descriptive Statistics

Survey completion rates are displayed in Table 1. In total, 1,676 individuals opened our surveys through SurveyMonkey Audience, SurveyMonkey's survey distribution service. Of the 1,315 individuals who answered at least one question, 913 (69 percent) finished the entire survey.[10] Completion rates were fairly consistent across the five surveys, each of which received between 219 and 379 responses. We are unable to comment on any sample selection bias arising from individuals dropping out of the survey—SurveyMonkey provides demographic information only for the paid, completed responses.

[8] 110 of 767 respondents (14.3 percent) in the surveys using cancer risks reported no personal, friend, or family history with cancer; 83 of 146 respondents (56.9 percent) in the lung disease survey reported no history with chronic lung disease.
[9] Focus group feedback indicated that few respondents thought about the magnitude of the health risks being considered.
[10] Our completion rates are likely affected by the surveys' exceptional length and complexity compared with most surveys distributed through SurveyMonkey, a platform typically used for shorter, market research surveys. Our surveys have 50 questions, many of which are cognitively burdensome. For a discussion of completion rates in SurveyMonkey, please see https://www.surveymonkey.com/blog/2015/06/25/tips-increasing-survey-completion-rates/.

Table 1. Completion Summary Statistics

Survey	Opened Survey	Started Survey	Finished Responses	Partial Responses	*Percentage Finished* Started Survey	Opened Survey
Base	500	379	266	113	70%	53%
Lung	280	220	146	74	66%	52%
Scale	301	219	160	59	73%	53%
Order A	309	235	171	64	73%	55%
Order B	286	262	170	92	65%	59%
Total	**1,676**	**1,315**	**913**	**402**	**69%**	**54%**

Notes: The Opened Survey column refers to all individuals who followed the SurveyMonkey Audience link to a new survey. Those that read through any opening instructions and answered at least one question are represented in the Started Survey column. Pilot survey results are omitted from this table.

Demographic information is summarized in Table 2. Several groups are overrepresented in our sample compared with national figures. In particular, whites, females, and older persons appear in higher proportions in our sample than in the population at large. Of our sample, 84 percent self-identify as white, compared with 74 percent of the US population. Male respondents constitute only 34 percent of our sample, and the age profile is skewed toward older age groups. The makeup of our sample likely reflects the population of internet users with spare time.

Survey respondents took 25 minutes on average to complete the survey. Similar to Dickie and Gerking (2011), concerns arose over the length of time respondents took on the survey. Equal proportions of respondents appeared to take the survey very quickly and very slowly—perhaps in more than one sitting; 55 respondents (6 percent) took more than 45 minutes to complete the survey, and many seemingly left the survey idle for several hours. Top-coding completed surveys at 45 minutes yields an average length of 19 minutes.[11] Pretests indicated that, at a minimum, the survey would take 8 minutes to complete, but 60 respondents (6.6 percent) took less than 8 minutes, likely because of skimming or skipping important instructions. On average, these respondents answered twice as many preliminary comprehension questions incorrectly.[12]

[11] The distribution of completion times is graphed in Figure A1 of Appendix I.

[12] A two-sample t-test with unequal variances indicates that the mean number of incorrect questions are statistically different between respondents taking less than and more than 8 minutes (t = -7.9).

Table 2. Demographic Summary Statistics

	SurveyMonkey Responses		*US Population*
Highest level of education*			
High school degree or less	82	9.0%	43.3%
Some college but no degree	199	21.8%	21.4%
Associate degree	78	8.5%	7.5%
Bachelor degree	281	30.8%	17.6%
Graduate degree	273	29.9%	10.3%
White	769	84.2%	74.2%
Male	313	34.3%	49.2%
Age			
18–29	130	14.3%	18.7%
30–44	158	17.3%	27.3%
45–59	299	32.8%	28.6%
60+	325	35.6%	25.5%
Family income**			
$0 to $24,999	112	14.2%	23.6%
$25,000 to $49,999	177	22.5%	23.2%
$50,000 to $74,999	160	20.3%	28.5%
$75,000 to $99,999	121	15.4%	11.5%
$100,000 to $149,999	136	17.3%	13.4%
$150,000 to $199,999	41	5.2%	5.7%
$200,000+	40	5.1%	5.6%
Prefer not to answer	126		

Notes: *US population percentages reflect only the population aged 25+. **Family income categories have been aggregated for comparison with US demographics. Percentages reflect only the respondents willing to answer income questions. For a more detailed breakdown of demographics by survey version, see Appendix I. Sources: US Census 2010, 2012, 2015.

4.2 Leaky Bucket Experiment

Results from the leaky bucket experiment are displayed in Table 3. Following Pirttilä and Uusitalo (2008), we convert the maximum tolerable leakage (MTL) midpoints for each respondent into inequality aversion parameters for income, ε.[13]

[13] MTL is converted to ε using the equation, $mtl = 1 - \left(\frac{y_1}{y_5}\right)^{\varepsilon}$, where *mtl* is the proportionate MTL, y_1 is the average income in the bottom quintile and y_5 is the average income in the top quintile. We use the top and bottom 40 percent

Table 3. Leaky Bucket Results, by Survey

(1) Maximum Tolerable Leakage	*(2) Inequality Aversion Parameter (ε)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
		Survey					
		Base	*Lung*	*Scale*	*Order A*	*Order B*	*Total*
0 (no transfer accepted)	0.00	39.8%	41.8%	36.9%	45.0%	40.0%	40.6%
0 – 0.25	0.07	14.3%	14.4%	14.4%	14.6%	18.2%	15.1%
0.25 – 0.5	0.25	11.7%	8.9%	11.3%	9.4%	7.1%	9.9%
0.5 – 0.75	0.53	10.2%	14.4%	18.1%	14.0%	18.8%	14.6%
0.75 – 0.9	0.94	5.6%	3.4%	5.0%	2.9%	3.5%	4.3%
0.9 - 1	1.62	18.4%	17.1%	14.4%	14.0%	12.4%	15.6%
Mean MTL		0.347	0.370	0.348	0.305	0.278	0.322
Corresponding ε		0.230	0.249	0.231	0.196	0.176	0.210

Notes: Maximum tolerable leakage (MTL) is the maximum percentage of money that disappears from the $1,000 transferred from the top 40% of households to the bottom 40% of households. Each cell displays the percentage of respondents in each survey with a given MTL. The inequality aversion parameter for each MTL is calculated at the midpoint of the interval. Likewise, mean MTLs use the midpoint.

Overall, we find that many respondents are willing to accept transfers in the leaky bucket experiment, indicating some level of inequality aversion: 59.4 percent of respondents were willing to accept a $1,000 transfer from the top 40 percent of households to the bottom 40 percent of households ($\varepsilon>0$). Willingness to accept the transfer is highest in the scale survey, where we start transfers at $100 rather than $1,000. The likelihood of accepting a transfer in the scale survey is not, however, statistically different from the likelihood in the other surveys ($p = 0.143$, one-tailed t-test). This suggests that the scale independence assumption underlying the Atkinson index is correct.

We see little to no evidence that respondents are lexicographically averse to leakage. Roughly three-quarters of respondents willing to make a no-leakage transfer also accepted a transfer with 25 percent leakage. This finding supports feedback from focus groups that indicated respondents were not fixated on the leakage so long as we avoided mentioning the instrument for redistribution (e.g., taxes).

rather than quintiles, but the formula is identical. The remainder of the income distribution does not enter into the calculation of ε.

Using interval midpoints for the MTLs, the mean MTL corresponds to a leakage of 32.2 percent and $\varepsilon = 0.21$. The median MTL is significantly lower, at 12.5 percent, corresponding to $\varepsilon = 0.07$. These values are similar to those reported in the leaky bucket literature. Amiel et al. (1999) report a mean $\varepsilon = 0.25$ and median ε values between 0.10 and 0.22. This suggests that our respondents have preferences similar to those participating in other such surveys.

Using equation (5), we apply these values of ε to calculate an Atkinson index for income, A. Mean incomes for household income quintiles in 2014 from the US Census Bureau are used in the calculation. Using the mean and median values of ε, we calculate A as 0.051 and 0.021, respectively. This implies that respondents are willing to give up between 2.1 and 5.1 percent of mean (aggregate) income if the remainder is equally distributed. Below, we compare this with respondents' Atkinson index for health risks.

4.2.1 Explaining Income Inequality Aversion

In this section, we investigate the predictors of inequality aversion. Table 4 displays how respondents' MTLs are affected by their self-reported political identification. Whereas 87.9 percent of extremely liberal respondents are willing to accept a no-leakage transfer, only 16.2 percent of extremely conservative respondents are similarly willing. These rates smoothly transition along the political spectrum. Similarly, the mean MTL for respondents decreases as respondents identify themselves as more conservative.[14]

[14] Our sample included more liberal respondents than conservative respondents (443 versus 260). Part of this may reflect US demographics, but it is likely that liberals are still overrepresented. See http://www.people-press.org/2015/04/07/a-deep-dive-into-party-affiliation/ for polls on party affiliation.

Table 4. Maximum Tolerable Leakage by Political Identification

(1) Political Identification	*(2)* No-Leakage Transfer Acceptance Rate (%)	*(3)* Mean MTL (%)	*(4)* Predictive Margins: Interval Regression	*(5)* Observations
Extremely liberal	87.9	54.5	59.9	99
Moderately liberal	79.8	44.3	48.6	253
Slightly liberal	64.8	31.7	32.8	91
Neither liberal nor conservative	57.1	33.1	32.3	210
Slightly conservative	44.0	20.1	20.4	84
Moderately conservative	22.3	11.7	13.6	139
Extremely conservative	16.2	10.1	12.1	37
Total	59.4	33.0		913

Notes: Mean MTLs use the midpoint of the intervals displayed in Table 3. Predictive margins for each political category use our preferred specification, column 2, from the interval regression displayed in Table 5.

The results in column 3 of Table 4—using the midpoint of the MTL intervals—are imprecise. The strong link with political affiliation suggests that other sociodemographic characteristics might explain outcomes. Because the MTLs are actually in interval form (see column 1 of Table 3), we follow Carlsson et al. (2005) and use an interval regression to examine the effects of various covariates, including political identification, on leaky bucket choices. In column 1 of Table 5 we present results for a base set of exogenous regressors. Our preferred specification (2) also includes political covariates. Political beliefs overwhelmingly explain much of respondents' MTL choices, and the predictive results are displayed in Table 4, column 4. Similar to the pattern seen in Table 4 (column 3), MTLs decrease as respondents become more conservative. But the relationship with political identification becomes monotonic (note the differences in columns 3 and 4 for the less extreme political identifications) and are more accepting of making a transfer for all but one group.

Turning to the other covariates, very high income individuals have lower MTLs compared with the lowest income category when controlling for other covariates. In other words, they are less willing to accept transfers to low-income households in the presence of leakage. Education, age, gender, having children, and survey version have no significant effect on respondents' MTL. Interestingly, Asians are more willing than whites to make leaky bucket transfers, and Hispanics are significantly less willing.

Table 5. MTL Interval Regression

	(1)		*(2)*	
	Coefficients	*Robust SEs*	*Coefficients*	*Robust SEs*
Education (omitted: no college)				
Some college	-0.0304	(0.0605)	-0.0596	(0.0584)
Associate degree	-0.0497	(0.0716)	-0.0484	(0.0690)
Bachelor degree	-0.0849	(0.0577)	-0.129**	(0.0550)
Graduate degree	-0.0496	(0.0579)	-0.117**	(0.0555)
Age (omitted: 18–29)				
30–44	-0.00498	(0.0505)	0.0251	(0.0469)
45–59	-0.0237	(0.0455)	-0.0112	(0.0416)
60+	-0.0369	(0.0453)	-0.00424	(0.0415)
Male	-0.0877***	(0.0282)	-0.0395	(0.0268)
Family income (omitted: less than $25,000)				
$25,000 to $49,999	-0.0319	(0.0573)	-0.0246	(0.0542)
$50,000 to $74,999	-0.123**	(0.0538)	-0.107**	(0.0516)
$75,000 to $99,999	-0.123**	(0.0587)	-0.111**	(0.0568)
$100,000 to $149,999	-0.0788	(0.0571)	-0.0876	(0.0541)
$150,000 to $199,999	-0.152**	(0.0731)	-0.108	(0.0700)
$200,000+	-0.236***	(0.0638)	-0.224***	(0.0609)
Prefer not to answer	-0.156***	(0.0590)	-0.112*	(0.0571)
Politics (omitted: neither liberal nor cons.)				
Extremely liberal			0.276***	(0.0541)
Moderately liberal			0.163***	(0.0394)
Slightly liberal			0.00295	(0.0502)
Slightly conservative			-0.123***	(0.0450)
Moderately conservative			-0.187***	(0.0381)
Extremely conservative			-0.208***	(0.0575)
Children in household			0.0387	(0.0321)
Constant	0.563***	(0.0757)	0.504***	(0.0758)
Observations	912		912	
Survey version	Yes		Yes	
Race	Yes		Yes	

Notes: Significance denoted by *** p<0.01, ** p<0.05, * p<0.1.

4.3 Coin Flip and Risk Aversion

We presented respondents with a series of questions designed to elicit their attitudes toward risk. The following situation was shown to respondents in a repeated fashion, with *X* varying from $10 to $90:

Consider a situation where you are presented with the following two options. Please select the option you prefer.

- *You receive $X.*
- *You flip a coin. If it shows heads, you receive $90. If it shows tails, you receive $10.*

The smallest certain amount that respondents would accept rather than taking a gamble is the certainty equivalent (CE) of the gamble. We identify respondents' certainty equivalents (CEs) by identifying where they switch from preferring the gamble (coin flip) to the certain amount. CEs are summarized in Figure 2.

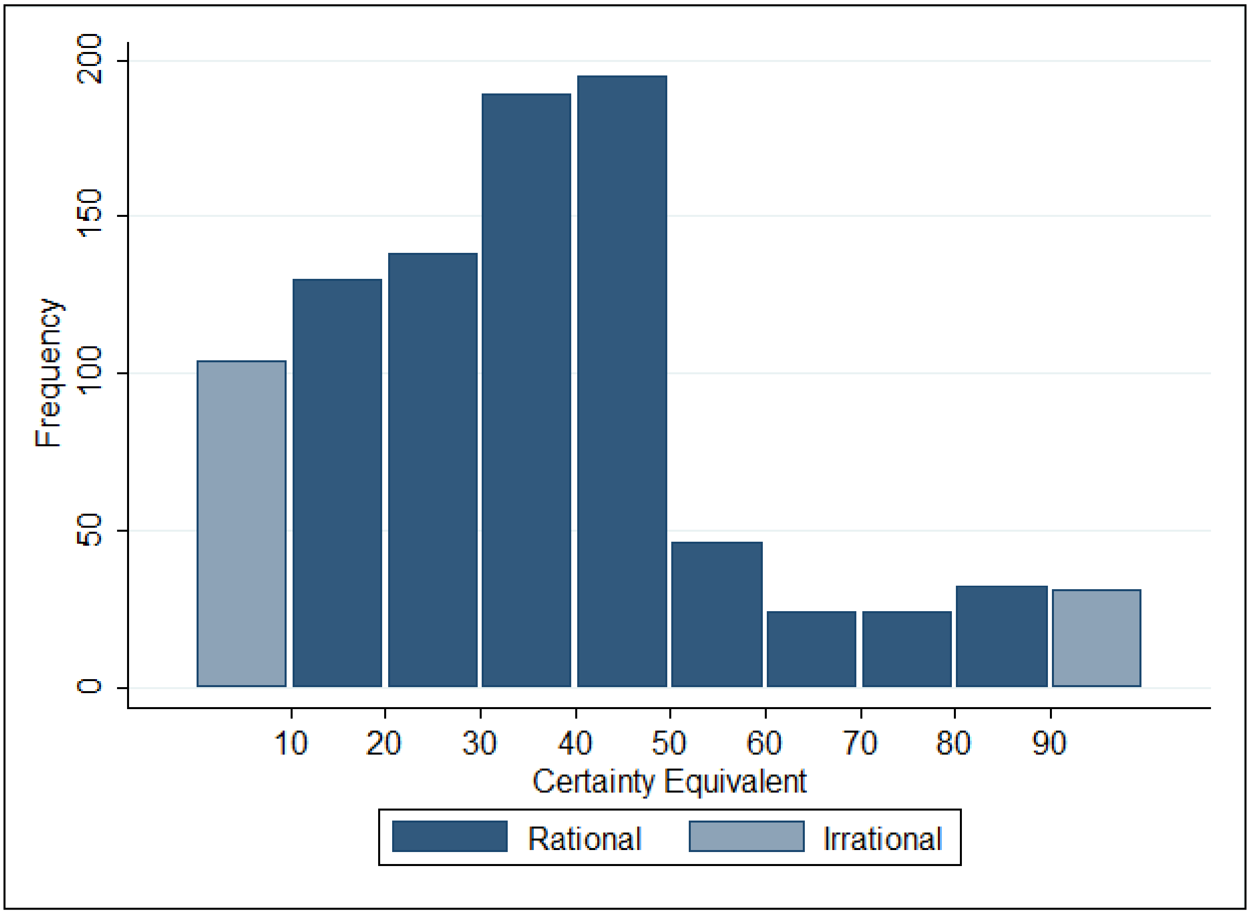


Figure 2. Certainty Equivalents for Coin Flip

There are two important takeaways from Figure 2. First, most respondents appear to be risk averse: 756 of 913 respondents (82.8 percent) prefer receiving a certain amount of money that is less than the expected value of the coin flip ($50) to undertaking the gamble. Second, a small portion of individuals (14.8 percent) exhibit responses that could be considered irrational, either preferring a certain $10 to a coin flip with a $10 minimum payment, or preferring the coin flip to a certain $90.[15] There is some evidence that respondents with irrational responses may have been rushing. Individuals who took less than eight minutes to complete the survey were nearly twice as likely (13.8 versus 24.1 percent) to have irrational responses in this section. Education may also play a role; individuals without a college degree were more likely to exhibit irrational responses (19.6 percent) than individuals with a college degree (12.7 percent). Finally, respondents reporting family incomes less than $50,000 were 2.3 times more likely to exhibit an irrational response (19.8 versus 8.6 percent).

Assuming constant relative risk aversion, we can calculate a coefficient of relative risk aversion (RRA) for each rational respondent. The coefficient, β is calculated using the following formula:

$$U(y) = \begin{cases} (1-\beta)^{-1}(y)^{1-\beta}, & \beta \neq 1 \\ \ln(y), & \beta = 1 \end{cases} \tag{9}$$

Utility is a function of y, the income received from the coin flip scenario, and β, the coefficient of RRA. The expected utility for the coin flip, 0.5**U(10)* + 0.5**U(90)*, is equated with *U(CE)*, the utility at the certainty equivalent. We then solve equation (9) to find β for each CE. These coefficients are presented in Table 6, along with the distribution of answers in our survey. Positive values for β imply aversion to risk, and negative values imply risk-loving attitudes.

Table 6. Coefficients of Relative Risk Aversion

CE	*< 10*	*15*	*25*	*35*	*45*	*55*	*65*	*75*	*85*	*> 90*
Coefficient of RRA (β)	∞	2.6	1.3	0.7	0.3	-0.3	-1.1	-2.8	-11.1	-∞
Frequency (%)	11.4	14.2	15.1	20.7	21.4	5.0	2.6	2.6	3.5	3.4

Notes: Certainty equivalents (CE) are expressed as the midpoints of $10 intervals ($10–20, $20–30, …, $80–90)

[15] Of the 135 irrational responses, 104, or 11.4 percent of the entire sample, exhibited a CE of less than $10, and 31, or 3.4 percent of the entire sample, exhibited CEs greater than $90.

The mean certainty equivalent for rational respondents of \$37.8 corresponds to β = 0.61. The median CE for all respondents is \$35, with a corresponding β = 0.74. In a similar study using coin flip outcomes of \$0 and \$100, Prosser and Wittenberg (2007) find a median CE of \$37, corresponding to β = 0.30.

4.4 Environmental Cleanups

4.4.1 Comprehension Questions

Following a description of the environmental cleanups scenario, respondents are asked to answer four true-or-false comprehension questions related to the script. Our aim is to ensure that respondents fully understand the script and are taking the survey seriously. The results from the comprehension questions are summarized in Table 7. The percentage of individuals who answered three or four of the statements correctly was 80.8, with 3 being the median outcome and 3.06 the mean outcome.[16]

Table 7. Comprehension Questions Percent Correct, by Survey

	Survey					
Number Correct	*Base*	*Lung*	*Scale*	*Order A*	*Order B*	*Total*
0	0.4	0.0	0.0	0.0	0.6	0.2
1	4.5	6.8	8.1	5.3	8.2	6.4
2	11.3	12.3	11.3	14.6	14.1	12.6
3	52.3	47.9	51.9	49.7	40.6	48.8
4	31.6	32.9	28.7	30.4	36.5	32.0
Mean Correct	**3.10**	**3.07**	**3.01**	**3.05**	**3.04**	**3.06**

Notes: Each cell represents the percentage of individuals in each survey with the level of comprehension displayed in the first column.

4.4.2 EDE Results for Health Risks

Figure 3 summarizes responses to the environmental cleanup sections. Through a set of dichotomous choice questions, we place bounds on the equally distributed equivalents (EDE) for each respondent, compared with a 1–9 risk distribution. Preferring a 7–7 distribution to a 1–9 distribution but rejecting an 8–8 distribution would yield an EDE between 7 and 8. EDEs above 5 indicate some level of inequality aversion. People who have EDEs above 5 prefer more equal distributions of population risk even if this means increasing the total risk in the population, and EDEs under 5 correspond to people who care more about population risk than its distribution. We find significant evidence of lexicographic preferences, which in our context are preferences

[16] Most respondents with one answer incorrect failed to recognize that Program A focuses cleanup in one randomly selected region. This is reflected in some open-ended responses—some respondents thought that the region with lower risks would be the economically advantaged group rather than a randomly chosen group.

for an equal distribution (versus the 1–9 distribution), regardless of the risk levels in the equal distribution.

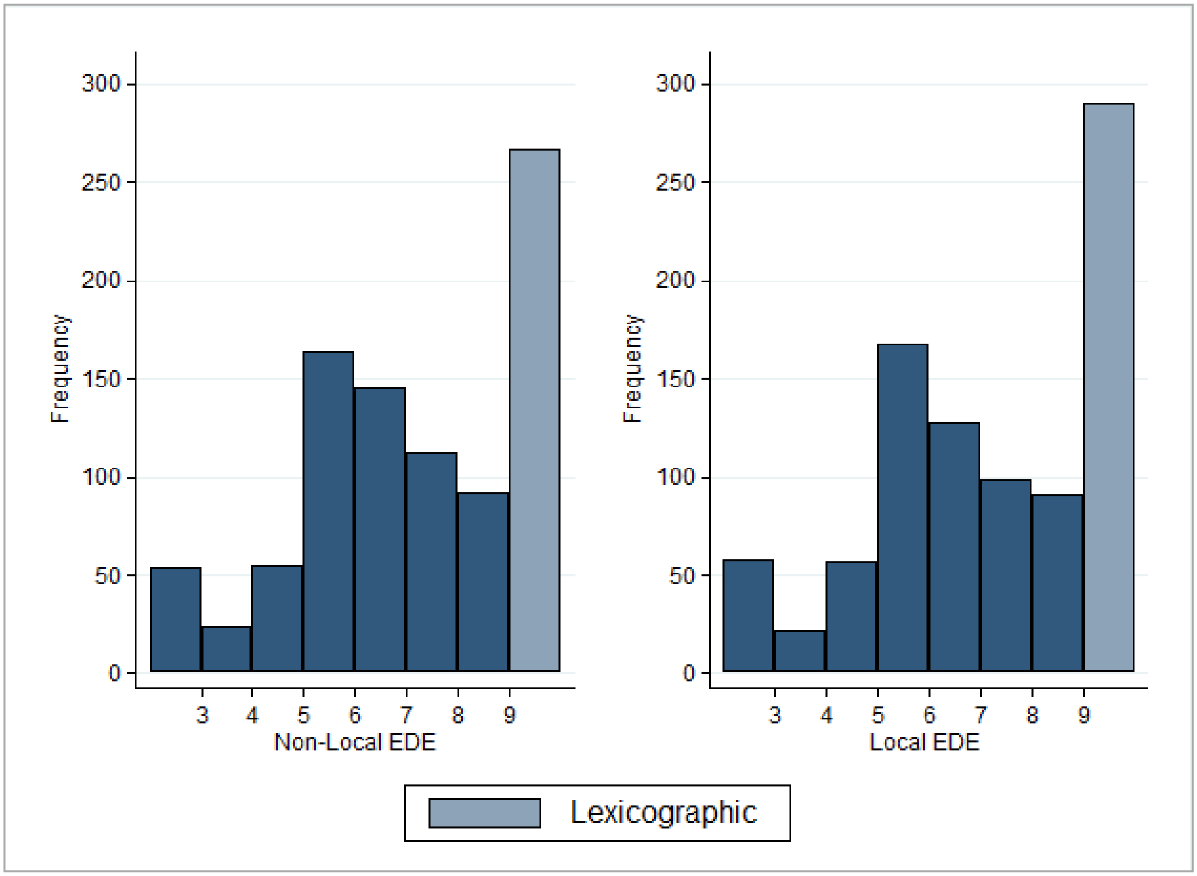


Figure 3. Environmental Cleanup EDEs

Most respondents have preferences consistent with inequality aversion. In the nonlocal context (the scenario in which the respondent does not live in the state), 85.4 percent of EDEs are more than 5. Most striking in Figure 3 is the number of lexicographic responses: 267 respondents (29.2 percent) in the case of nonlocal cleanups and 290 respondents (31.8 percent) in the case of local cleanups have EDEs with a lower bound of 9. These individuals prefer equal risk distributions where neither population group is better off compared with the 1–9 distribution. We discuss these lexicographic preferences below.

Tables 8 and 9 further summarize our results. Median EDEs in both the nonlocal and local scenarios are 7.5, again implying that respondents are generally inequality averse. For lexicographic respondents, we have only a lower bound on their EDE, 9. To calculate mean EDEs, we drop all lexicographic responses and assign EDEs to the midpoints of each interval. Mean EDEs for nonlocal and local cleanups are 6.1 and 6.0, respectively. [17]

[17] The two EDEs are not statistically different.

Table 8. Nonlocal Cleanup Results, by Survey

	Survey					
Nonlocal EDE	*Base*	*Lung*	*Scale*	*Order A*	*Order B*	*Total*
Less than 3	6.4	2.1	5.0	10.5	4.7	5.9
3–4	2.6	3.4	1.3	3.5	2.4	2.6
4–5	5.6	6.8	6.3	8.2	3.5	6.0
5–6	17.3	21.2	23.1	18.1	11.2	18.0
6–7	14.3	17.8	16.9	11.1	20.6	15.9
7–8	13.5	9.6	13.8	11.1	12.4	12.3
8–9	8.6	12.3	7.5	12.3	10.6	10.1
Greater than 9*	31.6	26.7	26.3	25.2	34.7	29.2
Mean EDE						
Non-lex. responses	6.0	6.2	6.1	5.8	6.3	6.1
Median EDE						
All responses	7.5	6.5	6.5	6.5	7.5	7.5
Non-lex. responses	6.5	6.5	6.5	5.5	6.5	6.5

Notes: Lexicographic responses are marked with an asterisk (*). Cells in the first eight rows display the percentage of respondents in a given survey with an EDE displayed in the first column.

Table 9. Local Cleanup Results, by Survey

	Survey					
Local EDE	*Base*	*Lung*	*Scale*	*Order A*	*Order B*	*Total*
Less than 3	7.1	2.7	8.1	8.8	4.1	6.4
3–4	2.3	2.1	2.5	2.9	2.4	2.4
4–5	5.6	4.1	8.1	7.0	6.5	6.2
5–6	19.5	24.0	20.0	15.2	13.5	18.4
6–7	12.8	13.0	14.4	14.6	15.9	14.0
7–8	10.5	9.6	9.4	12.9	11.8	10.8
8–9	9.8	12.3	9.4	8.8	10.0	10.0
Greater than 9*	32.4	32.2	28.1	29.8	35.9	31.8
Mean EDE						
Non-lex. responses	6.0	6.3	5.8	5.9	6.2	6.0
Median EDE						
All responses	7.5	6.5	7.5	7.5	7.5	7.5
Non-lex. responses	6.5	5.5	6.5	6.5	6.5	6.5

Notes: Lexicographic responses are marked with an asterisk (*). Cells in the first eight rows display the percentage of respondents in a given survey with an EDE displayed in the first column.

We convert the EDE interval midpoints to the inequality aversion parameter, α, using equation (7). The conversion is shown in Table 10. In addition to calculating α, we use equation (8) to calculate modified Atkinson indices, A', for each EDE.

Table 10. EDE to α Conversion

EDE	*< 3*	*3.5*	*4.5*	*5.5*	*6.5*	*7.5*	*8.5*	*≥ 9*
α	-1.3	-0.7	-0.3	0.3	1.1	2.8	11.1	∞
A'		-0.3	-0.1	0.1	0.3	0.5	0.7	

For mean and median EDE values of 6.1 and 7.5, the corresponding α parameters are 0.72 and 2.8. The large difference between these values reflects both the effect of lexicographic responses—included only in the median calculation—and the nonlinear relationship between EDE and α. The modified Atkinson indices, A', are 0.22 and 0.50 using the mean and median EDEs, respectively. An Atkinson index of 0.22 (0.50) implies that respondents are willing to accept an increase in average risks of 22 percent (50 percent) if the risks are equally distributed in the population.

4.4.3 Lexicographic Preferences

A significant portion of our sample—nearly 30 percent of respondents—exhibits lexicographic preferences with respect to health risk inequality. Regardless of the mean risk levels for the two distributions, these individuals always prefer the equal distribution. In this section, we attempt to explain this behavior by analyzing open-ended responses and comprehension questions, and we estimate a logit model to explain lexicographic preferences as a function of sociodemographic covariates.

Respondents were asked to explain their responses to the dichotomous choice questions. We analyze their explanations and find that 131 of 267 lexicographic respondents (49.1 percent) clearly cited equality, fairness, or affecting as many residents as possible.[18] Nearly two-thirds of the respondents included the words or roots *equal*, *same*, *even*, *fair*, or *equi-*, as in the following examples:

- *"Even with a greater loss it is a more 'fair & level' playing field for everyone."*
- *"You can't pick one region over another. It isn't fair."*
- *"10 for every 1000 is not a great outlook, but if everyone is even across the board; then it's a better decision."*
- *"I think everyone should have equal access to a clean environment."*
- *"I will always choose equal risk. Get used to it."*

[18] Most of the remaining 51 percent of open-ended responses are either vague (e.g., "Better outcome"), nonresponse (e.g., "xx," "n/a," or "fggrgh"), or indicative of confusion.

Although roughly half of respondents exhibiting lexicographic preferences seem to rationalize their responses through equality and fairness, it may be possible that this group fundamentally misunderstands the scenarios presented to them. We test this by using the preliminary comprehension questions as an indicator of how well respondents understand the scenarios presented to them. Of four comprehension questions, respondents answered 3.06 questions correctly on average. Figure 4 displays the nonlocal EDEs, broken down by whether respondents answered all four comprehension questions correctly. Respondents appear less likely to have EDEs on both ends of the histogram when they answer the comprehension questions well or perfectly.

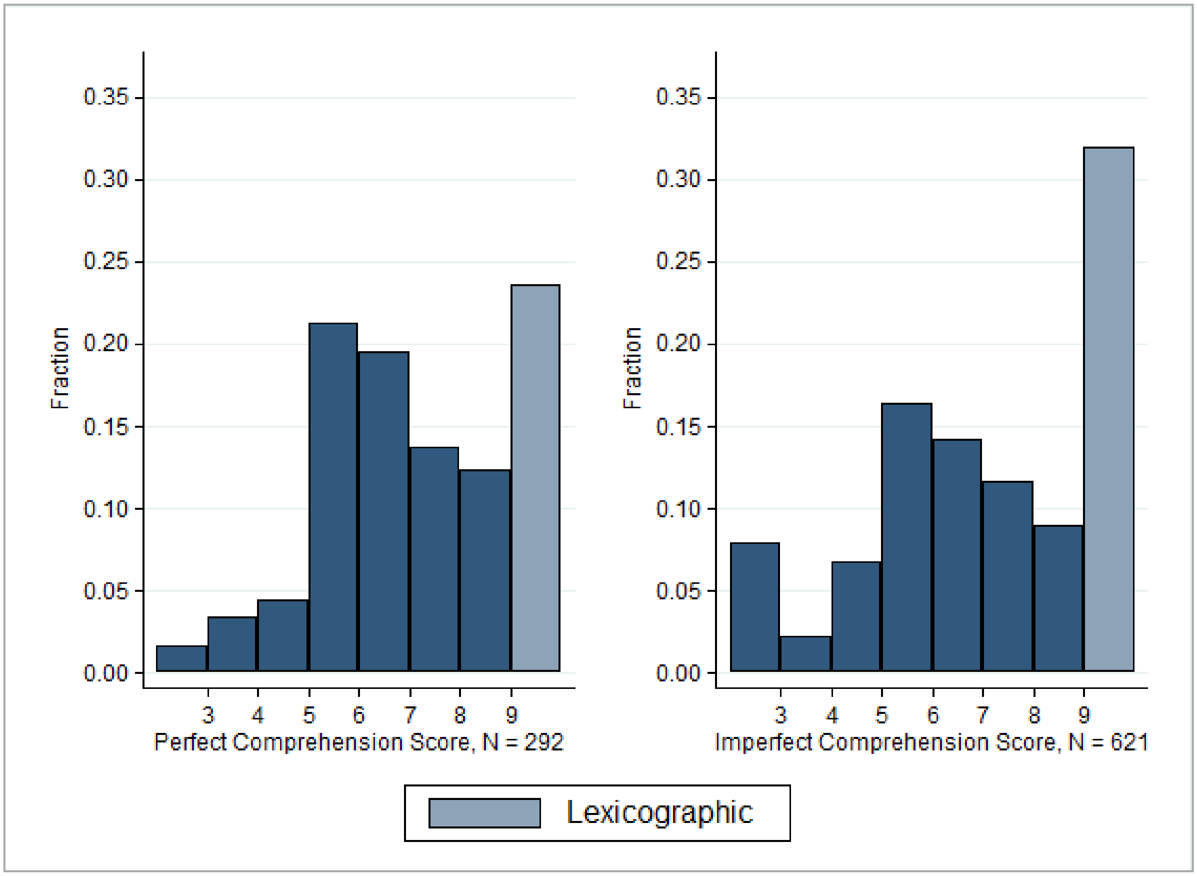


Figure 4. Nonlocal EDE, by Comprehension Score

Comprehension appears to affect the likelihood of exhibiting lexicographic preferences. Respondents answering all four comprehension questions correctly are 30 percent less likely to answer lexicographically than respondents with three or fewer comprehension questions correct. Despite this evidence that some lexicographic respondents may have misunderstood the scenarios, there remains a significant fraction of individuals (23.6 percent) with lexicographic preferences among a subsample who answered all four comprehension questions correctly.[19]

We also fit a logit model to estimate the likelihood of respondents' exhibiting lexicographic preferences. The results, displayed in Table 11, support the notion that ideological beliefs about fairness may help explain lexicographic responses. Political leanings appear to have a significant influence on the odds of answering lexicographically. Extremely liberal individuals are significantly more likely to exhibit lexicographic preferences than respondents who characterize themselves as slightly conservative or slightly or moderately liberal.

Coefficient estimates on the number of comprehension questions answered correctly indicate a decrease in the log-odds of exhibiting lexicographic preferences when all four questions are answered correctly. This relationship, however, is statistically insignificant. Similarly, there is a weak negative relationship between time spent on the survey and the likelihood of answering lexicographically. Estimates also indicate older individuals and those with less schooling are more likely to answer lexicographically.

[19] Among the subsample with a nonperfect comprehension score, 31.9 percent of respondents answer lexicographically.

Table 11. Logit Estimation of Lexicographic Preferences

	(1)		*(2)*		*(3)*	
Variables	*Coeffs*	*SEs*	*Coeffs*	*SEs*	*Coeffs*	*SEs*
Survey length (minutes)			-0.00948	(0.00648)	-0.0109*	(0.00656)
Understanding questions correct (omitted: four)						
One			0.183	(0.333)	0.109	(0.338)
Two			0.274	(0.255)	0.240	(0.262)
Three			0.252	(0.182)	0.234	(0.184)
Highest level of education (omitted: graduate degree)						
High school degree or equivalent	0.787***	(0.278)	0.631**	(0.294)	0.610**	(0.309)
Some college but no degree	0.448**	(0.209)	0.399*	(0.218)	0.334	(0.231)
Associate degree	0.471*	(0.279)	0.420	(0.291)	0.377	(0.299)
Bachelor degree	0.203	(0.197)	0.185	(0.202)	0.114	(0.209)
Political identification (omitted: extremely liberal)						
Moderately liberal			-0.530**	(0.267)	-0.545**	(0.271)
Slightly liberal			-0.737**	(0.347)	-0.799**	(0.353)
Neither liberal nor conservative			-0.157	(0.272)	-0.176	(0.276)
Slightly conservative			-0.620*	(0.344)	-0.680*	(0.351)
Moderately conservative			-0.118	(0.289)	-0.103	(0.297)
Extremely conservative			0.00732	(0.417)	0.0267	(0.426)
Age (omitted: 18–29)						
30–44	0.568*	(0.304)	0.479	(0.310)	0.426	(0.317)
45–59	0.940***	(0.271)	0.885***	(0.278)	0.888***	(0.287)
60+	1.017***	(0.270)	0.956***	(0.278)	0.962***	(0.287)
Male	-0.0147	(0.157)	-0.0945	(0.164)	-0.108	(0.168)
Constant	-1.947***	(0.285)	-1.407***	(0.388)	-1.385***	(0.512)
Observations	906		904		904	
Controls						
Survey version	No		Yes		Yes	
Family income	No		No		Yes	
Device	No		No		Yes	

Notes: Significance denoted by *** p<0.01, ** p<0.05, * p<0.1. Estimated logit model predicts the log-odds of exhibiting lexicographic preferences.

4.4.4 Comparing Local and Nonlocal Cleanups

Respondents may exhibit different attitudes toward distributions of risks or income when they are part of the affected scenario (see Clark and D'Ambrosio 2014 for a discussion about reference groups and the veil of ignorance). We test this theory by presenting respondents with two scenarios that each explicitly include or exclude them. Mean EDEs for the various survey treatments are summarized in Table 12, along with the difference between the EDE in the nonlocal setting (respondent does not live in the state) and the local setting (respondent does live in the state).

Table 12. Mean EDE, by Treatment

	Mean EDE		*Difference of*
Survey	*Nonlocal*	*Local*	*Means*
Base	6.04	5.97	0.03
Order A	5.81	5.89	-0.13
Order B	6.34	6.22	0.27**
Lung	6.24	6.28	0.02
Scale	6.08	5.83	0.21
Total	6.09	6.02	0.07

Notes: Significance in a paired t-test of means is indicated by * (10%) and ** (5%) next to the difference of means. Means use interval midpoints and include lexicographic responses.

Aggregating across all versions of the survey, there is no statistical difference in mean EDEs for the two scenarios. Switching the order of the nonlocal and local cleanup scenarios (version Order A), however, yields a significantly lower nonlocal mean EDE. On an individual level, 327 respondents (35.8 percent) had different EDEs in the two sections. Although roughly a third of the sample switched EDEs, 43.7 percent of respondents who switched changed their EDE by only 1 cancer case per 1,000 residents. The direction of the switch is split: 158 respondents (17.3 percent) shifted to lower EDEs in the nonlocal section, and 169 (18.5 percent) had lower EDEs in the local section. Figure 5 presents the difference between the two sections. Individuals with consistent EDEs are not displayed.

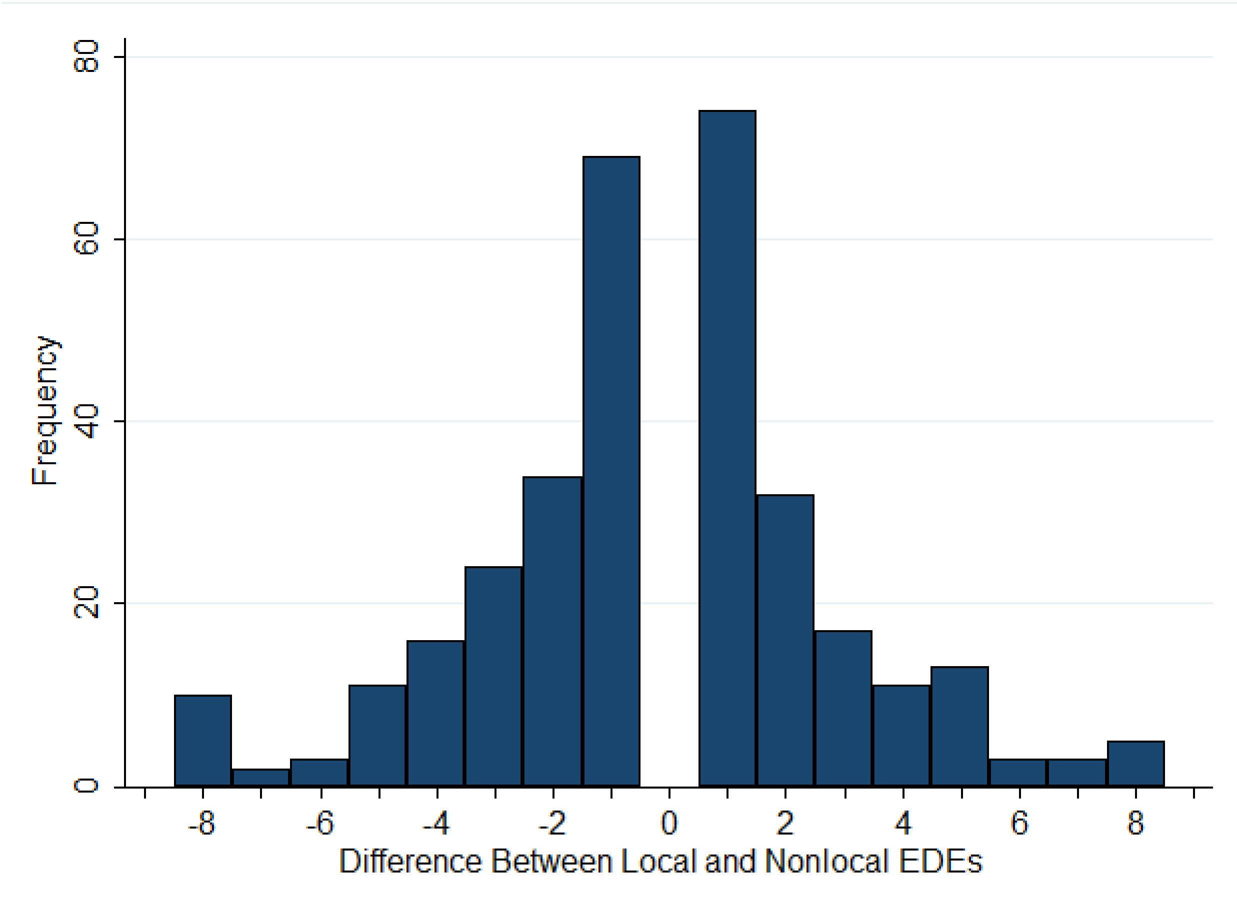


Figure 5. Histogram of Difference between Local and Nonlocal EDEs

We analyze respondents' open-ended responses in the local scenario to see whether responses were self-interested or socially focused. In all, only 57 of the 913 respondents (6.2 percent) explicitly discussed their own risks as a motivation for their response. The remaining individuals either made no mention of their own risks or stated their own risks were not relevant, as in these examples:

- *"I'd love to be in region 1 and have my chances lowered to 1 but it's only a 50/50 chance and I would rather go with something that is 100 percent. I don't letting [sic] betting on my health. I am also very unlucky and assume that I would be in the second region."*
- *"I would want it equal spread between the two. I would be very angry if I lived in the one that only got a partial clean up."*
- *"I don't make decisions/vote just for me but for the best for the country or whatever region or election I vote in. Everyone is in this together."*
- *"Even if I'm a part of the equation, I still believe in equality."*

We test whether individuals whose EDEs differ between sections are more or less likely to cite their own risks in the open-ended responses. Whereas 3.9 percent of individuals in the non-switching group mention their own risks, 10.1 percent of individuals who switch mention their own risks. Those with higher EDEs in the local portion are 2.9 times more likely to mention their own risk than non-switchers; respondents with higher EDEs in the nonlocal portion are 2.3 times more likely to mention their own risks. A small portion of respondents do seem affected by their inclusion in the scenario.[20] The direction of the shift in EDEs is not consistent between respondents, nor are most shifts large in magnitude.

4.4.5 Treatments

Comparing mean EDEs for each survey with the overall mean, we see some variation in means between the treatments (Table 12). Specifically, it appears that the ordering of questions has an effect on mean EDEs. Asking about local cleanups first (version Order A) yields a lower nonlocal mean EDE than in the base survey. When respondents are first asked to consider a situation with their own risks in play, they appear less likely to prefer equitable outcomes when they are not affected by the results. This effect, however, is not statistically significant (p = 0.159).

The order in which leaky bucket questions are asked also appears to affect responses to the health risk questions. When leaky bucket questions are asked before the health risk questions (version Order B), mean EDEs for the health questions are higher than in other versions of the survey. One likely reason for this is that the leaky bucket questions prepare respondents for thinking about inequality. This could lead them to choose more equal health risk distributions.

4.4.6 Explaining Attitudes toward Inequality

As with the leaky bucket experiment, we first examine the relationship between health risk inequality aversion and political leanings using mean EDEs. We then use interval regression to explain health risk inequality choices for a variety of covariates, including political identification. Table 13 presents the mean EDEs by political identification for non-lexicographic respondents.

Table 13. Mean EDEs and Atkinson Indices, by Political Identification

Political Leanings	*Rational Mean EDE*		*Atkinson index (A')*
Extremely liberal	6.15	6.26*	0.25
Moderately liberal	6.29		

[20] We also look at our "coin flip" questions, outlined above, to test whether attitudes toward monetary risk are correlated with answers to the health questions. We find virtually no correlation between the answers to the coin flip section and the two health sections.

Slightly liberal	6.31		
Neither liberal nor conservative	5.85		0.17
Slightly conservative	6.13		
Moderately conservative	5.93	5.95*	0.19
Extremely conservative	5.50		
Total	6.09		0.22

Notes: Mean EDEs displayed are for nonlocal cleanups and exclude lexicographic responses. EDEs are assumed to be at the midpoint of the respective interval, with responses less than 3 coded as 2.5. The two means for liberal and conservative respondents, marked with an asterisk, are statistically different using a t-test with unequal variances ($p = 0.0484$).

Dividing all liberal respondents and all conservative respondents into two groups yields means of 6.26 and 5.95, respectively. At the 5 percent level of significance, liberal respondents are more likely to be inequality averse toward health risks than conservative respondents. The associated Atkinson indices for each group are 0.25 and 0.19, respectively, implying a willingness to increase the mean health risk by 25 percent (for liberals) and 19 percent (for conservatives) if these risks are distributed equally in the population. Importantly, both groups are inequality averse as a whole.

Table 14 summarizes our interval regression results for local and nonlocal EDEs. Columns 1 and 3 present the base specifications before adding further controls. In our preferred specifications, columns 2 and 4, we add political beliefs, presence of children in the household, and whether the respondent belongs to an environmental organization.

Several demographic variables help explain respondents' inequality aversion. Age has a significant effect on EDEs: respondents over 45 years old have EDEs that are at least 1 cancer case per 1,000 residents higher than individuals under 30. Men appear to be less inequality averse than women. For nonlocal and local cleanups in our preferred specifications (columns 2 and 4), men have EDEs that are 0.394 and 0.659 lower than women when accounting for other factors. This effect is significant only in the local case. Additionally, individuals with children living in their household appear to be less inequality averse, preferring lower overall risks to equal distributions with higher risks. Respondents' race has no significant effect on inequality aversion.

Surprisingly in light of the leaky bucket results, when we control for other covariates in our interval regression, political beliefs seem to have no effect on inequality aversion.[21] Belonging or donating to an environmental organization, however, has a slight negative effect on respondents' EDEs, meaning that these individuals prefer more cleanup to an equal cleanup. The effect is not significant in the nonlocal scenario and is significant at the 10 percent level in the local scenario.

The survey fixed effects reveal that the order of questions may affect responses to the cleanup questions. In both the nonlocal and the local scenarios, asking the coin flip and leaky bucket questions first increases the expected EDEs of respondents, meaning they prefer more equality to more cleanup. Compared with the base survey, respondents receiving this version of the survey have nonlocal and local EDES that are 0.645 and 0.640 higher, respectively. These coefficients are significant at the 10 percent level. One plausible explanation for this pattern is that the income inequality questions sensitize some respondents to be more concerned about equality, which carries over to the health risk questions later in the survey.

We run these specifications a second time using only the respondents with non-lexicographic preferences.[22] These results are displayed in Table 15. The sample sizes in the nonlocal and local contexts decrease from 912 respondents to 592 and 565, respectively. There are several interesting changes. First, the effect of age on EDEs largely disappears, consistent with the finding that age increases the likelihood of lexicographic responses. A weaker relationship between age and inequality aversion does, however, hold in the nonlocal context. Second, education becomes important in the local context, with respondents with higher education levels preferring more equality. Finally, the effect of children in the household decreases in magnitude and significance.

[21] We have explored other specifications, including grouping political groups into larger bins. Our results on political beliefs are robust to a range of specifications.

[22] Our results are robust to restricting the sample to only respondents with perfect comprehension scores. There is an overall lack of significance using this restriction as well.

Table 14. EDE Interval Regression

	Nonlocal EDE		*Local EDE*	
	(1)	*(2)*	*(3)*	*(4)*
Education (omitted: no college)				
Some college	0.231	0.262	-0.424	-0.370
	(0.506)	(0.504)	(0.518)	(0.514)
Associate degree	-0.108	-0.0864	0.140	0.132
	(0.622)	(0.617)	(0.655)	(0.650)
Bachelor's degree	0.00885	0.0515	-0.537	-0.457
	(0.489)	(0.485)	(0.498)	(0.491)
Graduate degree	-0.118	-0.0609	-0.500	-0.365
	(0.497)	(0.495)	(0.505)	(0.504)
Age (omitted: 18–29)				
30–44	0.380	0.429	0.0960	0.197
	(0.351)	(0.356)	(0.376)	(0.383)
45–59	1.053***	1.127***	1.028***	1.113***
	(0.309)	(0.315)	(0.338)	(0.343)
60+	1.246***	1.164***	1.185***	1.052***
	(0.309)	(0.314)	(0.332)	(0.332)
Male	-0.356	-0.394	-0.610**	-0.659***
	(0.239)	(0.241)	(0.251)	(0.251)
Politics (omitted: neither liberal nor cons.)				
Extremely liberal		0.337		-0.0872
		(0.431)		(0.448)
Moderately liberal		-0.233		-0.380
		(0.319)		(0.341)
Slightly liberal		-0.359		-0.558
		(0.403)		(0.422)
Slightly conservative		-0.396		-0.505
		(0.417)		(0.475)
Moderately conservative		0.176		-0.317
		(0.400)		(0.432)
Extremely conservative		0.0249		0.373
		(0.735)		(0.766)
Children in household		-0.482*		-0.816***
		(0.267)		(0.290)
Belongs to environmental grp.		-0.259		-0.444*
		(0.235)		(0.250)
Constant	6.705***	6.908***	7.135***	7.621***
	(0.578)	(0.618)	(0.602)	(0.647)
Observations	912	912	912	912
Survey version	Yes	Yes	Yes	Yes
Race	Yes	Yes	Yes	Yes
Family income	Yes	Yes	Yes	Yes

Notes: Significance denoted by *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses.

Table 15. Non-lexicographic EDE Interval Regression

	Nonlocal EDE		*Local EDE*	
	(1)	*(2)*	*(3)*	*(4)*
Education (omitted: no college)				
Some college	0.412*	0.420*	0.599***	0.576***
	(0.225)	(0.223)	(0.204)	(0.206)
Associate degree	0.0210	0.0238	0.803***	0.754***
	(0.287)	(0.286)	(0.272)	(0.278)
Bachelor's degree	0.336	0.316	0.487**	0.440**
	(0.220)	(0.219)	(0.199)	(0.203)
Graduate degree	0.340	0.318	0.849***	0.808***
	(0.227)	(0.225)	(0.202)	(0.209)
Age (omitted: 18–29)				
30–44	0.265	0.279	-0.316*	-0.242
	(0.178)	(0.182)	(0.181)	(0.187)
45–59	0.287*	0.275*	0.0616	0.130
	(0.162)	(0.164)	(0.164)	(0.167)
60+	0.389**	0.374**	0.0922	0.0952
	(0.163)	(0.164)	(0.166)	(0.169)
Male	-0.138	-0.145	-0.0131	0.00444
	(0.123)	(0.125)	(0.122)	(0.124)
Politics (omitted: neither liberal nor cons.)				
Extremely liberal		-0.0222		0.0903
		(0.207)		(0.227)
Moderately liberal		0.0114		0.00687
		(0.160)		(0.164)
Slightly liberal		0.331		0.204
		(0.224)		(0.212)
Slightly conservative		0.0361		0.202
		(0.219)		(0.246)
Moderately conservative		0.109		-0.0354
		(0.197)		(0.196)
Extremely conservative		0.318		-0.257
		(0.267)		(0.265)
Children in household		-0.0130		-0.268*
		(0.136)		(0.142)
Belongs to environmental grp.		0.128		-0.0973
		(0.121)		(0.126)
Constant	5.885***	5.792***	5.515***	5.568***
	(0.276)	(0.301)	(0.235)	(0.266)
Observations	592	592	565	565
Survey version	Yes	Yes	Yes	Yes
Race	Yes	Yes	Yes	Yes
Family income	Yes	Yes	Yes	Yes

Notes: Significance denoted by *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses.

5. Conclusion

The distributional effects of health and safety policies often receive less attention than the monetized benefits of risk reductions stemming from these policies. We have argued that the utility of a policy depends both on the mean health outcome in a population and on how it is distributed. An Atkinson social welfare function for health risks could be used to evaluate programs that affect how environmental health risks are distributed in society. Our goal in this paper was to estimate the parameters of individuals' SWFs defined over environmental health risks.

Conducted in August 2015, our surveys include more than 900 respondents nationwide and provide us with information on attitudes toward inequality aversion. We use the responses from a series of dichotomous choice questions about hypothetical environmental cleanup programs to parameterize an Atkinson SWF for health risks. Roughly 30 percent of our sample exhibits lexicographic preferences in the context of health risks, preferring equal risk distributions regardless of the effect on mean risks. Nearly half of the lexicographic respondents explicitly rationalize their answers with references to equity and fairness. This group drives a wedge between mean and median estimates of our inequality aversion parameter, 0.72 and 2.8, respectively, implying modified Atkinson indices of 0.22 and 0.50. These values imply that respondents would be willing to accept an increase in average risks of 22 percent (using the mean inequality aversion parameter) and 50 percent (using the median inequality aversion parameter) if the risks were equally distributed in the population.

We compare our health risk inequality results with our findings on income inequality aversion. Using a "leaky bucket" experiment, we estimate mean and median income inequality aversion parameters (ε) of 0.21 and 0.07. These relatively low values are in line with earlier literature, including studies by Amiel et al. (1999) and Pirtillä and Uusitalo (2010). Our estimates imply that respondents would be willing to accept a decrease in average income of 2.1 percent to 5.1 percent if the income were distributed evenly in the population. By asking questions related to both income and health risks, we are able to conclude that respondents are significantly more inequality averse in the context of health risks.

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Appendix I. Survey Details

	Base Survey		Lung Survey		Scale Survey		Order A		Order B		**Total**	
Highest level of education												
High school degree or less	20	7.6%	15	10.3%	13	8.1%	14	8.2%	20	11.8%	**82**	**9.0%**
Some college but no degree	63	23.7%	35	24.0%	39	24.4%	29	17.0%	33	19.4%	**199**	**21.8%**
Associate degree	30	11.3%	10	6.8%	14	8.8%	11	6.4%	13	7.6%	**78**	**8.5%**
Bachelor degree	81	30.5%	39	26.7%	50	31.3%	55	32.2%	56	32.9%	**281**	**30.8%**
Graduate degree	72	27.1%	47	32.2%	44	27.5%	62	36.3%	48	28.2%	**273**	**29.9%**
White	219	82.3%	128	87.7%	136	85.0%	143	83.6%	143	84.1%	**769**	**84.2%**
Male	74	27.9%	57	39.0%	43	26.9%	70	40.9%	69	40.6%	**313**	**34.3%**
Age												
18–29	34	12.8%	19	13.0%	30	18.8%	21	12.3%	26	15.3%	**130**	**14.3%**
30–44	42	15.8%	21	14.4%	29	18.1%	34	19.9%	32	18.8%	**158**	**17.3%**
45–59	89	33.6%	50	34.2%	40	25.0%	58	33.9%	62	36.5%	**299**	**32.8%**
60+	100	37.7%	56	38.4%	61	38.1%	58	33.9%	50	29.4%	**325**	**35.6%**
Family income												
$0 to $9,999	12	4.5%	4	2.7%	10	6.3%	11	6.4%	11	6.5%	**48**	**5.3%**
$10,000 to $24,999	14	5.3%	13	8.9%	15	9.4%	10	5.8%	12	7.1%	**64**	**7.0%**
$25,000 to $49,999	62	23.3%	27	18.5%	29	18.1%	25	14.6%	34	20.0%	**177**	**19.4%**
$50,000 to $74,999	49	18.4%	24	16.4%	27	16.9%	29	17.0%	31	18.2%	**160**	**17.5%**
$75,000 to $99,999	33	12.4%	27	18.5%	18	11.3%	23	13.5%	20	11.8%	**121**	**13.3%**
$100,000 to $124,999	27	10.2%	10	6.8%	15	9.4%	24	14.0%	20	11.8%	**96**	**10.5%**
$125,000 to $149,999	8	3.0%	10	6.8%	5	3.1%	11	6.4%	6	3.5%	**40**	**4.4%**
$150,000 to $174,999	6	2.3%	3	2.1%	7	4.4%	2	1.2%	2	1.2%	**20**	**2.2%**
$175,000 to $199,999	5	1.9%	1	0.7%	5	3.1%	6	3.5%	4	2.4%	**21**	**2.3%**
$200,000+	9	3.4%	4	2.7%	8	5.0%	8	4.7%	11	6.5%	**40**	**4.4%**
Prefer not to answer	41	15.4%	23	15.8%	21	13.1%	22	12.9%	19	11.2%	**126**	**13.8%**

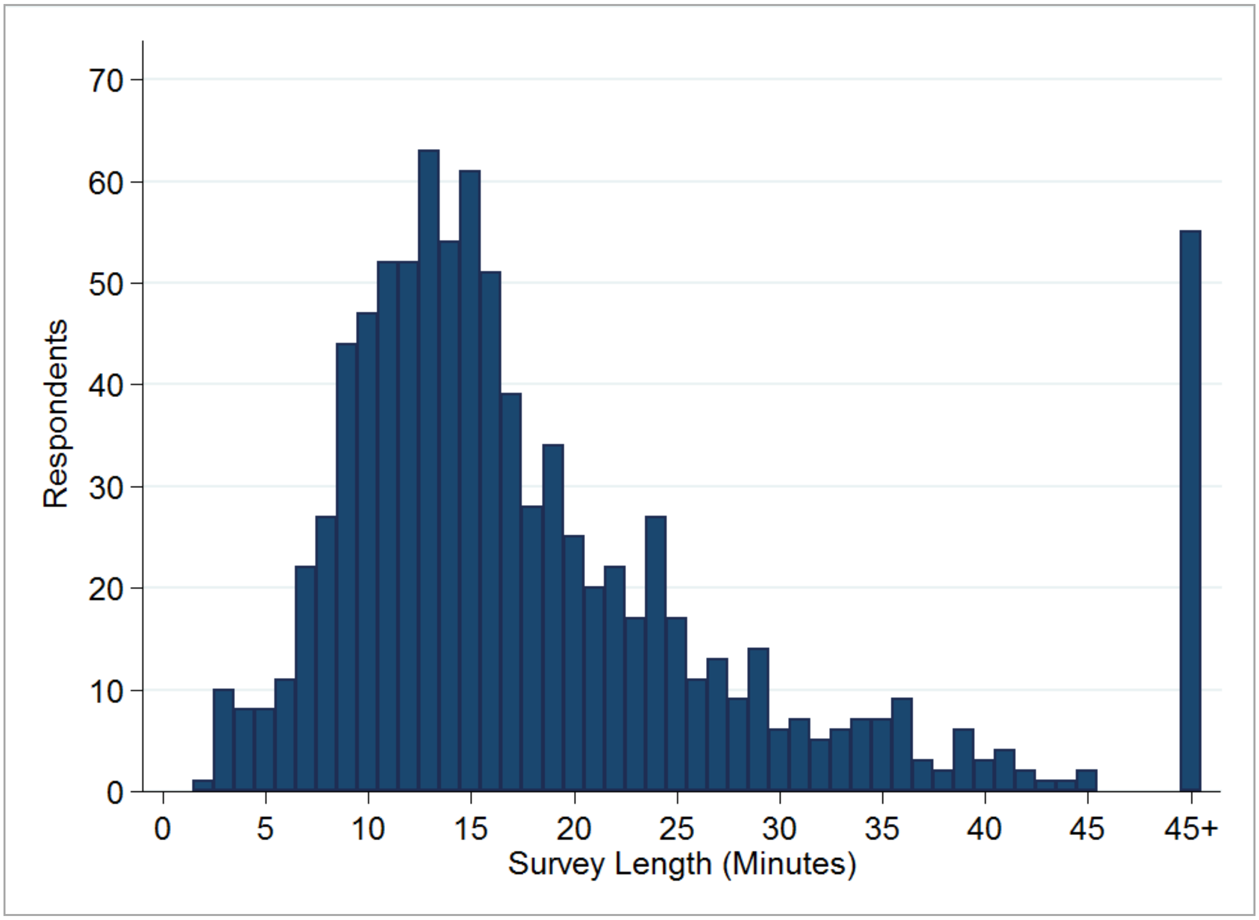


Figure A1. Survey Length Histogram

Appendix II. Survey Design Process

To arrive at our final survey design, we conducted a series of focus groups, one-on-one interviews, and online pilot surveys.

Four focus groups were held at Resources for the Future in fall 2014 and spring 2015. Advertisements were posted on Craigslist to generate a sample of hundreds of prospective participants in the Washington, DC, area. The final 30 focus group participants made up a roughly representative sample of US adults by age, race, gender, and education. Focus group respondents were asked to complete a draft survey, discuss their answers, and comment on the clarity of the questionnaire. Participants were compensated $75 for completing the two-hour focus group.

After conducting the focus groups, we migrated the paper survey onto SurveyMonkey, an online survey platform. SurveyMonkey features include questionnaire branching and question randomization. SurveyMonkey distributes surveys to its panels of respondents. Prior to online pilots, several one-on-one interviews with research assistants were conducted to test the functionality of the online survey. Finally, we launched an online pilot to test SurveyMonkey's respondent panel on June 2, 2015 (N = 134). We found that the release of our pilot survey induced answers primarily from respondents in the Eastern time zone and who were predominately older and female.

The final survey distribution took place from Sunday, August 9, through Wednesday, August 12, 2015, using SurveyMonkey's panel. Surveys were released at different days and times with the goal of obtaining a more representative sample of internet users. SurveyMonkey incentivizes respondents to answer surveys by offering entries into prize sweepstakes and donations to various charities. Millions of people take SurveyMonkey surveys each month, and the service conducts tests to ensure that members are representative of the US population. Nevertheless, as shown in Table 2, respondents' characteristics do not closely track national statistics for every variable observed.

Appendix III. Survey

The following pages are selected pages from the survey distributed through SurveyMonkey. The format of the pages may differ slightly from what was viewed in the electronic version.

Environmental Clean-Ups

A state's Department of Environmental Protection is considering two programs that will clean up pollution in the state. You do not live in this state, nor do you know anyone who lives there. You will be asked to consider both programs and to choose the one you think will do the state more good.

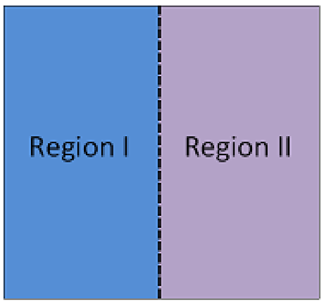
The two programs aim to reduce cancer risks resulting from environmental causes. There are many cancer-causing substances in the environment, and in most cases people are not aware of them. We want you to assume that people have certain cancer risks from exposure to these environmental pollutants and nothing they do can change those risks. All of the residents in the state start out with the same risk of cancer from environmental exposures.

However, the Department of Environmental Protection can reduce cancer risks by addressing pollution sources in the state.

Base Health Risk Survey

Program Description

Before choosing a program, the Department will divide the state into two regions with identical populations and demographics (e.g. income distribution, family size, race, etc):



Under **Program A**, one region would be selected randomly to have the majority of its pollution sources cleaned up. Please assume that Region I is selected randomly, resulting in the majority of its pollution sources being cleaned up. Region II would only have a few sources cleaned up. This clean-up method would lead to Region I having lower final risks than Region II.

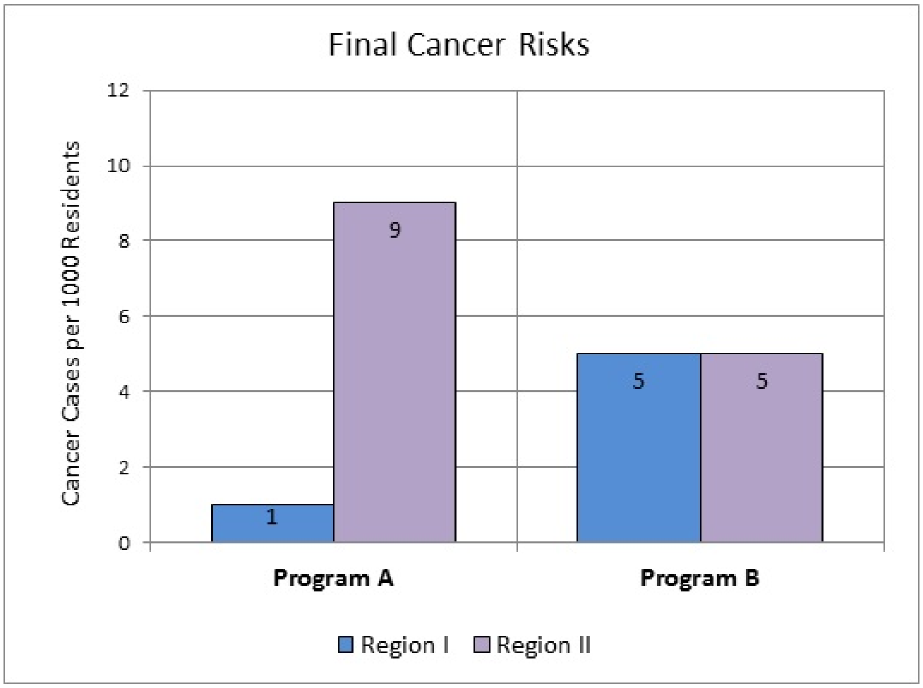
Under **Program B**, the state would select sources spread evenly across the entire state for clean-up. Everyone in the state (both regions) would have their cancer risks reduced to the same level.

Please assume the two programs have identical costs and that no further clean-up will take place after the chosen program is implemented.

The following questions will refer to "final" risks, which are the resulting cancer risks after a program has been carried out.

Base Health Risk Survey

* Please recall that Program A (left) will clean up Region I more than Region II, while Program B (right) will address pollution sources spread out evenly across both regions.



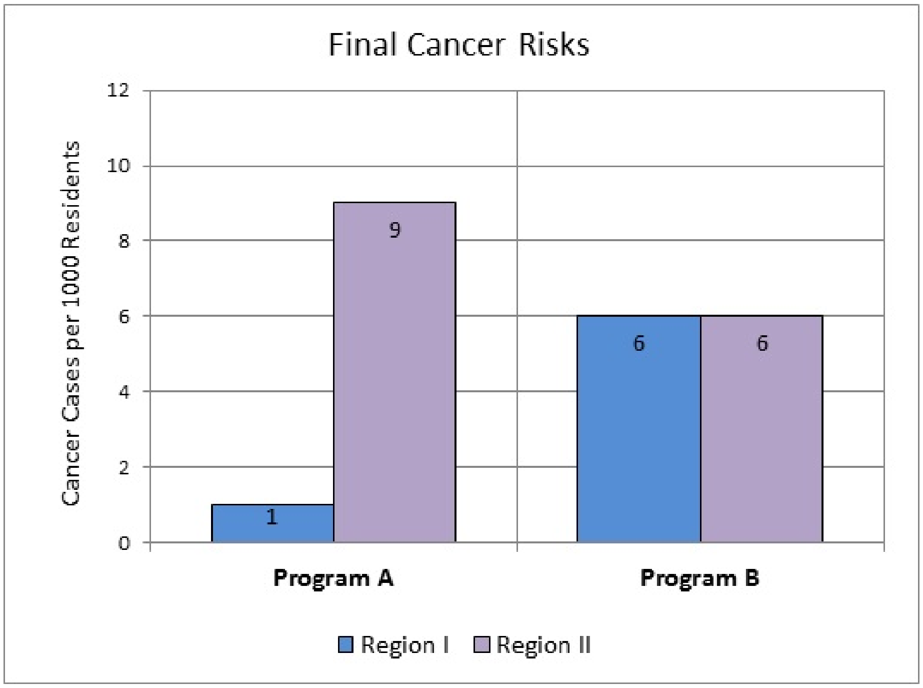
	Program A	Program B
Final risk for Region I	1 in 1000	5 in 1000
Final risk for Region II	9 in 1000	5 in 1000
Total cancer cases per 1000 residents	10	10

Based on the final risks shown in the graph and table, please indicate which program you advise the Department to choose.

- Program A
- Program B

* Please explain the reasoning for your choice.

* We would now like you to consider a very similar situation. The only difference is the final risks for Program B. **The final risks for both regions in Program B are now 6 cases per 1000 residents.**



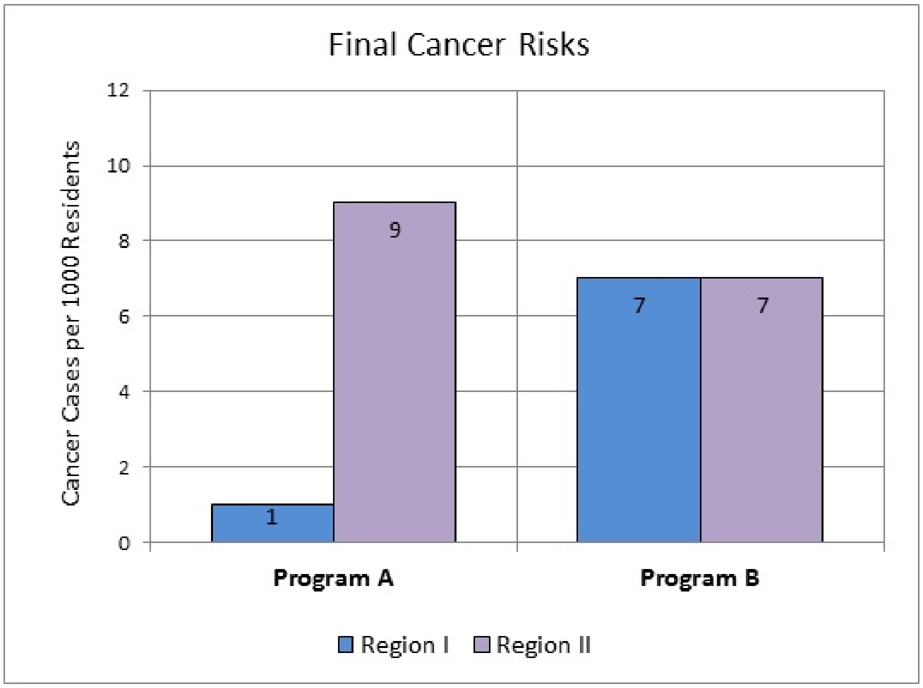
	Program A	Program B
Final risk for Region I	1 in 1000	6 in 1000
Final risk for Region II	9 in 1000	6 in 1000
Total cancer cases per 1000 residents	10	12

Based on the final risks shown in the graph and table, please indicate which program you advise the Department to choose.

- ○ Program A
- ○ Program B

Base Health Risk Survey

* **Now, the final risks for both regions in Program B are 7 cases per 1000 residents.**



	Program A	Program B
Final risk for Region I	1 in 1000	7 in 1000
Final risk for Region II	9 in 1000	7 in 1000
Total cancer cases per 1000 residents	10	14

Based on the final risks shown in the graph and table, please indicate which program you advise the Department to choose.

- ◯ Program A
- ◯ Program B

Base Health Risk Survey

Section II

The second part of this survey is very similar to the first section. You will again be asked to choose between programs that affect residents in an area of the country.

Now, please assume YOU live in the affected area This means that the current pollution levels are increasing **your** risk of cancer and the risks to others, and any clean-ups would reduce these risks. Recall that it is difficult to know what pollutants are in the air you breathe. Because of this, it is impossible for people, including you, to change their cancer risks from exposure to these environmental pollutants. All of the residents in the area start out with the same cancer risks.

The Department of Environmental Protection will reduce cancer risks by addressing pollution sources in the area.

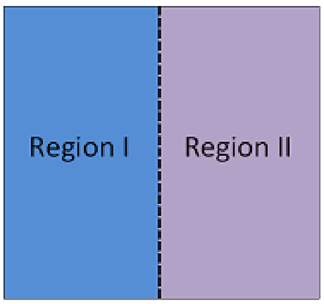
The "area of the country" is undefined to prevent you from guessing who is in each Program Region. The regions will again be split in a way that puts an equal number of residents in each region. The regions will also have identical demographic make-ups. **Please assume you do not know which region you live in.**

Base Health Risk Survey

Program Description

Before choosing a program, the Department will divide the area into two regions with identical populations and demographics (e.g. income distribution, family size, race, etc).

Again, you do not know which region you are in.



The set-up here is the same as previously, in that:

Under **Program A**, one region would be selected randomly to have the majority of its pollution sources cleaned up. Please assume that Region I is selected randomly, resulting in the majority of its pollution sources being cleaned up. Region II would only have a few sources cleaned up. This clean-up method would lead to Region I having lower final risks than Region II.

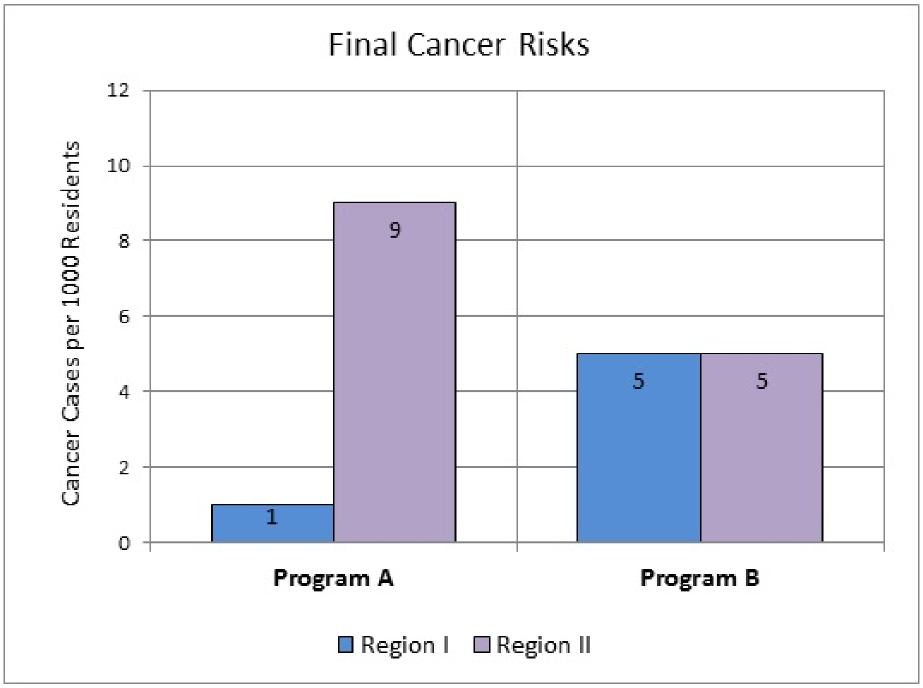
Under **Program B**, the Department would select sources spread evenly across the entire area for clean-up. Both regions would have their cancer risks reduced to the same level.

Please assume the two programs have identical costs and that no further clean-up will take place after the chosen program is implemented.

Base Health Risk Survey

* Please recall that Program A (left) will clean up Region I more than Region II, while Program B (right) will address pollution sources spread out evenly across both regions.

Please remember that you live in one of the two regions.



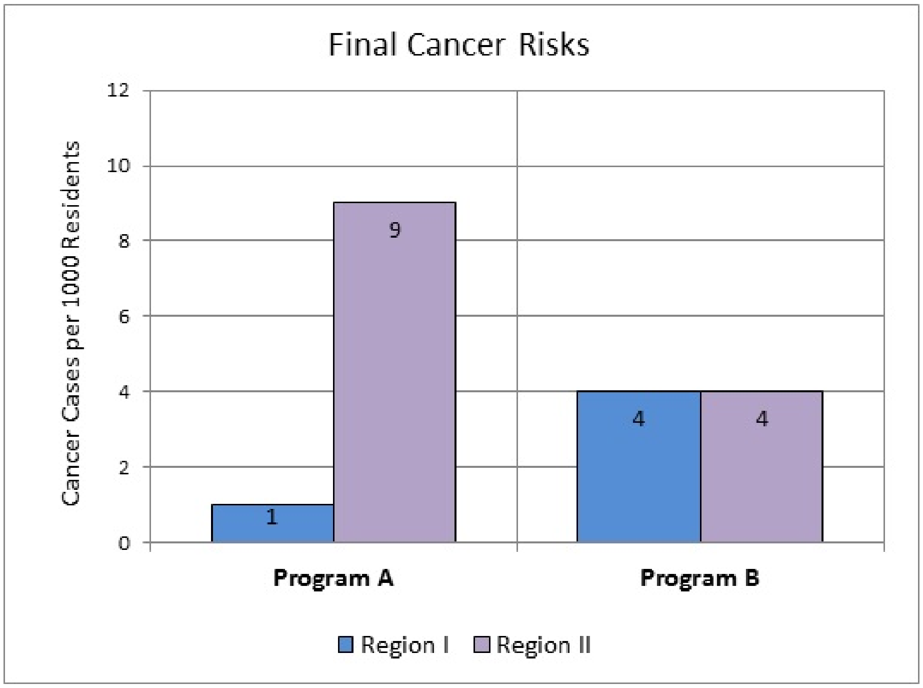
	Program A	Program B
Final risk for Region I	1 in 1000	5 in 1000
Final risk for Region II	9 in 1000	5 in 1000
Total cancer cases per 1000 residents	10	10

Based on the final risks shown in the graph and table, please indicate which program you advise the Department to choose.

- ◯ Program A
- ◯ Program B

* We would now like you to consider a very similar situation. The only difference is the final risks for Program B. **The final risks for both regions in Program B are now 4 cases per 1000 residents.**

Please remember that you live in one of the two regions.



	Program A	Program B
Final risk for Region I	1 in 1000	4 in 1000
Final risk for Region II	9 in 1000	4 in 1000
Total cancer cases per 1000 residents	10	8

Based on the final risks shown in the graph and table, please indicate which program you advise the Department to choose.

- ◯ Program A
- ◯ Program B

Base Health Risk Survey

Section III

The next few questions will ask you to make a choice between two options: receiving a certain amount of money, or flipping a coin to determine how much money you receive. For each question, please select the option you prefer.

* Consider a situation where you are presented with the following two options. Please select the option you prefer.

- ◯ You receive $10.
- ◯ You flip a coin. If it shows heads, you receive $90. If it shows tails, you receive $10.

Base Health Risk Survey

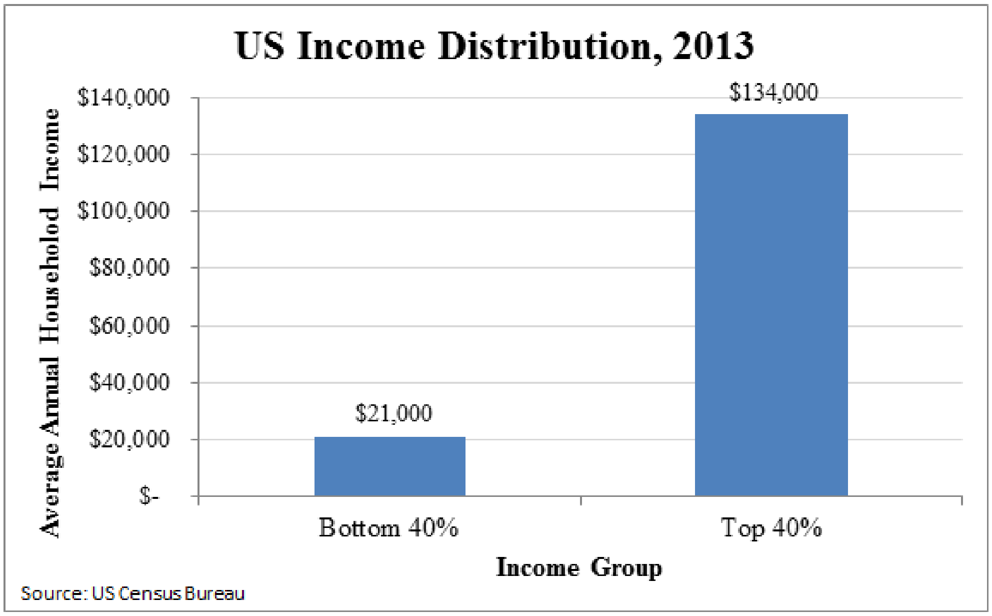
* Consider a situation where you are presented with the following two options. Please select the option you prefer.

- ◯ You receive $20.
- ◯ You flip a coin. If it shows heads, you receive $90. If it shows tails, you receive $10.

Base Health Risk Survey

Section IV

* The following graph shows average household income in the United States in 2013 for the bottom 40% of households and top 40% of households (the middle 20% are not shown). Each bar represents the same number of households.



The bottom 40% of households earned income of $21,000 on average in 2013. The top 40% of households earned $134,000 (on average) in the same year.

We would like you to consider the following thought experiment.**Assuming you have the authority, would you be willing to reduce the income of each household in the top 40% by $1000 to increase the income of each household in the bottom 40% by $1000?**

- ◯ Yes
- ◯ No

* Please explain your reasoning for this answer.

Base Health Risk Survey

* Please recall that the bottom 40% of households earned income of $21,000 on average in 2013. The top 40% of households earned $134,000 (on average) in the same year.

We would like you to consider the following thought experiment.**Would you be willing to reduce the income of each household in the top 40% by $1000 to increase the income of each household in the bottom 40% by $750?**

◯ Yes

◯ No