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VALUING HEALTH FOR ENVIRONMENTAL POLICY WITH SPECIAL EMPHASIS ON CHILDREN'S HEALTH ISSUES

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--Session One--

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Edited by Shi-Ling Hsu
Environmental Law Institute
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Disclaimer

Proceedings for Session 1, Wednesday, March 24, 1999

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Opening Remarks
by David Gardiner, Assistant Administrator, US EPA Office of Policy

I want to welcome all of you to this conference, and thank you for your time and effort over the next two days. The papers you present, and the ideas you discuss, may not sound particularly interesting, glamorous, or even understandable, to the public. The findings of this conference will not be reported on the nightly news.

But it's hard to exaggerate the importance of what you're hoping to accomplish. There can be little doubt that your work has huge implications for future environmental quality in this country, and for the future health of all Americans, particularly children. In the long run, your work will help people understand the full range of health benefits they enjoy because of our national commitment to environmental protection. And the more the public understands what they're getting for their environmental dollars, the more they'll support strong environmental programs in the future.

Economic analysis, and in particular cost/benefit comparisons, have played an important role in EPA's regulatory process for many years. We've become fairly sophisticated at using economic tools, and they've undoubtedly helped EPA refine and strengthen a variety of environmental regulations.

For a number of reasons, the role of economics is going to grow even more important in the future. In 1993, for example, President Clinton signed Executive Order 12866 requiring benefit/cost analyses of all regulatory actions likely to have an annual economic impact of more than $100 million. In addition, the Safe Drinking Water amendments of 1996 require EPA to determine whether the costs of regulating any drinking water contaminant justify the prospective benefits.

Because of concerns that environmental regulations cost too much compared to their benefits, Congress has imposed several new analytic requirements on EPA. The Unfunded Mandates Reform Act of 1995 requires EPA to choose the least costly, most cost-effective, or least burdensome option for achieving a given regulatory objective. The Small Business Regulatory Enforcement Fairness Act of 1996 gives Congress the opportunity to review and approve or disapprove environmental regulations based on benefit/cost analysis, among other things.

Most recently, the so-called Thompson language requires EPA and other federal agencies to estimate, for calendar year 2000, the total annual costs and benefits associated with all the Agency's regulations and paperwork. Moreover, Senator Thompson recently introduced a bill that would require this kind of overarching benefit/cost estimate every year. Clearly, the role of benefit/cost analysis at EPA is growing more important with every passing day.

This growing emphasis on economic analysis to justify whether EPA should act, and what to do, has thrown a bright light on the weaknesses of our current analytic tools. There seems to be widespread agreement that we're especially weak in the area of benefits valuation. Several years ago EPA's Science Advisory Board pointed out that, in their opinion, EPA continually underestimated the benefits of protecting ecosystems. EPA has been criticized often for emphasizing the cancer benefits of its regulations while minimizing other health benefits. When Carol Browner called on EPA to pay special attention to the special problems associated with children's health, we began to realize how little information was available to measure or monetize children's health benefits. In other words, as comparisons of costs and benefits are applied more extensively to justify environmental rules, our inadequate ability to quantify benefits becomes more and more troublesome.

That's why you're here: to improve the nation's ability to value health benefits, so environmental decisions based on benefit/cost comparisons are fair and well-balanced. There's a number of ways you can do this, some related to methodology, and some related to specific environmental problems. For example, we need help valuing reductions in mortality risks across the board. We need help understanding the effects of particulate matter on mortality, so we can improve benefit/cost analyses of the Clean Air Act. We need help valuing the avoidance of a number of drinking water related morbidity endpoints, like non-fatal cancers and microbial illnesses. Most of all, we need help estimating the benefits associated with protecting children's health.

Thirty years into our existence as an Agency committed to protecting public health, we have pitifully few studies on the specific effects of environmental pollutants on children's health, and pitifully few tools to value the specific benefits to children's health of environmental action. Children suffer different risks when exposed to the same environmental pollutants as adults. Consequently, the benefits to children's health have to be valued differently.

That kind of valuation will not be easy. What **is** the value of avoiding developmental impairment in a child? What **is** the value of avoiding a five point drop in a child's IQ? These are difficult questions. But we must find the answers if we expect to build public and Congressional support for tough measures to protect children's health.

This workshop is bringing together some of the country's leading experts on valuing health benefits, and in particular children's health benefits. I hope you learn a lot from each other, and from the research you have underway already. I'm especially optimistic about health valuation research currently funded by NSF/EPA grants, and I hope your discussions over the next two days help strengthen those studies.

Finally, I want give a special thanks to the two EPA offices that joined with the policy office to sponsor this conference. Staff from EPA's Office of Research and Development and from the Office of Children's Health Protection have shown how valuable cooperation across programmatic lines can be. Several members of EPA's Children's Health Advisory Committee also are participating here, and I welcome and thank you as well. You're all engaged in groundbreaking work that will provide the strong underpinning for what I hope will be an even more vigorous research program in the future.

Valuing health benefits, especially for children, is extraordinarily difficult, and there's a long, hard road in front of you. But your work is critically important to all Americans, today and in the future. So good luck in your efforts, and thank you again.

Introductory Remarks for Session I

by Melonie Williams, US EPA Office of Economy and Environment

In this session we will be discussing general issues in the valuation of mortality risks. While there are several categories of benefits that result from EPA regulations, quite often the lion's share of benefits is in the form of reductions in the risk of health effects. Hence, this is a particularly salient issue.

When valuing health effects in economic analyses of EPA regulations, the usual approach is to:

(1) Quantify the change in health endpoints (that is, the change in the number of cases expected to result from compliance with a rule);
(2) Divide cases into number of expected fatal vs. non-fatal cases;
(3) For fatalities, value the endpoint using the value of statistical life (VSL), where VSL is an aggregation of individual WTP for small decreases in risk of premature mortality.

Drawing from literature surveys by Viscusi [1993] and Fisher et al. [1989], EPA identified 26 studies that provide the best range of VSL estimates available at this time. To allow for probabilistic modeling of risk reduction benefits, analysts fit a Weibull distribution to the 26 estimates of mean WTP, which provided a central estimate of approx. $5.8m and a range of $700,000 to $16.3m (in 1997 dollars). EPA's draft Revised Guidelines for Preparing Economic Analyses recommend the use of $5.8m as the VSL point estimate for use in EPA benefits analyses.

Most of these estimates are based on the risk of occupational accidents to a middle-aged working population, where the associated fatalities are of an immediate and acute nature. The remainder are from contingent valuation studies that estimate WTP to avoid risks of premature death associated with transportation or occupational accidents. Unfortunately, the characteristics of the mortality risks in these studies seldom correspond to those of the risks affected by EPA policies, implying that current VSL estimates may be biased relative to the true social value of reducing risks of premature mortality from environmental causes. For example, time lags between exposure and manifestation of the health outcome may affect the value of risk reductions. The dread and lengthy morbidity associated with some health endpoints may increase the value of risk reductions. Moreover, the demographic characteristics of the study sample often differ from those of the individuals affected by EPA policies, while variability in the average age of the expected population, expected life years lost, health status, and income may also affect value. Consequently, policy analysts at EPA face a very difficult benefits transfer exercise when attempting to monetize the health benefits of EPA regulations.

One possible solution is to conduct partial adjustments to the current VSL estimates and sensitivity analyses along the demographic and contextual lines just mentioned. But we know that, in many cases, valid quantitative adjustments will be difficult, if not impossible. For example, there is evidence that WTP to reduce mortality risks is an inverted U-shaped function of age. A linear disaggregation of VSL to yearly values, which assumes that the value per statistical life year is constant, would therefore not adequately capture the relationship between changes in longevity and the social value of reduced mortality risks.

The theoretically preferred (but more expensive) alternative is to directly value the types of mortality risks EPA regulates, where the valuation mechanism considers the full context of the environmental risk; effects on the individual's survival curve, timing of the exposure vs. timing of the health endpoint, nature of the fatality, etc. The Krupnick et al. study that we will hear about in this session illustrates a value elicitation methodology that directly considers timing issues and the age at which individuals face mortality risks.

In general, as in the Krupnick et al. study, valuing environmental risks will require the use of stated preference techniques, primarily because of a lack of data required to appropriately examine market tradeoffs. The use of these techniques, however, introduces a host of additional problems.

A problem that is somewhat unique to this context is risk communication. In order to use the values we elicit to monetize the benefits of environmental regulations, we must elicit values for quantified risk changes. People don't quantify the risks they face every day, however, and they appear to exhibit some common characteristics in their perception of risk. These include overestimating small risks, valuing risk chances asymmetrically (from some reference point), and a concern for the specific characteristics of the risk independent of the magnitude (e.g., controllability and voluntariness).

A defensible survey study for the purposes of monetizing risk changes must ensure that respondents understand the commodity they are being asked to value, so solving this risk communication problem is a real priority. The two studies we'll see today examine the use of alternative risk communications devices and provide some insight into procedures for quantifying risk in survey instruments.

Evaluating the Effect of Visual Aids on Willingness-to-Pay for a Reduction in Mortality Risk: Preliminary Results

--Working Paper*--

PRESENTED BY:
Phaedra S. Corso
Centers for Disease Control and Prevention
Harvard University

CO-AUTHORS:
James K. Hammitt (Center for Risk Analysis, Harvard School of Public Health)
John D. Graham (Center for Risk Analysis, Harvard School of Public Health)

* This is a working paper developed for the US Environmental Protection Agency Office of Children's Health Protection, Office of Economy and Environment, and Office of Research and Development's workshop, "Valuing Health for Environmental Policy with Special Emphasis on Children's Health Issues," held on March 24-25, 1999, at the Silver Spring Holiday Inn in Silver Spring, Maryland.

I. Introduction

A well-established method for valuing non-market goods in the context of a benefit-cost analysis is contingent valuation (CV), where individuals are asked to state their willingness-to-pay (WTP) for some commodity by answering hypothetical survey questions. For conducting economic analyses to determine health policy, the CV methodology may be used to estimate the value of reductions in mortality. Although CV methodology is grounded in economic theory, critics of these methods argue that persons answering hypothetical WTP questions have difficulty assigning meaningful dollar values to reductions in risk to their health. This difficulty may be explained, in part, by the fact that people fail to distinguish between small and large probabilities. To combat this inherent problem within the CV methodology, risk communication tools, e.g., probability analogies, time or distance analogies, risk ladders, and other verbal and visual aids, have been developed to assist respondents in comprehending the magnitude of risk reductions.

A considerable amount of literature attempts to link WTP responses to specified numerical changes in respondents' probability of death, illness and/or injury on the basis of a specified method of risk communication[1]. Several of these studies have conducted internal and external scope tests to test the sensitivity of WTP responses to changes in the absolute or relative risk levels. An internal scope test is defined as the same respondent being asked to value different magnitudes of risk reduction – within sample. An external scope test is defined as different respondents being asked to value different magnitudes of risk reduction – between samples. Only a few studies, however, compare the results of these scope tests when the method of risk communication is varied.

A study by Loomis and duVair[2] compares the use of risk ladders and pie charts to communicate risk in the context of a CV survey. In an external scope test, they found that a variable for the absolute level of risk reduction (a 25%, 50% or 75% reduction in risk) was statistically significant for the groups that were exposed to a risk ladder or a pie chart (at a 10% and 5% level, respectively). This suggests that the level of risk reduction systematically influences WTP, holding all other covariates constant.

[1] For a summary of WTP studies of numerically specified health risks, see: Hammitt JK and Graham JD. Willingness to pay for health protection: inadequate sensitivity to probability? *J of Risk and Uncertainty* (in press).
[2] Loomis JB and duVair PH. Evaluating the effect of alternative risk communication devices on willingness to pay: results from a dichotomous choice contingent valuation experiment. *Land Economics*. 1993;69(3):287-98.

Another study, by Hammitt and Graham[3], compared the effects of verbal communication methods on sensitivity to scope. In a split sample, the authors compared the sensitivity to magnitude where a respondent was either exposed or unexposed to a probability analogy. In the exposed group, each numerical probability was accompanied by a corresponding analogy to the number of minutes in a year (e.g., a 20/100,000 annual risk is compared to 105 minutes in a year). In contrast to the sensitivity demonstrated by Loomis and duVair, Hammitt and Graham determined that the estimated sensitivity to magnitude was independent of whether respondents were exposed to probability analogies. In preliminary unpublished results, however, the authors determined that verbal analogies were modestly helpful in conveying magnitude of scope in an 'adding-up' test[4].

The purpose of this study is to advance the previous research conducted by Hammitt and Graham by comparing the use of visual communication methods on sensitivity to scope. Preliminary results from an external scope test of three visual aids for communicating risks – the use of a logarithmic scale, a linear scale, and a visual array of dots are presented for a contingent valuation study of the preference tradeoff between wealth and annual mortality risk.

II. The Survey

The survey, which took, on average, 20-25 minutes to complete, contained a section that tested the effects of visual aids on willingness to pay for auto safety. Two versions of the survey were prepared: one in which the initial annual risk of dying in a motor vehicle crash was 2.5/10,000, and the other in which the initial annual risk of dying in a motor vehicle crash was 2.0/10,000. For both versions, the purchase of a side-impact air bag would potentially reduce the annual risk of dying in a motor vehicle crash to 1.5/10,000.

A double-bounded dichotomous choice format was used to elicit WTP values. Study participants responded to an initial dollar amount and were then asked a second question involving a dollar amount that was higher or lower based on their initial response. The following bid vectors were used: <50,100,200>,

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[3] Hammitt and Graham, *op. cit.*

[4] In simultaneous valuations among independent groups, theory would predict that the $WTP_a + WTP_b = WTP_{a+b}$.

<25,50,100>, and <100,200,400>. A fourth bid vector, <200,400,800> was added after a preliminary review of WTP values[5].

III. The Visual Aids

To develop the communication devices, we drew on previous visual aids developed by Jones-Lee et al.[6], Hammitt[7] and comments from a focus group conducted in July 1998. Study participants were randomized into one of the three visual aid groups or into a fourth group, which was not provided visual aids. On the logarithmic and linear[8] scales, each rung of the ladder (or scale) represented a progressively higher annual risk. Several comparative annual risks were included to enhance the understanding of the small probabilities. Examples include the annual probability of being fatally struck by lightning (2 in 10 million) and the annual probability of dying in a fire (1.5 in 100,000). These comparative risks were chosen because pretesting suggested the study population understood these risks. Both risk scales showed the absolute reduction in risk level as movement down the rungs on the ladder; pre- and post-intervention risk levels were indicated by corresponding symbols.

The logarithmic and linear scales also included a "community analogy" adapted from Calman and Royston[9]. These analogies, which included pictures of the relevant population, enabled respondents to understand the magnitude of risk as it relates to a population. For example, a 1 in 10,000 risk implies, in community terms, that you could expect to find one person killed by a motor vehicle crash in every small town in the United States. A 1 in 1 million risk implies, in community terms, that you could expect one person killed by an automobile accident in every city in the United States. The third visual aid was an 11" x 17" display of 25,000 dots. A brief explanatory page provided several analogies to convey the magnitude of 25,000 in other contexts. For example, 25,000 feet is equal to the highest campsite in the world—on Mt. Everest, and 25,000 days is equal to the time elapsed until a newborn reaches age 70 years.

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[5] Data collection was temporarily suspended after 10% of the total sample was collected (n=129). At this time, we reviewed the WTP responses and determined that the bid vectors were too low.
[6] Jones-Lee M, Hammerton M, and Phillips P. The value of safety: results of a national survey. *The Economic Journal.* 1985; 95:49-72.
[7] Hammitt JK. Risk perceptions and food choice: An exploratory analysis of organic- versus conventional-produce buyers. *Risk Analysis*. 1990;10(3):367-374.
[8] The linear scale used in this survey was hierarchical in that each section on the scale that represented a smaller risk was proportionately smaller than the previous section.
[9] Calman KC and Royston GHD. Risk language and dialects. *BMJ*. 1997;315:939-942.

IV. Preliminary Results

Data were collected from November 1998 through March 1999, from a national sample of U.S. residents selected through random digit dialing. A total of 1,456 participants were initially recruited by telephone and subsequently mailed a visual aid packet. Within one to three weeks of the packet mailout, follow-up calls were made to recruits in order to complete the survey. Of those recruited, 69 (4.7%) never received a packet, 29 (2.0%) refused to complete the interview, 33 (2.3%) were unable to complete survey due to death or disability, and 254 (15.2%) were unreachable by telephone after six attempts. In this section, preliminary results are given for 1,104 completed telephone interviews, representing a 75.8% completion rate.

Table 1 presents the estimated regression equations used to describe WTP for the side-impact airbag, by visual aid. The regression equations were estimated by assuming a lognormal distribution. The regression in the first column presents results for the full sample. "Risk" is an indicator variable equal to 1 for the sub-sample presented with the larger risk reduction and 0 for the sub-sample presented with the smaller risk reduction, from 2.5/10,000 to 1.5 in 10,000 and from 2.0 in 10,000 to 1.5 in 10,000, respectively. Its coefficient estimates the logarithm of the ratio of WTP for the large risk reduction to the WTP for the small risk reduction, controlling for the other covariates (see "Ratio"). If WTP were exactly proportional to the magnitude of risk reduction, the value of "Ratio" would be ln(2)=0.693 (corresponding to the twofold absolute difference in risk reduction). The estimated coefficient on "Risk" is statistically significant from both zero and from ln(2). We can reject the hypothesis that WTP is insensitive to the magnitude of the risk reduction, as well as the hypothesis that WTP is proportional to the magnitude of risk reduction.

The remaining columns report analogous regressions for the sub-samples of respondents who received either the linear scale, the logarithmic scale, the array of dots, or no aid. These results vary by visual aid, with the array of dots most significantly affecting the sensitivity to the change in mortality risk. The hypothesis that WTP is insensitive to the magnitude of risk reduction can be rejected for the dots (at 1%) and for the logarithmic scale (at 5%), but not for the linear scale or no visual aid sub-samples. The hypothesis that WTP is exactly proportional to the risk reduction (i.e., that the coefficient equals ln(2)) cannot be rejected for the dots or the logarithmic scale, but can be rejected for the sub-samples that received either the linear scale or no visual aid. The hypothesis that WTP remains constant across risk levels (i.e., "Ratio"=1) can be rejected for the dots and for the logarithmic scale, but cannot be rejected for the sub-samples that received either the linear scale[10] or no visual aid.

V. Conclusions

This study was designed to test the effectiveness of three visual aids to communicate risk in the context of a contingent valuation survey. An external scope test was performed to test the sensitivity to changes in mortality risk between sub-samples. The findings of this preliminary analysis suggest that some types of visual aids may increase sensitivity to scope and may yield results that are consistent with the theoretically prescribed proportionality between WTP and the probability change associated with mortality risk reduction.

[10] The hypothesis that WTP using the linear scale remains constant across risk levels can almost be rejected using a one-sided test with 10% significance level. The value of the t-statistic is 1.58.

Table 1

External Magnitude Tests of WTP for Auto Safety
(Lognormal distribution)
2.5 to 1.5/10,000 vs. 2.0 to 1.5/10,000

	Full sample n=1,104	Linear n=288	Logarithmic n=264	Dots n=275	No Aid n=277
Constant	5.371***	5.63***	5.333***	5.068***	5.45***
(standard error)	(0.071)	(0.144)	(0.145)	(0.140)	(0.141)
Risk[a]	0.396***	0.318	0.502**	0.654***	0.097
(standard error)	(0.100)	(0.201)	(0.198)	(0.207)	(0.198)
Ratio[b]	1.48	1.37	1.65	1.92	1.10

*,**, *** denotes statistically significant from 0 at 10%, 5% and 1%, respectively.
[a] Indicator variable=1 for large risk reduction and 0 for small risk reduction
[b] Ratio of WTP for large risk reduction to WTP for small risk reduction estimated by the coefficient on "Risk".

MORTALITY RISK VALUATION FOR ENVIRONMENTAL POLICY

--Working Paper*--

PRESENTED BY:
Alan Krupnick
Resources for the Future

CO-AUTHORS:
Alan Krupnick (Resources for the Future), Anna Alberini (University of Colorado), Maureen Cropper (University of Maryland and The World Bank),
Nathalie Simon (USEPA)
With Kenshi Itaoka (Fuji Research Institute) and Makoto Akai (MITI)

* This is a working paper developed for the US Environmental Protection Agency Office of Children's Health Protection, Office of Economy and Environment, and Office of Research and Development's workshop, "Valuing Health for Environmental Policy with Special Emphasis on Children's Health Issues," held on March 24-25, 1999, at the Silver Spring Holiday Inn in Silver Spring, Maryland.

Mortality Risk Valuation for Environmental Policy

Alan Krupnick, Anna Alberini, Maureen Cropper, Nathalie Simon
With Kenshi Itaoka and Makoto Akai[11]

March 18, 1999

I. Introduction

Much of the justification for environmental rulemaking rests on estimates of the benefits to society of reduced mortality rates. Reductions in risk of death are arguably the most important benefit underlying many of EPA's legislative mandates, including the Safe Drinking Water Act, CERCLA, the Resource Conservation and Recovery Act and the Clean Air Act. In two recent analyses of the benefits of air quality legislation, *The Benefits and Cost of the Clean Air Act, 1970 - 1990* (USEPA 1997a) and EPA's *Regulatory Impact Analyses for Ozone and Particulates* (USEPA 1997b), over 80% of the monetized benefits are attributed to reductions in premature mortality.

Most benefit-cost analyses (including the above) rely on estimates of the value of reductions in risk of death produced by compensating wage studies, or contingent valuation studies that value risk reductions in the context of transport or job-related accidents. As we argue below, these estimates are inappropriate when valuing risk changes produced by environmental programs. The objectives of this paper are to explain why these estimates are inappropriate and to describe an improved approach to valuing reductions in risk of death from environmental programs, especially programs to reduce air pollution. We have implemented this approach in a pilot study in Tokyo, Japan. The paper provides estimates of the value of a statistical life based on the pilot study and describes extensions of the approach based on test results.

II. Why Existing Estimates of the Value of Mortality Risks Are Inappropriate in an Environmental Policy Context

A. The Nature of Mortality Risk Reductions from Pollution Control

Estimates of the mortality benefits from reducing pollution – in this case air pollution -- come from two types of epidemiological studies.[12] Episodic studies measure the impact of short-term exposures to pollution on mortality rates, using daily time series data. Prospective cohort studies measure the impact of long-term exposures to pollution by following a cross-section of individuals over time. Both types of studies, which are described briefly below, suggest that

[11] Respectively, the authors are with Resources for the Future, University of Colorado, University of Maryland and the World Bank, and the USEPA. Additional authors are with the Fuji Research Institute and MITI, Tokyo, Japan.

[12] The studies described here are those used to estimate the number of statistical lives saved by reducing air pollution in *The Benefits and Costs of the Clean Air Act, 1970-1990* and EPA's *Regulatory Impact Analyses for Ozone and Particulates*. Evidence from toxicological studies and cross-sectional epidemiological studies also support an association between air pollution and premature mortality.

most of the statistical lives saved by reductions in air pollution are persons 65 years of age and older.

Studies by Schwartz (1991,1993) and Schwartz and Dockery (1992a, 1992b) examine the association between daily mortality, by age and cause, and the criteria air pollutants. In Philadelphia, Schwartz and Dockery found a significant impact of total particulate matter (TSP) on deaths among persons 65 and over, but no significant effect of air pollution on deaths below the age of 65. The impact of particulates was greater for cardiovascular deaths and deaths due to chronic obstructive lung disease (COPD) or pneumonia than on all non-trauma deaths.

The prospective cohort study of Pope et al. (1995) followed 552,000 individuals in up to 151 U. S. cities. The study used a proportional hazard model to examine the effects of particulate exposure and other covariates on death rates. This model assumes that the impact of particulates is proportional to the conditional probability of dying at each age (given that one survives to that age), or the hazard rate.[13] The significant impact of particulates on the hazard rate implies that the benefits of reducing particulate exposure fall primarily on older persons, whose conditional probability of dying is higher than that of younger persons. Significant effects were observed for mortality only from heart and lung disease and lung cancer.

When using the Pope et al. study to estimate benefits from reducing air pollution it is usually assumed that a reduction in annual average PM concentrations (both PM2.5 and sulfates) will immediately reduce the hazard rate. This implies that a given reduction in PM will save a certain number of statistical lives. As the preceding paragraph implies, these statistical lives will be concentrated among older persons. This point is made explicit in Table 1, which shows the age distribution of statistical lives saved as a result of reductions in particulate exposures achieved by the Clean Air Act, based on Pope et al. (1995). These estimates show that three quarters of the statistical lives estimated to be saved in 1990 are persons 65 years of age and older.

This has two implications for valuing morality risks. For older persons, the correct valuation concept is what an individual would pay today for an immediate reduction in his risk of death. For younger persons, who will not experience significant risk reductions until they are older, the correct valuation concept, assuming that the costs of pollution control are incurred today, is what a person would pay today for a future risk reduction.

[13] The study finds that mortality rates decrease 0.7 percent for every $\mu g/m^3$ change in sulfates.

Table 1. Distribution of Premature Mortalities Avoided by the reductions in PM2.5 Under the Clean Air Act, for 1990

Age Group	Remaining Life Expectancy	Deaths Avoided
Under 65	25	45,000
65-74	14	43,000
75-84	9	54,000
>84	6	41,000

Source: EPA, *The Benefits and Costs of the Clean Air Act, 1970 to 1990*, draft report prepared for Congress, July 1997.

B. Current Approaches to Valuing Mortality Risk Reductions

Epidemiological studies suggest that reducing air pollution lowers death rates primarily among persons over 65. These benefits, furthermore, are more likely to accrue to people with chronic heart or lung disease and may occur with a lag. In spite of these findings in the medical literature, the dominant approach for valuing these reductions in death risks is simply to transfer estimates from compensating wage studies or contingent valuation studies that value risk reductions in the context of transport or job-related accidents.

1. Labor Market Studies

The main shortcoming of labor market studies is that they measure compensation received by prime-aged men for immediate reductions in risk of death. Since older people have fewer life-years remaining than prime-aged males, the compensation received in labor market studies may overstate the value of risk reductions to persons over age 65. Secondly, compensating wage studies measure compensation for a reduction in risk of death over the coming year, whereas exposure to air pollution (and to carcinogens) can result in delayed effects. When evaluating an environmental program today that will not reduce risk of death until the future, policy makers must know what people will pay today for future risk reductions.[14]

Attempts have been made to adjust estimates of risk reductions from the labor market literature for age and latency. Under certain strong assumptions, one can convert the value of a statistical life from a labor market study (or other source) into a value per life-year saved. The value of a life-year can then be multiplied by discounted remaining life expectancy to value the statistical lives of persons of different ages. The justification for these adjustments is the life cycle consumption-saving model with uncertain lifetime (Yaari, 1955; Shephard and Zeckhauser 1982;

[14] The delay in the realization of risk reductions could occur either because the installation of pollution control equipment today will not benefit young people until they become susceptible to the effects of pollution (the air pollution case described above), or because the program reduces exposure today to a substance that increases risk of death only after a latency period (e.g., asbestos).

Cropper and Freeman 1991; Cropper and Sussman 1990). According to this model, WTP for a reduction in the probability of dying over the coming year equals the present value of expected utility of consumption over the remainder of one's life, divided by the marginal utility of income.[15] In the special case in which utility of consumption at age t is constant for all t, WTP is proportional to discounted life expectancy. In this case, it is meaningful to speak of a value per life-year saved, which can be computed by dividing WTP by discounted life expectancy.[16]

To illustrate this calculation, suppose that the value of a statistical life based on compensating wage differentials is $5 million, and that the average age of people receiving this compensation is 40. If remaining life expectancy at age 40 is 35 years and the interest rate is zero, then the value per life year saved is approximately $140,000. If, however, the interest rate is 5 percent, then *discounted* remaining life expectancy is only 16 years, and the value per life-year saved rises to approximately $300,000. [17]

Computing a value per life-year saved clearly hinges on very restrictive assumptions, even if one believes the life-cycle consumption-saving model. It is also very sensitive to the choice of discount rate. Moore and Viscusi (1988) have used labor market data to infer the rate at which workers discount future utility of consumption; however, their models make very specific functional form assumptions in order to infer a discount rate from a single cross section of data.

2. Contingent Valuation Studies

Difficulties in measuring the impact of age and latency on WTP using labor market data have led to the use of stated preference methods to value a change in risk of death. In a contingent valuation study persons of different ages can be asked to value an immediate reduction in risk of death, and each respondent can be asked what he would pay today to reduce his risk of dying in the future. Before such approaches can be used, however, it must be demonstrated that valuation questions can be posed in a manner that is meaningful to respondents. Existing contingent valuation studies of mortality risks suffer from two problems: (1) They ask people to value small changes in their risk of death, which are expressed in units unfamiliar to most people, e.g., a 1-in-10,000 reduction in risk of dying over the coming year. (2) They ask people to attach a value to a commodity (e.g., a 1-in-10,000 reduction in risk of dying) that they have never purchased, or at least are not used to thinking about in this way. This has led to inconsistencies in responses to many contingent valuation surveys.

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[15] If an individual can save via actuarially fair annuities and borrow via life-insured loans, then one must add to this expression the effect of a change in the conditional probability of dying on the budget constraint.

[16] Formally, let j be the individual's current age and let $q_{j,t}$ be the probability that the individual survives to age t, given that he is alive at age j. The individual's remaining life expectancy is the sum of the $q_{j,t}$'s from j to T, the maximum age to which humans live. The individual's discounted life expectancy weights each $q_{j,t}$ by the discount factor $(1+r)^{j-t}$ before summing.

[17] Similar adjustments can be made to account for the effect of latency periods. According to the life-cycle model, a 40-year-old's WTP to reduce his probability of dying at age 60 should equal what he would pay to reduce his current probability of dying at age 60, discounted back to age 40.

a. Problems in Comprehending Quantitative Risk Changes

To elaborate on the first problem, people appear to have difficulty perceiving small risk changes. This may result, in part, from an inability to handle fractions.[18] In a recent study of the value of mortality risks in the U. S. (Hammitt and Graham, 1998), 32% of respondents did not know that 5/100,000 was a smaller number than 1/10,000. One way to circumvent this problem is to use visual aids--to darken squares on a sheet of graph paper to show the size of a risk change or to place risks on a risk ladder. [19]

Even when care is taken to communicate the size of small risk changes, however, people often do not distinguish the magnitude of these changes. Evidence of this is the fact that, in many surveys, people's WTP for reductions in risk of death does not increase with the size of the risk reduction. In a survey of WTP for reductions in risk of death in the context of highway safety (Jones-Lee, Hammerton and Philips, 1985), there was no statistically significant difference in the amount people would pay for a 1 in 100,000 reduction in risk of death during a bus trip versus a 7 in 100,000 reduction. Presumably, both numbers were perceived as "small." Similar problems were encountered by Smith and Desvousges (1987) in a study of WTP to reduce exposure to hazardous waste. Respondents were told their current risk of exposure to hazardous waste (R) and their probability of dying from the waste (after a 30-year period) given that they were exposed (q). WTP for reductions in probability of exposure (holding q constant) were insensitive to the change in R. Hammitt and Graham (1998) encountered similar problems in their survey of WTP for air bags. The WTP for a 10 in 10,000 risk reduction was estimated to be only 23 percent larger than WTP for a 5 in 10,000 risk reduction. When respondents were presented with larger initial risks and risk reductions of 15 in 10,000 and 10 in 10,000, the differences in WTP were even smaller (only 6 percent).

b. Problems in Valuing Quantitative Risk Changes

Even if people are able to understand the magnitude of a risk change, it may be difficult for them to place a dollar value on it. This is because people are unaccustomed to purchasing quantitative risk reductions. There are two problems here. People are often aware of the risk factors associated with a given cause of death and may actually engage in risk averting or risk reducing behavior; however, they are unlikely to know the magnitude of the risk reductions resulting from these behaviors. For example, people will state that they wear seat belts to reduce risk of injury and death in an auto accident, but it is difficult for them to quantify the benefits of wearing a seat belt. Secondly, as in the seat belt example, many of the activities people engage in to reduce

[18] According to our research, this is a difficulty that can be largely avoided if surveys express risks in the same units of the denominator.

[19] Another way to avoid the problem of small probabilities is to describe programs that will reduce the number of deaths in a population. For example, a road safety program in one's state could reduce the number of motor vehicle deaths from 1,000 to 900 per year. The problem with this approach is that the value a person places on such a program is likely to reflect his WTP to reduce risk of death to others as well as to himself. The appropriate welfare measure for evaluating life saving programs is what all affected individuals would pay to reduce risks to *themselves alone* (Jones-Lee, 1991).

their risk of death do not cost them money. This is true of most behavioral changes (diet, smoking, exercise) and even of the purchase of medical services (cancer screening tests) when they are paid for by health insurance. [20]

CV surveys have been occasionally used to place a value on the mortality risk reductions associated with environmental, transportation safety or health programs (Mitchell and Carson, 1986; Smith and Desvousges, 1987; Jones-Lee et al. 1985; Hammitt and Graham, 1998). These studies found that while many respondents report positive WTP amounts to secure such risk reductions, a considerable fraction of the respondents is likely to have WTP equal to zero. Some respondents fail to grasp the basic notions of probability, and others ascribe similar WTP amounts to grossly different risk reductions. With few exceptions (Mitchell and Carson; Smith and Desvousges), most of these studies dealt with accidental death risks, as opposed to risks involving latency or late-in-life risk.

The most recent exception is Johannesson and Johansson (1996), who report on the first study we know of that values extensions to life expectancy. They conducted a telephone survey of a random sample of adult Swedes, asking respondents to report their willingness to pay for a new medical technology that would extend the remaining duration of their lives, assuming survival to age 75. The WTP question was worded as follows:

> "The chance for a man/woman of your age to become at least 75 years old is X percent. On average, a 75-year-old lives for another 10 years. Assume that if you survive to the age of 75 years you are given the possibility to undergo a medical treatment. The treatment is expected to increase your expected remaining length of life to 11 years. Would you choose to buy this treatment if it costs SEK C and has to be paid for this year?"

Respondents were to give yes or no answers to this question.

Based on the over 2000 completed surveys, Johannesson and Johansson fit a logit model predicting the likelihood of a positive response to the WTP question as a function of the amount C stated to the respondent, respondent age, income, educational attainment and gender. They found results consistent with economic theory, in that WTP increases with respondent age. Predicted WTP was, however, relatively low, due to the large number of responses consistent with very low, or zero, WTP.

Despite the novelty of its approach, in many respects the Johannesson and Johansson study leaves much to be desired. First, it was conducted via telephone, which many researchers find an inadequate means of communicating complex, hard-to-understand commodities, such as mortality risks, and precludes the use of visual aids. Second, although the goal of the survey was to value a change in life expectancy, the commodity respondents were to value was not well-

[20] Studies that have obtained "reasonable" WTP values for risk reductions (values of the same magnitude as compensating wage studies) often provide implied value cues to which respondents can anchor their answers. In the Jones-Lee et al. (1985) study, for example, people were told that they were given £200 to spend on the bus trip and were asked how much of this they would spend to travel on the safer bus. It is also the case that the researcher can, by altering the size of the risk reduction valued, help guarantee a "reasonable" value of a statistical life. If the risk reduction valued is small (on the order of 1 in a million) a WTP of only a few dollars will generate a value of a statistical life in the range of values found in compensating wage studies.

defined, in the sense that respondents could have easily interpreted it to be a year added on to the end of life. Third, the published article is silent about the survey development work, and respondent debriefing. Finally, the risk change respondents are to value is extremely large, to the point of being implausible when the risk reduction is to be delivered by an environmental policy.

III. Improving on These Approaches

Our goal is to design a survey to estimate WTP for reductions in mortality risks that can be used to evaluate the benefits of environmental programs. This requires that we ask older persons to value an immediate reduction in their risk of dying and younger persons to value a future reduction in their risk of dying. It also requires that we address problems--in particular, insensitivity to scope--that have been encountered in previous surveys. We describe our survey instrument below. The instrument has been developed over a period of several years, as a result of extensive one-on-one interviews in the United States, and pretests in the U.S. and Japan. We describe the results of the Japanese pretest and modifications to the survey that we have made subsequently. The modified survey will be administered in Canada, in Japan and in the United States later this year.

The survey instrument that we have developed differs from previous efforts in several important respects:

- First, the current target population is persons 45 to 75 years old. This is appropriate in light of the goal of the survey, but also necessary if we are to meaningfully discuss reductions in mortality risks outside of the context of transport accidents. It is only in middle age that risks of death from cardiovascular disease, respiratory illness and cancer become significant in industrialized countries.

- Second, we discuss mortality risks in 10-year intervals. Extensive use of focus groups and one-on-one interviews convinced us that most people find it easier to imagine a positive probability of dying over a ten-year interval than over a one-year interval. The use of 10-year intervals also allows us to represent risks in terms of chances per 1,000, which can be shown on graph paper.

- Thirdly, we ask people to pay for a product that will reduce their risk of dying over a ten-year interval by 5 in 1,000 and 1 in 1,000. These risk changes correspond to *annual* risk changes of 5 in 10,000 and 1 in 10,000, respectively, which are of the magnitude estimated to occur from air pollution reductions.[21] As noted above, some surveys deal with risk changes so small that a WTP of a few dollars generates a value of a statistical life in the $5-$10 million-dollar range.

- Finally, we note that the method of delivering risk reductions in our survey is a private good, not covered by health insurance. Although we believe that our estimates can be used to value the benefits of environmental programs, we believe that it is inappropriate to presents respondents with risk reductions *delivered by* environmental programs. Environmental

[21] They are also of the magnitude of risk changes that are observed in labor market studies.

programs usually reduce the risk of dying for all people in an exposed population; hence, it is difficult for the respondent to separate his own risk reduction from that of others.

A. Survey Description

Throughout our survey, we are motivated by two important concerns: (1) that respondents find the commodity to be valued understandable and meaningful, and (2) that they accept that mortality risks can be mitigated at a cost and that many people, if not themselves, perform such mitigation as part of everyday life.

The first section introduces probability of dying and probability of surviving and proposes simple practice questions to familiarize respondents with these concepts. The main task of this section is to clearly communicate probabilities and test for comprehension, eschewing tests of mathematical ability. First we describe two cities, City A and City B. The cities are identical in every way, except that in one city 10 persons out of every 1,000 of the respondent's age and gender will die over the next 10 years, whereas in the other, only 5 persons out of every 1,000 of the respondent's age and gender will die. Then we show the subject a graph of the risks for one of the cities and ask him or her to identify which city it is. Finally, we ask: "If you had to move to one of two cities, which city would you prefer, or are you indifferent between them?" (The risks in each city are represented using colored grid squares to convey probability.

Another major element that increases the understandability of the commodity is to state all probabilities in terms of chances per 1,000. After extensive one-on-one interviews and focus group testing, we concluded that the use of grids with more than 1,000 squares (i.e., 10,000 or 100,000) results in reduced cognition and a tendency to ignore small risk changes as being insignificant. Because we wanted annual risk changes to be smaller than 1 in 1,000, however, we expressed the commodity as a risk change over 10 years *totaling* x per 1,000. Baseline risks and payment schedules were also put in 10-year terms.

The second section presents respondents with age- and gender-specific leading causes of death and introduces common risk-mitigating behaviors, illustrative risk reductions, and illustrative costs. As noted above, one difficulty in asking people to value quantitative risk reductions is that, although people often engage in risk-reducing behaviors (e.g., cancer screening tests, taking medication to reduce their blood pressure or cholesterol levels), they have no idea how much these actions reduce their risk of dying. We present results from cost-effectiveness studies that quantify the reductions in risk of dying (over 10-year periods) from common risk-reducing behaviors.

The third section communicates baseline risks for someone of the respondent's age and gender and asks them to accept this risk as their own for the purpose of the survey (the acceptance of the baseline risk is tested in debriefing questions). To fix this baseline in the respondent's mind, he or she is asked to create their own baseline risk graph by marking squares on a blank grid.

The fourth section elicits information about WTP for risk reductions of a given magnitude, occurring at a specified time, using dichotomous choice methods. In one subsample, respondents are first asked if they are willing to pay for a product or action that, when used and paid for over the next ten years, will reduce baseline risk by 5 in 1,000 over the 10-year period (WTP5); in the second WTP question, risks are reduced by only 1 in 1,000 (WTP1). In another subsample, respondents are given the 1 per 1,000 risk change question first. This design permits both internal and external scope tests. To impress the risk change on the respondents, we ask that they erase the appropriate number of squares from their personal baseline risk graph.

Our final series of dichotomous choice questions focuses on future risk reductions. The WTP questions are preceded by a question concerning the respondent's perceived chance of surviving to age 70. This question encourages the respondent to think about his future. A variety of surveys have shown that individuals are reasonably good at estimating future survival probabilities (Hamermesh, 1985; Hurd and McGarry, 1996) and are able to value risk changes occurring in the future (Johannesson and Johansson, 1996). The respondent is then told his gender-specific chance of dying between ages 70 and 80 and is asked, through dichotomous choice questions, his WTP each year over the next ten years for a future risk reduction beginning at age 70 and ending at age 80 *which totals* 5 in 1,000 (WTP5_70). The respondent is reminded that there is a chance he may not survive to age 70, making a payment today useless. He is then given the opportunity to revise his bid. During an extensive debriefing section of the survey, the respondent is asked whether he thought about his health state during this future period.

In sum, our WTP questions differ from those in earlier CV surveys in six respects: (1) the timing of the risk reductions, (2) the timing of the payment, (3) the tailoring of baseline risks to age and gender, (4) the extensive use of visual aids, (5) the addition of questions to gauge the strength of a respondent's conviction in his WTP responses, and (6) the abstract nature of the commodity and payment vehicle.

Although keeping the risk reduction scenario abstract may depart from the recent CV literature and the NOAA panel recommendations (Arrow et al., 1993), we argue that, according to the discounting human lives literature, respondents are willing and able to make choices among abstract life-saving programs (Hurd and McGarry, 1996, Cropper, Aydede, and Portney, 1994). In addition, we argue that being specific about the attributes of the risk and mitigation approach may lose as many people as it gains because some respondents will not believe that the specifics apply to them. While we do provide the respondent with some examples of mitigating activities that could produce the risk reductions in question, we emphasize that the activity could take any number of forms, allowing respondents to focus on the size of the risk reduction itself.

IV. Tokyo Pilot Survey

Thus far we have developed and refined the mortality risk questionnaire based on a total of 27 personal, "think-aloud" interviews lasting approximately one hour each and have completed a 60-person pre-test of the survey instrument in the U.S. This survey development, plus a similar number of personal “think-aloud” interviews in Tokyo, led to a 316-person pilot study administered in Tokyo with our partners, the Fuji Research Institute. The Fuji Research Institute is a non-profit research group that has received funding for this project from Japan's Ministry of International Trade and Industry (MITI).

A. Sampling and Survey Administration

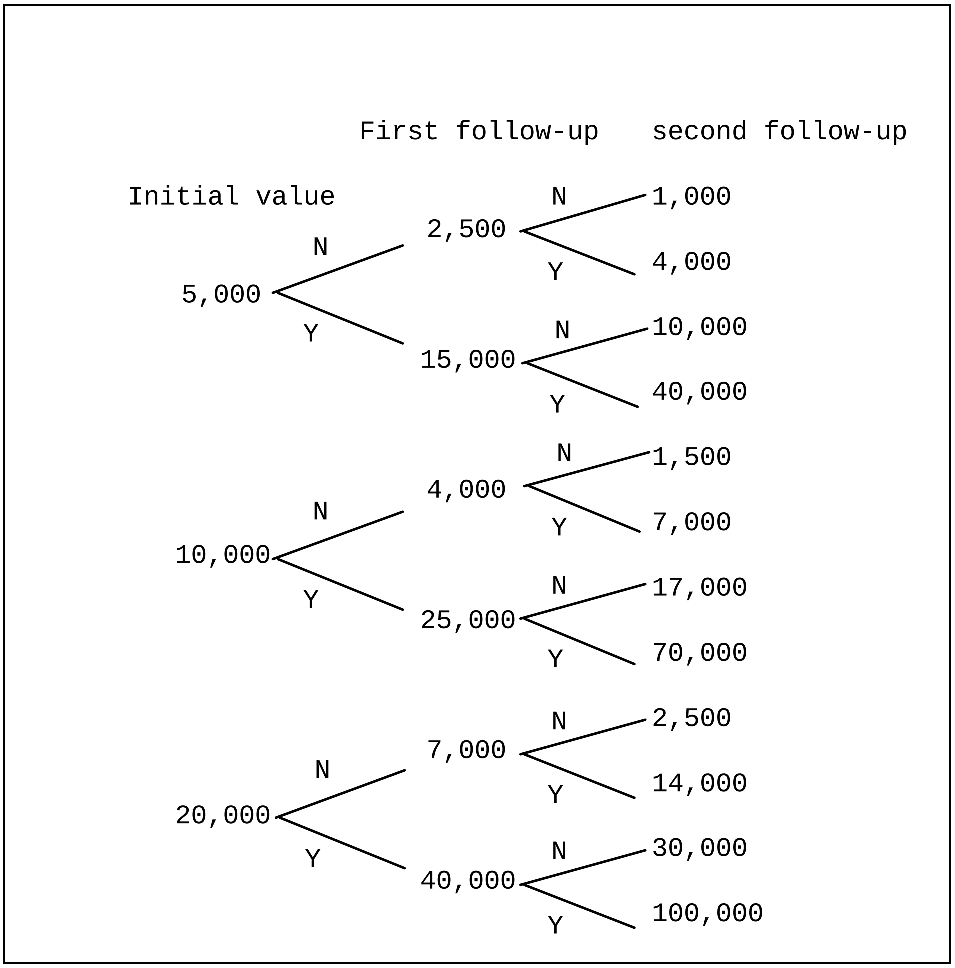
316 adults were recruited in Tokyo during February and March of 1998. Three age groups were sampled: 30 to 44, 45 to 54, and 55 to 64.[22] We focused on respondents aged 30 and older to ensure that the respondents' baseline mortality risk would be large enough for the 5 in 1,000 risk reductions to be meaningful – i.e., that a risk reduction of 5 in 1,000 would result in a positive mortality risk for the respondent.[23] With the cooperation of ten companies, we recruited 80 participants from employee rosters, most of them male. We recruited the rest of the participants from Tokyo by random telephone calls. Interviewers made appointments with the participants and conducted the interviews in the participants' residence or place of business. Participants were randomly assigned to two subsamples. Subsample I (161 people) received the WTP5 question first. Subsample II (155 people) received the WTP1 question first.

The Japanese questionnaire uses a dichotomous choice format with two follow-up questions. The yen bids assigned to the respondents were varied within each subsample, as shown in Figure 1.

[22] As noted above, our current focus is persons 45 to 75 years old.

[23] The mortality risk of Japanese women under the age of 35 is less than or close to 5 in 1,000.   A risk change of 5 in 1,000 would result in a chance of death equal to zero.

Figure 1: Bidding Structure (yen)



B. Descriptive Statistics

Table 2 provides descriptive statistics for the entire sample. The average age of respondents is 47 years old, with 8% of the sample above 60. Most of the women in the sample are housewives, although housewives comprise only 20% of the population. Mean household income is $63,000, which is above the Tokyo average of $54,000. Forty percent of the sample has attended some college.

The remaining statistics in the table relate to baseline risk of dying (see below) or are taken from the debriefing section of the survey and are used as covariates explaining WTP. The high fraction of individuals who thought of effects to others when answering the WTP questions (47%) has an unclear interpretation. It is possible that these people thought of the impact of their own death on loved dependents; alternately, they may have erroneously assumed that the risk reduction for which they were paying would accrue to other people as well as to themselves. No respondents answered our probability test incorrectly, but 14% and 36% were indifferent to whether they lived in City A or City B when the mortality risk difference was 5/1000 and 1/1000, respectively.

Table 2: Summary of Respondent Characteristics

Respondent Characteristics	*Mean*	**Standard deviation**
Sex (% female)	53.8	
Age (years)	47.4	8.9
Age Distribution (%) 30-34 35-39 40-44 45-49 50-54 55-59 60-64	 13.3 9.5 14.9 21.5 17.7 15.5 7.6	
Housewife (%)	43	49
Self-employed (%)	31	46
Employed by others (%)	26	44
Household Income (million yen): Mean Median	 8.31 6.84	 4.10
College (%)	40	49
Perceived probability of surviving until age 70	0.66	0.22
Baseline risk	0.039	0.035
Percentage risk reduction	29	28
Respondent did not think risk was his own (%)	23	42
Respondents thought of effects to others when answering payment question (%)	47	50
Respondent thinks it is unwise to start paying now for risk reduction to be incurred over ten years (%)	47	50
Respondent did not think of his or her own health in answering payment questions (%)	64	48
Currently in good health and not hospitalized over the last 5 years (%)	76	42
Percent indifferent to City A/City B choice when mortality risks differ by: 5/1000 1/1000	 14 36	

The raw responses to the WTP questions for contemporaneous risk reductions are provided in Tables 3a and 3b. "Version" indicates the three starting bids. The typical bimodal distribution of responses is observed, although there are many bids in the interior of the frequency distribution.

Table 3a. Frequency of response for WTP5 (subsample I)

Version	NNN	NNY	NYN	NYY	YNN	YNY	YYN	YYY	Total
1	10	4	2	0	5	5	16	8	50
2	8	4	7	2	9	4	11	10	55
3	13	5	8	1	6	4	9	10	56
total	31	13	17	3	20	13	36	28	161

Table 3b. Frequency of response for WTP1 (subsample II)

Version	NNN	NNY	NYN	NYY	YNN	YNY	YYN	YYY	Total
1	11	6	5	0	7	7	10	5	51
2	12	4	8	1	5	5	9	10	54
3	9	12	7	4	3	7	6	2	50
Total	32	22	20	5	15	19	25	17	155

C. Estimates of WTP

To estimate mean or median WTP, it is first necessary to combine the responses to the initial and follow-up payment questions and obtain the lower and upper bounds of the interval around each respondent's WTP amount. Next, assuming that WTP follows a specified distribution *F*, we estimate the distribution's parameters, θ, by maximum likelihood techniques. Formally, the log likelihood function is:

(1) $$\log L = \sum_{i=1}^{n} \log[F(WTP_i^H;\theta) - F(WTP_i^L;\theta)]$$

where WTP^H and WTP^L denote the upper and lower bounds around respondent i's unobserved WTP amount.

We experimented with Weibull, log normal, exponential, logistic and log logistic distributions for WTP, assuming that the WTP variables for each of three risk reductions are independent of one another.[24] Results for the best fitting distributions are reported in Table 4, along with the implied value of a statistical life, based on a discount rate of 3%.

[24] Statistical theory suggests that treating our variables as independent is unlikely to affect much the point estimates of the parameters and the predicted mean or median WTP values. Standard errors, however, may be biased when one ignores the potential correlation between WTP for the different risk reductions. See Farhmeir and Tutz (1994).

Table 4. Annual WTP and VLS. Pooled subsamples.
All WTP figures are annual payments for 10-years, expressed in US dollars.

Commodity	Median WTP *(Mean WTP)*	Standard Error	Best Fit	Implied VSL (000) (r=3%)
5 in 1,000 risk change over the next 10 years (WTP5)	$113 **(323)**	$13	Weibull	$193 **($551)**
1 in 1,000 risk change over the next 10 years (WTP1)	$50 **(148)**	$6	Weibull	$427 **($1,262)**
5 in 1,000 risk change from age 70 to age 80 (WTP5_70)	$22 **(169)**	$4	Weibull	$38 **($288)**

As shown in Table 4, the estimated median WTP for decreases in mortality risk of one (WTP1) and five (WTP5) in one thousand are $50 and $113 per year, respectively. The implied value of statistical life (VSL) for WTP1 is $427,000 using a discount rate of 3 %. The VSL for WTP5 is $193,000. However, the WTP falls to only $38,000 when the risk change is experienced between ages 70 and 80 (WTP5_70).

As is expected in these types of surveys, mean responses are considerably higher than the median responses, leading to a tripling of the VSL for contemporaneous risk reductions and more dramatic increases for the future risk reduction case. Still, these estimates are far below those reported in labor market studies, which average around $5 million 1990 USD.

A two-follow-up question format was used to obtain these estimates; however, this did not yield dramatic differences in WTP compared with WTP estimates computed from responses to the first follow-up question. Median WTP5 for the entire sample was $123 with the latter approach, compared to $113 with the two question follow-up approach. Median WTP1 was $69 for the one follow-up approach compared to $50 for the two follow-up question format.

Because of possible ordering effects, we provide WTP estimates for each subsample. Table 5 shows that respondents given the 1 in 1,000 risk change as the first commodity to value (subsample II) have higher median WTP5 values than respondents who valued the 5 in 1,000 risk reduction first (subsample I). The same ordering effect can be observed for WTP1 and WTP5_70. We therefore focus on WTP estimates from the first WTP question seen by respondents.

Table 5. Annual Median and Mean WTP: Separate samples. All figures expressed in US dollars, and all calculations based on the Weibull distribution.

Commodity	**Median WTP (Standard Error)**		**Mean WTP**	
	Subsample I	Subsample II	Subsample I	Subsample II
WTP5	109 (17)	118 (17)	337	310
WTP1	36 (5)	72 (11)	106	194
WTP5_70	14 (3)	34 (7)	113	231

The results reported in Table 5 can also be used to perform internal and external scope tests. Internal scope tests formally show that, within a given subsample, larger risk reductions command greater WTP (holding constant the time horizon for the risk reduction), while a risk reduction of the same size is valued more highly if it starts immediately, as opposed to when the respondent reaches age 70.

The external scope test compares median WTP for the first risk reduction valued by respondents, which differs between subsamples I and II) using a Wald test. The WTP figures to be compared are those displayed in the shaded cells of Table 5. The Wald test statistic is equal to 3.45, and falls between the 5% and 10% confidence levels. A larger sample size would be likely to improve on this result.

The sensitivity of WTP to scope is not altered significantly by deleting the responses of individuals who: (i) are indifferent between living in city A and city B; (ii) think it "unwise" to begin to pay now for a risk reduction to be realized 10 years into the future; (iii) do not believe that the baseline risk is their own; or (iv) think that the intervention might affect others.

The CV literature (Hammitt and Graham, 1998) suggests that results can be affected by limiting observations to respondents who indicate that they are certain of their WTP responses. We found that 32% of our complete sample were "certain" of their responses to the WTP5_70 question, 52% were "somewhat certain," and only 16% were "not certain at all." However, the WTP estimates and scope test results were virtually identical after dropping individuals who were "not certain at all."

D. Relationship of WTP1 and WTP5 to Risk Measures

Earlier theoretical and empirical work has focused on whether WTP depends on baseline risk, on the absolute or relative size of the risk change, and on the individual's age. To explore these relationships, we fit a number of alternative regression models, as reported in Table 6. The underlying econometric model in all cases is:

(2) $$\log WTP_i^* = \mathbf{x}_i \beta + \varepsilon_i$$

where WTP* is true willingness to pay, ε is a normally distributed error term, the vector **x** contains a measure of baseline risk or risk change (or a transformation of them) and β is a vector of coefficients. We choose to work with a log normal distribution for WTP to keep the interpretation of the coefficients straightforward. In practice, the fit afforded by the log normal distribution is very close to (and only slightly worse than) that of the Weibull distribution, and results are robust to replacing one distribution with the other.

Table 6. WTP5. Log normal distribution. (T statistics in parentheses).

	A	B	C	D
Intercept	9.3161 (35.99)	93.95 (13.31)	9.5096 (37.12)	9.3165 (18.86)
Baseline risk	2.8431 (0.55)			
Log(baseline risk)		0.1001 (0.51)		
Relative risk reduction			-0.3043 (-0.46)	
Respondent is a male				0.6485 (1.86)
Age 35 to 39				-0.3604 (-0.50)
Age 40 to 44				-0.4757 (-0.74)
Age 45 to 49				0.4508 (0.77)
Age 50 to 54				-1.3572 (-2.01)
Age 55 to 59				0.1941 (0.29)
Age 60 to 64				-0.4504 (-0.52)
σ	2.0896 (12.68)	2.0895 (12.68)	2.0894 (12.70)	1.9984 (12.71)
Log likelihood	-314.05	-314.07	-314.09	-307.48

Table 6 shows that WTP5 increases with the baseline risk and decreases with the relative risk reduction, but not in a statistically significant fashion. The predictions for WTP offered by specifications (A), (B) and (C) are very similar, despite the different functional form for the regressor. Depending on the specification, WTP is about $82 for the 10-year risk change experienced by a person in the 30 to 34 years old age group, increases to about $94 for a 40-to-45 year-old, and is between $107 and $114 for the oldest respondents in the sample, the 60-to-64 year-olds.

However, when baseline risk and the percentage risk change variables are replaced with a gender dummy and dummies for the respondent's age group, the relationship between age and WTP appears to be non-monotonic, while males bid more. We refrain from drawing firm conclusions on the age effect, because most of the coefficients in the latter model are statistically insignificant and the sample (161 people) is small.

The results for WTP for a 1 in 1,000 risk change reveal a qualitatively similar story. The magnitude of the coefficients of baseline risk and the relative risk change is (in absolute terms) are generally larger than the corresponding coefficients in Table 6. The age effects (relative to the 30-35 age group) are consistently (if insignificantly) positive; i.e., older people are WTP more for a given risk reduction than younger people.

E. Relationship of WTP5 and WTP1 to Other Regressors

In addition to log baseline risk we added dummy variables to capture certain aspects of survey participants' understanding of the survey and their acceptance of the scenario. Specifically, we created dummies to indicate whether the respondent (i) did not believe the baseline risk was his or her own; (ii) took into account effects to others when answering the WTP questions; (iii) deemed it unwise to start paying today for the risk reduction; (iv) did not consider his or her future health in answering the WTP questions; and (v) was indifferent between city A and B.[25]

We found that all coefficients have the expected signs, except for the dummy indicating that the respondent thought about effects on others when answering the WTP questions. Most of the coefficients are insignificant. The variable that has the strongest association with WTP is the dummy for whether the respondent deems it unwise to start paying at this time. Its coefficient is negative and significant at the 1% level, and implies that respondents holding such an opinion have median WTP values that are about 75% to 70% -- depending on whether we refer to WTP for 5 in 1,000 or 1 in 1,000 risk reduction -- lower than those of other respondents. This finding is robust to dropping regressors from the right-hand side of the model. We do not have a ready explanation for why respondents who took into account effects on others should report lower WTP. We note, however, that the presence of a bequest motive may lower WTP (Cropper and Sussman (1988).

We also examined the effects on WTP5 and WTP1 of income, a college dummy, occupational dummies, a dummy (HEALTHY) denoting whether the respondent currently does not have serious health problems, nor has been hospitalized in the last five years, plus log baseline risk. Few individual characteristics turned up significant in the regressions. Most likely, this is due to the small sample sizes. Only the occupational dummies are significant in the equation for WTP5, but these variables do not appear to significantly influence WTP1. Although insignificant, the income elasticity of WTP is in line with that from earlier studies (0.3).

[25] When we estimate the model for WTP for a 1 in 1,000 change, we form a dummy that takes on a value of one if the respondent declared himself or herself indifferent between city A and city B, when city A was described to have a mortality rate of 3 in 1,000, and city B of 2 in 1,000. When the estimate the model for a 5 in 1,000 change, we focus on indifference between city A and city B, when one has a mortality rate of 5 in 1,000 and the other of 10 in 1,000.

F. Relationship of WTP5_70 to Other Regresssors

In table 7, we report some of the results of regressions explaining WTP for a risk reduction beginning at age 70. The regressors include a gender dummy, dummies for the respondent's age group, the respondent's self-assessed likelihood of surviving to age 70, and a dummy variable indicating whether the respondent believes it "reasonable" ("wise" in Japanese) to start paying now for a risk reduction to be delivered starting from age 70.

Table 7 shows that WTP is not explained by respondent age and gender, and that even the variable measuring the probability of surviving to age 70 does not have a statistically significant coefficient. However, as in earlier regressions, the belief that it is wise to start paying now for a risk reduction to be delivered starting at age 70 *is* positively and significantly associated with WTP.

Table 7. WTP for risk reduction starting from age 70.

Variable	Subsample I	Subsample II
Intercept	6.2084 (7.00)	6.9135 (9.72)
Male	-0.3984 (-0.97)	-0.2058 (-0.52)
Age group 35 to 39	0.7805 (0.92)	0.3827 (0.47)
Age group 40 to 44	0.1953 (0.26)	-0.2650 (-0.36)
Age group 45 to 49	0.4526 (0.66)	1.5758 (2.37)
Age group 50 to 54	-0.1081 (-0.14)	0.2959 (0.46)
Age group 55 to 59	0.8672 (0.11)	0.6306 (0.87)
Age group 60 to 64	0.3822 (0.38)	0.7435 (0.92)
Chance of surviving to age 70	0.0106 (1.08)	0.0045 (0.52)
Wise to pay now for risk reduction beg. at age 70	2.4620 (4.67)	2.6876 (5.90)
σ	2.1644 (10.60)	2.2179 (11.12)
Log likelihood	-245.95	-258.58

V. Further Extensions

The analysis of the pilot study results in Tokyo, together with the results of a small U.S. pre-test suggested a number of modifications of the survey instrument. Planning for the full-scale surveys to be conducted in Canada and the U.S., plus a follow-up survey in Japan suggests still other modifications. The most important are noted below:

1. To save money and standardize the survey, we have made the survey fully self-administered on a computer. Ancillary benefits are many, including: facility in targeting graphics and questions to the age and gender of the respondent; better graphics than are realistically possible with hardcopy; better comprehension of information presented by reinforcing the written text with voiceovers, so that respondents will both see and hear the questions. This last point is particularly important given point 2 below.
2. We will enlarge our sampling frame to include the 65-75 year age group. This age group was excluded in the Tokyo survey due to concerns about communicating probabilities and other concepts to this group. We have now heavily tested the survey with individuals in this age group with good success. Subjects in this group will be asked only the WTP questions for contemporaneous 10-year risk changes.
3. We will be including more extensive health status questions in the survey. These variables were rudimentary in the Tokyo survey, which may account for their lack of significance. We plan to use standard questions to describe the quality of life to aid in the estimation of a health status index in the literature.
4. We have developed additional education screens on the meaning of probability and risk of death. Specifically, we have added a series of questions to reinforce the time dimension of the risk changes, what we mean by risk of death and how risk changes with age, among other things.
5. Finally, our budget will permit the further development and administration of a CV survey identical to the one described in this section, but expressing mortality risk changes in terms of life expectancy changes. A comparison of results for both surveys should reveal which format is superior in eliciting internally and externally consistent responses.

VI. Conclusions

Mortality risk reductions associated with reduction in pollution are not easily valued. These mortality risks are generally realized later in life or by older people. Only one study to date (Johannesson and Johansson, 1996) has been able to incorporate the futurity characteristic and none have heavily sampled older people. In addition, CV studies of mortality risk present convincing evidence that small changes in probabilities are not being successfully communicated to respondents. Our work may eventually overcome these difficulties. Not only have we developed a survey instrument that focuses on mortality risks realized in the future, but the questionnaire is administered in-person with extensive use of visual aids. Tests of cognition are imbedded in the instrument. The new survey will be administered to seniors as well as younger people.

Our preliminary results from the Tokyo pilot indicate that individuals are able to distinguish between different magnitudes of small changes in mortality risks and between the same change in these risks occurring at different times (although the latter has not yet been subjected to an external scope test). Changes to the survey and a big increase in sample size may improve performance on the internal validity tests and the results of the scope tests. Although the current results can only be considered suggestive, if they were to remain after administration of the survey to a larger sample and subject to some other caveats, they would imply that the VSL's currently used in benefit-cost analyses of environmental policies are significant overestimates.

Examples of other caveats include the effect on WTP of involuntary exposure to risk and altruism. One could argue that our scenarios already involve involuntary exposure because a person's baseline risk is based on his age and gender (over which he obviously has no control) and then he is given the opportunity to take steps to reduce those risks. As for altruism, including the effect of altruism on willingness to pay would no doubt increase WTP above our estimates. However, including what is termed benevolent altruism (where an individual cares about other's utility) would lead to serious double counting of benefits, while including paternalistic altruism (where an individual cares about other's consumption) would not. Here one possible line of argument is that individuals view individuals outside of the family benevolently and view those inside the family paternalistically. In this case, our VSL estimates might be underestimates of adult VSL because their altruistic feelings towards other family members are not included.

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Discussion of Corso, Hammitt and Graham paper

by Lauraine Chestnut, Stratus Consulting

It was very reassuring that these external scope tests showed statistically significant differences in willingness to pay (WTP) for different magnitude risk changes when the visual aids were used. This suggests that: (i) WTP responses are sensitive to the quantitative information in the question, when this information is effectively communicated, and (ii) people can give sensible answers to sensible questions (it has been demonstrated that bad survey questions will give useless results--the question is whether good survey questions can elicit useful results).

WTP responses are expected to be different, but how big should the difference be? The authors assume that the difference should be proportional to the absolute difference in the magnitude of the risk change, but there may be others ways to look at this:

- The ratio of the absolute changes in risk for the two questions (2.5/10,000 to 1.5/10,000 versus 2.0/10,000 to 1.5/10,000) was 2, but as a percentage change from the baseline the ratio was 1.6. The ratios of WTP ranged from 1.4 to 2.0 when one of the visual aids was used. There is no particular reason why 2.0 is necessarily "right" and the other ratios "wrong."

- Something other than proportional WTP, however, does pose some problems for benefits transfer applications. How should we adjust WTP for risk changes other than those for which the original estimate was made? In practice we have been assuming proportionality, but this may not be correct.

It was interesting that the risk ladders gave smaller differences in WTP than the dots. It would be useful to try to understand possible reasons for the apparent differences in the effect of risk ladders versus dots in terms of communicating the magnitude of potential risk changes. A few apparent differences include:

- differences in the risk denominator (in the ladders was 10,000, but was 25,000 with the dots);

- the ladders gave much more information about the sizes of other kinds of risks as well as the auto risk in the WTP question, which might have dwarfed the difference between the two auto risk increments; and

- the dots and the ladders might differ in terms of how much they focus the respondent on the numerator versus the denominator in the risk numbers.

The survey included several questions that were not analyzed yet by the authors. It would be interesting to see how respondents' assessments of their own risk relative to the average risk affected their WTP. Do people take the average risk presented as their own or do they edit to their own circumstance and answer WTP accordingly? Another question is how does the subject's own assessment of their confidence in their WTP answer relate to the magnitude of their WTP answer and to the scope test? Some studies have been finding higher mean WTP for subjects who say they are confident in their answers. Perhaps the scope test would show stronger results for this group as well.

This paper reports a nice test of alternative visual aids, but there remain many difficult questions to address including:

- Respondents still have difficulties answering questions about small changes in risks. Is 1/10,000 the smallest they can handle? It seems that 1/1,000,000 is too small, although it may be relevant to some policy decisions. People do make daily decisions on such small risks (e.g., whether to walk to the light to cross the street or to save time and jay walk), but we have not found ways to make such choices credible to survey respondents.

- Fallacy of aggregation: each small risk (e.g. each air toxic reg.) may seem inconsequential to an individual answering a questionnaire, but the small risk changes may add up to something the public sees as significant when many environmental programs are considered together. Policy analysis requires that we assess the incremental costs and benefits of each policy decision, but is this how we should be asking questions to the public?

- Are WTP responses sensitive to differences in order of magnitude in the risk change presented? Risk changes bigger than 1/10,000 seem to bring smaller value of statistical life responses.

- Do baseline risk levels matter? Are people looking at percent change or absolute change when they assess the magnitude and value of the risk change? Studies have looked at some of these questions, but answers are unresolved.

Discussion of Krupnick, Alberini, Cropper, and Simon paper
by Steve Crutchfield, USDA Economic Research Service - Summarization

Mr. Crutchfield opened his remarks by discussing the responsibilities of his division, which focuses on food safety issues, most recently those involving pesticides and salmonella poisoning. The topic of valuation of risk reduction is thus one that is of great interest to his office.

Studying the risks to children raises interesting ethical issues. For example, suppose airbags were found to cause death to 300 kids, but save the lives of 1000 adults. Should we use them? The implicit question raised is, whose life counts?

The Krupnick paper is important and of particular interest to Mr. Crutchfield and his division, because it is an attempt to deal with latency issues. That is, how do we value the small probability of a very bad future outcome? Crutchfield was discouraged to hear that 32% of the people thought that 1/10,000 was greater than 5/1000, emphasizing that people have had trouble even comprehending let alone evaluating small risks. Therefore, the decision by Krupnick, et al. to ask the CV question in terms of a 10-year period was a good one. Mr. Crutchfield was encouraged by the thought given to exactly how to communicate the risk to respondents, which is crucial to the adequacy of results.

Mr. Crutchfield agreed that the biggest problem with existing approaches to valuation of statistical lives have to do with the inadequacy of the labor markets as analogs to the valuation of statistical lives by the general populace. The valuation of a statistical life of a group of middle-aged construction workers is not very generalizable to other sectors of the population.

Mr. Crutchfield expressed concern about whether we should be valuing strictly private goods. People are concerned about health risks in part because of the public nature of the risk. That is, some part of the willingness to pay for a risk reduction is the desire to also insulate others from the risk. Children's health generally is a good example, and the Alar example is salient also.[26] This can also be irrational – in the Alar example, a prominent actress made a TV commercial and vowed never to buy an apple again. At any rate, people have less ability to rationally handle risks to children. One solution may be to phrase CV questions so as to protect *households*, not children.

Finally, Mr. Crutchfield expressed some concern over how the nature of the death affects willingness to pay. Are automobile accidents a relatively easy way to die, as compared with a long, prolonged illness? The USDA has had to deal with this problem recently, as a pork parasite that causes dementia and other very bad and painful symptoms has cropped up. This has posed a different kind of challenge to his office.

[26] Alar is a pesticide applied to apples that was popularly feared to have exceptionally harmful effects on consumers, a fear that was later found to be exaggerated. Alar is often cited as an example of irrational fears of very low risks.

Policy Discussion for Session I

by Melonie Williams, US EPA Office of Economy and Environment

A significant component of my job is to provide technical assistance in the conduct of economic analyses to the Office of Ground Water and Drinking Water. Several proposed rules pursuant to the SDWA reduce the occurrence of cancer causing contaminants in drinking water supplies. Many of these cancers disproportionately affect older individuals, and the evidence suggests that there is some lag time between exposure to a carcinogen and manifestation of the cancer illness - what we in the agency have been calling the latency period.

As I mentioned at the start of this session, we generally use a value of a statistical life (VSL) point estimate of $5.8m based on estimates of WTP to reduce the risk of premature mortality from accidental death. Obviously, the characteristics of these risks and the characteristics of the populations studied are quite different from those associated with cancer risks, suggesting that the VSL estimates may over- or understate what affected individuals would be willing to pay to reduce these risks. This difficult benefits transfer problem has sparked considerable debate within the agency and among stakeholders.

In the absence of studies that directly value these types of risks, it has been suggested that we make partial adjustments to the current VSL estimates. The Office of Management and Budget (OMB) is forcefully arguing that we should discount VSL over an estimated latency period. Several stakeholders and public health scientists are arguing for the use of QALYs (quality-adjusted life years). Some have suggested procedures for age-specific adjustments. The Krupnick et al. study presented in this session suggests a direct procedure for accounting for latency and longevity. Failure to account for these factors, (age - in the case of an elderly affected population - latency, and quality of life) is thought to cause an upward bias in current VSL estimates.

From the pure economist's perspective of consumer sovereignty, it seems obvious that age and latency adjustments should be made. Nevertheless, this must be considered in its proper context. For example, it has been argued that making these adjustments accounts only for the upward bias that may exist in current VSL estimates. Discounting for time will reduce benefits estimates, and while age adjustments can go both ways, most of the age debate has focused on adjusting downward to account for an elderly affected population and fewer life-years lost. It is argued that making these adjustments ignores the possible downward bias in the current VSL estimates, and that making those adjustments may only serve to bias benefit estimates even more relative to the "true" value. Finally, we cannot ignore that there are equity and distributional issues involved here that spark passion in the political debate about whether or not to do them. For example, it has been argued that age adjustments violate constitutional rights to equal protection.

I have just recently begun studying this literature, but there appears to be some evidence that people place a premium on the value of avoiding the risk of a cancer death over the risk of an immediate accidental death. This premium may derive from disutility associated with dread, pain and suffering, and from periods of morbidity associated with protracted deaths. One survey study by Jones-Lee, Hammerton, and Phillips [1985] reports that mean willingness to pay to reduce anonymous cancer deaths in the following year was 3 times that of an equivalent reduction in anonymous traffic fatalities in that same year. They also found that the mean value of reducing cancer deaths was twice as high as that of reducing deaths from heart disease. Although this study doesn't assess WTP to reduce **own** risks, it suggests that people would be willing to pay more to reduce their risk of premature death from cancer than they would to reduce their risk of an accidental death.

What would be the net effect of a positive time preference and a cancer premium? In a survey study by Magat, Viscusi, and Huber [1996], respondents were presented with a choice between relocating to one of two towns that involved a tradeoff between increased auto fatality risk and increased lymphoma risk. Respondents indicated an indifference between avoiding the risk of an automobile accident and avoiding an equal risk of contracting non-curable lymphoma.

The survey instrument is silent regarding the timing of risks, so there are two possible interpretations. One is that people thought the timing of the risks and the health endpoints were identical and were indifferent to them, i.e., a death is a death is a death. This would imply that latent endpoints should be discounted. Alternatively, respondents may have considered a cancer latency period when formulating their response. The interpretation would then be that the present value of avoiding a cancer risk that would manifest in *n* years was considered by respondents to be approximately equal to the value of reducing the risk of dying in an auto accident over the next year.

It is an arguable point, but I believe it is more reasonable to assume that people considered some latency period when formulating their response. It seems unlikely, given all the information available about cancer, that people believe a change in exposure could manifest itself immediately in a cancer illness. In that case, this study suggests that a cancer premium may just offset the effects of discounting over the latency period.

Other evidence suggests that people may be willing to pay more to reduce risks that are involuntary and less controllable. This is interesting, but I believe these variables lie on some continuum and I'm not sure how we could quantify voluntariness and controllability in useful ways. Finally, sveral studies provide evidence that reductions in mortality risks are normal goods. This suggests that current estimates might be biased with respect to income, primarily because wage/risk studies examine a relatively narrowly defined segment of the population.

The upshot is that there may be counterbalancing sources of bias in current VSL estimates. To our knowledge, however, the only quantitative adjustments that have been proposed in the literature and that have shown up in final EPA reports are those that address the upward bias. Even these seem second-best at best; linear age adjustments do not capture the true nature of the relationship, and the appropriate procedure for discounting latent health effects is likely to be quite different from a simple financial calculation. Why do we focus on these particular quantitative adjustments? Does the literature not support quantitative adjustments along the lines I've just discussed?

We are trying to answer this question and are in the midst of evaluating the literature for evidence that can be used for partial adjustments in the benefits transfer. Nonetheless, this is the short-term solution. The long-term solution will be to value environmental risks more directly.

The studies presented in this session make significant advances toward using stated preference methods to affect that solution.
I have always been troubled, however, by the use of the abstract risk in the Krupnick et al. study. The authors state that being specific about the risk attributes may contaminate the results because some respondents may not believe the risk applies to them. I understand this concern. But, if we cannot be specific about the risk, and a death is not a death is not a death, how can we know that the values we elicit are appropriate for a given policy context?

I would like to throw that question out for open discussion, along with some additional questions we have at EPA.

Questions for Discussion

If we cannot be specific about the risk when eliciting values, how can we know that the values we elicit are appropriate for a given policy context?

A few new studies are ongoing at EPA (e.g., Schulze et al. presented in the next session). Are there others?

At what point can we be confident in using new studies? Is the required weight of evidence 26 new studies?

In the meantime, should we forge ahead and make those partial adjustments for which we have some empirical support, ignoring others? Or is the end result likely to be more biased than our initial estimates?

If not now, then at what point can we be confident in making partial adjustments? Where do we draw the line between acceptable second-best adjustments and unacceptable second-best adjustments?

The literature provides suggestions for adjusting to account for an older affected population. What should be done at the other end of the age spectrum, when a policy or regulation disproportionately impacts children?

How are other agencies valuing mortality risks?

The studies presented in this session suggest that proper risk communication requires costly survey modes. This may be prohibitively expensive. Can we think of cost-effective ways to adequately communicate risk information?

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Question and Answer Period for Session I

Matt Clark, US EPA Office of the Chief Financial Officer, asked Alan Krupnick, Resources for the Future, how the estimates of a value of a statistical life (VSL) of $70,000 to $100,000 can be two or three times the median income, and whether this casts some doubt on their validity. Mr. Krupnick responded that the bid amounts were actually small amounts, on the order of $100, and are expressions of the willingness to pay for a small change in risk. The value of a statistical life is a convenient means of measuring the value of a change in risk, which is obtained by dividing the bid amount by the change in risk. Mr. Krupnick stated that since the bid amounts were fairly small, income did not play a very large part in their expressions of willingness to pay. William Schulze, Cornell University, made the point that in fact theoretically, these VSL estimates may be too low, since the VSL can be much greater than income, and in fact greater than wealth at any given time.

Richard Belzer, Washington University, suggested that it would have been helpful to have a fuller discussion of the criticisms of the Office of Management and Budget (OMB) position on estimates of the value of a statistical life. Mr. Belzer felt that their rejection of certain components of valuations should have been characterized as "corrections" rather than as "piecemeal." Melonie Williams, US EPA Office of Economy and Environment, responded that this characterization was merely meant to distinguish these types of suggestions from direct elicitations of value. Bryan Hubble, US EPA Office of Air Quality Planning and Standards, remarked that Ms. Williams's point was that it is important to look for both upward and downward "corrections." Mr. Clark added that it is interesting that OMB never seems to suggest upward corrections. Mr. Belzer agreed, and stated that his broader point was that there are joint commodity problems, such in the case of cancer, where there is not only the death, but the unpleasantness of the process. Mr. Krupnick pointed out that there is a political aspect to this problem. One interesting aspect of his study was that after the survey, they told the respondents about the purpose of the survey, and how it is for purposes of valuing improvements in air pollution. Once respondents hear this, they express great enthusiasm, and say that they would have been willing to pay much more than their stated willingness to pay amount.

Al McGartland, US EPA Office of Policy, commented that a problem with using the study by Pope, et al. (1995)[27] to translate a change in pollution into terms of a change in mortality risk was that the study posed the hypothesized health endpoint as being of an immediate nature, not a future reduction in risk. From a regulatory aspect, of what relevance is a young person's current willingness to pay for a risk reduction at the age of 80? Should we not find an 80-year old and count backwards to determine the value of a reduction in risk at age 80? Otherwise, there is a danger of double-counting or oversampling older people. Mr. Krupnick responded that there are many aspects to this, but that the latency of the risk itself is a salient question, along with contemporaneous risk reduction questions.

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[27] Pope, C.A., M.J. Thun, M.M. Namboodiri, D.D. Dockery, J.S. Evans, F.E. Speizer, and C.W. Health, Jr. 1995. "Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults," *American Journal of Respiratory Critical Care Medicine* **151,** 669-674. The study was an attempt to determine the effects of particulate matter pollution on death rates.

F. Reed Johnson, Triangle Research Institute, pointed out that there are two separate problems being discussed here: one is the quality of risk communication, and the other is the quality of the risk valuation. With regard to the latter, the questions are: once we have instilled in respondents a higher degree of sophistication with regard to the hypothesized good, what do we learn from these "trained seals" that we create, and what do they tell us about the preferences of "real seals"? Mr. Krupnick responded that this is a fairly deep philosophical question, not necessarily an economic one. Mr. Krupnick noted that he had co-authored a paper with Maureen Cropper on the willingness to pay for the same good as in the Viscusi paper, but questioning some experts in addition to laypersons on their willingness to pay, trying to get at the differences between the two.

Mr. Hubble asked if researchers were imposing our own set of risks upon others, and secondly, whether we can obtain a valuation of the aggregate risk from adding up the willingness to pay for small risks. Mr. Krupnick responded to the second point by noting that this type of analysis is necessarily one of the margins. To broaden the applicability, it may be possible to redefine what the margin is for purposes of risk analysis. Phaedra Corso, Centers for Disease Control, commented that there was a recent (1998) article on Mr. Hubble's point in the journal Risk Decision and Policy, by Frederick and Fischoff.

Laurie Chestnut, Stratus Consulting, agreed that aggregation was a difficult issue, and cited the example of how a change in visibility due to a short-term emissions reduction was not necessarily perceptible, but that over ten years, the change was very large. Mr. Krupnick responded that this was a problem of defining clearly the regulatory proposal. Obviously the visibility change from regulating one power plant is imperceptible, which just means that we should not regulate only a single power plant. Ms. Chestnut also commented on the meaning of having a risk reduction take effect in the distant future. Mr. Krupnick acknowledged that much of the effect for seniors is in the area of contemporaneous reductions, and that this point was similar to one made by Mr. McGartland earlier. Mr. McGartland also pointed out that there was some conditionality about future risk reductions, in that respondents may not necessarily live to the age at which the risk reduction occurs. Mr. Krupnick emphasized that it this a matter of defining the correct risk reduction "good," so as to ferret out ancillary benefits or disamenities.

Clay Ogg, US EPA Office of Policy, posed a question of methodological approaches, asking how many contingent valuation (CV) studies should be done before one actually switched over to another approach. Mr. Ogg also opined that in choosing between credible estimates and goods matching the regulatory policy, it was more useful to have the credible results.

Amalm Mahfouz, US EPA Office of Water, suggested that in attempting to contend with the spectrum of ages and risks, perhaps it is better to ask older people who currently have some illnesses. A better measure of willingness to pay might be obtained by asking older people who currently have an illness what they would have been willing to pay earlier in life to avoid whatever malady they currently have. The broader point is that it is better to ask people with knowledge of the malady what their valuation is, rather than people with no knowledge whatsoever. Mr. Krupnick said he attempted to do this in a focus group, asking fully-informed subjects what they would have been willing to pay to avoid their current illness, but had trouble formulating meaningful questions that could be answered by the subjects.

Thomas Crocker, University of Wyoming, pointed out that in addition to eliciting values, it would be worthwhile to look at behavior of respondents, to see whether they already do things to insulate themselves from risk. Or, conversely, they may underestimate the risk because they fail to do things that other people do to avoid risk. Finally, Mr. Crocker made the point that there are distributional consequences of these policies, in that wealthier people have more ability to adapt. Mr. Krupnick agreed, but stated that this was not squarely a CV issue.