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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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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 <u>every</u> 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 <u>whether</u> EPA should act, and <u>what</u> 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.

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[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

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[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.

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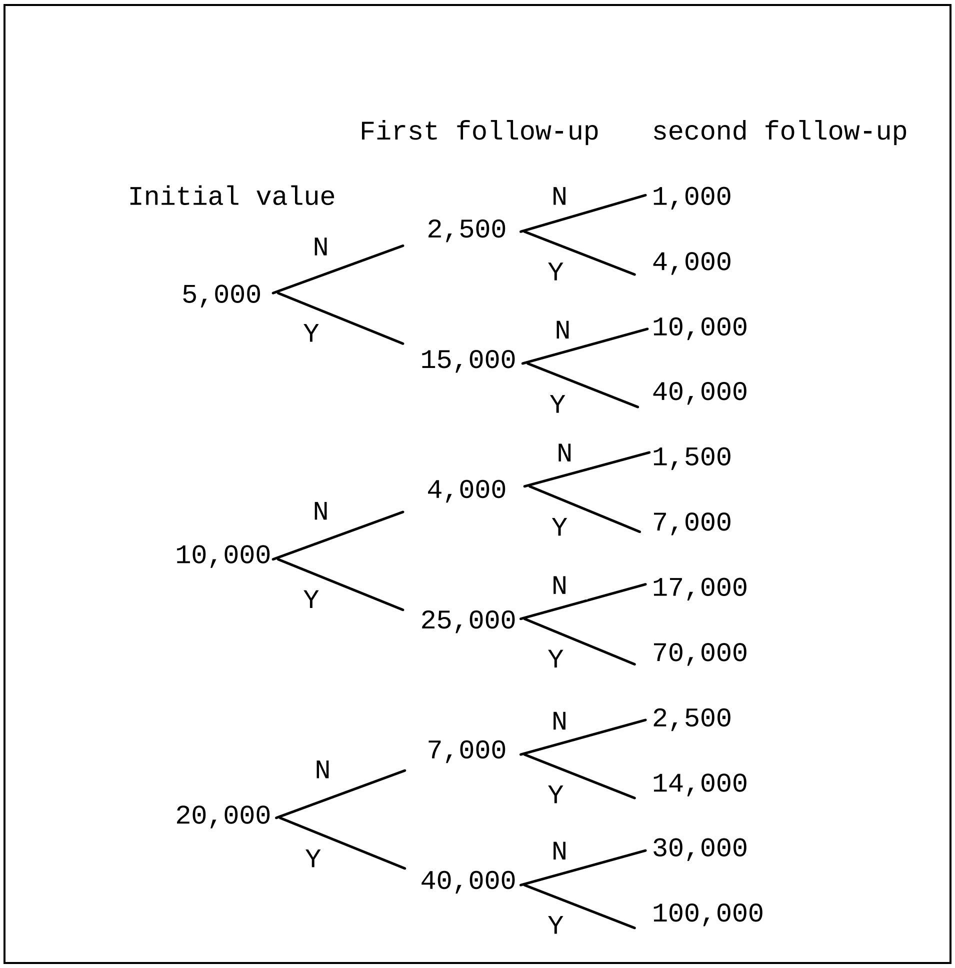
[22] As noted above, our current focus is persons 45 to 75 years old.

[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	13.3	
35-39	9.5	
40-44	14.9	
45-49	21.5	
50-54	17.7	
55-59	15.5	
60-64	7.6	
Housewife (%)	43	49
Self-employed (%)	31	46
Employed by others (%)	26	44
Household Income (million yen):		
Mean	8.31	4.10
Median	6.84	
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	14	
1/1000	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:

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

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 $\mathbf{x}$ 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.

[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.

June 1999

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

PROCEEDINGS OF THE SECOND WORKSHOP IN THE ENVIRONMENTAL POLICY AND ECONOMICS WORKSHOP SERIES

-- Session Two--

A Workshop sponsored by the
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Disclaimer

Proceedings for Session Two, Wednesday, March 24, 1999

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Introductory Remarks for Session II

by Chris Dockins, US EPA Office of Economy and Environment

I intend to make these introductory remarks rather brief. I have never been to a workshop, conference session, or seminar where people have left saying to themselves: "That was good, but I wish they had spent more time on the introductory comments."

My first thought when I was asked to introduce this session and to serve as moderator was "why me?" You may be wondering the same thing. I confess to not being heavily published in this field. I have, however, spent a substantial portion of my time over the last two years or so writing on the subject of health valuation for environmental policy. Melonie Williams – who offered the introduction and policy discussion for the morning session – Melonie and I work in the same office in EPA's Office of Policy. Our jobs, and those of our colleagues involve providing support to analysts elsewhere in the agency as they perform economic analyses. This is the context in which I and others at EPA have done a great deal of our writing: memoranda, explanatory notes, evaluating or proposing approaches for benefit analysis, reviews (by request) of ongoing benefits analyses. A major emphasis in this work is helping to apply existing valuation literature to the analysis of environmental policy actions.

There is no need for me to remind everyone here that EPA is facing new challenges in the economic analysis of health benefits, due in part to statutory requirements and other mandates. But a brief description of some of the Agency's efforts in support of the economic analysis of non-fatal health effects might be productive. My focus is on using values from revealed and stated preference methods rather than cost-of-illness figures. Cost-of-illness estimates still play a prominent role in our economic analyses for a number of reasons, but we recognize that estimates of willingness-to-pay are generally preferred. My purpose here is to provide some context for the "for Environmental Policy" portion of the workshop title, not to review many of the more technical issues surrounding morbidity risk valuation.

To begin with, I want to provide one illustration of how the agency has responded to increasingly available literature on willingness to pay values for non-fatal health effects. I admit that I am providing a time series sample of one, but the illustration, I think, is useful.

In 1983, EPA performed an extensive benefit analysis of the health effects from proposed new National Ambient Air Quality Standards. The benefit analysis looked at acute and chronic morbidity effects in addition to premature fatalities. Although the analysis clearly indicated, a preference for WTP value estimates for these effects, Volume II of the report notes specifically that there were no existing applicable values available in the literature. This limited the analysis to a second-best approach based on lost earnings, lost non-work time, and direct medical expenditures. The authors recognized that cost-of-illness estimates provide only a rough lower bound of benefits, and they performed plausibility checks to better understand the implications of this approach.

Compare this to work used in the 1997 EPA report *The Costs and Benefits of the Clean Air Act.* (Similar work was used in the benefit analysis of the 1997 NAAQS for particulate matter and ozone). Setting aside differences in available concentration-response and risk data, this report monetizes changes from nine distinct non-fatal health endpoints, not including a suite of hospital admissions. These conditions include chronic bronchitis, acute upper and lower respiratory symptoms, acute bronchitis, shortness of breath, and minor restricted activity days. The final report indicates that of these nine endpoints, all but one (work-loss days) utilized a value either directly from WTP studies or derived from WTP studies.

True, many of these symptoms are relatively minor – chronic bronchitis is the most severe – and the value of reduced mortality risks dominated the empirical results. But this is not always the case for EPA benefit analysis and, anyway, it misses the point. The fact is that as literature available to support practical economic analysis has grown EPA analysts have made earnest attempts to employ this literature. At least, we can conclude that from this limited sample.

I don't wish to overstate this conclusion. Some of the studies from which values were obtained are considered by some to be dated. There are also still problems with matching health effect values to endpoints affected by environmental polices, generally. This is not simply a matter of lacking estimates to work with – policy analysts always want more data. There are questions of how to apply existing work:

- to assess the suitability of existing estimates for use in benefits analysis
- to combine multiple valuation estimates for the same or similar effects
- to interpolate or extrapolate to health effects that differ from those in the original studies.

The economics literature is not ignoring these questions. Neither is EPA. A few other activities might provide additional context and illustrate the importance of this topic for EPA analysts.

Last year our office conducted an in-house survey to assess opinions regarding economic research priorities for the Agency. The survey collected information from a large number of EPA analysts involved in economic work. Aggregating across Agency offices, the greatest research needs appeared to be (1) improving methods to value changes in ecosystem form and function, and (2) valuing changes in morbidity risks.

Prior to this survey, EPA's Social Science Discussion Group (an internal workgroup) initiated an effort to produce a practical reference document for Agency analysts. This document, the *Handbook for Non-Cancer Health Effects Valuation*, now exists in a final draft form that has been subject to some external peer review. It should soon be available to analysts in a web-based format. Among many other things, the Handbook includes a summary of existing valuation estimates and devotes quite a bit of effort to issues associated with applying these estimates to environmental policies. The focus is on practical considerations in this benefit transfer exercise.

The increase in available WTP estimates for non-fatal effects – and in the need to incorporate these values into benefit analysis – has created a demand for work to support more careful consideration of how to apply them.

Historically, one constraint to fully utilizing valuation estimates for non-fatal health effects has been a lack of risk estimates commensurate with those often available for cancer risks. The use of "reference doses" approaches, for example, does not provide estimates of probability changes that economists can use directly. However, there have been some efforts at EPA to develop quantitative risk estimates for non-cancer health effects. Although the methods being explored cannot be implemented on a large scale right now, they may offer more to work with in the future.

I should note here that even in the absence of quantitative risk estimates, WTP values for morbidity effects may be valuable for performing analyses that supplement benefits assessments. Arsenic in drinking water, for example, is associated with a number of non-cancerous health effects (including kidney and liver damage, and vascular changes leading to hypertension), but the data do not support quantitative estimates of the number of potential cases. Estimates of value for these effects would at least allow for some breakeven or switch point analysis to inform decision makers.

Finally, analysts from across the agency are working with the newly-created Office of Children's Health Protection to explore how economics would estimate values for changes in the health status of children. A major concern for this group – and what may be a major concern for the agency – is related to chronic effects in children, including developmental and cognitive impairments. Of course, tomorrow's session will discuss some of these issues in more detail. I note this now simply to indicate the importance of valuation for other morbidity risks.

The papers presented in this session begin to address these, and other, concerns. The first paper, presented by Dr. William Schulze, serves as our segue from the previous session to this one, as well as a link to tomorrow's discussion. The paper also provides a break in the discussion of stated preference methods, obtaining valuation estimates from actual behaviors. This work, it should be noted was supported by EPA's Office of Air and Office of Policy.

The second paper, presented by Dr. Reed Johnson, assesses alternative – and combined – stated preference approaches to estimate WTP for components of health impairments. As an EPA economist I can appreciate that the work appears to be developed with benefit transfer applications to environmental policies clearly in mind.

Valuing Reduced Risk for Households with Children or the Retired

--Working paper*--

PRESENTED BY:
William Schulze
Cornell University

CO-AUTHORS:
Laurie Chestnut (Stratus Consulting)
Timothy Mount (Cornell University)
Weifeng Weng (Cornell University)
Hong Kim (Cornell University)

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Valuing Reduced Risk for Households with Children or the Retired[1]

Timothy Mount
William Schulze
Weifeng Weng
Hong Kim
(Cornell University, Ithaca, NY)

Laurie Chestnut
(Stratus Consulting, Boulder CO),

Paper prepared for the workshop on "Valuing Health for Environmental Policy with Special Emphasis on Children's Health Issues," March 24-26, 1999 in Silver Spring, Maryland.

Presenter: William Schulze, Department of Agricultural, Resource, and Managerial Economics, Cornell University, Ithaca, NY, 14853;
e-mail: wds3@cornell.edu; phone (607) 255-9611.

Section 1: Introduction

Little work has been done either theoretically or empirically to value morbidity and mortality either for children or retired adults. This paper addresses both of these issues by first presenting a theoretical model of how families value risk and then examining family automobile purchases. In particular, we show that parents may value risks to their children's lives and health (the model assumes two altruistic parents) through Nash cooperative bargaining to determine how much money to invest in the health and safety of their children. To allow empirical estimation of values, automobile safety is then shown to be a family public good, where the marginal investment cost of purchasing a safer automobile is set equal to the usage- weighted sum of the values of statistical life (VSL) of family members. We use data on automobile purchases to estimate how much families with children spend on automobile safety and how much families with retired members and no children spend on safety, for comparison to families without children or retired members. This allows estimation of an average value of a statistical life (VSL) for each type of family.

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Our research using secondary data is a preliminary effort to determine the feasibility of collecting a national data set to allow estimation of separate values for mortality and possibly morbidity for different family members from choices made concerning both the type of vehicle and usage pattern by family members. A major limitation of the secondary data we use here is that only the usage of weighted average statistical values of life per family member can be estimated for single car families. We examine families with different compositions to attempt to see if differences exist.

The paper is organized as follows: Section 2 presents a simplified theoretical model of family automobile purchase decisions focusing on safety and how safety values for each individual are determined in a family setting. Section 3 describes our empirical work estimating a hedonic price function for automobiles showing a positive association between risk of fatal accident and price as well as our estimates of average implied values of life for different family groups. Section 4 discusses anomalies in the hedonic price function that have been estimated here and by others. In addition, we present descriptive information concerning automobile safety that will become important for improving value estimates in future research. Finally, we summarize our findings and implications for future research in Section 5.

Section 2. Theoretical Issues

How willingness to pay (WTP) for health and safety may vary with the age of the person at risk is a very important policy question for which we have little well-established empirical data. Cropper and Freeman (1991) address this question with a life-cycle consumption-saving model that they apply with a quantitative example to examine how WTP for a risk reduction in the current time period can be theoretically expected to change over a person's lifetime. This model is based on the premise that a person makes consumption and saving decisions over time to maximize personal utility. Because this model is based on the premise that utility is a function of consumption, the authors note that if there is additional utility derived from survival per se, then the life-cycle model provides a lower bound estimate of WTP. The quantitative example depends on assumptions regarding a lifetime pattern of earnings, endowed wealth, the rate of individual time preference, and other parameters of the model. These will all vary for different individuals, and uncertainty exists empirically about population averages for many of these factors. However, using reasonable values to calibrate the model is illustrative. Cropper and Freeman note that if consumption is constrained by income early in life, the model predicts that VSL increases with age until age 40 to 45, and declines thereafter. Shepard and Zeckhauser (1982) also illustrate this point with numerical examples for the life-cycle model. When they estimate the model with reasonably realistic parameters and assume no ability to borrow against future earnings or to purchase insurance, they find a distinct hump in the VSL function with a peak at around 40 years and dropping to about 50% of the peak by 60 years. When they allow more ability to borrow against future earnings and to purchase insurance, the function flattens and at 60 years drops only to 72% of the VSL at age 40. However, the hump shape to the VSL over a person's lifetime remains.

The conclusions reached by these theoretical analyses of the effect of age on WTP for mortality risk reduction using the life-cycle model are somewhat consistent with the empirical findings obtained by Jones-Lee et al. (1985). However, the empirical findings show that WTP varies with age much less than would be predicted by the life-cycle models. In this stated preference study, respondents gave WTP estimates for reductions in highway accident mortality risk and the answers showed a fairly flat hump-shaped relationship between VSL and age, peaking at about age 40. Although the directions of the changes in WTP with age are consistent with what the life-cycle models predict, the magnitudes of the changes are smaller. The Jones-Lee et al. results show that at age 65 the VSL is about 90% of the VSL of a 40-year-old person.

It is often suggested that WTP will be lower for the elderly than for the average adult because expected remaining years of life are fewer. This expectation is based on the presumption that WTP for one's own safety declines in proportion to the remaining life expectancy. Some analysts have suggested that effects of age on WTP might be introduced by dividing average WTP per statistical life by average expected years of life remaining (either discounted or not) to obtain WTP per year of life (Miller, 1989; Harrison and Nichols, 1990). Such a calculation implies very strong assumptions about the relationship between life expectancy and the utility a person derives from life; namely, that utility is a linear function of life expectancy. Although this might be correct, it is also plausible that this calculation will result in significant understatement of

WTP for the elderly. An understatement could result for a number of reasons. One is that there may be a value to being alive that is independent of the amount of time one expects to live. Another is that as one ages, the remaining time may be more highly valued than it was in midlife. In fact, the retired are now often characterized as “healthy and wealthy.”

Determining appropriate WTP values for changes in mortality risks to children poses some particular analytical challenges. Children are not the economic decision makers whose preferences can be analyzed to determine an efficient allocation of society's resources regarding their own health and safety, so both revealed and stated preference approaches must rely on parental decisions to show what WTP for children's health and safety might be. Based on the expected relationship between WTP and expected life-years lost, it may be reasonable to assume that reductions in risks to children are valued equal to or greater than risks to adults. On the other hand, the life-cycle consumption-saving models show increasing WTP for risk reductions between the ages of 20 and 40, reflecting the typical pattern of increasing income and productivity during this stage of life. Extending this to children might suggest lower WTP for reducing risks to children, however, this pushes beyond the theoretical constructs of the life-cycle model regarding an individual as an economic decision maker. The only theoretical model which addresses these concerns, with respect to dependent children, has been developed by Chestnut and Schulze (1998). Their work treats the case of a family with non-paternalistic altruistic parents who engage in Nash cooperative bargaining to determine health and safety expenditures on their children and the implied VSL. We use this model as a starting point for our analysis.[2]

[2] It should be pointed out that some interesting revealed preference empirical approaches based on a household production function framework to analyze household expenditure decisions as they relate to children's health have been attempted (Agee and Crocker, 1996; Joyce et al. 1989). These analyses infer implicit WTP for changes in children's health as revealed by expenditure decisions of the household. Limitations in available data and analytical difficulties in properly specifying and verifying modeled relationships pose challenges for this approach; however, its basis in actual household decisions and behavior is an important strength. Estimates of WTP for changes in mortality risk for children are not directly available from these two studies, but similar approaches might be applied to obtain such WTP estimates.

Given the state of existing research, our first task is to develop a model that can potentially explain the behavior of households with dependent children. This model is developed in the context of automobile safety to allow empirical estimation of an appropriate family VSL, since the existing theoretical literature only considers individuals rather than families, with the exception of the work by Chestnut and Schulze mentioned above. Our work here paraphrases this earlier work and adds a hedonic market for automobile safety.

We begin by considering the case of a single individual with no family who may, or may not, survive for a single period. The following notation will be useful:

c = consumption,

w = wage income,

r = risk of a fatal automobile accident,

Π = probability of survival without automobile fatality risk,

Π-r = probability of survival with automobile fatality risk,

H(Π) = health expenditures (increasing in Π),

P(r) = automobile price (decreasing in r), and

U(c) = strictly concave utility function.

Note: subscripts denote derivatives where appropriate.

The individual must make two choices. First, the baseline probability of survival, Π, is chosen subject to the constraint that increasing Π increases health expenditures, H(Π), consequently reducing both consumption, c, and money available for purchasing a car, P. Similarly, the individual chooses how risky a car to drive, r, taking into account that lower r implies that the price of the car, P(r), is greater. Investments in health, Π, and automobile safety, reducing r, are chosen prior to realizing whether or not the individual will survive. The individual is assumed to maximize expected utility,

(1) $(\Pi\text{-r})U(c)$,

where the death state provides no utility because the individual has no family, subject to the budget constraint,

(2) $(\Pi - r)(w - c) - P(r) - H(\Pi) = 0.$

This budget constraint assumes that costless insurance (available for expected value) is available both to cover the purchase price of the automobile, P, and initial health and other safety investments, H. Most car loans, in fact, carry life insurance for the amount of the loan, and life insurance could presumably cover the costs of other health and safety investments. The optimal choice of Π is then determined by

(3) $H_{\Gamma} = VSL,$

and, the optimal choice of r is determined by

(4) $-P_r = VSL,$

where,

(5) $VSL \equiv (U/U_c) + w - c.$

Equation (3) sets the marginal health cost of increasing the odds of survival equal to the value of the individuals statistical life (VSL) while equation (4) sets the marginal increase in price for purchasing a safer car equal to the VSL as well. The VSL is defined in (5) for the case of perfect insurance markets and is equal to the monetized value of utility, (U/U_c), which is lost in death, plus the excess of earnings over consumption. The interpretation of this relationship is much clearer in the family setting that we treat below, so we will defer discussion.

The model developed above can readily be extended to a family setting by using the Nash cooperative bargaining between parents approach employed by McElroy and Horney (1981).

Following our previous work (Chestnut and Schulze, 1998), we modify the notation used above, again considering a single car family (the case we analyze empirically), as follows:

n = the size of the family,

$i = 1, 2, \ldots, n$ denotes individual family members,

$i = m = 1$ denotes the mother,

$i = f = 2$ denotes the father,

$i = k = 3, \ldots, n$ denotes children,

c_i = consumption of the ith family member,

w_i = wage of family member i,

r = automobile fatality risk, the same for all family members,

Π_i = probability of survival, excluding automobile fatality risk, of i,

$H(\Pi_1, \ldots, \Pi_n)$ = family health expenditures (increasing in Π_i),

$P(nr)$ = automobile price (decreasing in total family risk, nr),

$U^k(c_k)$ = child's utility function,

$U^i(c_i; \ldots, (\Pi_k - r)U^k(c_k), \ldots)$ = parent's utility function ($i = m, f$), and

E^i = bargaining threat point of expected utility in divorce ($i = m, f$).

The family must decide how much to allocate to each family member for consumption, spending on the health of each (and in so doing select survival probabilities), and on the safety level of the single automobile they purchase for all. Note that the demand for driving is inelastic in this model, since the only driving choice is over the risk of the chosen automobile. The hedonic price function for the automobile is now taken as P(nr) so that the total family risk level determines the price of the car. All of the existing hedonic price analyses of automobile safety use total fatalities per year for a vehicle model divided by the total number of that model on the road as the risk variable. Thus, the risk measure is not divided by occupancy (n in this theoretical model). It is, in fact, plausible to suppose that it is more expensive to increase the safety for each of four passengers than for one, so this assumption may be reasonable.

The utility functions of both the father and mother are assumed to depend not only on their own consumption, but also on the expected utilities of each of their children. The children's utility is assumed to be solely a function of their own consumption.

Investment in the safety and health of their children is a public good to the parents, which is the subject of negotiation, as is the level of consumption of each. The Nash cooperative bargaining model assumes that the solution maximizes the multiplication of the increase in the expected utility of the outcome over the threat point expected utility in divorce for the mother and the father. The threat points are assumed, in models of the family, to be a function of divorce laws, job opportunities, etc. Thus, in the Nash cooperative bargaining solution,

$$(6) \qquad [(\Pi_m\text{-}r)U^m(c_m;..,(\Pi_k\text{-}r)U^k(c_k),..)\text{-}E^m]\ [(\Pi_f\text{-}r)U^f(c_f;..,(\Pi_k\text{-}r)U^k(c_k),..)\text{-}E^f],$$

is maximized with respect to c_i, Π_i , and r, subject to the budget constraint,

$$(7) \qquad \sum_{i=1}^{n} \Pi_i(w_i - c_i) - P(nr) - H(\Pi_1,\ldots\ldots, \Pi_n) = 0.$$

The resulting conditions for allocating health expenditures and survival probabilities take the form:

$$(8) \qquad H_i = U^i/U^i_c + w_i - c_i \equiv VSL_i \qquad i = 1,\ldots\ldots,n.$$

The remarkable fact is, that, in spite of the complicated structure of the problem specified above, the implied VSL_i for each family member shown in (8) is identical in form to that for the single individual shown in (5) above. The interpretation of the VSL_i can be illustrated with the following examples. Imagine that the mother is the sole breadwinner with a stay-at-home father. In this case, assuming that the children are young, $w_i - c_i < 0$ for the other family members and $w_m - c_m > 0$ for the mother. Thus, if the mother were to die, this would be a severe financial blow to the rest of the family and the mother's VSL would reflect this relative to the VSL of other family members. For young children it is clear that $w_k - c_k < 0$ in the short run. However, in the inter-temporal version of the model, $w_k - c_k$ is replaced by its discounted present value, which may be positive. U^i/U^i_c depends solely on c_i in the single period model and on the lifetime consumption pattern in the full inter-temporal model. The important point is that the child's consumption depends in youth on the parents' income and wealth. Further, if parents find the value of their child's smile to be high enough, the child's consumption will be maintained, by them, at a high level, leading to a high VSL. A young child's utility may also be large from relatively small levels of financial consumption, also leading to a high VSL. These arguments suggest that the VSL of children is a purely empirical question and depends not only on their own life cycle wealth but also on their family's wealth.

Finally, the choice of automobile risk, r, is determined by

$$(9) \qquad -nP_r = \sum_{i=1}^{n} VSL_i.$$

Thus, the safety of the shared family vehicle is determined by a public good condition which sets the marginal cost of obtaining a safer vehicle for each individual equal to the sum of the VSLs of individual family members. The slope of an estimated hedonic price function for automobile safety is $-P_r$, which, by (7), is equal to the average VSL for the family, $\sum_{i=1}^{n} VSL_i/n$. Thus, if we examine P_r for different households with a single car, we can obtain estimates of the average value of life for those households. However, the average is a weighted average where the weights are determined by each family member's use of the vehicle.

Section 3. The Hedonic Model of Implied Average Values of Statistical Life for Different Families.

The econometric model used here is based on the work of Rosen (1974), Atkinson and Halvorsen (1990), and Dreyfus and Viscusi (1995) on hedonic pricing.

Atkinson and Halvorsen (1990) use the data for 112 models of new 1978 automobiles to obtain estimates of the VSL. Since the available fatality data is a function of both the inherent risk of the vehicle and the driver's characteristics, the drivers' characteristics are included in the regression as control variables. The VSL is calculated based on WTP. Their estimated VSL for the sample as a whole is $3.357 million 1986 dollars.

The data used in Dreyfus and Viscusi (1995) differ from those used in earlier studies in that they reflect actual consumer automobile holdings. Dreyfus and Viscusi (1995) use the 1988 Residential Transportation Energy Consumption Survey together with data from industry sources. They generalize the standard hedonic models to recognize the role of discounting on fuel efficiency and safety. The estimates of the implicit value of life range from $2.6 to $3.7 million and the estimates of discount rate range from 11 to 17 percent.

We utilized both the industry data source of the vehicle attributes and the households' choice of automobiles to estimated the willingness-to-pay for changes in the risks of mortality and to derive the per capita value of statistical life for different types of households. The hedonic price equation can be written, following Atkinson and Halvorsen (1990):

$$(10) \qquad P_{auto} = f(R, A),$$

where P_{auto} is the price of automobile, R is the inherent mortality risk associated with the automobile, and A is a vector of other characteristics. The available mortality data, F, is a function of both R and a vector of the involved driver's characteristics D. Assuming that F is monotonic in R, equation (1) can also be written as:

$$(11) \qquad P_{auto} = g(F, A, D),$$

The function form used for the estimation is

$$(12) \qquad \log(P_{auto}) = \alpha_0 + \sum_k \alpha_k \log(X_k) + e,$$

where X_k is a representative regressor and e is an unobserved residual.

The 1995 National Personal Transportation Survey (NPTS) is used to obtain information on the household's choice of automobiles. 1995 NPTS was conducted by the Research Triangle Institute (RTI) under the sponsorship of the U.S. Department of Transportation (DOT). The survey covers 42,033 sampled households. A sub-data set of 4036 one-car households holding a 1990-1995 model year vehicle were merged with vehicle attribute data collected from industry and other sources for the same years. The vehicle price data is gathered from *NADA Official Used Car Guide,* and other attribute data is collected from *NADA Official Used Car Guide*, *Ward's Automotive Yearbook*, and *Consumer Reports*, respectively. The vehicle mortality rate is measured by the number of fatalities occurring in each make/model/year vehicle per 1000 of that vehicle sold. The number of fatalities is based on the information from the U.S. Department of Transportation's Fatality Analysis Reporting System (FARS) for calendar year 1995-1997. For model year 1990-1994 vehicles, the average of the FARS 1995 and 1996 fatalities is used, while for model year 1995 vehicles, the average of the FARS 1996 and 1997 fatalities is used. Since the mortality rate is jointly determined by the inherent mortality risk associated with the automobile and the driver's characteristics, a vector of driver's characteristics is also included in the model to provide control variables. The variables of driver's characteristics are gathered from FARS 1995-1997. The variables used are summarized in Table 1, while Table 2 shows the descriptive statistics of selected vehicle attributes. The selection of vehicle attributes and driver's characteristics is similar to Dreyfus and Viscusi (1995) and Atkinson and Halvorsen (1990).

Least square estimates of the log linear model are presented in Table 3. Two equations are estimated separately. The first equation omits fuel economy, while

Table 1. Variable Definition

Variable Name	Definition
Price	Vehicle price as of end-of-year 1995.
Value Retained	Original sales value retained, as of end-of-year 1995.
Mortality Rate	Number of fatalities occurring in that make/model/year vehicle per 1000 of that vehicle sold.
City Fuel-efficiency	Miles per gallon in city area.
Reliable Rating	A discrete variable coded from 1 to 5, 5 is the highest while 1 is the lowest.
Acceleration	The horsepower-to-weight ratio.
Traditional Styling	Length plus width divided by height.
ClassX	Discrete variables coded as 1 for the appropriate class. Class1 to class7 represent small, middle, large, luxury, SUV, van, and pick-up truck, respectively.
YearXX	Discrete variables coded as 1 for the vehicle model year.
Young Driver	Proportion of fatalities in this make/model/year vehicle in which the driver was younger than 25 years.
Older Driver	Proportion of fatalities in this make/model/year vehicle in which the driver was 45 or older.
Alcohol	Proportion of fatalities in this make/model/year vehicle in which the alcohol involvement was reported.
Gender of Driver	Proportion of fatalities in this make/model/year vehicle in which the driver was male.
Seat Belt	Proportion of fatalities in this make/model/year vehicle in which the driver was wearing a seat belt.
Previous Offenses	Proportion of fatalities in this make/model/year vehicle in which the driver had no previous offense.
Late Night	Proportion of fatalities in this make/model/year vehicle which occurred between 12:00am to 5:59am.
One-car Accident	Proportion of fatalities in this make/model/year vehicle in which only one vehicle was involved.

Table 2. Descriptive Summary of Selective Variables

Variable	Mean	Standard Deviation
Price	15703.53	9371.57
Value Retained	0.7720	0.1753
Mortality Rate	0.1345	0.0994
City Fuel-efficiency	20.26	4.82
Reliable Rating	3.019	1.321
Acceleration	0.0475	0.0102
Traditional Styling	4.451	0.519

Table 3. Parameter Estimates

Variable	Model 1 Estimated Coeffiecent	Model 1 Standard Error	Model 2 Estimated Coeffiecent	Model 2 Standard Error
Constant	8.7815	0.2268	12.0281	0.2557
Value Retained	0.4974	0.0530	0.5224	0.0456
Mortality Rate	-0.0525	0.0084	-0.0348	0.0072
City Fuel-efficiency	…	…	-0.9421	0.0480
Reliable Rating	0.0855	0.0128	0.1388	0.0113
Acceleration	0.3227	0.0421	0.2158	0.0366
Traditional Styling	0.6176	0.0943	0.3036	0.0827
Class2	0.2624	0.0200	0.0754	0.0197
Class3	0.4112	0.0349	0.1312	0.0332
Class4	0.8388	0.0272	0.5354	0.0281
Class5	0.7817	0.0318	0.1935	0.0406
Class6	0.6518	0.0314	0.1878	0.0359
Class7	0.2802	0.0312	-0.1093	0.0334
Year91	0.1076	0.0232	0.1032	0.0199
Year92	0.2095	0.0258	0.2063	0.0222
Year93	0.3099	0.0293	0.3122	0.0252
Year94	0.3859	0.0325	0.3909	0.0279
Year95	0.4618	0.0353	0.4675	0.0303
Young Driver	0.0237	0.0373	0.0471	0.0321
Older Driver	-0.0223	0.0306	-0.0369	0.0263
Alcohol	0.0585	0.0364	0.0421	0.0313
Gender of Driver	0.0520	0.0284	0.0076	0.0245
Seat Belt	-0.0054	0.0276	0.0015	0.0238
Previous Offenses	-0.0048	0.0293	-0.0179	0.0252
Late Night	0.0362	0.0406	0.0216	0.0349
One-car Accident	0.0217	0.0287	0.0065	0.0246
R^2	0.8311		0.8752	

the second equation includes that variable. All coefficients of vehicle characteristics are significant at the 99 percent significance level. None of the coefficients of driver's characteristics is significant at the 95 percent significance level. Since driver's characteristics should be included as control variables based on the model structure, they are kept in the model.

Model 2 shows the negative sign for the coefficient of fuel economy. Since keeping all other vehicle characteristics constant, it should cost more to produce a more fuel-efficient engine, and since consumers would be less willing to pay for a car with poor fuel economy, the sign of the coefficient is wrong. Comparison between Model 1 and Model 2 also shows that the coefficient on mortality rate is not robust. In fact, adding more regressors into the model drives the coefficient of mortality rate down. Since our main purpose is to compare the differences of per capita value of statistical life (VSL) among different types of households, both models presented in Table 3 are used to illustrate the effects of the different specifications.

The estimated VSL is:

(13) $$VSL = \frac{\beta_m \, price}{\text{mortality rate}} / \left(\sum_{t=1}^{L} \left(\frac{1}{1+r} \right)^t \right),$$

based on the NPTS data for the household's choice of automobiles, where r is the discount rate, set to 10 percent, L is the remaining vehicle life. The expected life of vehicle is set as 6 years. The means of estimated per capita VSL for different types of households, based on the estimates of Model 1 and 2, respectively, are presented in Table 4. From Table 4, we can see that the means per capita VSL are very similar for different types of households, which leads to the conclusion that the value of a statistical life for children and seniors may not differ appreciably from that of other age groups.

Table 4. The Mean of Estimated Per Capita Value of Statistical Life (VSL) for Different Types of Households

Household Category	VSL based on Model 1 (million)	VSL based on Model 2 (million)
Grand Mean	2.730	1.809
Household No One Retired/No Kid	2.729	1.808
Household With Kids	2.643	1.751
Household With Retired Member/No Kid	2.811	1.862

Section 4. Empirical Evidence about Automobile Safety

Since the estimated coefficient for safety in the hedonic price equation is not robust to changes in the specification of the model, it is important to consider how the model can be improved. One of the main limitations of the standard single-equation specification is that the effects of the vehicle's physical characteristics are confounded with the characteristics and behavior of the family or individual that uses the vehicle. Although it is quite reasonable to consider that a safer vehicle would cost more to buy, using actual fatality data to measure safety is dependent on driving behavior as well as the physical characteristics. This is illustrated in Table 5 which reports relative death rates per vehicle year for different types of vehicle (values < 100 indicate fewer fatalities than average). In most categories of vehicle, larger vehicles have lower fatality rates. For luxury vehicles, the rates for the medium and large sizes are essentially identical, but for sports cars, the rate for medium sports cars is substantially larger than it is for small sports cars. This is likely to reflect the behavior of the drivers of sports cars as much as it does the physical safety of the vehicles.

Table 5: Relative Annual Death Rates of Drivers and
Passengers by Type of Vehicle, 1991-5

	Sports	2 door	4 door	Luxury	Wagon, Minivan	Sports Utility	Pickup
Small	146	154	135	-	112	174	-
Medium	191	120	88	62	63	81	153
Large	-	81	74	65	52	60	106

100 is average
< 100 implies fewer fatalities than average
> 100 implies more fatalities than average
Source: Insurance Institute for Highway Safety, September 1997

To clarify this situation, one should distinguish between 1) the probability of having an accident that involves at least one fatality and 2) the probability of surviving in such an accident. The probability of having an accident is definitely influenced by driving behavior and is probably influenced by the vehicle's characteristics as well. The probability of survival, on the other hand, is definitely influenced by the physical characteristics of the vehicles involved in the accident, and possibly by the characteristics of the driver and the occupants (e.g. very young children and very old people may be less able to recover from injuries). These issues are illustrated in Table 6 by the average survival rates for different ages of the occupants of vehicles in which at least one fatality occurred.

Table 6: The Average Survival Rates for Occupants of Vehicles
by Year and Age Group (Percent)

Age	All Accidents			≥ 1 Occupant is		
	1995	1996	1997	1995	1996	1997
≤5	67	66	67	67	66	67
6-15	67	68	69	77	77	77
16-21	48	49	48	71	69	69
22-24	42	42	43	66	67	64
25-64	31	31	31	58	59	58
≥ 65	24	23	22	26	31	35

Every observation has at least one fatality in the vehicle.

Source: Fatality Analysis Reporting System, US Department of Transportation

In general, the survival rates by age group in Table 6 are highly consistent across years. For All Accidents, the survival rates for young children (≤5 years old) are much higher than they are for other age groups. For the oldest age group (≥ 65 years old), the survival rate (22%-24%) is only one third of the rate for young children (66%-67%). However, most accidents do not involve young children. To provide an alternative comparison across age groups, the corresponding survival rates for accidents with at least one very young child as an occupant are also shown in Table 6. Hence, these alternative rates are more representative of the survival rates of different age groups relative to the survival rates for children ≤5 years old. Using this measure, children from 6-15 have the highest survival rates, and the rates decline with age after that, but they are higher than the corresponding values for All Accidents. The rates for people ≥ 65 years old (26%-35%) are substantially lower than all other age groups. These results provide some evidence that people ≥ 65 years old are more vulnerable to fatalities in an accident. It should be pointed out, however, that these differences in survival rates may reflect the choice of seat (e.g. children are more likely to travel in the rear seat than adults) as well as the medical susceptibility of the individuals to injuries.

The information in Table 7 provides some evidence about the relative safety of different seats in a vehicle. Using data on accidents with a fatality, vehicles were selected in which there was a driver, at least one front seat passenger and at least one rear seat passenger. Hence, the values in Table 7 represent the survival rates when all three types of occupant were involved in an accident simultaneously. Once again, the survival rates are consistent across years. Passengers in the rear seats have substantially higher survival rates than people in the front seats, and passengers in the front seat have slightly lower survival rates than the drivers.

Table 7: Survival Rates in Accidents with a Fatality*
by the Location of the Seat of the Occupant

Type of Occupant	1995	1996	1997
Driver	62	62	61
Front Seat Passenger	58	61	61
Rear Seat Passenger	70	70	69

*At least one of every type of occupant is in each vehicle.

Source: Fatality Analysis Reporting System, U.S. Department of Transportation

The evidence about the effects of the characteristics of the driver on safety is more complicated to interpret. The average survival rates for different age groups (the same as Table 6) from 1995-1997 are broken down by the age and gender of the driver in Table 8. The expectation was that the survival rates for occupants would be lower when young male drivers were involved, for example. However, there are no consistent differences between male and female drivers in Table 8. Nevertheless, the survival rates are substantially lower for children and young adults when the drivers are also young (25 years old) and highest when the drivers are old (≥ 65 years old). For older occupants, the lowest survival rates correspond to the same age group as the driver, presumably because many of the accidents involve only a single occupant/driver.

Table 8: Survival Rates of Occupants by the Age and the Gender of Driver, 1995-1997 (Percent)

		Age and Gender of Driver					
		Male			Female		
Age	All drivers	24	25-64	≥65	24	25-64	≥65
5	67	62	69	80	61	68	83
6-15	68	61	72	84	63	72	86
16-21	49	47	70	78	44	72	88*
21-24	42	37	61	87*	39	67	43*
25-64	31	48	29	59	47	31	66
≥65	23	20	28	23	24	25	22

*Less than ten fatalities reported
Source: Fatality Analysis Reporting System, U.S. Department of Transportation

The previous discussion shows that actual fatality rates vary by the age of the occupant, the location of the seat of an occupant and the age of the driver. The first attempt to develop an objective measure of vehicle safety, that was independent of driving behavior, was to use standardized crash data from the Consumers Union. These data simulate the severity of the injuries to occupants from hitting a wall at 35 mph. While data show the expected higher safety for larger cars, they also give a relatively low rating for Sports Utility Vehicles (SUV) even though these vehicles are generally larger than most cars. The standard crash tests correspond to head-on collisions between two identical vehicles, and consequently, the accidents simulated in the crashes are more severe when the vehicles are heavier. One reason for driving a large SUV is to gain a safety advantage over other vehicles in an accident. A good measure of safety for different vehicles should reflect the characteristics of a "typical" accident, and in this respect, an SUV should have a relatively high safety rating.

A more promising approach to developing an objective measure of safety is to try to isolate the effects of the physical characteristics of the vehicles from the driving behavior using regression techniques with the actual fatality data. The first step was to select accidents that involved two vehicles (from the seven categories of private vehicles discussed in the previous section). The objective of the model was to predict the survival rate of the occupants in one vehicle, using the physical characteristics of that vehicle and of the "other" vehicle as explanatory variables. In addition, the characteristics of the driver and of the occupants are also likely to be important as explanatory variables. The general form of the regression equation can be written as follows for an accident involving vehicles i and j:

$$S_i = f(W_i/ W_j, G_i, G_j, O_i)S_{ij} + e$$

where S_i is the survival rate for vehicle i

S_{ij} is the survival rate for both vehicles combined

W is the weight

G is a vector of other physical characteristics

O is a vector of occupant characteristics

e is an unobserved residual

The multiplicative form of S_{ij} in the equation is designed to reflect the severity of each accident. If all occupants in both vehicles in an accident are killed, then all survival rates are zero and $S_{ij} = S_i = S_j = 0$.

Preliminary results using this type of model are encouraging. The signs of coefficients are logical and the magnitudes are estimated relatively accurately. Weight is clearly an important factor, and the survival rates of occupants in small vehicles are much lower if they hit a large vehicle rather than another small vehicle. When the final form of the equation has been selected, it will be used to predict the survival rates for individual vehicles hitting an average vehicle in a typical accident. Under this scheme, small vehicles will be at a relative disadvantage in the simulated accident, but large vehicles, like an SUV, will be heavier than the average vehicle, and therefore, the corresponding predicted survival rate will be relatively high. This will provide a clear link between safety and the weight of a vehicle. Hence, the ambivalent role of the weight of a vehicle in a standard model of the hedonic price of a vehicle can be clarified. Although heavier vehicles are safer, they are likely to be more expensive to buy and more expensive to operate, because they are less fuel-efficient. The implications of these different relationships will be explored in more detail as part of the next component of our research.

Section 4. Conclusions

Our analysis in the preceding sections, while encouraging for our proposed national survey of automobile usage, points out some important potential difficulties.

First, from the theoretical model of Section 2, it is apparent that we must collect data on usage by individuals, by automobile type, to estimate fraction of usage by age (child, adult, or senior) for multiple car families.

Second, since risk differs depending on seating position, these data must be collected as well.

Third, the role of weight in vehicle safety must be explored further. Since such attributes as safety, interior room, cargo space, and fuel economy are all correlated with vehicle weight, no reliable estimate of marginal cost of safety can be identified from the hedonic price function until a likely simultaneous equation bias problem is solved.

Finally, although considerable theoretical speculation exists that the value of a statistical life should differ by age, we find little support for this hypothesis in our preliminary analysis.

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Willingness to Pay for Air-Quality Related Health Improvements: A Multiple-Format Stated-Preference Approach

--Working Paper*--

PRESENTED BY:
F. Reed Johnson
Triangle Economic Research

CO-AUTHORS:
Melissa Ruby (University of North Carolina at Chapel Hill)
William Desvousges (Triangle Economic Research)

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A Multiple-Format Stated-Preference Approach

F. Reed Johnson*

Melissa C. Ruby**

William H. Desvousges*

* Triangle Economic Research
** University of North Carolina, Chapel Hill

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1000 Park Forty Plaza
Suite 200
Durham, NC 27713

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Phone: 919-544-2244
Fax: 919-544-3935
E-mail: frj@ter.com

Abstract

This study uses stated preference (SP) analysis to measure willingness to pay to reduce acute episodes of respiratory and cardiovascular ill health. The SP survey employs a modified version of the health-state descriptions used in the Quality of Well Being index. The four health-state attributes are symptom, episode duration, activity restrictions, and cost. Preferences are elicited using two different SP formats: graded-pair and discrete-choice. The different formats cause subjects to focus on different evaluation strategies. Combining two elicitation formats yields more valid and robust estimates than using only one approach.

We obtain estimates of indirect utility function parameters using advanced panel econometrics for each format separately and jointly. Socioeconomic differences in health preferences are modeled by allowing the marginal utility of money relative to health attributes to vary across respondents. Because the joint model captures the combined preference information provided by both elicitation formats, we use these model estimates to calculate willingness to pay.

The results demonstrate the feasibility of estimating meaningful WTP values for policy-relevant respiratory and cardiac symptoms, even from subjects who never have personally experienced these conditions. Furthermore, because WTP estimates are for individual components of health improvements, estimates can be aggregated in various ways depending upon policy needs. Thus using generic health attributes facilitates transferring willingness-to-pay estimates for benefit-cost analysis of a variety of potential health interventions.

Willingness to Pay for Air-Quality Related Health Improvements: A Multiple-Format Stated-Preference Approach

The economic analysis of many health-intervention and regulatory programs often requires evaluating the benefits of improved health. Obtaining credible measures of the economic value of morbidity, however, is one of the more difficult problems facing health economists. The existence of insurance, universal health-care systems, and market participants that are unrepresentative of the population of policy interest often obscure essential supply-and-demand relationships. Thus, revealed-preference information generally has proven to be an insufficient basis for obtaining policy-relevant values of human health. In addition, studies which use contingent valuation (CV) are not well suited to valuing multiple health-state attributes. Health economists increasingly are turning to stated-preference (SP) approaches as an alternative.[3]

This study demonstrates the feasibility of applying SP techniques to elicit values for health conditions described in terms of symptom, activity restriction, and duration. Furthermore, by combining two SP elicitation methods, graded-pair and discrete-choice, the estimates presented in this study are more valid and robust measures of benefits than could be obtained from a single format. Our results demonstrate the sensitivity of results to the symptoms being considered as well as to the activity restrictions associated with those symptoms. Subjects clearly indicate systematic preferences for milder morbidity effects over more severe ones. These preferences translate into WTP estimates that vary logically with severity.

SP methods evolved as market-research tools for evaluating consumer behavior and predicting sales of new products (Cattin and Wittink, 1982; Wittink and Cattin, 1989). SP recently has been applied in environmental and health economics as an alternative to CV methods.[4] Viscusi, Magat, and Huber (1991) and Krupnick and Cropper (1992) (using the Viscusi data) use SP analysis to elicit a value from subjects for reducing chronic health risks. Other SP studies have elicited preferences for other health and health-care attributes, including Ryan, McIntosh, and Shackley (1998), Chakraborty, Gaeth, and Cunningham (1993), Ryan and Hughes (1997), Bryan et al. (1997), and Van der Pol and Cairns (1998), and Propper (1995).

In this study, specified health states consist of multiple attributes. We presume that people have preferences for different levels within these attributes and are willing to accept some trade-offs among them. The utility obtained under different health states is derived from the revealed trade-

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[3] Terminology has not been standardized among various disciplines. In this study, we use the term "stated preference" to refer to a group of techniques used primarily in market-research studies to measure consumer preferences. The term "conjoint analysis" also has been used to describe some of these techniques. Although contingent valuation also could be called a SP technique, CV was developed independently by environmental economists and generally relies on a different set of elicitation formats and analytical approaches.

[4] In the resource economics literature Gan and Luzar (1993) use SP to value hunting trips in Louisiana. Mackenzie (1993) values hunting trips in Delaware using SP analysis. Opaluch et al. (1993) also use SP to describe public preferences for siting a noxious facility. Adamowicz, Louviere, and Williams (1994) and Adamowicz et al. (1997) use SP to explain recreational site choice selection. Johnson et al. (1995) use SP to estimate electric customers' willingness to pay for environmental and other attributes of electricity generation. Roe, Boyle, and Teisl (1996) use SP to value the effects on sport fishing of implementing alternative management plans to restore runs of Atlantic salmon in Maine.

offs.[5] By including a cost attribute, we can use the implicit marginal utility of money to scale changes in health-state utility in monetary units.

SP Elicitation Formats

Two types of SP analysis lend themselves to valuing health effects.[6] The first, *graded pairs*, measures subjects' valuations of variations in attributes by requiring them to evaluate trade-offs among various attributes. In a graded-pair format, subjects sequentially are presented with several different pairs of bundled commodities, represented as sets of attribute levels, and asked to compare each pair. They are asked to rate the intensity of their preference for one of the pairs on a numerical scale, say from 1 to 7, where 1 indicates a strong preference for the first bundle, 7 indicates a strong preference for the second bundle, and 4 indicates indifference between the two bundles. The subject is asked to rate a series of these pairs, with each pair having different attributes or attribute levels. (See Viscusi, Magat, and Huber, 1991, for an example of this approach in valuing bronchitis risks.)

Discrete choice, in contrast, confronts subjects with several different products or programs simultaneously and simply asks them to identify the most-preferred alternative in the choice set.[7] As with the graded-pair approach, each commodity is described as a set of attributes. However, the subjects do not provide a rating of the intensity of their preferences. Typically, each subject is shown a series of these choice sets to evaluate.[8]

Each of these SP approaches has its advantages and disadvantages. The graded-pair format provides intensity-of-preference information and thus is statistically more efficient than the discrete-choice method which simply elicits commodity preferences. Graded pairs also are somewhat easier to design and provide opportunities to check on subject attentiveness and coherence of expressed preferences (Johnson and Desvousges, 1997; Johnson, MacNair, and Fries, 1997). However, graded pairs are more cognitively difficult than choices, requiring subjects to identify which profile they prefer and the degree to which they prefer it. Furthermore, graded pairs may require more complex statistical analysis to account for variations in the interpretation of the scale across subjects (Johnson and Desvousges, 1997). Finally, when graded pairs do not include a constant alternative across repetitions, the data may not be clearly linked to an unambiguous welfare reference point needed for benefit-cost analysis.[9]

Choice-format questions avoid these problems at the cost of statistical efficiency and perhaps less depth in preference searching. Discrete choices can be less burdensome to subjects, depending upon the number of alternatives and the number of attributes in a given choice set. Also, discrete-choice formats conventionally include a status-quo, or "opt-out", alternative in every choice set (Olsen and Swait, 1997). This status-quo option provides an unambiguous reference point for

[5] Defining the properties of such preferences has been explored by multiattribute utility theory (Keeney and Raiffa, 1978). For an application to health-state utility, see Torrance, Boyle, and Harwood (1982).

[6] A third format, *ranking*, has also been used in market research. For a more extensive review of experimental design possibilities, see Green, Tull, and Albaum (1988).

[7] For a review of choice experiments in marketing applications, see Carson et al. (1994).

[8] This approach has been used in modeling travel behavior, evaluating new products, and estimating recreation demands. See, for example, Louviere and Hensher (1982). Health studies which use this approach include Bryan et al. (1997), Propper (1995), and Ryan and Hughes (1997).

[9] Roe, Boyle, and Teisl (1996) use a graded-pair format with a constant reference alternative. However, including such an alternative diminishes the statistical efficiency of the graded-pair format.

welfare changes. Finally, some researchers (Louviere, 1988; Olsen 1992) have argued that a discrete-choice task, in contrast to graded pairs, corresponds more closely to how real-world decisions are made and thus is a better predictor of choice. However, other researchers disagree (Huber et al., 1993) and suggest that the graded-pair approach, because it provides a more intense searching of preferences, can predict choice better than discrete-choice formats. Elrod, Louviere, and Davey (1992) found that both graded-pair and choice formats predicted choices equally well for a conventional market good.

Huber et al. (1993) argue that each format has relative merits because each relies on a different cognitive process for eliciting preferences.[10] The different formats cause subjects to focus on different evaluation strategies. The graded pairs encourage thinking about the value of marginal tradeoffs among attribute levels. In contrast, the choice task encourages subjects to eliminate alternatives that are unacceptable for a particular attribute. Real-world behavior exhibits both of these strategies. Indeed, Huber et al. have found that employing more than one elicitation format may predict choice better than using one format alone, simply because each format requires different heuristics and may provide only a partial picture of preferences. In this study, we have adopted this approach and apply both graded-pair and discrete-choice formats to estimate joint WTP estimates.

Table 1 shows the levels associated with each attribute in the two SP formats. The experimental design consists of main-effects, nearly orthogonal arrays of 40 graded pairs and 40 choice sets using the attribute levels in Table 1. Given subjects' practical time and attention constraints, we administered eight graded pairs and eight choice sets to each subject, each set of which was drawn randomly from five design blocks.

Graded-pair and discrete-choice sp questions

The survey was administered by computer, and Figure 1 shows an example of a graded-pair screen. In this example, the price is expressed as illness-related costs.[11] The subjects indicate their preferences for Condition A versus Condition B. The complete SP exercise presents a series of these graded pairs to subjects and records their ratings. Because there is no unambiguous baseline reference point in the graded-pair questions and no health conditions with zero cost, the graded-pair questions are designed to obtain information on marginal trade-offs among health attributes and costs.

[10] See also Huber (1997), Tversky, Sattath, and Slovic (1988), Payne (1976, 1982), and Huber and Klein (1991) for discussion of the different cognitive processes involved in graded-pair versus choice tasks.

[11] The payment vehicle for both formats is described as illness-related costs that are not covered by the government health system or a company insurance plan. These costs are associated with items that reduce discomfort or the length of illness (such as vitamins, medicines, air filters or humidifiers, special foods or liquids, or other optional treatments). These costs also may include such costs as child care while sick or transportation to the doctor. Subjects were instructed to assume that any missed time from work would be covered by paid sick leave.

Table 1. Attribute and Attribute Levels Shown in Graded-Pair and Discrete-Choice Comparisons

ATTRIBUTE	LEVEL	DESCRIPTION		
Symptom	Nose	Stuffy/runny nose and sore throat		
	Eye	Eye irritation		
	Flutter	Fluttering in chest and feeling light-headed		
	Breath	Coughing, wheezing, shortness of breath		
	Ache	Coughing or wheezing with fever, chills, or aching all over		
	Swell	Shortness of breath, and swelling in ankles and feet		
	Pain	Pain in chest or arm		
Duration		**1**	**5**	**10**
		1-day episode	5-day episode	10-day episode
Daily Activity	NoLim	You can go to work, go to school, do housework, participate in social or recreational activities, and have no physical limitations.		
	SomeLim	You can go to work, go to school, do housework, and participate in social or recreational activities, but you have some physical limitations (trouble bending, stooping, or doing vigorous activities) because of this health condition.		
	NoSoc	You can go to work, go to school, do housework, but you have some physical limitations (trouble bending, stooping, or doing vigorous activities), and cannot participate in social or recreational activities because of this health condition.		
	AtHome	You cannot leave your house, go to work, go to school, do housework, participate in social or recreational activities, and you have some physical limitations (trouble bending, stooping, or doing vigorous activities) because of this health condition, but you can care for yourself.		
	NeedHelp	You cannot leave your house, go to work, go to school, do housework, participate in social or recreational activities, and you need help caring for yourself (feeding, bathing, dressing, toilet) because of this health condition.		
	InHosp	You are in hospital and need help caring for yourself (feeding, bathing, dressing, toilet).		
Annual Costs (Canadian $)	**Graded-Pair**		**Discrete-Choice**	
	$10		$50	
	$25		$100	
	$50		$200	
	$100		$300	
	$200		$500	
	$500		$750	

Figure 1. Example of Graded-Pair Question

Category	Condition A	Condition B
Duration of Episode	5 days	1 day
Symptoms	Eye irritation (itching, burning, redness)	Pain in chest or arm
A. Daily Activities	• CAN go to work, go to school, do housework • CANNOT participate in social or recreational activities • Have SOME physical limitations • CAN care for yourself	• CANNOT leave your house, go to work, go to school, do housework, and participate in social or recreational activities • Have SOME physical limitations • CAN care for yourself
Total costs of this episode to your household	$50	$200

1	**2**	**3**	**4**	**5**	**6**	**7**
A is much better	A is somewhat better	A is slightly better	A and B are about equal	B is slightly better	B is somewhat better	B is much better

Please press a number from 1 to 7 that best reflects your rating.

Figure 2 illustrates the discrete-choice format used in this study. The discrete-choice format directly elicits total values for movements from a given diminished health state to the subject's current health state. The left-hand profile consists of a relatively severe hypothetical initial condition with zero cost. Alternatives A and B represent two courses a subject could choose if experiencing the initial condition. Alternative A portrays a condition of intermediate severity and intermediate cost. Alternative B is described as the subject's current health-state on the day of the survey with a relatively high cost. In essence, subjects can choose to remain in a relatively severe condition and not pay any additional costs for treatments outside the government health plan or insurance plan, or they can choose to pay for additional treatments to improve their health to their current health state.

Figure 2. Example of Discrete-Choice Question

Category	Initial Condition	Alternative A	Alternative B
Duration of episode	5 days	1 day	Your level of health as it is today. You do not experience this episode.
Symptom	Shortness of breath and swelling in ankles and feet	Shortness of breath and swelling in ankles and feet	
Daily Activities	• Are in hospital • Need help caring for yourself	• CANNOT leave your house, go to work, go to school, do housework, or participate in social or recreational activities • Have SOME physical limitations • Need help caring for yourself	
Additional costs to your household	$0	$300	$500

1	2	3
Prefer Initial Condition	Prefer Alternative A	Prefer Alternative B

Please press a number from 1 to 3 that best reflects your choice if faced with these options.

Unlike the graded-pairs section, the conditions that subjects evaluate must be related to obtain meaningful values. Therefore, while this format has the advantage of obtaining values for changes in health relative to an identified reference point, it potentially has the disadvantage of reducing the salience of the symptom attribute if subjects focus on changes in other attributes. Furthermore, the structure of the choice experiment assumes that subjects can exchange money for specified health improvements. For most people in the general population in good health, the choice sets include two options worse in health attributes and better in cost than current health, as intended. However, some subjects' current health may be worse than one or both of the hypothetical alternatives. In such cases, at least one of the options would be preferred, or dominant, in all of the attributes, and thus choices would reveal less information about trade-off relations.

The final survey instrument was developed through extensive pretesting, including two focus groups, three pretests, and a large-scale pilot test. The survey incorporates several state-of-the-art features including a computerized format, an information treatment with quiz questions, and detailed health-history questions. The instrument was administered to 399 randomly recruited subjects in the Toronto area between March and July 1997. Each subject answered 16 graded-pair or choice questions.

Analysis of Graded-pair Data

Graded-pair responses are ordinal ratings of utility differences between attribute-level pairs. Estimation strategy thus should account for the discrete, ordinal nature of the response variable. In this section, we describe a general model for estimating subject utility functions from such data and a procedure for calculating marginal WTP using the estimated utility functions.[12] We assume that individual indirect utility can be expressed as a function of commodity attributes and personal characteristics:

$$U^i_{st} = V^i(X_{st}, Z^i, P_{st}; \beta^i, \delta^i) + e^i_{st} \qquad \textbf{(1)}$$

where:

- U^i_{st} is individual i's utility for commodity profile st, where s = L, R, denoting the left-side and right-side profiles for pair t, and t = 1,...,8
- $V^i(\cdot)$ is the nonstochastic part of the utility function,
- X_{st} is a vector of attribute levels in profile st,
- Z^i is a vector of personal characteristics,
- P_{st} is the cost of the commodity profile,
- β^i is a vector of attribute parameters,
- δ^i is the marginal utility of money, and
- e^i_{st} is a disturbance term.

The utility difference for profile pair t, dU^i_t, is simply:

$$dU^i_t = V^i_{Rt} - V^i_{Lt} + \varepsilon^i_t \qquad \textbf{(2)}$$

where V^i_{Rt} and V^i_{Lt} are the indirect utilities associated with the right-side and left-side profiles, respectively, and $\varepsilon^i_t = e^i_{Rt} - e^i_{Lt}$ is the associated disturbance term. The disturbance term captures the effects of unobserved factors, including possible inherent ambiguity of subject preferences and cognitive errors.

The difference in indirect utility for commodity pair t, dU^i_t, often is specified as a simple linear function of attributes:

$$dU^i_t = V^i_{Rt} - V^i_{Lt} + \varepsilon^i_t = \left[\sum_h \beta_h \cdot X_{hRt} + \delta \cdot P_{Rt}\right] - \left[\sum_h \beta_h \cdot X_{hLt} + \delta \cdot P_{Lt}\right] + \varepsilon^i_t \qquad \textbf{(3)}$$

where h indexes attributes. This specification assumes that attributes neither are substitutes nor complements for each other, so a change in the level of one attribute does not affect the marginal utility of any other attribute.[13]

[12] The first social-science application of this approach was by McKelvey and Zavoina (1975). For a recent application to environmental and health valuation, see Johnson and Desvousges (1997).
[13] See Keeney and Raiffa (1978) for an analysis of the properties of such utility functions.

The effects of personal characteristics on utility differences do not appear in Equation (3) because subject personal characteristics do not vary between the left and right sides of the screen. Controlling for such variables requires interacting them with commodity attributes or prices that do vary between profiles. For example, we can estimate the marginal utility of money as a function of individual characteristics Z^i and employ a functional form that allows for diminishing marginal utility of money.

$$\begin{aligned} dU^i_t &= V^i_{Rt} - V^i_{Lt} + \varepsilon^i_t \\ &= \left[X_{Rt} \cdot \beta + (Z^i \cdot \gamma) \cdot \sqrt{P_{Rt}}\right] - \left[X_{Lt} \cdot \beta + (Z^i \cdot \gamma) \cdot \sqrt{P_{Lt}}\right] + \varepsilon^i_t \end{aligned} \quad \textbf{(4)}$$

where γ is a vector of marginal-utility-of-money parameters.[14]

Similarly, the β coefficients on attributes also could be allowed to vary across subjects by making them functions of individual characteristics. It also is possible to employ more general nonlinear specifications of continuous attribute variables or interactions among attribute variables.

We do not observe dU^i_t directly. Instead, we observe C^i_t, which is a discrete rating category related to the unobserved dU^i_t of interest. The appropriate approach, therefore, is ordered logit or probit, which incorporates both the discreteness and the natural ordering of the data. This study uses ordered probit which assumes the error term is normally distributed. To estimate ordered-probit models, the data are sorted so that the preferred profile is on the right, making $dV^i_t = V^i_{tR} - V^i_{tL} \geq 0$.[15] We construct the rating categories by recoding responses accordingly, so that 0 indicates indifference and 3 indicates maximum difference.[16] Because probit assumes the Equation (3) error term ε^i_t is distributed $N(0,\sigma^2)$, the probability of observing response C^i_t is:

$$\text{Prob}(C^i_t = k) = \Phi\left[\mu^i \cdot \left(\alpha_k - dV^i_t\right)\right] - \Phi\left[\mu^i \cdot \left(\alpha_{k-1} - dV^i_t\right)\right] \qquad k = 0,1,..,3 \quad \textbf{(5)}$$

where Φ is the cumulative standard normal distribution function, the α_k are threshold constants, and scale parameter μ^i is the inverse of the standard deviation.[17]

Because the health-valuation survey collects eight responses from each subject, it is appropriate to estimate a panel model that accounts for correlated errors in each subject's series of ratings. A random-effects model incorporates an individual-specific error term, so that

$$\varepsilon^i_t = \eta^i_t + \lambda^i \quad \textbf{(6)}$$

[14] The square root form was chosen over linear or log by estimating a Box-Cox model.
[15] This procedure assumes that subjects have no systematic preference for screen location.
[16] Because the original response scale indicates both which profile is preferred and how much it is preferred, this rearrangement maps response 3 into 5, 2 into 6, and 1 into 7. Response 7 indicates maximum utility difference and 4 indicates indifference, so C^i_t equals the recoded response minus 4.
[17] The maximum-likelihood procedure used to estimate the model parameters normalizes the α_o threshold at $-\infty$ and α_5 at $+\infty$ and does not include an intercept term.

where η^i_t is a common error term, and λ^i is an individual-specific error term distributed $N(0,\rho^2)$. Equation 5 now becomes

$$\mathrm{Prob}(C^i = k^i_1, k^i_2, \ldots, k^i_8) = \int_{-\infty}^{\infty} \phi(\lambda^i) \cdot \prod_{t=1}^{8} \left\{ \Phi\left[\mu^i \cdot \left(\alpha_{k_t} - dV^i_t\right)\right] - \Phi\left[\mu^i \cdot \left(\alpha_{k_t - 1} - dV^i_t\right)\right] \right\} \; d\lambda^i \qquad \textbf{(7)}$$

where $\phi(\lambda_i)$ is the normal probability density function for λ_i.[18]

Most ordered-category data contain no information on how scale might vary across subjects, and thus it usually is normalized uniformly to one. However, graded-pair data include multiple observations for each subject, and thus it is possible to obtain scale estimates. We can account for nonuniform scale by letting ε^i_t vary across subjects so that $\varepsilon^i_t \sim N(0,1/\mu_i^2)$.[19] Alternatively, we can make μ_i a systematically varying parameter that is a function of personal characteristics Y^i, such as income and education, so that $\varepsilon^i_t \sim N[0,1/\mu(Y^i)^2]$.

Estimating individual scale parameters provides a means of quantifying the coherence of individual rating patterns and of controlling for different levels of variance in subjects' error terms. Subjects who refuse to solve or have difficulty solving the utility-difference problem and who enter random or repetitive ratings will have unusually noisy ratings and thus larger estimated variance. Scale estimates thus provide a means of testing whether groups of subjects are experiencing problems with the survey design. The consistency of a subject's rating pattern can vary by degree of attentiveness, quantitative orientation, age, educational background, susceptibility to fatigue, and other factors. In addition, we can identify individual subjects who may have failed to perform the rating task properly. Finally, individual scale estimates help account for differences in how subjects interpret and use the 0-to-3 rating categories. Some subjects may be reluctant to use the entire range of ratings, which is a common problem in graded-pair elicitations (Mackenzie, 1993).

Analysis of Discrete-Choice Data

The SP survey also included a series of choice judgments with three alternatives in each choice set. The linear specification of utility analogous to Equation (4) for the three alternatives is:

$$\begin{aligned} U^i_{jt} &= V^i_{jt} + \varepsilon^i_{jt} && \equiv X_{jt} \cdot \beta + (Z^i \cdot \gamma)\sqrt{P_{jt}} + \varepsilon^i_{jt} && j = 1, 2 \\ U^i_{jt} &= V^i_0 + \delta^i_t + \varepsilon^i_{0t} && \equiv H^i \cdot \omega + (Z^i \cdot \gamma)\sqrt{P_{jt}} + \varepsilon^i_{jt} && j = 3 \end{aligned} \qquad \textbf{(8)}$$

where U^i_{jt}, j = 1, 2, is the utility of each of the two alternative health profiles, and U^i_{jt}, j = 3, is the utility of the current-health alternative. V^i_0 is the subject's status-quo health-state utility, H^i is

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[18] See Butler and Moffitt (1982) for derivations used in estimating this model.

[19] The way to generalize μ in a probit-type model is to retain the normalization for the base category that $\mu^i_o = 1$. For all other categories, $\mu^i_k = \mu^i$ is modeled as a function of individual characteristics. This guarantees that the estimated value of μ will be positive for every observation and that α_k adjusts to account for the normalization of the base category.

a vector of health-history variables, and ω are associated parameters. Other variables were defined previously.

Assuming ε follows a type-one extreme-value error structure, the probability that alternative j will be selected from choice set t is the standard conditional-logit expression:

$$\mathrm{Prob}(C_t^i = j) = \frac{\exp(\mu^i \cdot V_{jt}^i)}{\sum_{k=1}^{3} \exp(\mu^i \cdot V_{kt}^i)} \tag{9}$$

where C^i_t is the selected alternative in each of 8 choice sets, μ^i is the scale parameter, and V^i_j is the determinate part of the utility of alternative j.[20] Thus, the probability that an alternative will be selected is the ratio of the utility that alternative provides relative to the sum of the utility that each alternative in the choice set provides. Note that individual characteristics fall out of this expression unless interacted with health attributes. The scale parameter μ^i also generally is not identifiable in such models and is normalized at one. However, because we have multiple observations for each subject, we can estimate $\mu^i = \mu(Z^i)$.

Like the ordered-probit analysis described above, the conditional logit model specified by Equations (6) and (7) is estimated using maximum-likelihood. That is, given the characteristics of the alternatives in the choice sets presented to subjects, the model estimates coefficients that maximize the likelihood that we would observe the actual choices in the sample. Thus, the coefficients show the relationship between the probability of selecting an alternative and the health attributes of that alternative.

Conditional logit models are known to be subject to violations of the irrelevance of independent alternatives assumption (IIA). This condition requires that the ratio of probabilities for any two alternatives be independent of the attribute levels in the third alternative. Tests of the choice data indicate that conditional logit estimates do not satisfy this requirement. Under these conditions, parameter estimates are biased. Furthermore, conditional logit does not account for correlations within each subject's series of choices. Revelt and Train (1998) recently have proposed using random-parameter logit (RPL) for SP data similar to ours. RPL is not subject to the IIA assumption, accommodates correlations among panel observations, and accounts for uncontrolled heterogeneity in tastes across subjects.

Modifying Equation (8) to introduce subject-specific stochastic components for each β:

$$U_{jt}^i = V_{jt}^i + \varepsilon_{jt}^i \qquad \equiv X_{jt} \cdot (\beta + \eta^i) + (Z^i \cdot \gamma)\sqrt{P_{jt}} + \varepsilon_{jt}^i \tag{10}$$

Equation (9) now becomes:

$$\mathrm{Prob}\left[C^i = \left(C_{i1}^i, C_{i2}^i, \ldots C_{i8}^i, \right)\right] = \prod_{t=1}^{8} \left[\frac{\exp\left[\mu^i \cdot V_{jt}^i(\beta *)\right]}{\sum_{k=1}^{3} \exp\left[\mu^i \cdot V_{kt}^i(\beta *)\right]} \right] \tag{11}$$

[20] The basic exposition of the properties of this model can be found in McFadden (1981).

where now $\beta^* = (\beta + \eta^i)$. In contrast to conditional logit, the stochastic part of utility now may be correlated among alternatives and across the sequence of choices via the common influence of η^i. McFadden and Train (1997) show that any random-utility model can be approximated by some RPL specification.

Calculating Willingness to Pay

Estimating the parameters of the utility function enables us to quantify the value of changes in commodity attributes. The units of the estimated utility index essentially are arbitrary. However, this arbitrary measure can be converted into a dollar metric using the estimated marginal utility of money. Let X^o_j indicate the status quo vector of attribute levels. In our case, this corresponds to the subject's current health state. The cost of X^o_j is P^o_j, which we take to be zero. X^*_j indicates a changed vector of attribute levels corresponding to a given combination of symptom and activity level. The willingness to pay for a given change in commodity attributes (X^*_j - X^o_j) is the amount of money (P^*_j - P^o_j) that would leave subject i indifferent between the payment and the change in attribute levels, so that P^*_j satisfies

$$V^i[X^*_j, Z^i, P^*_j; \beta^i, \delta^i(P, Z^i)] = V^i[X^o_j, Z^i, P^o_j; \beta^i, \delta^i(P, Z^i)] \qquad \textbf{(12)}$$

In the linear specification of Equations (3) and (9), the β coefficient for each attribute represents its constant marginal utility. The negative of the coefficient of the price attribute is interpreted as the marginal utility of money, or the utility derived from more dollars. Thus,

$$WTP^i(X^*_j - X^o_j) = \frac{\sum_h (X^*_{hj} - X^o_{hj})\, {}^{\partial V^i}\!/\!_{\partial X_{hj}}}{-\partial V^i / \partial P} = \frac{\sum_h (X^*_{hj} - X^o_{hj})\beta^i_h}{-(Z^i \cdot \gamma) / (2 \cdot \sqrt{P})} \qquad \textbf{(13)}$$

where h indexes attributes.

Allowing the marginal utility of money to vary with personal characteristics allows for differences in tastes to affect the relative utilities of health and money, even though the β_j parameters are constant across subjects. This specification facilitates transferring WTP estimates to populations with different demographic characteristics than our sample. Thus, because WTP estimates are obtained by dividing the health coefficients by the marginal utility of money, changing values of the personal characteristics included in the utility of money function affects the WTP estimates.

Any payment less than or equal to $WTP^i(X^*_j - X^o_j)$ leaves individuals at least as well off as they would be if the change (X^*_j - X^o_j) had not occurred. Because we recover the parameters for a complete utility index, WTP can be constructed for any utility difference, assuming that the marginal utility of money is constant for all utility differences of interest.[21]

Graded-Pairs estimates

Table 2 contains the definitions of the variables used in all analyses in this study. Attributes are effects-coded rather than dummy-variable coded, so the omitted categories NOSE and NOLIM are the negative sum of the included symptom, interacted with the log of duration, and activity

[21] Because utility is a nonlinear function of price, WTP is a function of some assumed price level. The WTP calculations reported below incorporate average price combinations that occur with different symptom/activity levels.

categories.[22] The daily activity restriction levels represent the additional disutility of experiencing these restrictions compared with experiencing no limitations (NOLIM). We report both nominal and normalized coefficients. The normalized coefficients rescale the health index from zero to one, with the INHOSP coefficient equal to zero (worst) and the NOLIM coefficient equal to one (best).

The graded-pairs experimental design precludes particular attribute combinations from appearing in the paired comparisons in order to make the bundles more credible to subjects. For example, the relatively mild symptoms "Stuffy/runny nose and sore throat" (NOSE) and "Eye irritation" (EYE) are never seen with activity restrictions greater than "Social and recreation limitations" (NOSOC), nor with costs greater than \$100.[23] Similarly, more severe conditions are never seen with the mildest activity-restriction level NOLIM.

Table 2. Variables Used in Analysis

VARIABLES	DESCRIPTION
NOSE	Stuffy or runny nose and sore throat
EYE	Eye irritation
FLUTTER	Fluttering in chest and feeling light-headed
BREATH	Coughing, wheezing, shortness of breath
ACHE	Coughing or wheezing with fever, chills or aching all over
SWELL	Shortness or breath, and swelling in ankles and feet
PAIN	Pain in chest or arm
LNDAYS	Log of the number of days of episode (1, 5, 10) plus one
SOMELIM	Activity Level 2: You can go to work, go to school, do housework, and participate in social or recreational activities, but you have some physical limitations (trouble bending, stooping, or doing vigorous activities) because of this health condition.
NOSOC	Activity Level 3: You can go to work, go to school, do housework, but you have some physical limitations (trouble bending, stooping, or doing vigorous activities) and cannot participate in social or recreational activities because of this health condition.
ATHOME	Activity Level 4: You cannot leave your house, go to work, go to school, do housework, participate in social or recreational activities, and you have some physical limitations (trouble bending, stooping, or doing vigorous activities) because of this health condition, but you can care for yourself.
NEEDHELP	Activity Level 5: You cannot leave your house, go to work, go to school, do housework, participate in social or recreational activities, and you need help caring for yourself (feeding, bathing, dressing, toilet) because of this health condition.
INHOSP	Activity Level 6: You are in hospital and need help caring for yourself (feeding, bathing, dressing, toilet).

[22] This specification facilitates comparisons between graded-pair and choice formats. Symptom was held constant within choice sets in the choice questions, so it is necessary to interact duration with symptom in the choice models. Transforming duration allows for diminishing marginal utility of duration.

[23] Thus NOSE and EYE are never seen with ATHOME, NEEDHELP, and INHOSP, as well as values of \$200 and \$500.

SQTCOST	Square root of the cost levels per year (Can$10–Can$750)
SCORE	Quiz score (percent correct)
AGE	The midpoint of the age category
AGESQUARED	The square of AGE
EDUCATION	Number of years of education
SYMPTOMATIC	Dummy variable = 1 if subject has ever been diagnosed with any cardiovascular or respiratory conditions or other serious illnesses
VIMPORTANT	Number of health factors subjects indicated as being very important to a person's health (0-4)
HISCORE	= 1 if subject scored 75% or better on the quiz
HIAGE	= 1 if subject is 60 years old or older
NOPAIDLEAVE	= 1 if subject is working but does not have paid sick leave
FAILCHECKS	= 1 if subject provided questionable or inconsistent answers in parts of the survey
HIINFORMATION	= 1 if subject acquires health information a few hours per week or more
ASTHMA	= 1 if subject has experienced asthma in past year
BRONCHITIS	= 1 if subject has experienced chronic bronchitis/ emphysema in past year
LUNGINFECTION	= 1 if subject has experienced lung infection (pneumonia, acute bronchitis) in past year
HEARTDISEASE	= 1 if subject has experienced heart disease symptoms in past year
INCOME	Household income before taxes in 1996
PAINRATING	Rating of pain or discomfort on a scale of 0 (no discomfort) to 8 (severe discomfort), summed over all symptoms.
FREQILL	Frequency of illness on a scale of zero (never) to four (almost all or all the time), summed over all symptoms.
FREQHOME	Frequency of staying home because of illness in past year on a scale of zero (never) to four (almost all or all the time), summed over all symptoms.
CH_A	Alternative specific dummy for the first alternative in each choice set (Initial Condition)
CH_B	Alternative specific dummy for the middle alternative in each choice set (Alternative A)
RHO	Random effects correlation coefficient for subject's eight SP questions

Table 3 reports estimates for the graded-pair, ordered-probit panel model. This model estimates and controls for the correlation among the subject's eight SP answers. The correlation coefficient, RHO, shows that there is significant correlation among the eight SP questions. Controlling for this correlation affects the significance of several variables.[24]

[24] See Johnson, et al. (1998) for comparisons with non-panel ordered-probit estimates.

Symptom attribute levels are interacted with the log of duration to facilitate comparisons with the discrete-choice estimates. There is no natural ordering of symptom disutility, so we have no specific expectations about relative magnitudes. Nevertheless, it is not surprising that the coefficients on NOSE and EYE indicate higher utilities than the other symptoms. Overall, there is relatively little variation in the normalized symptom coefficients compared to the activity-level coefficients. Nevertheless, five of the seven symptoms are significantly different than the overall mean symptom effect.

Unlike the symptom variables, the activity-restriction levels have a natural ordering with "no limitations" (NOLIM) representing the best activity-restriction level and "in hospital" (INHOSP) representing the worst activity-restriction level. All of the coefficients on the activity-restriction levels are significantly different than the mean activity effect. The coefficients of SOMELIM and NOSOC are reversed in order, but are statistically equivalent, indicating that subjects did not have strong preferences for not being able to participate in social and recreational activities and having physical limitations versus simply having physical limitations. The remaining coefficients decrease monotonically, as expected, indicating that greater activity restrictions result in greater utility losses.

Except for VIMPORTANT, the utility of money covariates are significant, suggesting that different groups of subjects have different preferences for health-state/money tradeoffs. Subjects with higher quiz scores have lower WTP for improved health, while older, more educated, and symptomatic subjects have higher WTP. The significance of the scale parameters indicates that subjects used the rating scale differently. Of the significant coefficients in the scale function, subjects with high quiz scores and no paid sick leave had less noisy responses, while elderly subjects and subjects who failed more consistency checks had more noisy responses.

Table 3. Graded-Pair Ordered-Probit Panel Model

Variable	Coefficient		Normalized	T-ratio
Health Attributes				
NOSE*LNDAYS	0.2720	***	0.6096	4.38
EYE*LNDAYS	0.1610	***	0.5432	6.33
FLUTTER*LNDAYS	-0.0862	***	0.3953	-3.38
BREATH*LNDAYS	-0.0301		0.4288	-1.34
ACHE*LNDAYS	-0.1426	***	0.3615	-5.13
SWELL*LNDAYS	-0.1559	***	0.3535	-7.39
PAIN*LNDAYS	-0.0182		0.4360	-0.63
NOLIM	0.9242	***	1.0000	6.88
SOMELIM	0.0803	***	0.4949	2.52
NOSOC	0.1243	**	0.5212	3.75
ATHOME	-0.1026	**	0.3854	-2.01
NEEDHELP	-0.2796	***	0.2795	-7.22
INHOSP	-0.7466	***	0.0000	-6.87
Utility of Money Function (*SQTCOST)				
CONSTANT	-0.021935			-1.22
SCORE	-0.0002413	**		-2.18
AGE	0.000392	**		2.13
EDUCATION	0.0004650			0.46
SYMPTOMATIC	0.009791	**		2.13
VIMPORTANT	-0.003691			-1.61
Scale Function				
HISCORE	0.1502	***		2.69
HIAGE	-0.2579	***		-4.09
VIMPORTANT	-0.0003			-0.01
NOPAIDLEAVE	0.1024	*		1.70
HIINFORMATION	-0.0423			-0.63
FAILCHECKS	-0.2967	***		-5.10
Constants				
ALPHA1	-1.2148			
ALPHA2	-0.1648			
ALPHA3	0.6591			
RHO	0.1260	***		5.95
Likelihood Ratio Chi-sq.	536***			
McFadden R-square	0.076			
Percent correctly predicted	42.4			
Number of observations	2752			

*** Significant at the 1-percent level or better

** Significant at the 5-percent level or better

* Significant at the 10-percent level or better

Discrete-choice estimates

We estimated conditional-logit choice models that are widely used in the market research literature.[25] Nevertheless, there is reason to be concerned about several sources of bias in such estimates. First, the conditional logit models assume that differences in WTP across subjects

[25] These results are not reported here. See Johnson, et al. 1998.

arise only from differences in the marginal utility of money. The utility weights for health attributes are assumed to be the same for all subjects. Second, unbiased conditional logit estimates require satisfying the IIA assumption. Tests of the choice data indicate that conditional logit estimates do not satisfy this requirement. Under these conditions, parameter estimates are biased. Finally, conditional logit estimates assume errors in each subject's series of answers are uncorrelated. The model assumes, in effect, that we sampled 2,752 subjects instead of asking eight questions of 344 subjects.

As discussed above, random-parameters logit (RPL) avoids all three of these potential sources of bias. Table 4 reports the RPL results. Because each parameter includes both a systematic and random component, the model estimates a mean and standard error for each distribution. Although we can construct parameters for the omitted categories NOSE and NOLIM, there are no corresponding standard-deviation estimates for those variables.

Unlike the graded-pair format, subjects evaluated the choice alternatives relative to their current health, which always was represented by the third alternative across choice sets. In addition to the same health attribute and utility-of-money variables, the discrete-choice RPL estimates include standard-deviation estimates for the health attributes, current health covariates, and two alternative-specific constants that indicate the probability of choosing the first or second relative to the third alternative.

We again have effects-coded the health attributes, so the coefficients on the omitted attributes NOSE and NOLIM are reported as the negative sum of the included categories. We interpret statistical significance relative to mean effects for the health attributes. Symptom variables are interacted with duration because symptom was held constant within each choice set. Table 4 also reports both nominal and normalized coefficients.

Table 4. Choice Random-Parameter Logit Panel Model

Variable	Coefficient		Normalized	T-ratio
Health Attributes				
NOSE*LNDAYS	0.4522	**	0.9675	2.12
Estimated St. Dev.	---			
EYE*LNDAYS	0.1653	**	0.7995	2.07
Estimated St. Dev.	-0.0001	***		0.00
FLUTTER*LNDAYS	-0.1851		0.5944	-2.17
Estimated St. Dev.	0.0134			0.02
BREATH*LNDAYS	-0.0786		0.6568	-0.94
Estimated St. Dev.	-0.0081			-0.01
ACHE*LNDAYS	0.1101		0.7672	1.19
Estimated St. Dev.	0.0074			0.01
SWELL*LNDAYS	-0.1916	*	0.5906	-1.99
Estimated St. Dev.	-0.1016			-0.29
PAIN*LNDAYS	-0.2723	***	0.5434	-3.23
Estimated St. Dev.	-0.0273			-0.04
NOLIM	0.5078	*	1.0000	1.78
Estimated St. Dev.	---			
SOMELIM	0.4864	***	0.9875	4.87
Estimated St. Dev.	0.3133	**		2.10
NOSOC	0.5998	***	1.0538	6.06
Estimated St. Dev.	-0.4752	***		-3.57
ATHOME	0.0038		0.7050	0.04
Estimated St. Dev.	-0.5444	***		-3.82
NEEDHELP	-0.3971	***	0.4704	-3.30
Estimated St. Dev.	0.5104	***		2.59
INHOSP	-1.2007	***	0.0000	-6.22
Estimated St. Dev.	-1.4752	***		-10.01
Utility of Money Function (*SQTCOST)				
CONSTANT	-0.1967	***		-9.35
SCORE	-0.0000276	***		-3.69
AGE	0.000323			1.16
EDUCATION	0.000716	***		8.81
SYMPTOMATIC	0.008012	*		1.72
VIMPORTANT	-0.011477	***		-3.33
Current Health Function				
ASTHMA* FREQHOME	-0.0953	***		-4.39
BRONCHITIS	-0.7115	***		-3.21
LUNGINFECTION	-0.2569	***		-4.42
HEARTDISEASE* FREQHOME	-0.1335	***		-3.98
AGESQUARED	0.0000508	***		2.56
INCOME	0.002608	***		7.46
PAINRATING	0.003662	***		3.72
VIMPORTANT	0.0986	***		4.54
FREQILL	-0.1030	***		-6.94
FREQHOME	0.2059	***		7.14
Alternative-Specific Constants				
CH_A	-1.2888	***		-4.29
CH_B	0.2423			1.24
Likelihood Ratio Chi-Square	557***			
McFadden R-Square	0.093			
Percent correctly predicted	39.3			
Number of observations	2752			

*** Significant at the 1-percent level or better ** Significant at the 5-percent level or better * Significant at the 10-percent level or better

Symptom was allowed to vary within pairwise comparisons in the graded-pair format but was held constant within choice sets. Because of this difference in the experimental design, we expected to see corresponding differences in estimated symptom utility weights. In particular, we expected to see less variation among the symptom coefficients compared to the graded pairs. Instead, we observe more variation but lower statistical significance relative to the mean effect. Moreover, all the normalized choice coefficients are larger than the corresponding pairs coefficients. PAIN is now the worst condition and ACHE now ranked as one of the milder conditions rather than one of the more severe conditions, as indicated in the pairs estimates.

In contrast to the symptom attribute, all activity levels but ATHOME are statistically significant. Again, except for the normalized endpoints, the choice activity coefficients are larger than the corresponding pairs activity coefficients. In particular, we observe very little difference in the choice NOLIM and SOME activity levels, while there is a large decline in utility between NOLIM and SOME in the pairs estimates. We continue to see NOSOC rated higher than SOME, but the difference again is insignificant. We observe the same pattern of signs in the marginal-utility-of-money function as in the graded-pair model. However, the constant term, VIMPORTANT, and EDUCATION now are significant, while AGE is not. Because of differences in scaling, it is not possible to directly compare magnitudes of utility-of-money parameter differences between the two models.

All four of the respiratory and cardiovascular conditions in the current-health function are statistically significant and indicate worse health than overall average health in the sample. ASTHMA and HEARTDISEASE were insignificant when entered independently, but significant when interacted with FREQHOME. Thus ASTHMA and HEARTDISEASE are associated with lower than average health only when they are severe enough to require staying home. Of the four conditions, chronic bronchitis is by far the most serious, with disutility 2.5 times greater than the next most serious condition, while asthma is the least serious.

Age-squared also is positive and highly significant. Generally we expect that older people experience lower levels of health than younger people. It is worth noting, however, that we are modeling subjective health utility, not health per se. This result may be interpreted as saying that older people obtain higher levels of utility from the health they have. This is consistent with the positive sign on AGE in the utility-of-money function, which says that older people value money less than health compared to younger people.

Recall that the experimental design required that cost be ordered from zero to high values among alternatives A, B, and C, while activity restrictions are ordered inversely.[26] Thus some subjects may have tended to choose B simply because it had better health than A and lower cost than C. CH_B is significant in models where money and current health functions are treated as constants, but insignificant when these functions are included. This result means that including utility of money and current health functions eliminates the middle-alternative bias. However, the significant negative coefficient for A indicates that subjects chose A relative to B and C less often than the explanatory variables alone would predict.

Joint graded-pair, discrete-choice estimates

Our goal is to obtain estimates suitable for use in a wide range of benefit-cost applications. Because each SP format has strengths, as well as limitations, we pool the data and estimate a joint

[26] Note that Figure 3 labels the three alternatives that were presented to subjects as the Initial Condition, Alternative A, and Alternative B. However, we refer to these alternatives in the analysis section as Alternatives A, B, and C, respectively.

model to capture all the available information on subjects' preferences in one set of parameters. For example, the subjects paid more attention to symptoms in the pairs format than in the choice format, while they paid more attention to costs in the choice format. Estimating overall preferences in a joint model thus provides a more complete picture of subjects' utility functions for calculating WTP than does either format individually.

Although it would be interesting to estimate a joint panel model, such estimates are beyond the scope of the present study. Instead, we estimate a pooled model using the same specifications as the panel models discussed above, but do not control for intra-subject correlations. We then compare the results with the individual panel models.
From equation (1),

$$U^i_{st} = \lambda_f \cdot V^i(X_{st}, Z^i, P_{st}; \beta, \delta^i_s) + e^i_{st} \tag{14}$$

where now s indexes an attribute profile in either a graded-pair or choice repetition. We include a choice-utility scale function to control for different variances in the two data sets, so $\lambda_f=\lambda_c$ for the choice format and $\lambda_f=1$ for the graded-pair format.[27] The utility parameters β are constrained to be the same for both elicitation formats. However, the utility of money function parameters are estimated separately. Thus,

$$\delta^i_f(Z^i) = \left[\gamma_{fo} + \sum_m \left(\gamma_{fm} \cdot Z^i_m\right)\right] \tag{15}$$

where again f indexes the graded-pair and choice formats, respectively. We include the same utility of money variables used in previous models. The joint model also incorporates the current health condition variables used previously, so that WTP values can be estimated relative to different individual current-health reference points. Information on current-health utility comes only from the choice format. Finally, we combine SOME and NOSOC into a single category. Previous results indicated that subjects discriminated poorly between these two mild-restriction categories.

[27] The joint model omits the within-data set scale parameters, which had negligible effect on other parameters and do not enter into WTP calculations.

Figure 3. Comparison of Joint and Individual-Panel Models

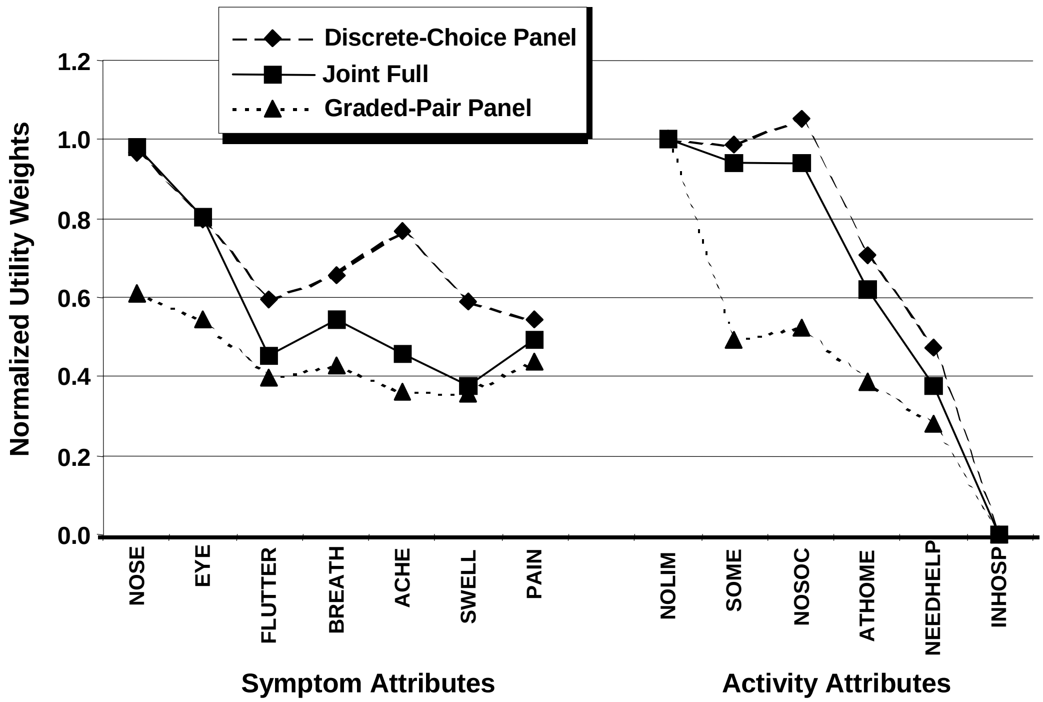

Figure 3 compares the joint estimates with the discrete-choice and graded-pair panel models. The joint estimates fall between the two panel estimates in nearly every case. The joint estimates track the graded-pair point estimates somewhat more closely than the discrete-choice estimates for the more severe symptoms. Conversely, the joint estimates track the discrete-choice estimates more closely for the activity categories. Thus the joint estimates have the desired property of giving more weight to the format with the smaller variance for each parameter.

Table 5 reports estimates for the joint model. As in previous models, we present both nominal and normalized coefficients. The pattern of normalized symptom utility weights reflects the variability in the graded-pair model rather than the discrete-choice model, as we hoped. The coefficients for NOSE and EYE are significantly different from the other symptom variables. Only BREATH is significantly different than the other conditions at the 10 percent level. Thus, the results of the symptom levels show similar variation to the pairs symptoms but some of the significant differences among the more severe symptoms have been attenuated, reflecting the influence of the discrete-choice estimates.

As in the choice model, only ATHOME is statistically insignificant relative to the mean activity effect. Furthermore, all activity levels are significantly different from each other and decrease monotonically as daily activity restrictions become more severe.

Utility of money functions are estimated separately for the graded-pair and discrete-choice data to account for systematic differences between the two formats. The implicit marginal utility of money is much smaller in the graded-pair data than the discrete-choice data. There are two possible reasons for the large difference in marginal effects. First, the nature of the discrete-choice task induces subjects to focus on the attribute levels themselves, rather than on differences among the attribute levels. Most people solve the choice valuation problem by eliminating undesirable alternatives based on one or two unattractive attribute levels. Consequently, the task itself simply may cause subjects' to pay more attention to the cost attribute in evaluating alternatives. Second, because symptoms were held constant across two of the three alternatives, subjects did not have to pay as much attention to this attribute as they did in the pairs task. Therefore, they may have had more cognitive energy to focus on the other

Table 5. Joint Model

Variable	Coefficient		Normalized	T-ratio
Health Attributes				
NOSE*LNDAYS	0.2572	***	0.9829	5.52
EYE*LNDAYS	0.1405	***	0.8035	7.04
FLUTTER*LNDAYS	-0.0871	***	0.4535	-4.59
BREATH*LNDAYS	-0.0294	*	0.5422	-1.69
ACHE*LNDAYS	-0.0831	***	0.4596	-4.08
SWELL*LNDAYS	-0.1372	***	0.3764	-7.91
PAIN*LNDAYS	-0.0609	***	0.4938	-3.05
NOLIM	0.2683	***	1.0000	4.47
SOMELIM/NOSOC	0.2299	***	0.9410	9.39
ATHOME	0.0225		0.6220	0.84
NEEDHELP	-0.1387	***	0.3741	-5.36
INHOSP	-0.3820	***	0.0000	-9.48
Utility of money function (*SQTCOST)				
CH_CONSTANT	-0.1072	***		-6.54
CH_SCORE	-0.0001819	**		-2.17
CH_AGE	0.000297	*		1.65
CH_EDUCATION	0.003968	***		5.13
CH_SYMPTOMATIC	0.003815			1.03
CH_VIMPORTANT	-0.004019	**		-2.09
GP_CONSTANT	-0.007188			-0.40
GP_SCORE	-0.0002305	**		-2.22
GP_AGE	0.000432	**		2.44
GP_EDUCATION	-0.0005507			-0.53
GP_SYMPTOMATIC	0.008877	*		1.82
GP_VIMPORTANT	-0.004918	**		-2.17
Current Health Condition				
CH_ASTHMA* FREQHOME	-0.0658	***		-2.58
CH_BRONCHITIS	-0.3523	**		-2.29
CH_LUNGINFECTION	-0.1679	***		-2.53
CH_HEARTDISEASE* FREQHOME	-0.1621	***		-2.50
CH_AGESQUARED	0.0000267	*		1.62
CH_INCOME	0.001624	***		4.39
CH_PAINRATING	0.002615	***		2.46
CH_VIMPORTANT	0.0466	***		3.27
CH_FREQILL	-0.0496	***		-2.85
CH_FREQHOME	0.1124	***		3.44
Relative Scale Function				
CH_HISCORE	0.9345	***		5.03
CH_HIAGE	-0.8042	***		-3.69
CH_VIMPORTANT	0.0718			1.20
CH_NOPAIDLEAVE	-0.1327			-0.77
CH_HIINFORMATION	-0.3505	*		-1.80
CH_FAILCHECKS	0.1819			0.89

Table 5. Joint Model (Continued)

Variable	Coefficient		Normalized	T-ratio
Alternative-Specific Constants				
CH_A	-0.5327	***		-3.28
CH_B	0.2809	**		2.14
GP_ALPHA1	-1.1330			
GP_ALPHA2	-0.1635			
GP_ALPHA3	0.6159			
Likelihood Ratio Chi-Sq.	827***			
McFadden R-square	0.063			
Graded-Pair Percent Correctly Predicted	42.1			
Choice Percent Correctly Predicted	47.5			
Number of Observations	5504			

***Significant at 1-percent level **Significant at 5-percent level *Significant at 10-percent level

attributes, including cost. The other utility of money coefficients exhibit similar patterns as in the previous two models.

The relative scale function fixes differences in variance in the two data sets. We use the same scale variables as before, but their interpretation is different in this model. The relative scale function indicates how the variance or noise varies systematically in the choice data set relative to the pairs data set. A positive coefficient indicates a source of lower variance in the choice data. Overall, this function is positive, indicating that the pairs data contains significantly more noise than the discrete-choice data. This result is not surprising because of the more cognitively burdensome nature of the pairs task.

Willingness-to-Pay Estimates

As discussed above, we can convert the parameters of the utility index shown in the previous models into a dollar metric by rescaling the index using the marginal utility of money. Employing SP techniques allows us to recover WTP estimates for all relevant combinations of symptoms and activity levels in the experimental design.[28,29]

The confidence interval is obtained by drawing 1000 times from the multivariate normal distribution of coefficients and their variance-covariance matrix. The foregoing calculation is performed for each draw, and the confidence-interval lower and upper bounds are the fifth and ninety-fifth percentile values.

Table 6 shows WTP estimates and 90-percent confidence intervals to avoid one-day, five-day, and ten-day episodes of the relevant symptom and activity level combinations, given subjects' baseline health for the past year. The first column of estimates shows WTP estimates for the MILD activity restriction, which combines SOMELIM and NOSOC. We show zero WTP for one-day episodes of NOSE, EYE, and BREATH. The point estimates for these symptoms are negative, meaning that the estimated average baseline current health in our sample actually was less than the estimated utility for these outcomes. Moving from these health states to current health would reduce welfare, hence the negative point estimate for WTP. However, the upper bound of the 90-percent confidence interval for BREATH is positive. This result is not surprising considering that approximately 36 percent of our 344 subjects have experienced cardiovascular and respiratory conditions within the past year. In addition, nonsymptomatic subjects may suffer from a variety of other ailments. Thus, the results show that on average this sample of subjects is not willing to pay to avoid an episode of these mild conditions.

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[28] Some combinations of attribute levels, such as having a stuffy nose and sore throat and being in hospital, are not plausible and thus WTP estimates for these combinations are not presented because they fall outside the range of the experimental design.

[29] For example, the average willingness-to-pay to avoid one day of fluttering in the chest and feeling light-headed that confines subjects to their homes but allows them to care for themselves is calculated as follows:

$$\mathrm{WTP(BREATH,\ ATHOME, Days)} = \frac{\mathrm{Current\ Utility(Days)} - \mathrm{Utility(BREATH,\ ATHOME, Days)}}{\mathrm{Marginal\ Utility\ of\ Money}}$$

$$= \frac{\mathrm{Ln}(1+1)\cdot V_{Current} - \left[\mathrm{Ln}(1+1)\cdot \beta_{BREATH} + \beta_{ATHOME}\right]}{\frac{1}{2}\cdot\left[\frac{-dV}{d\mathrm{Cost}^{CH}} + \frac{-dV}{d\mathrm{Cost}^{GP}}\right]}$$

$$= \frac{0.6931\cdot 0.2955 - \left[0.6931\cdot(-0.0294) + (0.0225)\right]}{\frac{1}{2}\cdot\left[\frac{0.01975}{2\cdot\sqrt{375}} + \frac{0.05859}{2\cdot\sqrt{202}}\right]}$$

$$= 158$$

where CH and GP refer to choice and graded-pair estimates, respectively and cost is averaged over all the screens where these two health attribute levels appear for each question format. Using more precise coefficients and means, the actual value is \$208 with a bootstrapped 90 percent confidence interval of \$129 to \$287.

Table 6. Willingness to Pay Estimates for Each Symptom/Activity Level Combination for One-Day, Five-Day, and Ten-Day Episodes (1997 Canadian $)

		Daily Activity Levels			
Symptoms	**Duration**	**MILD[a]**	**ATHOME**	**NEEDHELP**	**INHOSP**
NOSE	1 day	0[b]	3	-[c]	-[c]
		(-168/-83)	(-50/57)		
	5 days	0[b]	29	-[c]	-[c]
		(-204/4)	(-89/148)		
	10 days	0[b]	44	-[c]	-[c]
		(-225/53)	(-110/199)		
EYE	1 day	0[b]	54	-[c]	-[c]
		(-119/-32)	(-2/108)		
	5 days	29	162	-[c]	-[c]
		(-76/138)	(44/282)		
	10 days	85	222	-[c]	-[c]
		(-53/232)	(67/379)		
FLUTTER	1 day	24	171	288	427
		(-26/73)	(114/236)	(232/359)	(352/517)
	5 days	310	468	588	704
		(192/438)	(341/615)	(462/741)	(568/870)
	10 days	468	631	754	857
		(309/641)	(466/825)	(589/955)	(684/1065)
BREATH	1 day	0[b]	158	286	448
		(-60/49)	(100/225)	(224/363)	(371/536)
	5 days	266	435	566	712
		(141/405)	(299/589)	(427/732)	(566/872)
	10 days	415	589	721	857
		(249/602)	(411/789)	(537/937)	(668/1058)
ACHE	1 day	26	199	335	513
		(-36/86)	(133/275)	(267/420)	(426/623)
	5 days	362	544	682	845
		(214/523)	(382/722)	(529/866)	(677/1046)
	10 days	547	734	873	1027
		(350/762)	(524/967)	(668/1114)	(813/1278)
SWELL	1 day	56	229	365	535
		(-1/117)	(164/306)	(295/452)	(443/644)
	5 days	439	621	761	908
		(296/598)	(469/799)	(598/954)	(737/1111)
	10 days	650	837	979	1114
		(459/869)	(634/1073)	(767/1228)	(896/1375)
PAIN	1 day	14	190	329	510
		(-48/75)	(125/263)	(260/411)	(426/611)
	5 days	338	522	663	827
		(193/489)	(370/693)	(508/841)	(665/1015)
	10 days	516	705	848	1002
		(322/719)	(503/934)	(645/1084)	(791/1240)

[a] MILD combines SOMELIM and NOSOC .
[b] Negative point estimate shown as zero WTP. See text for interpretation.
[c] These combinations fall outside the scope of the experimental design.

Table 6 also shows that as activity restrictions increase for a given symptom (that is, as one moves to the right from "no limitations" to "in hospital"), WTP also increases. Differences between WTP estimates in adjacent activity levels generally are not statistically significant. Examining how WTP changes across symptoms for a given activity level reveals that differences are even less significant. Overall, WTP estimates show the most dramatic differences across activity levels, and while there are differences among the symptoms, these differences appear to be less salient to subjects for a given activity limitation.

Conclusions

Using two different SP elicitation formats is a significant improvement over previous health-valuation studies. The two formats induce subjects to employ different evaluation strategies. Thus, combining both formats allows us to capitalize on the information provided by each format and on the different cognitive processes that subjects use in each situation. The two formats also differ in their formal utility-theoretic basis. The graded-pair format elicits values for marginal tradeoffs among health-states, whereas the discrete-choice format elicits total values to avoid a given condition relative to the subject's current health. Thus, each elicitation format offers certain advantages, and we believe that employing both formats provides more robust and valid estimates.

Comparisons of WTP estimates from the joint model with the few published estimates for similar conditions based on conventional CV methodology indicates our estimates are not systematically larger or smaller (Johnson, et al., 1998). However, unlike other studies in the WTP literature, our SP estimates are derived from complete multi-attribute health-state descriptions that are clearly specified and consistent across the same sample of subjects. Thus we are able to explicitly account for the separate effects of symptoms, duration, activity restrictions, and current health on WTP.

The results demonstrate the feasibility of estimating meaningful WTP values for policy-relevant respiratory and cardiac symptoms, even from subjects who never have personally experienced these conditions. Furthermore, because WTP estimates are for individual components of health improvements, estimates can be aggregated in various ways depending upon policy needs. Thus using generic health attributes facilitates matching outcome values more accurately than previously was possible to evaluate a variety of health-care interventions and policies.

The ultimate purpose of conducting this study was to generate valuation estimates that can be applied in benefit-cost analysis. Applications in the area of environmental health could include federal and provincial programs to reduce sulfur dioxide, ozone, particulates, and other pollutants that can aggravate heart and lung conditions. In addition, valuation estimates could be used by electric utilities and other industries to assess the benefits of pollution-control equipment, evaluate alternative power-generation options, establish optimal emission caps for emissions trading, assess the dispatching of fossil-generation stations to meet excess demand, using full-cost accounting, and evaluate the costs and benefits of imports and exports of electricity from and to the United States.

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Discussion of Schulze, Chestnut, Mount, Weng and Kim paper

by Clark Nardinelli, US FDA Center for Food Safety and Applied Nutrition

The authors use the relationship between prices and safety features of automobiles to estimate the value of a statistical life for children and retired persons. The work is still at an early stage, so some of my comments will no doubt apply to things that will be changed later. My comments deal with (1) the theoretical model, (2) the variables included in the regressions, (3) the sample of single car households, and (4) the interpretation of the estimated willingness to pay for safety by the households in the sample.

(1) The model is plausible and sufficiently general. I would have approached the problem differently, but I had no trouble seeing how my preferred approach could fit within the model. The model derives an implicit value of statistical life for a family with non-paternalistic altruistic parents who determine health and safety expenditures on their children through Nash cooperative bargaining. The value of a statistical life derived from the model is the sum of the monetized value of the utility lost at death and the difference between wage income and consumption expenditures. The hedonic price for automobile safety is equal to the average value of a statistical life for the family. The model implies that the value of a statistical life can be derived from hedonic regressions on automobile safety features. If the value of a statistical life varies by age, then households with children should have a different willingness to pay for automobile safety than households without children.

(2) The model is straightforward; the hard part is designing hedonic regressions that will tease out the safety premium from the other features affecting price. The authors admit that the regressions reported in the paper are their first try. In later versions, they should consider including variables for geographic differences. The estimated premium on safety could well be distorted if regional and city differences are not accounted for. For example, based on my casual observations, people in New Orleans drive differently than people in Sacramento. The quality of roads and the weather will also affect the demand for automobile safety and other features. In addition to gender, I recommend including some additional demographic variables, such as ethnicity. Finally, designing hedonic regressions does not follow strict by-the-book rules, so I urge the authors to play around with the regressions as much as possible. Finding the right combination of variables and form that will generate defensible estimates of willingness to pay for automobile safety by ages of household members will not be easy.

(3) The data present another difficulty. The results presented here come from 4,000 one-car households. This sample – as the authors point out – is not representative, so we should be careful about concluding much about the results. The finished project will be based on over 40,000 households and will not be restricted to one-car households. I look forward to seeing the results from the full sample.

(4) The tentative results of the exercise are that willingness to pay for safety does not vary much across households by age. Because this workshop is more concerned with

children than with retired people, I restrict my comments to the apparent similarity between households with children and households without children.

The results presented in the paper fail to demonstrate that the value of a statistical life is approximately the same for children and adults, all else the same. I think that a hidden income effect is at work in the regressions. In his presentation -- but not in the written version I received -- William Schulze showed some additional results that strongly indicated that an income effect was at work. In the paper's model, the value of a statistical life is inversely related to consumption expenditures. Households with children typically have higher consumption expenditures than other households. The presence of children in a household therefore lowers discretionary income, which reduces the ability to purchase safety. The same estimated values of a statistical life for households with children and households without children might well indicate a greater concern for children's safety. The concern, however, may be offset by the reduced discretionary income.

The similar average values of a statistical life for the households in the sample may also reflect other effects not picked up by the regressions. One possibility is that one-car households are relatively homogenous. Another possibility is that differences in discount rates may be affecting the results. I have not thought much about these two influences, but I want to mention them

I like the approach taken in this paper. As Professor Schulze said in his introductory remarks, the paper represents the first part of a large project aimed at using market prices for safety to generate estimates of the value of a statistical life by age. I look forward to later versions of this paper and to other products of the broader research agenda.

As a government economist, part of my job is to defend the value of a statistical life to risk managers. Risk managers want a good, clear story. A good defense of the value chosen therefore requires being able to tell a plausible story justifying the choice. I have found that the most persuasive stories use market prices and behavior; risk managers can understand revealed preferences based on market results. Research of the kind undertaken by Professor Schulze and his collaborators can make my job a lot easier.

Discussion of Johnson, Ruby and Desvouges paper

by Fred Kuchler, USDA Economic Research Service -- Summarization

Mr. Kuchler focused his remarks upon a comparison of conjoint analysis with contingent valuation. Both involve hypothetical transactions, rather than cash or arms-length transactions. Both essentially ask respondents what they think.

In 1993 NOAA convened their expert panel and came up with six possible problems with contingent valuation: (1) inconsistency with rational choice, (2) it gives rise to estimates that are implausibly large. (3) respondents do not demonstrate awareness of their budget constraint, (4) the issues presented to respondents are too complex, (5) the extent of the markets for the hypothesized goods are unknown, (6) part of respondents' bids may be due to a "warm glow" effect.

How does conjoint analysis fare on these points vis-à-vis contingent valuation? With respect to problem (3), conjoint analysis fares well, since out-of-pocket costs (in the Johnson paper, for example) are an important aspect of the scenarios presented to respondents. With respect to problem (4), the issues do not appear to be too complex, as the scenarios seemed to be within their ranges of experience. With respect to problem (6), the private goods presented to respondents (at least in the Johnson paper) give rise to no warm glow effects at all. With respect to problem (1), the models hypothesized by Johnson seemed to be based upon an indirect utility function that included many health attributes that interacted with out-of-pocket costs, which is consistent with rational choice, and furthermore in Johnson's model the marginal utility of money was diminishing.

With respect to problem (2), Mr. Kuchler calculated the value of a year of life by taking the standard value of a statistical life and annuitizing it over 36.5 years, using a discount rate of 3%. He found that value of a year of life having a value of $225,000, or a value of a day of between $600-700. The largest value for a day of illness obtained in the present paper was $535 per day, but for a person with a very bad illness. These results thus make sense, since the estimated willingness-to-pay to avoid illness (even severe illness) is less than willingness-to-pay to avoid death.

With respect to problem (5), the present paper focuses upon the willingness to pay by adults, so does not measure the willingness to pay for children, although an instrument might be designed to accomplish that.

The problem is that the health outcomes hypothesized here are certain, not probabilistic, so the good does not match the good that regulatory agencies provide. So the pertinent question is how do we translate the value into something probabilistic, so that it is usable by EPA?

Policy Discussion for Session II

by Nick Bouwes, US EPA Office of Pollution Prevention and Toxics -- Summarization

Mr. Bouwes expressed appreciation that the work being done for this workshop accounts for the benefits of environmental protection, for which estimates are still lacking. Many of the benefits estimates used by the EPA Office of Pollution Prevention and Toxics are lower-bound estimates. For example, valuing the benefits of lead protection regulation typically is accomplished by calculating the foregone income from a decrement in IQ attributable to lead poisoning, as well as medical costs and remedial education costs. Also, the office is developing a Cost of Illness handbook, containing estimates of the direct costs of 25 diseases.

Mortality provides a conceptually straightforward health endpoint: death. However, morbidity studies require the consideration of separate valuations of different health endpoints. This challenge can only be met by alternative approaches, such as contingent valuation, stated preference and cost of illness. In evaluating these different approaches, it is necessary to ask if the approach is immediately applicable, and if not, how much would it cost for EPA to undertake a valuation of a regulation? Although the cost of illness approach provides lower-bound estimates, regulations often have alternatives, so more precise estimates are necessary.

With respect to the paper by Schulze et al., Mr. Bouwes queried whether it was in the wrong session. If there are extensions to other health endpoints, they should have been presented. For example, there could have been an application to the measurement of a value of a statistical life with a latency period.

Mr. Bouwes wondered if baby seats were included in the Schulze study. Mr. Schulze replied that there was no data on the use or location of baby seats. Mr. Bouwes asked if the propensity of sport utility vehicles to roll over was considered in the safety considerations, to which Mr. Schulze replied that sport utility vehicles are still safer.

On the paper by Johnson et al., Mr. Bouwes wondered why Mr. Johnson used a joint estimator rather than the sole estimator for valuing a preferable health scenario.

With respect to both papers, Mr. Bouwes inquired as to the cost of performing these studies. Mr. Bouwes raised the issue of trading off the soundness of the theoretical foundation of the studies against the resources needed to carry out these studies.

Question and Answer Period for Session II

Johnson, Ruby, and Desvouges paper:

Bill Harbaugh, University of Oregon, asked F. Reed Johnson, Triangle Economic Research, if it is possible to check to see if the respondents in his study were providing rational responses that were consistent with economic theory. Mr. Johnson replied that it was possible to check for transitivity and monotonicity. Violations of standard microeconomic assumptions do occur, but it is probably largely due to the demanding nature of the survey, since the error is correlated with things like respondents' education, age, and the amount of time respondent had spent on the survey.

In response to the ex ante problem posed by Fred Kuchler in his discussion of Mr. Johnson's paper, i.e., that of obtaining the value of a good that is certain and applying it to a good that is probabilistic, Mr Johnson responded that there are two ways to treat this problem. One is the approach adopted by Krupnick, et al., to treat it as an ex ante problem, and simply get people to value it directly. The Triangle Economic Research approach is to obtain an ex post value, ascertain the probability of the person suffering this malady, and convert the ex post value to an ex ante one. If one knows something about a respondent's risk preferences, then in principle it should be possible to convert an ex post value to an ex ante value. Alan Krupnick, Resources for the Future, added that the existing estimates of symptom days are all ex post, and most are of low quality, so at the least, Mr. Johnson's paper is a vast improvement over existing estimates.

Lauraine Chestnut, Stratus Consulting, queried whether this was really ex post, or simply ex ante with a time lag. Mr. Johnson agreed that this was ex post only in the sense that they had eliminated the uncertainty. This study also oversampled people that actually have had the maladies that are hypothesized, and collected data on current health, and found that current health is a very strong determinant of willingness to pay. Similarly, in another Triangle Economic Research study on smokers, they found that whether the respondent was a smoker was a very strong determinant of willingness to pay.

Clay Ogg, US EPA Office of Policy, pointed out that the income variable used in Mr. Johnson's study was likely to be correlated with having kids, and therefore with willingness to pay.

An unidentified speaker asked Mr. Johnson about the plausibility of the results and wondered if the study took place in Los Angeles instead of Toronto, whether there would be many more episodes of air pollution violations, and whether this would alter the results. Mr. Johnson responded that air pollution was not mentioned, because they wanted to decouple the study from the regulatory context. Mr. Johnson added that he would be reluctant to transfer the results to non-Canadians.

William Schulze, Cornell University, cited a study of paraplegics, and pointed out that they are not necessarily any less happy than the rest of us, so even though our willingness to pay to avoid the risk of becoming paraplegic is high, the ability of people to adapt is often overlooked. Mr. Johnson agreed that this was an interesting and an important phenomenon. Analogously, Mr. Johnson cited his own study, in which he found that older people have a statistically significantly higher level of perceived health than younger ones.

Ellen Post, Abt Associates, asked why both Mr. Krupnick and Mr. Johnson made sure to obtain valuations without reference to any air pollution issues. Mr. Johnson responded that this is a split in philosophy; Richard Carson would say that the context is part of the value derived by the respondent -- if warm glow makes them feel good, why not include it in their valuation? Mr. Johnson stated his disagreement with this philosophy, and noted that is hard enough to get respondents to focus in on the attributes of the hypothesized good, without having them try to sort out their feelings. Mr. Johnson acknowledged that this is, in Mr. Krupnick's words, a "deep philosophical question." Ms. Post followed up and pointed out that when people express a higher willingness to pay for air pollution reduction, that they are not just registering their outrage, but also fear, which is a legitimate aspect of their valuation. Mr. Johnson responded that he would like to allow people's broader preferences to count, but did not want to be in the position of judging which fears were justifiably part of their preferences, and which were not, e.g., psychosomatic headaches. Mr. Schulze also responded to Ms. Post's question by pointing out that staying with private good scenarios keeps the valuations free of warm glow problems.

Thomas Crocker, University of Wyoming, pointed out that while the expert knows more about the subject, individuals know more about their preferences, and while there is an argument that perhaps more weight should be accorded to experts, the importance of understanding individual preferences should not be underestimated.

Nick Bouwes, US EPA Office of Pollution Prevention and Toxics, stated that EPA is currently working with estimates of the cost of illness, and wondered if it would be worthwhile comparing estimates. EPA's cost of illness estimates should be a lower bound for the willingness to pay to avoid these serious illnesses, however.

Bryan Hubble, US EPA Office of Air Quality Planning and Standards, inquired as to whether scenarios included multiple symptoms. Mr. Johnson responded that they did not.

<u>Schulze, Chestnut, Mount, Weng and Kim paper:</u>

Richard Belzer, Washington University, inquired as to the multicollinearity problems inherent in using vehicle weight as a proxy variable for safety. Mr. Schulze responded that some more econometric adjustments would be made. Mr. Belzer pointed out that another attribute that could be captured by the weight variable is comfort. Mr. Schulze responded that this data can not be obtained because data on vehicle model and year are not available. This data might be obtained by primary data collection.

Mr. Krupnick asked about actual injury rates, which are probably correlated with fatality rates. Mr. Schulze acknowledged that this was correct, and that his studies results should be considered as including both injuries and fatalities. Mr. Krupnick then pointed out that the result should not be called a "value of a statistical life" because of the joint production problem of some vehicles reducing both injuries and fatalities.

Steve Crutchfield, USDA Economic Research Service, suggested that some other overall index of operation costs should be used, rather than gasoline mileage and suggested that insurance costs may be a good index, except that Virginia captures much of its revenue through a property tax. So Mr. Crutchfield suggested that location-specific cost variables are called for. Mr. Schulze agreed, but pointed out that these cost variables also capture some of the benefits of the vehicle, as gas mileage is likely to be correlated with safety.

Mahesh Podar, EPA Office of Water, asked if crash-worthiness test results were considered, and Mr. Schulze replied that they were, but dismissed because these tests are conducted using similar-sized vehicles, so cannot measure the relative safety of different vehicles.

Kenneth Acks, Costs and Benefits Newsletter, reiterated the problem of collinearity between the comfort and safety variables, to which Mr. Schulze acknowledged that the good needed to be treated as a joint products problem.

Mr. Ogg asked if there was a problem with income being correlated with many other variables that might determine the value of the statistical life in question, to which Mr. Schulze replied that in the hedonic formulation, the income effect can be separated out.

Mr. Bouwes pointed out that even with the same income, one wouldn't necessarily expect the same expenditures with children, since children have many expenses other than just vehicle safety. Mr. Weifeng Weng, Cornell University, co-researcher with Mr. Schulze, responded that income was adjusted for family size. Mr. Crocker complemented Mr. Schulze's study, remarking that this is one of the few studies that have endogenously modeled risk. Robin Jenkins, US EPA Office of Economy and Environment, asked if the incomes of the respondent families matched the incomes of the U.S. population generally, especially given that 30% of the U.S. population lives in poverty. Mr. Schulze responded that even the poorest respondent families in his sample were still spending a substantial amount of money on child safety. This was one of the most significant results of the study -- that the amount of money being spent on child safety was relatively income-invariant.

Brian Caulkins, Washington State Department of Ecology, asked if one could impute the value of an adult life for one who was working inside the home, to which Mr. Schulze replied that a use-weighted mean was used in the analysis, so that the value of a housewife or househusband was accurately accounted for.

Mr. Crocker asked if individuals might have different views of the efficacy of safety technology, and wondered if this might affect their willingness to pay for automobile safety features. A lower confidence in safety features may cause the respondent to reveal a value that is lower than the individual's actual willingness to pay for risk reduction.

Mr.Belzer posed a problem regarding vehicle choice in multiple-car households and driving teenagers. Most parents will choose the heaviest, safest vehicles for their teenagers. In this sense, it is the parents that are valuing safety on behalf of their teenage children. Yet the fact that these children have risky driving habits must affect vehicle choice and willingness to pay for safety features.

Jim Neuman, Industrial Economics, Inc., asked if Mr. Schulze had considered asking automobile manufacturers for marketing studies on preferences for automobile safety features, to which Mr. Schulze replied that he suspected that lawyers would probably not permit the release of such data. Mr. Neuman continued by asking whether conjoint analysis would be more probative. Mr. Schulze said he believed that this was still essentially a contingent valuation problem.

Peter Negelhout, US EPA Office of Economy and Environment, pointed out that while accidents are random, drivers can take defensive measures to minimize risk, such as choosing where and when to drive. Mr Schulze agreed, and emphasized that automobile safety is only one of the things people do to reduce risk.

Elyce Biddle, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, followed up on Mr. Neuman's point by encouraging Mr. Schulze to seek out marketing studies from automobile manufacturers, since they may not be as reluctant to release such information as Mr. Schulze might think.

June 1999

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

PROCEEDINGS OF THE SECOND WORKSHOP IN THE ENVIRONMENTAL POLICY AND ECONOMICS WORKSHOP SERIES

--Session Three--

A Workshop sponsored by the
US Environmental Protection Agency's Office of Children's Health Protection,
Office of Economy and Environment, and Office of Research and Development

Edited by Shi-Ling Hsu
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Disclaimer

Proceedings for Session 3, Thursday, March 25, 1999

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Opening Remarks

by Norine Noonan, Assistant Administrator, Office of Research and Development

I want to welcome you to the second day of this workshop on *Valuing Health,* with today's emphasis on *Children's Health.* The Office of Research and Development is delighted to be working with the Policy Office and the Office of Children's Health Protection to sponsor this workshop. I also want to add my welcome to the members of the EPA Children's Health Advisory Committee who are here today.

I am particularly proud of the fact that this workshop links research funded under our Science to Achieve Results (STAR) program with specific Agency goals in children's health protection, and overall needs in support of cost-benefit analysis. I like to emphasize the fact that the "Science" under STAR is to **Achieve Results,** that address critical Agency needs. This workshop is the second in a series of five workshops that link ORD's economics and policy research to Agency policy issues.

I would like to tell you a little more about the valuation research and other research addressing children's health that ORD is conducting.

1. Some of the research papers being discussed at this seminar has been funded under the ORD Science to Achieve Results Program. The STAR program funds extramural research through competitive grants addressing high priority science needs at a level of approximately $100 million per year.

2. Since FY 95 we have issued a solicitation jointly with NSF called Decision-Making and Valuation for Environmental Policy. 53 grants totaling over $9 million have been funded to date. The FY 99 solicitation closed on Feb. 1 and 93 new proposals were received.

3. Research on approaches to value human health (reduction in morbidity and mortality), including projects related specifically to children's health, have been one of the topics of focus in the Decision-Making and Valuation research. Along with research on valuation of ecological systems, this research addresses one of the priority needs that has been identified by the Agency to support its cost-benefit analysis.

4. ORD is supporting a wide range of other research through both the STAR program and through each of our laboratories and centers addressing children's health. Research areas include:

   – Human studies of exposure and effects

     -Field studies of children's exposure to pesticides, PCBs and air toxics

     -Childhood susceptibility to the effects of air pollutants

-Environmental exposures and human neurological function
-Endemic waterborne disease in children

-the NHANES survey

-In addition, last year through the STAR program, ORD, jointly with NIEHS, funded eight Centers of Excellence for Research on Children's Health and Disease Prevention.

– Laboratory Studies using animal models

-Effects of Pesticides
-Effects of air pollutants
-Developmental tox of PCBs
-Toxicokinetics of TCDD

– Methods Models and tools for risk assessments - examples:

-Exposure factors handbook for adults and children
-Biomarkers for risk assessment in children and mothers

– Risk Management research

-We have identified several areas of risk management research that have applicability to children's health protection, including research on drinking water treatment, particulate matter and indoor air.

Again, thank you for inviting me to share some thoughts with you on this important issue. I look forward to hearing and participating in some of the discussion today.

Opening Remarks

by Ramona Trovato, Director, US EPA Office of Children's Health Protection

Ms. Trovato expressed appreciation for the risk assessment and risk reduction valuation work being done by conference attendees and others in the field of environmental economics, and emphasized how critically important economic analysis has become to EPA decisions. Ms. Trovato stated that the work being done in this area affects the standards set by EPA.

Ms. Trovato described the functions and agenda of the EPA Office of Children's Health Protection, an office with about twelve people, including one economist. The Office has an advisory committee of approximately 40 people, including a subcommittee on economics, which actually came up with the idea for this conference. Ms. Trovato expressed great excitement about the papers being presented in this session and at this conference, in that this work will help the general public better understand the policies of the Office of Children's Health. In particular, it is important that the work be couched in such a way that the public can understand explicitly the inherent trade-offs that are made when EPA establishes standards of exposure. For example, the benefits can be expressed in terms of fewer asthma attacks, or more days that children can play outside.

The Office of Children's Health Protection was created by executive order in May of 1997, and was directed to consider children's health protection in EPA's environmental standard-setting. It is the position of the EPA administrator that all public health standards shall consider the health effects on children, so the Office is in the process of attacking this task from an economic point of view and a risk assessment point of view. One approach is to identify the institutions in EPA that affect children. The Office is thus working with the EPA Office of Risk Assessment to identify special risk assessment issues affecting children, such as pesticide use and regulation. The Office is also working to help educate parents and caregivers about what can be done to improve children's health, such as vacuuming and damp-wiping lead-contaminated walls (if removal of the lead paint is infeasible). The EPA is also further developing methods on standard-setting, and has developed a rule-writing guide for regulations, and economics is particularly important here because of the cost-benefit analysis required for rule-writing. As part of the EPA Office of Policy's economic guidebook for general rule-writing for the entire agency, there will be a special section on rule-writing as it pertains to children's health.

There are a number of areas particularly deserving of attention. Research is needed to apply existing data on adults to draw some inferences on the implications for children. But this is only a short-term solution, because children have different exposure thresholds, and society has special values for children's health. In addition, EPA needs to answer the questions of how pain and suffering can be valued, and the value of avoiding lifelong illnesses and deficiencies. This is particularly challenging research because one cannot simply ask children for valuations, nor can we simply ask parents for their valuations. Thus, new and innovative methods for valuing children's health benefits are of great importance to the Office of Children's Health.

Introductory Remarks for Session III

by Ed Chu, US EPA Office of Children's Health Protection

Mr. Chu pointed out that there are many differences between children and adults in both physiology and their behavior, and emphasized the behavioral differences in particular. Mr. Chu asserted that children are not rational economic agents, are not consumers in a traditional sense, and do not earn income, spend or make economic choices. Also, children have a limited ability to understand the concept of death, future prospects or risk. These differences challenge the fundamental assumptions of economics. While the discussion yesterday focused upon the difficulties of getting adults to reveal their true preferences, getting children to reveal their preferences is likely to be even more difficult. There exist two options for measuring the value of risk reduction for children: to extrapolate adult values to children, or to obtain indirect valuations from parents or caregivers. With respect to the first option, issues arise as to what adjustments will need to be made. With respect to the second option, there is some literature that suggests that the valuation of children's health is consistent with models of a household production function, but there is an issue as to a public good aspect of adult valuations. Although EPA has begun this work, there are no finished studies on this topic at this time. Mr. Chu issued a call for more work to be done in this area as soon as possible. The Office of Children's Health, in addition to developing a part of EPA's guidebook on economic analysis in rulemaking, is working actively with economists to identify the gaps in current understanding, which has led to the commissioning of two of the papers being presented at this workshop.

Valuing a Statistical Child's Life:
The Case of Bicycle Safety Helmets
--Working Paper*--

PRESENTED BY:
Robin R. Jenkins
Environmental Protection Agency, Office of Policy, Economic and Policy Analysis Division

CO-AUTHORS:
Nicole Owens
Environmental Protection Agency, Office of Policy, Economic and Policy Analysis Division
Lanelle Wiggins
Environmental Protection Agency, Office of Policy, Economic and Policy Analysis Division

* 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.

Valuing a Statistical Child's Life:
The Case of Bicycle Safety Helmets

by

Robin R. Jenkins, Nicole Owens, Lanelle Bembenek Wiggins

United States Environmental Protection Agency,
Office of Policy,
Economic and Policy Analysis Division

March, 1999

US Environmental Protection Agency
401 M Street, SW (2172)
Washington, DC 20460
email: jenkins.robin@epa.gov
owens.nicole@epa.gov
wiggins.lanelle@epa.gov

1. Introduction

There are many reasons to suspect that the value of a statistical *child's* life (VSCL) is different from the value of a statistical life (VSL) for an adult. The most obvious is that children have longer lives ahead of them. Children also have unknown potential that might be worth a premium to preserve. These factors might suggest that the value of a statistical child's life is actually higher than a statistical adult's. Suggesting just the opposite, however, is that children generally earn no wages at all or, at best, earn very low wages relative to adults.

Results from many different contingent valuation surveys reported by both the public health and economics literatures suggest that VSL and the value of other health benefits do, in fact, depend on the age of the affected population.[1] These surveys do not estimate dollar valuations of statistical lives. Rather, they collect information on the public's preferences for saving lives, or improving health, of individuals who belong to one age group versus another. The public health literature has examined preferences regarding sub-populations of all different ages, including children. Generally, this literature concludes that health benefits are more valuable when bestowed upon children or adults who are rearing children than when bestowed upon people in other stages of life. The economics literature has *not* analyzed preferences for saving very young lives (those under 20 years old), but it has considered preferences for different age categories of adults. Generally, it concludes that preferences regarding the value of life are hump shaped. Cropper et al. (1994) report peak values occurring at age 28; Jones-Lee et al. (1985), at ages 45 to 54. Both literatures suggest not only that the age of a "statistical" person affects valuation of life but that there is a potentially complicated relationship between the two variables; for example, that young children and the parents of young children might be valued more highly than people in other stages of life.

Despite this strong evidence of a link between age and valuation, virtually all of the VSL estimates in the economics literature have been derived from adult populations and thus represent adults better than children.[2] We found only one estimate of the VSCL. Carlin and Sandy (1991) examine mothers' purchase and use of child safety car seats for children aged four or under and estimate in 1985 dollars a VSCL of $526,827. Values of various categories of adult morbidity are also abundant in the economics literature but, again, there are only a handful of morbidity values estimated for children. Those that do exist generally rely on the cost-of-illness approach with some exceptions that rely on the averting behavior or contingent valuation approaches.[3]

Our research helps fill the void of estimates of VSCL by estimating the VSL for two age categories that span the middle years of childhood -- ages 5 to 9 and ages 10 to 14 -- as well as

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[1] Examples from the public health literature include Williams (1988), Busschback et al. (1993) and Lewis and Charney (1989). Examples from the economics literature include Jones-Lee et al. (1985) and Cropper et al. (1994).

[2] For a survey of this literature, please see Fisher, Chestnut, and Violette (1989) and Viscusi (1992).

[3] For a survey of this literature, please see Dickie and Nestor (1998).

for an adult age category. Because we estimate VSL for both children and adults using the same methodology and similar data, we fill another gap by providing the first set of VSL estimates that are directly comparable across child and adult age categories.

There is a pressing need to fill this void. In 1997 President Clinton signed Executive Order (E.O.)13045, "Protection of Children from Environmental Health Risks and Safety Risks" which requires federal agencies to assign a high priority to assessing health and safety risks that disproportionately affect children.[4] It also requires assessment of the health or safety effects on children of many planned health and safety regulations. A common tool for assessing health effects is to estimate *values* of changes in probabilities of death or illness. Such estimates are usually components of a proposed regulation's benefit-cost analysis. In fact, the Office of Management and Budget (OMB), as part of guidance to agencies conducting economic analysis of proposed regulations, states that the age of the exposed population will affect the *value* of reduced risk and should therefore be reflected by the economic analysis of a regulation.[5] Thus, policy makers have an enhanced need for estimates of the VSCL.

We derive our estimates of the VSL for children and adults from price data for bicycle safety helmets – products that reduce a child's probability of death by head injury from bicycle riding by 79 percent (Thompson et al., 1996).[6] Bicycle safety helmets are unique safety devices because they are sized for wearers of different ages; there are helmets for adults and for different age categories of children. Thus, when a parent purchases a helmet we can infer with great certainty the age range of the child for whom the helmet is intended.

A bicycle helmet yields utility strictly by improving safety since it does not generate any other positive effects.[7] A bicycle helmet does confer *disutility* through discomfort and possibly by

[4]Examples of federal regulations likely to disproportionately affect children include Environmental Protection Agency (EPA) rules on drinking water contaminants – because of children's high consumption of water per unit of body weight. EPA rules on pesticides for fruit and vegetables for analogous reasons. EPA rules on lead in paint or gasoline affect children disproportionately because lead ingestion does particular damage to developing brains. Other examples of federal regulations that have large effects on children can be found in the public health arena; including the rules and regulations dealing with inoculations against childhood diseases and illnesses.

[5]Please see the OMB Guidance for Economic Analysis of Federal Regulations Under E.O. 12866, dated January 11, 1996, p. 32.

[6]Head injury is the leading cause of death in bicycle accidents. During the five year period from 1984 to 1988, 62 percent of bicycle accident deaths in the US involved head injury (Sacks et al. 1991). Children are at particular risk. According to the National Safe Kids Campaign (1997), bicycles are associated with more childhood injuries than any other consumer product except the automobile.

[7]This is unlike products such as large cars which confer safety but also confer comfort and possibly prestige. For these products, economists must try to econometrically tease out the portion of price going to purchase safety versus other positive attributes.

reducing the wearer's physical attractiveness. This suggests that the purchase price of a helmet is a lower bound of the willingness to pay (WTP) for the protection it bestows. The actual WTP includes both the purchase price and the value of the disutility.

The combination of these three factors -- that helmets substantially reduce the risk of death from bicycle accidents; are purchased separately for children and, even better, for specific age ranges of children; and yield positive utility solely through safety improvements -- provides a unique opportunity to estimate the value of a statistical child's life (VSCL) using a calculation that relates child bicycle helmet prices to the reduction in the risk of head injury death from bicycle accidents attributable to wearing a helmet.

This paper begins with a review of relevant literature. Section 3 presents a theoretical model. Section 4 empirically implements the model. Section 5 compares our VSL estimates to others. Section 6 discusses conclusions and policy implications.

2. The Safety Product Market VSL Literature

A child's bicycle helmet belongs to a small set of consumer goods whose exclusive purpose is to provide protection from harm. Several existing papers have estimated the VSL by examining purchases of goods from this small set. For our purpose, the most relevant is an examination of mothers' purchase and use of child safety seats by Carlin and Sandy (1991). Other relevant papers include a pair of studies by Dardis (1980) and Garbacz (1989) which examines purchases of smoke detectors and a 1979 paper by Blomquist which analyzes seat belt usage.

Carlin and Sandy (1991) collect data on car seat usage from 10 cities in Indiana. At a site for each city, surveyors, with the help of state troopers, stopped every passing car that carried a child who appeared to be aged four or under. Data was collected as to whether the child was properly restrained and drivers were asked to complete a follow-up questionnaire and return it by mail. Carlin and Sandy combine the following data: drivers' reported wage rates; a price of car seats estimated at about $80 in Indiana; an estimated amount of time spent harnessing and unharnessing the child; and data from the states of Washington and Tennessee on the reduction in the probability of death faced by a child wearing a car seat. They estimate in 1985 dollars a VSCL of $418,597 which they amend to $526,827 by appending the costs of raising a child.

In her examination of smoke detector purchase and use, Dardis (1980) collects information on smoke detector costs and the reduction in the probability of fire death and injury that smoke detectors provide. Costs include purchase price of smoke detectors and annual replacement cost of batteries. Purchase price is based on catalog prices of Sears, Roebuck and Company. She approximates subjective probabilities by actual relative frequencies of fire deaths and injuries. She obtains safety effectiveness data from a study by the National Bureau of Standards that found that smoke detectors provide 45 percent protection against death and 30 percent against injury. Dardis' estimates of VSL range from $101,165 to $676,266 in 1976 dollars. Her estimates vary according to the discount rate assumed, the proportion of the cost of the smoke detector attributed to death risk reduction and not injury risk reduction and the year in which benefits and costs were incurred.

Garbacz (1989) extends Dardis's research by improving the estimate of the effectiveness of smoke detectors. Garbacz criticizes the estimate from the National Bureau of Standards that smoke detectors provide 45 percent protection against death. because it does not take systematic account of factors other than smoke detectors that may alter the probability of a fire death. For decades before smoke detectors were introduced in the US, fire deaths were already experiencing a downward trend. Thus, Garbacz develops an "economic model of accidents" to better explain fire deaths over time.

Garbacz concludes that smoke detectors are much less effective at reducing the rate of home fire deaths than previously thought. Only about 9 percent of fire deaths would be offset if all households had smoke detectors. He re-estimates the VSL with a method similar to Dardis's, but with two adjustments. The first adjustment is to replace her estimate of smoke detector effectiveness with the estimate derived from his model. The second is to only choose fire death classifications that are likely to be affected by a smoke detector. (He asserts that Dardis included inappropriate data.) After making these adjustments to Dardis's 1979 VSL of $153,797, Garbacz obtains a new estimate of $1,073,559 (both are in 1976 dollars).

In a 1979 paper, Blomquist estimates the value of life based on the willingness of individuals to pay to use an automobile seat-belt to reduce the risk of accidental death. Blomquist states that the average value of life could be obtained empirically except that the average costs of using seat belts are unknown. Seat-belt-use costs consist of money costs and disutility costs. In part because there is no sticker price of seat belts, Blomquist spends much effort estimating the time costs of wearing a seat belt. He concludes that over the course of a year, 3.342 hours are spent fastening, adjusting and unfastening seatbelts. His estimate of VSL reflects a disutility cost of zero. He estimates an average value of life of about $370,000 in 1978 dollars.

To facilitate comparison, Table 1 converts the VSL estimates from these four papers, and others based on tradeoffs made outside the labor market, into 1997 dollars. Carlin and Sandy's estimate of VSCL is at the low end. We compare these to our own VSCL estimates in Section 5 below.

3. <u>A Theoretical Model</u>

Consumer safety product markets give information about the VSL because the use of safety products by consumers is an "averting behavior." Economic theory predicts that an individual will consume a protective (or mitigating) good as long as the value of benefits (reduced risk) are greater than the cost of obtaining and using the good. In the case of bicycle helmets, a consumer purchases a helmet if her value for the reduced risk of head injury (whether resulting in death or not) is greater than the cost of the helmet, including the sticker price, time and disutility costs. When a parent is considering purchasing a helmet for a child, it is the parent's value for reduced risk of head injury to the child that must be greater than the cost of the helmet.

We turn to *parent's* valuations of reduced risk just as Carlin and Sandy (1991) did when they estimated VSCL by evaluating mothers' decisions about their own children's use of car seats.[8] For at least two reasons, we make no effort to model (or estimate) a child's *own* willingness to pay for reduced risk. First, children generally do not make independent economic decisions since even if a child has her own wealth, she is not in control of it. Second, children are generally considered too immature to make good safety decisions for themselves, much less to judge trade-offs between wealth and safety. Instead, we rely on parents' WTP for their own child's safety which seems a natural alternative.

In the theoretical development that follows, we assume that a parent makes purchase decisions in an effort to maximize a utility function which she believes represents her child's true well-being/utility. Following Freeman (1993), assume that a child derives utility from the consumption of a composite good, X, with a price normalized to one. Let X^0 represent the initial endowment of X. Suppose that the child faces a risk of death from head injury from bicycling, ρ. The parent can attempt to control this risk by purchasing a child's bicycle helmet.[9] Because the only positive effect of a helmet is reducing the risk of head injury, assume that a helmet affects the child's risk of death but does not convey utility directly; i.e., the quantity of helmets, h, is not an element of X but

(1) $$\rho = \rho(h).$$

Because helmets reduce the risk of death,

(2) $$\partial\rho/\partial h < 0.$$

We construct a simple one-period choice model. Assuming that the utility associated with death is zero, expected utility is

(3) $$E[u] = [1 - \rho(h)] \cdot u(X) \text{ where } X = X^0 - P_h\, h$$

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[8]In fact there is other precedent for relying on parents' preferences over their own childrens' risks. Agee and Crocker (1996) rely on parents' decisions to treat their children's body burdens of lead to infer WTP for reduced burdens. In a variation on the theme, Viscusi, Magat and Huber (1987) examine the preferences of adults who live with young children rather than of parents. They compare responses from two subsamples: adults who live with young children and those who do not. They discuss differences in the two subsamples' values of reducing health risks to children from misuse of household chemicals. Finally, Joyce, Grossman and Goldman (1989) examine pre-natal and neo-natal intensive care costs to estimate mothers' WTP for improved air quality to benefit their infants' health.

[9]Of course, the risk is not controlled if the child does not actually wear the helmet. Our empirical estimates of VSCL will take account of this possibility.

and where P_h represents the cost of the helmet, specifically its purchase price, P, plus any time or disutility costs, C, associated with its use; that is, $P_h = P + C$. Assume that the parent maximizes equation (3) for the child with respect to h. This gives the following first order condition:

$$(4) \qquad [1 - \rho(h)]\,(\partial u/\partial X)\,(-P_h) + u(X)\,(-\partial\rho/\partial h) = 0$$

which suggests

$$(5) \qquad - P_h \,/\, (\partial\rho/\partial h) = u(X) \,/\, \{\, [1 - \rho(h)]\,(\partial u/\partial X)\}.$$

The right hand side of equation (5) is an expression for parents' marginal willingness to pay (MWTP) for a reduction in the risk of death from head injury that her child will face, obtained by taking the total differential of $E(u)$, setting it equal to zero and solving for $dX/d\rho$. We conclude that an empirical estimate for MWTP is given by the left hand side of equation (5).

The model presented is based on the assumption that helmets are divisible. In fact, the purchase of a helmet involves a 0-1 decision. The helmet is purchased if its marginal benefit (the right hand side of equation (5)) is equal to or greater than its marginal cost (the left hand side of equation (5)). The equality of willingness to pay and marginal cost occurs only for the marginal purchaser of the good.

Empirical implementation of equation (5), suggests that:

(6) VSL = (annualized cost of a safety good)/
(change in the probability of death due to purchase of the good).

4. <u>Estimation of the Value of a Statistical Child's Life</u>

As discussed in the Introduction above, a combination of three factors suggests that the case of child bicycle safety helmets presents a unique opportunity to operationalize the model presented above and estimate VSL for *children*. Recall the three factors -- that helmets substantially reduce the risk of death from bicycle accidents; are purchased separately for children and, even better, for specific age ranges of children; and yield positive utility solely through safety improvements. These three factors and the structure of available data lead us to estimate VSCL for two age categories -- 5- to 9-year-olds and 10- to 14-year-olds and VSL for one adult age category -- 20- to 59-year-olds. Implementation of the model requires two data items for each age group -- the annualized cost of a bicycle safety helmet and the reduction in the probability of head injury death that results from buying a helmet.

4.1 The Annualized Cost of a Bicycle Safety Helmet

To obtain the annualized cost of a bicycle safety helmet we use helmet price data reported by *Consumer Reports* (1997). They provide prices for 10 "youth" helmets and 10 adult helmets collected by a national survey.[10] *Consumer Reports* states that to ensure that safety features are effective, manufacturers recommend replacing helmets after three to five years. Thus, we assume a helmet life of four years.

We calculate annualized cost differently for youth and adult helmets. For the two children's age categories, we start by averaging the 10 youth helmet prices. But recall that besides purchase price, time and disutility costs are potentially an important part of the annualized cost of using a bicycle helmet. In their safety-product-market-based estimations of VSL, Carlin and Sandy (1991), and especially Blomquist (1979), spend substantial effort estimating the time spent fastening and unfastening child car safety seats and seat belts respectively. For helmets also, there is a time cost of fastening and unfastening straps. Disutility costs of helmets include the discomfort of wearing a helmet and other vanity costs like flattened or wrinkled hair. However, for the two child age categories, the time and disutility costs are largely paid by the children wearers. Parents might not assign these costs the same weight they would assign were they to be paid by adults. We assume a zero value for these costs which suggests that our estimates of VSCL are lower bound estimates since true annualized costs would include positive, though probably small, values for these costs.

The estimation of annualized cost for the adult age category is less straight forward. Unlike prices of child helmets, prices of adult helmets vary dramatically. The *Consumer Reports*' adult helmet prices range from $25.00 to $135.00 whereas the "youth" helmet prices range from $9.00 to $40.00.[11] The wide variance in adult helmet prices suggests that these helmets differ more widely than children's helmets. *Consumer Reports'* analysis is that the variance in price is not correlated with safety factors but with ventilation. ". . . the most dramatic contrasts between helmets are in price and how well they ventilate the head." *(Consumer Reports*, p. 34) And, elsewhere, "Unfortunately, the best-ventilated new helmets don't come cheap. The *Helios* costs $135, and its closest rivals in ventilation cost between $60 . . . and about $100." (*Consumer Reports*, p. 34) None of the "youth" helmets in the *Consumer Reports'* survey is priced above $40 leading us to conclude that ventilation is not nearly as important a variable for youth helmets as for adult helmets.

Supporting this assertion is *Consumer Reports'* rating of venting for youth helmets compared to their rating for adult helmets. Out of five possible scores, all but one of the ten

[10] "Youth" are children aged 5 to 14.

[11] The mean adult helmet price is $68.00 and the variance is $1,390; the mean youth helmet price is $24.20 and the variance, $138.18. A Barlett test (Milton and Arnold 1990) confirms that the variance of adult helmet prices is significantly larger than that for youth prices. The test statistic is X^2_1 and equals 6.93 with an associated P value between 0.01 and 0.005.

youth helmets received the two lowest scores.[12] On the other hand, all but two of the ten adult helmets received the three highest scores.[13] Apparently, and not surprisingly, adults are more comfort conscious than children and must pay a price for the extra comfort.

Important to note, however, is that the more expensive adult helmets do not convey a comfort level above what a helmet-free rider would experience. When one purchases a helmet, one is not purchasing two separate positive attributes – safety and comfort, since even the most comfortable helmets are less comfortable than no helmet. In other words, the portion of the helmet price going towards comfort clearly reflects WTP for *safety* for those purchasers. The adult purchasers of expensive, well ventilated helmets are attempting to buy themselves out of the discomfort costs that purchasers of cheaper helmets must pay. Unfortunately, because we have no information on the percent of the population who buys expensive versus inexpensive helmets, we can not use the information about WTP offered by these high helmet sticker prices. Thus, we estimate the annualized cost of an adult helmet by averaging the prices of the two adult helmets with the second lowest *Consumer Reports* ventilation rating; i.e., the lowest rated adult helmets. This gives the average price of adult helmets which have a comfort level comparable to children's helmets. This estimate of the annualized cost of an adult helmet is an effort to assign a zero value to time and disutility costs which suggests that our estimates of VSL are lower bounds. This parallels our estimates of VSCL.

For all three age categories, then, annualized cost is calculated as the average price of a helmet distributed over four years assuming a discount rate of 3 percent.[14] The second column of Table 2, "Data That Vary By Age" gives the estimated annualized costs for each age category. Note that the estimate is different for children relative to adults but is the same for the two children's age categories.

A final issue regarding annualized cost arises because bicycle helmets decrease the probability of head injury whether or not the injury results in death. Sacks et al. (1991) review death certificates and emergency department injury data for the U.S. for the five year period from 1984 through 1988. They report 1,985 head injury deaths and 905,752 head injuries from bicycle accidents. The predominant injuries were minor. However, a significant percentage of injured people (6.8 percent) were hospitalized. Given the potential importance to helmet purchasers of the prevention of head injury, we follow Dardis's analysis of smoke detectors and estimate a pair of VSLs for each age category; one that attributes the entire purchase price to death risk reduction and a second that attributes half of the price to injury risk reduction. Of course, the greater the proportion of cost attributed to injury risk reduction, the lower the estimated VSL.

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[12]The one exception received the middle score.

[13]The two exceptions received the second lowest score.

[14]Specifically, annualized cost = (average price) x $r/\{1 - 1/(1+r)^t\}$ where t is the average life of the helmet and r is the discount rate.

4.2 The Reduction in the Probability of Head Injury Death

Implementation of the model requires a second data item for each age group -- the reduction in the probability of head injury death caused by purchasing a bicycle helmet. To calculate this reduction, we collect several underlying data items. We review these data for the aged 5 to 9 category. Data and sources for the other age categories are the same except where noted. Please see Table 2 for a summary of data and sources.

The 1997 estimated population of children aged 5 to 9 is 19,668,500 (U.S. Census Bureau 1998).[15] Results from a national survey conducted in 1994 were that approximately 72.7 percent of children ride bicycles (Sacks, et al. 1996). Applying this percentage to 1997 population data gives an estimated bicycle riding population of children aged 5 to 9 of 14,299,000. Based on data from the Centers for Disease Control (CDC) (1998), we estimate that in 1997, ninety-three 5 to 9 year-olds died in pedal cycle traffic deaths.[16,17] Sacks et al. (1991) examine U.S. death certificate data for 1984 through 1988 and report that 64.1 percent of 5 to 9 year-olds experienced "head-related" deaths. If this percentage held for 1997 there would have been 59.77 deaths that were head-related. Based on a 1994 national telephone survey, we assume that of the bicyclists, helmets are worn by 31.8 percent of the 5 to 9 year-olds and 17.5 percent of 10 to 14 year olds (Sacks, et al., 1996).

We circumvent the need to develop an econometric model -- such as the one developed by Garbacz (1989) to estimate the effectiveness of smoke detectors -- by relying on previously published statistics in the public health literature. Thompson et al. (1996) in a case-control study with emergency room controls, find that 79 percent (68 percent) of severe brain injuries suffered by children aged 6 to 12 (adults aged 20 and older) are preventable by wearing a helmet.[18]

Our estimation of VSL would be improved if we had information on how closely the public's perception of the risk reduction caused by helmet wearing matched actual risk reduction. In principle, the perceptions of consumers are what affect purchase decisions. Some error is introduced by relying on actual risk reduction. However, it is limited by education campaigns, helmet standards and mandatory helmet laws that have educated the public about the protection

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[15] Calculated by averaging the 1996 and 1998 estimated populations of children aged 5 to 9.

[16] The CDC reports pedal cyclist traffic-related deaths in *U.S. Injury and Mortality Statistics* (http://www.cdc.gov/ncipc/osp/usmort.htm). However, only pre-1996 statistics are available. The 1997 estimate (93.25) was calculated by averaging the number of deaths for children ages 5 to 9 from 1995 (96), 1994 (91), 1993 (94), and 1992 (92).

[17] This figure represents only the number of motor vehicle involved deaths. In 1995, approximately 20 additional deaths occurred for children aged 14 and under from non-vehicle accidents (National Safe Kids Campaign, 1997). As this statistic is unavailable for our age categories, we adopt the conservative assumption that zero deaths occur from non-vehicle accidents.

[18] A severe brain injury is the category of head injury most likely to result in death.

offered by helmets. Additional error is introduced by our use of a national average risk reduction rather than a risk reduction that varies according to the household's physical setting (proximity of busy roads or safe bicycle trails, for example), other household characteristics, bicycle characteristics, and so on. We were unable to find estimates for how risk might vary according to these factors. We do, however, take into account that the risk reduction bestowed by helmets varies according to the age of a bicyclist.

Given the data values presented above, we estimate that 79.83 head-related deaths would have occurred in 1997 among children aged 5 to 9 in the absence of bicycle helmets.[19] Again, helmets are estimated to prevent 79 percent of fatalities, implying a reduction of 63.06 head-related deaths. When combined with the number of 5- to 9-year-old children riding bicycles, this gives a probability reduction of 4.41 $\times 10^{-6}$.[20] Table 2 summarizes these data for all three age categories.

There is an important concern regarding risk reduction caused by the *purchase* of a helmet. In practice, helmets are not worn all the time. A variety of sources report that the percent of people wearing helmets is approximately one half the percent who own (Rodgers 1996; Sacks et al. 1996). Thus, we present an additional estimate of VSL for each age category: one assuming that at the time of purchase, parents (or adults purchasing for self) expect the helmet to be worn 100 percent of the time and a second that more closely reflects actual experience by assuming that parents (or adults purchasing for self) expect that the helmet will be worn only 50 percent of the time. The second assumption is similar to one made by Dardis (1980) and Garbacz (1989) that consumers imperfectly replace smoke detector batteries so that smoke detectors are only operational 80 percent of the time.

4.3 Calculation of VSL

Table 3 summarizes estimates of VSL for three age categories. In the first column are estimates for purchasers who at the time of purchase expect that the child or that self will always wear a helmet while bicycling. We believe that the second column gives an improved set of estimates – a set based on an underlying assumption that more closely reflects actual experience; namely, that purchasers expect the helmet to be worn only half the time the bicyclist is riding. It is this second set of estimates that we will discuss below. All estimates appearing in the first two columns are based on the assumption that the purchaser places no value on the reduction in the probability of injury bestowed by a helmet. The third column gives estimates for purchasers who

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[19] The estimated number of head-related fatalities in the presence of helmets is:
(.682 x n x p) + (.318 x .21 x n x p) = 59.77 where
n = total number of bicycle riding children aged 5 to 9;
p = probability of pedal cycle traffic death from head-injury.
Here, 69 percent of children aged 5 to 9 do not wear helmets. Thirty one percent do wear helmets and have a smaller probability of dying than the non-helmet wearers. The estimated number of head-related fatalities for 1997 in the absence of helmets is n x p = 79.83.

[20] (63.06)/(14,299,000)=.00000441.

expect the helmet to be worn half the time *and* who assign equal weight to reducing the probability of death versus injury.

As we discussed when developing the theoretical model, the correct interpretation of our estimates of VSCL is that they apply only to the marginal purchaser of bicycle helmets. The results of a national survey of over 5000 households conducted in 1994 suggest that 57.5 percent of children aged 5 to 9 in the United States owned a helmet (Sacks et al. 1996). This suggests that approximately 45 percent of parents “have” a lower VSCL than our estimate and 55 percent of parents have a VSCL equal to or greater than our estimate. Thus, for the aged 5 to 9 category, our estimate of $2,952,218 is close to the median VSCL.

Our estimated VSCL for the aged 10 to 14 category is $2,117,234, lower than that for the younger children. Driving our result is that the probability of a bicycle accident head injury death for the older age group is greater. Hence helmets bestow greater protection upon these children for the same price.

The same national survey mentioned above found that 42.3 percent of kids aged 10 to 14 owned a helmet (Sacks et al. 1996). This suggests that our VSCL estimate for this age category is higher than the median. This supports the conclusion that VSCL is lower for the older children.

Finally, our estimate of VSL for the aged 20 to 59 category is $3,923,398, the highest of the three estimates. The primary factor driving this result is that relative to the average price of a child’s helmet, the price of an adult helmet is higher. Approximately, 35 percent of adults in the U.S. own helmets. Thus, our estimate of VSCL is higher than the median.

Interestingly, our results contradict the popular hypothesis that the value of a life varies directly with the expected number of life years remaining. They suggest a more complicated relationship between age and VSL -- a relationship that might depend, in turn, on the relationship between parent and child. Generally, a parent is wholly responsible for a child’s well-being when she is born and gradually transfers that responsibility to the child as the child matures. This could explain why a parent-determined VSCL would decline as a child ages.

There are at least two possible reasons why the adult VSL is highest. One is that despite that we averaged prices of only the lowest comfort rated adult helmets, relative to children’s helmets, adult helmets might generally be built with greater attention to comfort. The fact that the average price of even the lowest rated adult helmets is lower than the average price of youth helmets supports this hypothesis. If this is so, part of the adult purchase price is going to decrease the disutility costs of helmet wearing. Because children pay these costs as disutility, our estimates neglect these costs and hence we understate the true VSCL.

A second possible reason for why the adult VSL is highest is that these values are revealed by adults for themselves whereas the children’s values are revealed by parents for their own children. Perhaps willingness to pay to preserve one’s own life is indeed highest. This suggests that relying on a third party, even when that party is a parent, to estimate values of reduced risk might not be an acceptable alternative to collecting preferences from individuals about themselves. Since one can not expect reasonable formulations of preferences or of market trade-offs from children, perhaps the best estimate of VSCL is a VSL estimated for an adult population.

5. <u>Comparison of VSCL with other VSL Estimates</u>

Tables 4 and 1 present two different sets of VSL estimates in 1997 dollars. Table 4 summarizes 26 high quality estimates from hedonic wage analyses and a few from analyses of contingent valuation surveys.[21] Only adults are represented by these estimates. The hedonic wage analyses tend to focus on specific portions of the adult population; usually, blue collar workers and manual laborers. Our own estimates are in the range presented by Table 4 but at the low end of that range. This is similar to other estimates of VSL based on data from markets other than the labor market.

Recall that Table 1 summarizes VSL studies based on tradeoffs outside the labor market. Many of these studies represent the adult population at large and hence avoid the problem presented by hedonic wage analyses of representing only a small portion of the adult population. Table 1 summarizes several VSL estimates based on safety-product-market analyses. These estimates are most appropriate to compare to our own. In the final row of Table 1 is the only other estimate of VSCL of which we are aware – by Carlin and Sandy (1991). Recall that this VSCL was estimated for children aged 4 and under. Relative to it, regardless of the assumptions invoked, our estimates of VSCL are always at least a third higher. Relative to the entire range of estimates summarized by Table 1, most of which apply to adults, our estimates are in the upper range.

6. <u>Policy Relevance</u>

In response to recent directives such as E.O. 12866, "Regulatory Planning and Review," and the Omnibus Appropriations Act of November 1998 which requires the Thompson Report (a report on the total costs and benefits of an agency's regulations during the year 2000), policy-makers are making a concerted effort to value the benefits and costs of regulations and policies in order to better justify government expenditures. In the past, government analyses were decidedly slanted toward valuing the costs of regulations. Today, policy makers are also interested in obtaining accurate *benefit* estimations. Many such benefits are reduced risks; of contracting a fatal health condition, for example, or of being injured in an automobile accident. One way to measure these benefits is to estimate values of the resulting improvements to human health that save statistical lives.

To refine valuation of health benefits, the population as a whole can be viewed as a

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[21] In 1997, the U.S. Environmental Protection Agency (EPA) completed *The Benefits and Costs of the Clean Air Act, 1970 to 1990* (EPA 1997) wherein an approach for valuing mortality risk, subject to extensive peer review, was developed. Twenty-six high quality, policy-relevant value of life studies were identified. They are summarized by Table 4.

collection of sub-populations, defined along many possible lines. Many federal regulations and policies clearly do not impact all equally (e.g., Occupational Safety and Health Administration's regulation on logging operations affects loggers, primarily adult males, while the Environmental Protection Agency's (EPA's) rules on lead paint have a large effect on children). Despite the long history of the value of life literature, little attention has been paid to estimating values for sub-populations.

To policy-makers, children make up a particularly important sub-population. E.O. 13045, "Protection of Children from Environmental Health Risks and Safety Risks" requires federal agencies to give priority to assessing health and safety risks that disproportionately affect children. In addition, it requires agencies to assess the health or safety effects on children of many planned health and safety regulations.[22] It is not uncommon for a federal regulation to affect children disproportionately. A host of example regulations have been promulgated by the EPA. Due to children's high consumption of water per unit of body weight, EPA rules on drinking water contaminants disproportionately affect children. Rules on pesticides for fruit and vegetables are similar. Other examples can be found in the public health arena; most notably the rules and regulations dealing with inoculations against childhood diseases and illnesses.

Our research is an early effort to estimate the value of a statistical child's life which ultimately could help inform policies specifically concerned with valuing children's health improvements. We do not mean to suggest that our estimates should be adopted by policy makers to represent VSCL. Rather we hope that our estimates are one set of contributions to a growing number of estimates of VSCL derived from many different sources of data and with different methodologies. Further research is needed to construct a range of VSCLs similar to that which exists for adults.

Currently, to estimate the value of a policy's reduced mortality risk to children, economists transfer a VSL estimated for an adult population to the relevant child population. Our results suggest that this practice might over-estimate parents' assessment of those benefits. It might not over-estimate a child's own assessment of benefits. Perhaps a better estimate of a child's own assessment of benefits – better than parent's WTP -- is a WTP estimated from a population assessing their own risks; in other words, an adult WTP for adult risk reductions. To better represent a child's future preferences, transferring adult VSLs to child populations might be preferred to estimates of parent-determined VSCLs. In any case, our results are that the VSL for the age group 20 to 59 is approximately 18 percent greater than for the age group 5 to 9. This suggests that transferring adult VSLs to child populations does not produce gross mis-estimations.

[22] We recognize that many of the risks associated with federal regulations and policies, particularly environmental regulations, differ significantly from the risks associated with bicycle riding. One such important difference concerns the fact that death is immediate in the case of bicycle riding, whereas deaths associated with cancer (and other similar illnesses resulting from exposure to environmental hazards) often have long latency periods. It is important to note, however, that we compare our VSCL estimates to adult-based estimates also dealing with reductions in risks of immediate death.

Tables

Table 1
VALUE OF STATISTICAL LIFE STUDIES BASED ON TRADEOFFS OUTSIDE THE LABOR MARKET
(values in 1997 dollars)

Study	Nature of Risk, Year	Component of the Monetary Tradeoff	Value of Statistical Life
Ghosh, Lees, & Seal (1975)	Highway speed-related accident risk, 1973	Value of driver time based on wage rates	$0.08 million
Blomquist (1979)	Automobile death risks, 1972	Estimated disutility of seat belts	$1.44 million
Dardis (1980)	Fire fatality risks without smoke detectors, 1974-1979	Purchase price of smoke detectors	$0.72 million
Portney (1981)	Mortality effects of air pollution, 1978	Property values in Allegheny Co., PA	$0.96 million
Ippolito &Ippolito	Cigarette smoking risks, 1980	Estimated monetary equivalent of effect of risk information	$0.84 million
Garbacz (1989)	Fire fatality risks without smoke detectors, 1968-1985	Purchase price of smoke detector	$2.40 million
Atkinson & Halvorsen (1990)	Automobile accident risks, 1986	Prices of new automobiles	$4.80 million
Carlin & Sandy (1991)	Automobile accident fatality risks to children not in a car seat, 1985	Purchase price of car seat	$0.75 million

Except for the last row, this table is from Viscusi, V.K., "The Value of Risks to Life and Health", *Journal of Economic Literature* (December 1993), see article for full references for these studies. Values are updated to 1997 dollars using the Gross Domestic Product deflator.

Table 2
Data That Vary by Age

Age	Annualized cost of a bicycle safety helmet[23]	1997 population (U.S. Census Bureau 1998)	Percent of population who ride bikes	1997 bike-riding population	1997 pedal cycle deaths (CDC 1998)	percent of deaths related to head injury (Sacks et al 1991)	percent wearing helmets all or most of the time	percent of fatalities preventable with helmet use (Thompson et al. 1996)	1997 head-injury related pedal cycle deaths in the absence of helmets	1997 deaths prevented with universal helmets	probability reduction	1997 deaths prevented - helmets worn 50 percent of the time	probability reduction - helmets worn 50 percent of the time
5-9	$6.51	19,668,500	72.7[24]	14,299,000	93.25	64.10	31.8[25]	79	79.83	63.06	4.41e-06	31.53	2.21e-06
10-14	$6.51	19,066,500	72.7	13,861,346	143.50	64.80	17.5	79	107.90	85.24	6.15e-06	42.62	3.07e-06
20-59	$10.76	146,451,000	20.2[26]	29,583,102	351.75	59.40	18.3[27]	68	238.62	160.07	5.41e-06	81.13	2.74e-06

23 The annualized cost of a bicycle helmet was calculated in the following manner. First, the average price for helmets suitable for "youths" (children aged 5 to 14) was calculated with information from *Consumer Reports* (1997) which lists prices for 10 children's helmets based on a national survey. The average cost of an adult helmet was calculated based on the price of the two helmets receiving the lowest ventilation rating in *Consumer Reports*. *Consumer Reports* states that to ensure that safety features are effective, manufacturers recommend replacing helmets after 3 to 5 years. Assuming a helmet life of 4 years, we calculated annualized cost as: average price * $r/\{1 - 1/(1+r)^t\}$ where $t = 4$ (the average life of the helmet) and r is the discount rate. We assume that $r=0.03$.
24 Sacks et al. (1996).
25 Sacks et al. (1996).
26 Bolen et al. (1998).
27 Bolen et al. (1998).

Table 3
Value of a Statistical Life by Age Range and Assumptions
(1997 dollars)

Age	Helmet worn all the time	Helmet worn 50 percent of the time	Helmet worn 50 percent of the time and equal weight on death and injury[28]
5-9	$1,476,109	$2,952,218	$1,476,109
10-14	$1,058,617	$2,117,234	$1,058,617
20-59	$1,961,699	$3,923,398	$1,961,699

[28]For children it is assumed that the helmet is worn 50 percent of the time. That is, the parent purchasing the helmet, knowing she doesn't have control over the child's actions 100 percent of the time, realizes that the child will not always wear the helmet. Similarly, it is assumed that adults know, at the time of purchase, they will not wear a helmet all of the time.

Table 4 **VALUE OF STATISTICAL LIFE ESTIMATES** (mean values in 1997 dollars)		
Study	**Method**	**Value of Statistical Life**
Kneisner and Leeth (1991 - US)	Wage-Risk	$0.7 million
Smith and Gilbert (1984)	Wage-Risk	$0.8 million
Dillingham (1985)	Wage-Risk	$1.1 million
Butler (1983)	Wage-Risk	$1.3 million
Miller and Guria (1991)	Contingent Valuation	$1.5 million
Moore and Viscusi (1988)	Wage-Risk	$3.0 million
Viscusi, Magat and Huber (1991)	Contingent Valuation	$3.3 million
Marin and Psacharopoulos (1982)	Wage-Risk	$3.4 million
Gegax et al. (1985)	Contingent Valuation	$4.0 million
Kneisner and Leeth (1991 - Australia)	Wage-Risk	$4.0 million
Gerking, de Haan and Schulze (1988)	Contingent Valuation	$4.1 million
Cousineau, Lecroix and Girard (1988)	Wage-Risk	$4.4 million
Jones-Lee (1989)	Contingent Valuation	$4.6 million
Dillingham (1985)	Wage-Risk	$4.7 million
Viscusi (1978, 1979)	Wage-Risk	$5.0 million
R.S. Smith (1976)	Wage-Risk	$5.6 million
V.K. Smith (1976)	Wage-Risk	$5.7 million
Olson (1981)	Wage-Risk	$6.3 million
Viscusi (1981)	Wage-Risk	$7.9 million
R.S. Smith (1974)	Wage-Risk	$8.7 million
Moore and Viscusi (1988)	Wage-Risk	$8.8 million
Kneisner and Leeth (1991 - Japan)	Wage-Risk	$9.2 million
Herzog and Schlottman (1987)	Wage-Risk	$11.0 million
Leigh and Folson (1984)	Wage-Risk	$11.7 million
Leigh (1987)	Wage-Risk	$12.6 million
Gaten (1988)	Wage-Risk	$16.3 million

Table 4 **VALUE OF STATISTICAL LIFE ESTIMATES** (mean values in 1997 dollars)
See Viscusi, V.K., *Fatal Tradeoffs* (Oxford University Press, 1992), for full references for these studies. Values are updated to 1997 dollars using the Gross Domestic Product deflator.

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Discussion of Jenkins, Owens, and Wiggins Paper

by Mark Dickie, University of Southern Mississippi -- Summarization

Dr. Dickie complemented the paper, commenting that a bicycle helmet provides a private good within the family, which differs from other work in the safety market literature, which have dealt with smoke detectors and automobile safety features. The bicycle helmet also provides a specific age match for safety for both adults and children, since both adults and children wear helmets, which differentiates it from the literature on child safety seats, for example. The research method is also advantageous in that the approach can be implemented quickly, and that there were not problems with primary data collection.

Dr. Dickie also noted some disadvantages of the approach taken in this paper. This approach gives rise to a problem with joint products, in that bicycle helmets provide both protection from death and protection from injury, making it difficult to sort out valuations for avoidance of each outcome. There are also possible mismatches between parents' perceptions of risk. in that they may under or over-estimate the kinds of risks involved. Finally, there are potential problems in accounting for children's behavior, and the need to monitor their use of bike helmets.

The results are credible, and the estimates are reasonably similar to that of other studies that have been done in this vein of literature. In terms of comparing the adult values with the child values, there is only so much that can be concluded from this study, because it is not known what the median values are for the different age groups. Thus, if the distributions for the various age groups are different, one could be comparing individuals in different percentiles of the age groups.

Another issue pertaining to the comparison across age groups, the ratios for the values of statistical lives is about 1.4 from the younger age group to the older, which is approximately the same as the inverse of the ratio of risk reduction. This raises a question as to whether the data is suggesting that the risk reduction alone is accounting for the willingness to pay; if that is the inference, then the result raises some doubts, since one would think that the value of a statistical life falls with age. This inference can be drawn from the comparison of either of the childrens's age groups with the adult age group.

Dr. Dickie pointed out that the fraction of each age group that wears bike helmets is different. He posed the question as to whether or not the value of a statistical life should be adjusted for the fraction of time that the bike helmet is actually worn. Dr. Dickie also speculated that if better data on disutility costs were available (there is insufficient variation in the discomfort data), some hedonic analysis may be possible. Finally, Dr. Dickie queried whether child-rearing *costs* should be considered along with the value of a statistical life for a child, offsetting some of the benefits of risk reduction. In summary, Dr. Dickie praised the work, which is a logical extension of the earlier paper by Carlin and Sandy[29] on the value of a statistical life.

29 Carlin, P. and R. Sandy. 1991. "Estimating the Implicit Value of a Young Child's Life." *Southern Economic Journal*, 58(1):186-202.

Valuing Children's Health and Life: What Does Economic Theory Say About Including Parental and Societal Willingness To Pay?

--Commissioned Paper*--

William T. Harbaugh
Department of Economics
University of Oregon
Eugene, Oregon 97403-1285
harbaugh@oregon.uoregon.edu

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Valuing Children's Health and Life:
What Does Economic Theory Say About Including
Parental and Societal Willingness To Pay?

Abstract: Governments can and do adopt many policies that will improve the health and reduce the mortality risks of children. Given this, estimates of the value of improvements in children's health and reductions in their mortality risk are needed so that governments can rationally choose which of the many possible policies to adopt. These estimates should be based on an appropriate measure of value that is based on economic theory. This paper examines what economic theory has to say about what sorts of elements should be counted in that value, and how that value should then be used in decision-making.

1. Introduction:

Governments can adopt many policies that will improve the health and reduce the mortality risks of children. Given this, estimates of the value of improvements in children's health and reductions in their mortality risk are needed so that governments can rationally choose which of the many possible policies to adopt and how far to pursue them. These estimates should be based on an appropriate measure of value that is based on economic theory. This paper examines what economic theory has to say about what sorts of elements should be counted in that value, and how that value should then be used in decision-making.

The paper begins with a discussion of the various reasons why children's own willingness to pay (WTP) is unacceptable as a measure of value. I first ignore altruism by parents and other adults. I present short discussions of young children's psychological inability to imagine death, their generally high discount rates, the high degree of risk-taking behavior in adolescents, and the short time horizons of both children and adolescents. I argue that these preference related issues mean that own WTP for health and safety improvements are poor measures of the true benefits of these goods to children. I show that an additional difficulty arises from children's inability to borrow against future income.

I argue that these aspects of children's preferences and budget constraints can lead them to make decisions which can be Pareto improved on by a social planner. That is, even if parents and non-related adults are not altruistic, it may be possible for government to adopt policies that alter the voluntary decisions of children in ways that make some of the children, parents, and other adults better off and none worse off. I show how own WTP should be altered in order to provide the information necessary for such decisions.

I then focus on what I believe is a more significant question: how to account for the altruistic feelings that parents and other members of society have for the health and safety of children. It is commonly argued that parents and to a lesser extent society in general have a legitimate interest in children's welfare. In practice, parents almost universally provide their children with far more health and safety than they would voluntarily consume. While the effect is usually less extreme, society also tends to provide children with more of these goods than their families would voluntarily provide, and in "dysfunctional" cases this effect can also be very large. It is much rarer (though not unheard of - adults often believe that some degree of risk taking is part of growing up) for parents to insist that children are being too safe, or for society to take the opinion that parents are being overprotective.

While I have argued above that part of this protective behavior may be explained by a model where decisions are made by benevolent planners, rather than by altruism in the usual sense, altruism is also an important, and potentially more important factor. How altruistic preferences should be correctly incorporated into policy decisions is not obvious.

For the purposes of this paper two kinds of distinctions in altruistic preferences are relevant. The first is that between non-paternalistic and paternalistic altruism. In the former the utility of one person (the child) is an argument in the utility of another (the adult.) In the latter it is the level of consumption of a particular good by the child, say safety, that enters the preferences of the adult. This distinction is potentially important. Others have shown that, under certain circumstances, if parents care about the utility of children, then incorporating adults WTP for children's safety can result in more safety than is socially optimal. I examine the reasonableness of the assumptions on which this result is based and how sensitive this conclusion is to those assumptions. For example, I assume that there is some constraint on cash transfers to children, and look at second best solutions. There are obvious reasons why in multi-period models parents may prefer not to make cash transfers to children, even if they really care about the utility of their children.

The second distinction is between pure and impure altruism. Pure altruism is where the level of utility or consumption of the child enters the adult's utility. Both the non-paternalistic and the non-paternalistic cases above would be examples of pure altruism. Impure altruism is where the amount of the adult's contribution to the child's utility or consumption enters the donor's utility. This might be either because the donor feels good when he donates, or because he gets some benefit when other people notice he has donated.

It is well established that impure altruism is an important explanation for donations to charities and contributions to small groups in experimental settings. It seems likely that this is also true for contributions by adults to charities that help children. It is an open question as to whether parent's support of their own children is an example of pure or impure altruism.

I address the question of how preferences that incorporate impure altruism will affect WTP for the well-being of another, and how measures of WTP that include impure altruism should be used in making policy decisions.

2: Some Simple Problems with Own Willingness to Pay:

Although there is no ideal measure, economists generally agree that for the purposes of conducting benefit-cost analysis and making policy decisions the amount that a person is willing to pay to acquire a good is a useful measure of the good's value. In later sections of this paper I will discuss what happens to the validity of this measure if people other than the purchaser care about how much of it the purchaser consumes. The purpose of this section is to argue that - even ignoring externalities and altruism - this measure should not be applied to reductions in children's mortality and morbidity rates.

<u>Different conceptions of what death means.</u>

One argument is that young children simply lack the ability to imagine death. Carey (1985, pp. 13-40 and 60-65) reviews the psychological literature and finds a consensus that there are three stages in children's understanding of death. Until age 5 or so, children typically see death as a form of sleep, and while they see it as painful, because it involves separation from parents, they do not understand that it involves an final end to the body's biological processes. For example, they ask questions such as "How do dead people go to the bathroom?" and they speak of the need to whisper when talking at funerals to avoid waking up the deceased. Elementary age children do understand that death is terminal, but not that it is an inevitable biological fact. They often attribute the death of a person described as bad to that person's bad deeds or bad nature. However, elementary age children do understand that things such as poisons and falls and cancer can kill a person, and that once dead they aren't coming back. By about age 9 or 10, children seem to understand death as adults do.

It seems likely that children not only do not understand death as adults do, but that they do not understand that their conception of death is going to change in a way that makes death more unacceptable. Since death is irreversible, this means that we can argue that a child's WTP for a given reduction in the probability of death will be a downward biased measure of the true benefits to them of that reduction.

Changes in Discounting and Risk Aversion

A similar problem arises because children and adolescents discount the future at high rates (Krause and Harbaugh, 1998). Again, it seems likely that children do not understand that their discount rates will decline as they grow older, though the evidence on this is less conclusive. If they are faced with giving up current consumption for future increases in health or decreases in the risk of death, and if they fail to realize that their discount rate will decline, they will discount these improvements at the current rate instead of at a rate that declines with age. Again, this will mean that own WTP for safety improvements will undervalue the true benefits of the improvements.

On the other hand, if given a chance to trade off their current (but not future) health for increased future consumption, children will *underestimate* the value of future consumption, and presumably choose too much current health. Unfortunately, children seem to have relatively more opportunities of the first sort.

While risk aversion also seems to increase with age, and adolescents are well know for their willingness to take far greater risks to health than adults will accept, changes in risk aversion are probably not the source of problems of the above sort. This is because risks are typically one shot affairs. Adults are not forced to repeat the sorts of risks that they take as children. One exception might be addictions. Adolescents might be willing to take the chances that, say, cigarette smoking entails, while adults are not. However, once addicted, the adult may essentially be stuck continuing to accept repeated risks of heath damage that he would be unwilling to agree to with his current preferences. Note that this could happen even if the adolescent had made a rational forward looking decision to become addicted, as in Becker (1989).

Restricted Access to Credit

Even if there were no problems of the sorts described above, and children were able to make fully rational choices, another difficulty arises because children's current incomes are very low relative to their permanent incomes. Legal prohibitions on their rights to sign contracts make it essentially impossible for them to borrow against their future earnings. This means that, in the common situation where the cost must be paid now and the health benefits or risk reduction come later, children would be unable to borrow to make optimal choices, given their preferences. The simple solution to this problem would be to remove the borrowing constraint, but the costs of doing this will be large, if the sorts of problems described above *do* exist.

3. Should Social Planners Try to Improve on the Decisions of Children?

The above issues suggest the possibility of Pareto improving changes in children's own choices regarding health and safety, even if we ignore the possibility that adults are actually altruistic towards children. This is slightly different from the usual situation where the social planner’s approach is used. The typical setup is the case where one person’s actions affect another’s. While these children are making bad decisions, those decisions are only affecting themselves (again ignoring altruism).

Still, it seems clear that in every case considered in section 2 above, it is possible at least in theory to construct a Pareto improvement. For example, consider the under-investment in activities that increase future health, caused by temporarily high discount rates. The social planner needs only to borrow and make the investments for the child, then have the child pay pack the loans when older.

In short, I am arguing that it’s possible to give plausible normative and positive explanations, that have nothing to do with altruism, for interfering in children’s own decision’s. This is important because it suggests that the interference in children’s decisions we *do* observe may not solely be the result of altruism, where that is defined as an adult’s willingness to sacrifice his own consumption for that of a child’s. As we will see below the question of how to include WTP that is derived from altruistic preferences is complicated. I believe this adds another layer of complication, requiring that empirical efforts to measure WTP for children’s safety must also determine the motives behind that WTP.

4. Altruism.

In this section I address the question of how to account for the altruistic feelings that parents and other members of society have for the health and safety of children. For expositional purposes I will often take the (hopefully) oversimplified point of view that these altruistic feelings all run in one direction, from adults to children. I will also often assume that adults are more altruistic toward their own children than to other children. These conventions will make it more obvious as to how the theory, which was often developed for more general purposes, applies to the question at hand. I should note that there are models of the evolutionary development of altruism, described in Bergstrom 1996 and Sober and Wilson 1998, that predict these sorts of preferences.

For the purposes of this paper two kinds of distinctions in altruistic preferences are relevant. First is the distinction between non-paternalistic and paternalistic altruism. Non-paternalistic altruism means that the altruist cares about the well-being of other people *as those other people define their well-being*. In other words the utility of the other person is an argument in the altruists utility function. Paternalistic altruism means that the altruist cares about some particular aspect of a person's well being, not their utility. For our purposes that something will generally be safety.

It has been shown that, under certain circumstances, if people are non-paternalistically altruistic, then incorporating their WTP for the safety of others will result in more safety than is socially optimal. I examine the reasonableness of the assumptions on which this result is based, how sensitive this conclusion is to those assumptions, and how applicable this result is to the question of children's health and safety.

The second distinction is that between pure and impure altruism. Impure altruism is an important explanation for donations to charities and for contributions to small groups in experimental settings. It seems almost certain that this motive is also an important one for contributions by adults to charities that help children. It is an open question as to whether parent’s support of their own children is an example of pure or impure altruism. I address the question of how preferences that incorporate impure altruism will affect WTP for the well-being of another, and how measures of WTP that include impure altruism should be used in making policy decisions.

4.1 Non-paternalistic and paternalistic altruism.

In this subsection I review work by others on the appropriate way to include WTP for reductions in the mortality and morbidity rates of others. I show that in general it is not sufficient to just look at revealed or reported WTP, and that instead it is necessary to understand both the motives behind the willingness to pay, and the constraints on the altruist and the recipient.

Non-Paternalistic Altruism

Bergstrom (1982) proved what at first glance seems to be a rather astonishing result about how non-paternalistic altruism affects the socially optimal level of safety. With a few relatively innocuous assumptions he shows that the conditions for the Pareto optimal level of public safety are the same whether people care about others or not.

The intuition is very simple if we view safety as a private good. Safety is expensive and providing it means someone must consume less of some other good. If that someone is the recipient, he gets less consumption and more safety than he would have voluntarily consumed, and so is worse off than before. Since the altruist cares about the recipient's utility, he is also worse off. This is obviously not a Pareto improvement, much less Pareto optimal.

So suppose the altruist pays for the safety. The recipient is better off because he has more safety, a good he cares about. The altruist is better off because of the increase in the well-being of someone he cares about, but worse off because of the decrease in his own consumption. It's not clear if this is a Pareto improvement, but it can be shown that it's not Pareto optimal.

Suppose that the altruist gives the recipient cash equal to the cost of the safety, instead of safety. The recipient would then buy the amount of safety that maximizes his utility. This would leave the recipient with no less utility than before, and assuming the marginal utility of consumption was positive, with more utility. Since the altruist cares about the recipient's utility he'd be better off with this larger utility increase than he would be with the smaller increase he got by giving safety. So there's a way to make everybody better off: redistribute money and let people by the amount of safety they find optimal, that is where there WTP equals the marginal cost of provision. This is just the standard argument for transfers of money rather than goods.

Bergstrom extends it to the situation where safety is a non-rival good. The argument is essentially the same: if we provide more safety than is optimal by the usual Samuelson rule, people must be consuming less of others goods than is optimal. So increasing a person's safety beyond the amount people would voluntarily buy cannot be Pareto optimal. This is not to say it's bad, just that we can do better.

In the context of the question of how to account for parental and social valuations of children's safety, this result says that society should not provide children with anymore safety than children would voluntarily buy themselves, since we could always do better by redistributing income instead. In the context of this paper, which is concerned with the question of how to value improvements in children's health, the implication is that, if we are trying to achieve the efficient amount of safety, we should use the child's own value *and not add a term for their parents willingness to pay for safety*.

Note that this is not quite the same as saying that the socially optimal quantity of children's safety, with parental or societal altruism, is the same as the level that would be optimal without that altruism. Instead, we are saying that the marginal conditions for optimality are the same. If benevolent altruists transfer money to children, then so long as safety is a normal good, the amount needed to satisfy the children's own condition for optimality will increase.

<u>But what if the altruists are paternalistic?</u>

There are several difficulties with using this result as a prescription for what should and should not count in benefit cost analysis. First, there is abundant evidence, beginning with the very origin of the word paternalistic, that parents, and society in general, are concerned with children's safety, and not their utility. In such a situation Jones-Lee (1991) shows that it is correct to consider *all* the altruist's WTP for the recipient's safety when determining the socially optimal level of safety.

Some intuition for this result is as follows. First, suppose we ignore the altruist's WTP in setting the recipient's safety. Now consider a slight increase in safety. This makes the recipient better off, since his safety goes up, and it also makes the altruist better off, for the same reason. Continue this process until the altruist's WTP is fully incorporated into the decision to buy safety, that is so he is no longer willing to pay for more safety.

Can we find a Pareto improvement to this situation? Obviously we can't make the altruist better off unless we can somehow induce the recipient to increase his consumption of safety even more. But we are already providing the recipient with more safety than he was willing to buy voluntarily. Again, this logic is developed for the case where safety is a private good, but the conclusion also holds if it is rival.

An explanation for why WTP from non-paternalistic altruists should count too.

In this part of the paper I argue that an important assumption of the Bergstrom model is unlikely to apply to the case of parents and children. As a result I will argue that, *even when parents are non-paternalistic altruists,* it is appropriate to include some portion of their WTP for safety into the calculation of the socially optimal amount of safety.

Bergstrom assumes that transfers of money to children and transfers of goods are equally expensive. However, if it is cheaper to transfer a particular good, say safety, to a recipient than it is to transfer cash, the Bergstrom result no longer holds. For example, suppose that it costs $3 to transfer $2 of cash (or of the consumption good), but only $1 to transfer $2 of safety. Then clearly it is no longer always possible to create a Pareto improvement to a safety transfer by making a cash transfer instead.

Arguably, the most important reason why it is expensive to transfer cash to children is the distortions that the prospect of these transfers create. While at first glance it might seem obvious that cash transfers to children will distort their behavior, the issue is actually rather subtle. Becker's (1981) well known rotten-kid theorem showed that there are plausible circumstances where, rather than cause children to distort their behavior in *inefficient* ways, cash transfers can actually cause them to act *efficiently*.

Suppose that the parent is an altruist who is going to make a cash transfer to the child.

The child knows this, and knows that this transfer is going to be an increasing function of the parent's wealth. By choosing actions that maximize that wealth, the child will maximize the transfer. So in this situation the prospect of a cash transfer from the altruistic parent actually serves to *reduce* inefficient distortions in the child's behavior.

The problems with this argument are both empirical and theoretical. Peters et al. (1997) in an ingenious experiment with family members show that children simply do not behave this way towards their parents. Either they don't understand the game, or they don't believe their parents are altruists. The second problem is that under more realistic assumptions the theoretical prediction no longer holds.

Bergstrom (1989) shows the rotten-kid theorem only holds in restrictive circumstances. One of several ways that cash transfers can produce distortions is if the child can commit to actions before the adult, as Bergstrom shows in a two-period model. Suppose that in period 1 the child has a choice between consuming \$1 and investing it in a way that will increase the family's period 2 earnings by \$1(1 + r). The child knows that his altruistic parent will divide the second parent income up between the parent and the child, so the child has a choice of \$1 now or a *portion* of the \$1(1 + r), later. Suppose that r is greater than the child's and the parent's discount rates, so that it is efficient to make the investment. If the portion of family income that the parent intends to share is small enough, it is quite possible the child will prefer *not* to make this investment, even though doing so would be efficient.

Bruce and Waldman (1990 and 1991) further develop this idea in a way that is relevant to the question of safety. They develop a two-period model like Bergstrom's, and use it to show that it may be optimal for even non-paternalistic altruists to give gifts in kind rather than cash. Their explanation is similar to Bergstrom's argument above and is explicitly based on Buchanan's (1975) "Samaritan's Dilemma," which was concerned with the adverse incentives of welfare programs. The dilemma for the parents is that if they promise their children a future cash transfer that is inversely related to the child's future wealth, they will induce children to work less than is optimal, and also to under invest in activities that increase their productivity. The intuition they give is that by spending more now and less in the future, children increase the marginal utility of future consumption, and this higher marginal utility will induce altruistic parents to increase their transfer. This distortion is inefficient.

Bruce and Waldman argue that parents can avoid this inefficiency by giving their children an in-kind transfer instead. They argue that the ideal good is one that forces the children to increase their savings, and they use education and down payments on a home as good examples. Children would like to convert these gifts to cash, spend the cash on current consumption, and then collect higher last period transfers from their parents, but the nature of these particular sorts of gifts makes this very difficult.

A similar and perhaps even stronger story could be told about morbidity. Children naturally, and generally correctly, believe that their parents will take care of them if they are injured or get sick. Suppose that a child with these beliefs is given the opportunity to sacrifice $1 of consumption now, in order to get a reduction in morbidity with a present value of $2 to the parent and the child. Obviously , it would be optimal to make the sacrifice. But, suppose the child knows that if they consume the $1 now, their parents will increase their future bequest, since they will be poorer in the future, *and* that if after not buying the safety they do get injured, their parents will take care of them. In such a situation children will obviously have an incentive to consume rather than invest that is even stronger than that which occurs with regular investments.

Note that the situation with risks to life is somewhat different than that of risks to health. Parents cannot make second period transfers to their children that can compensate them for death, as they can for injury and illness. Because of his, children will have no particular incentive to consume too little of forms of safety that specifically reduce death. Since in practice risks of morbidity and of mortality are correlated, this means that the problem of children under-investing in safety is somewhat mitigated.

Applying Bruce and Waldman's results to the case of safety has shown that children will tend to under-invest in safety to an even greater extent than in other things. This provides a justification for policies that increase safety above the amount that children will purchase voluntarily. The question is how far to go. Since both parents and society in general may be making second period cash transfers to children, both will be in a situation where their transfers are distorting behavior, and both will conceivable be in a situation to implement policies to increase children's safety.

For simplicity, I will assume that there is only one altruist, the parent. The analysis will be similar with more than one. We want to know how we should use the child's and the parent's WTP for safety in determining the optimal level of safety. First, recall that the fact that the altruists are making second period cash transfers causes the recipient to choose less safety than would otherwise be optimal, even if the altruist's preferences are ignored. So it is clear that there is scope for the altruist to do as Bruce and Waldman recommend and increase the provision of safety. The question is how far, and in particular should the quantity decision also incorporate the parent's WTP?

As argued above, for Bergstrom's result that we should ignore the altruist's WTP for safety to hold it must be possible to transfer money at the same cost as safety. Is that possible here? We already know that, because he cannot pre-commit to a transfer, the cash transfers from the parent will be distortionary. The question is, can the government do any better? In practice, we would have to say no. For example, neither SSI payments, Medicare, or Medicaid benefits discriminate against those whose conditions are the result of their own decisions, such as smoking or riding a motorcycle without a helmet.

Interestingly, if the government *could* pre-commit to a transfer, this would still not necessarily eliminate the distortionary effects. Parents still might undo the governments commitment by adjusting their own transfer to reflect the recipient's marginal utility of second period income.

So, I argue that in the two period model, the WTP for safety of parent's and other altruists, generally *should* be considered when making decisions about how much public safety to provide children, even if the altruists have entirely non-paternalistic motives. This is contrary to Bergstrom's conclusion. Note that it does not matter whether we measure WTP by observing parent's purchases of private safety or use CV questions about public safety. In either case, the estimated WTP should be used in government decision-making.

While the Bergstrom / Jones-Lee results are interesting, they do not apply under what I believe are the most realistic conditions. The Bruce and Waldman (1990) assumptions are more realistic, and the give a contradictory result. The conclusion for pure altruism is that, when determining the socially optimal level of safety, we should include even non-paternalistic altruist's

WTP for increases in children's safety.

4.2 Impure altruism:

Now I consider the situation where parents derive a benefit that depends on the amount of contribution they make towards their child's utility or safety. There are numerous reasons why this may be the case. Suppose that parents derive utility not from how safe their kids are, but from the actions they take to make them safer. Any parent who has found themselves worrying not only about whether their child is safe, but about whether they have taken the right steps to insure their safety knows what I mean here. Having your child suffer from an accident feels bad, but knowing that you could have done something to prevent that suffering, and failed to do it, feels even worse. Or, suppose that parents get utility when other people see that they have taken "proper" steps to ensure the safety of their children, or disutility when others see they have neglected something.

These sorts of feelings may not be uncommon. Andreoni (1988) shows that giving to charities cannot be explained without this "warm glow" motive, and work by Palfrey and Prisbrey (1997) show in an experimental setting that it is a far more important motivation than pure altruism is for giving to strangers. Harbaugh (1998) argues that *public* recognition of these gifts are important motivations as well. Our question is how, if at all, WTP for safety that is motivated by warm glow should be used for government decision making.

There are two very different possible issues here. The first is Kahneman and Knetsch's (1992) argument that the warm glow motive may explain people's responses to contingent valuation (CV) studies. That is, when people are asked if they would be WTP $20 to reduce a child's risk of death they respond yes, not because they value the reduction, but because they know they get a warm glow from contributing. Kahneman and Knetsch give a convincing argument that if this motive is in fact behind CV responses, these responses do not represent WTP in the usual sense.

But, that is not to say that impure altruism should be ignored. Suppose that the experimental results on strangers also apply to adult's altruistic feelings toward children: it's their contribution to children's safety, not the overall amount of safety the children have, that matters to the adults. Now consider a program that would solicit donations from adults and use the money to improve child safety. The "warm glow" motive would obviously lead to an additional benefit of such a program, beyond the safety improvement itself, and ignoring this additional benefit could lead policy makers to incorrect decisions.

The difficulty arises when trying to take measures of WTP from an altruist that are in part based on warm glow and then using those measures the determine the benefits of policies that do not provide the same warm glow. For example, suppose we estimate WTP by looking at contributions to a charity that promotes children's safety, and then use these estimates to determine the benefit of adopting a policy that will provide similar amounts of safety but be funded by taxation. Since taxes are involuntary, there presumably is no warm glow associated with paying them, and we will have overestimated the benefits of the policy. On the other hand, voting for such a policy, and the associated tax increase, is a voluntary act that presumably does create some warm glow benefits. In fact, it's quite possible that people might get some benefit from paying a tax to provide a benefit to others even if that tax is involuntary.

These sorts of possibilities obviously raise many questions. To my knowledge there is virtually no work on their theoretical implications for how WTP should be used. Similarly, there is little empirical understanding of how warm glow type benefits change with the method of payment.

5. Conclusion:

While I have argued that theory does *not* say that the appropriate level of safety is obtained simply by equating the sum of own, parental and societal WTP for a child's safety to the marginal cost of provision, I have provided numerous reasons why children should be provided a level of safety that exceeds the amount that would be optimal if we looked only at their own WTP.

My first arguments were made from the position of a social planner, and ignored the possibility of altruistic preferences. Instead I relied on the argument that children's safety choices suffer from failures that must be corrected, in order to achieve the efficient level of safety. I began with the evidence that very young children do not take death as seriously as adults do. Since death is permanent and they do not realize that their preferences will change, children will under-invest in safety. Second, even once children reach an adult understanding of death, they cannot borrow against future earnings. This market imperfection leads them to under-invest in safety. Third, adolescents are notorious for taking extraordinary risks with their health and safety, by the standards of adults. If they do not understand that their risk aversion will drop substantially as they get older, they may commit to patterns of behavior now that are not optimal. Along similar lines, even if children could borrow, their discount rates are higher than the rates they will have as adults. If they take their current discount rates as permanent, they will again under-invest in safety.

All these problems can be seen as market failures which lead children to purchase too little safety, and which should be corrected by government policies that provide additional amounts. Similarly, they lead to children's own reported or observed WTP for safety to be lower than what is optimal. When considering optimal levels of such publicly provided forms of safety as a clean environment, this means that the usual rule, to provide the public good in a quantity that sets the sum of WTP equal to marginal cost, will lead to too little provision of children's safety. I believe that one empirical approach that might produce more useful estimates of the correct WTP would be to use estimates of own WTP for safety from adults, and apply them to children.

I then turned to the question of altruism. It is obvious that parents, and to a presumably lesser extent non-related adults are willing to pay money to reduce children's morbidity and mortality. However, it is not so obvious how this WTP should be counted when determining whether a given policy should be adopted. The reason for this is that if we count altruist's WTP for safety, while ignoring their WTP for other things (for example, education), society will provide children with more safety and less of the other goods than is optimal. I argued that despite this theoretical result, there were some good reasons to include the WTP of parents and other adults for safety in a measure of the benefits of children's safety. First, if the altruism is *paternalistic*, in the sense that the altruist cares about, say, only the recipient's, WTP for safety should be counted. It would seem relatively simple to design CV studies that would determine to what extent the altruistic preferences of parent's and non-related adults toward children are specifically directed toward safety.

A second reason for why altruist's WTP matters is that, even with non-paternalistic or benevolent altruism, safety transfers may be cheaper than cash transfers, and that for this reason it may be optimal, in a second best sense, to consider altruist's WTP for safety. I argue that the informational requirements necessary to do this correctly are likely to be quite high, but of course that does not mean this should be ignored.

Another complication is impure altruism. I argue that there is substantial evidence that this is an important reason for charitable contributions to public goods, and that this suggests it is almost certainly an important part of the WTP by non-related adults for children's safety, if not for parents. Properly accounting for this sort of WTP in policy considerations requires a good understanding not only of WTP, but of how that WTP differs for different payment vehicles such as voluntary contributions and mandatory taxation. Again, this sort of information will require substantial empirical work of a new sort in order to correctly incorporate this motive.

To conclude, it is clear that there are many convincing reasons, well grounded in economic theory and common sense, for why a child's own WTP for safety improvements that reduce mortality and morbidity will be an underestimate of the social WTP for safety. The preferences of altruistic parents and other relatives, and of unrelated but still concerned adults, surely matter for determining what portion of it's resources society should devote to children. However, there are good reasons why the optimal amount to spend on children's safety cannot be found simply by adding up the WTP for safety of the various interested parties. Accurate measures of the social benefits of policies that increase children's health will require more than just measures of children's own preferences for safety and the altruistic preferences of their parents and of society at large. In this paper I have argued that we will also need measures of such things as the severity of the distortions that transfers create, and of the effect of payment methods on altruism.

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Contingent Valuation and Children's Health

Commissioned Paper*

PRESENTED BY:
George Tolley
Department of Economics
University of Chicago

C0-AUTHORS:
Robert Fabian
School of Public Health
University of Illinois at Chicago

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CONTINGENT VALUATION AND VALUING CHILDREN'S HEALTH

George Tolley* and Robert Fabian**

The special problems in valuing child health--including mortality, acute morbidity, and especially chronic and latent illness effects--all call for estimation by contingent valuation (CV) as a matter of default, since CV alone can elicit values when other evidence is lacking. The problem becomes how to extend the large amount of work on adult mortality and morbidity to estimation for children. With regard to mortality, the major evidence on values connected with adult mortality is from wage hedonics and is not applicable to children, who have yet to enter the labor force. With regard to morbidity, CV has emerged as one of the only ways to estimate values connected with adult morbidity, in view of the conceptual inadequacy and bias in the cost of illness approach and the inability of wage and land value hedonic approaches to yield useable estimates of illness values. Studies of averting behavior or household behavior in the face of risk can also throw light on how health risks are valued, and in some cases the approaches can be used complimentarily.

Contingent valuation has been recognized as an important and valid source of value estimates since its acceptance by the 1993 NOAA panel, which pointed out several needs for

*Department of Economics, University of Chicago
**School of Public Health, University of Illinois at Chicago

quality assurance in CV. Since that time, improved ways to meet these needs have been developed, and consideration of other needs and issues has further advanced the state of the art. The resulting best available methods can and should be used in child health CV estimation as we will discuss. The more fundamental challenge is to incorporate into CV the very special health valuation issues that arise for children. These include: questions of how to view the utility of children who are not yet responsible for their own decisions and who do not have the capacity to reason fully in terms of what is in their best own long run interests; how to discount future developmental and mortality effects on children from chronic exposure sometimes with latency; and how to take account of distinctions in value of health to the child as an individual human being, value placed on child health by parents and others acquainted with the child, and values of people at large for whom child well-being is cared about altruistically as well as with self interest in view of the importance of children to the future of society. In this paper, we deal with the implications of such issues for CV, suggesting approaches indicating that CV is promising and feasible for estimating child health values.

In Part I, we consider the prerequisite theory of child health values needed to guide contingent valuation estimation. We develop the theory of the own value of life over life with emphasis on child ages. We then distinguish three additive components of child health value: 1) own value to the child taking account of effects over life discounting back to the child's present age but using valuations the child will have as an adult with more rational decision-making powers than the child has at present, 2) value to persons acquainted with the child, and 3) value to society at large. The discussion brings out what is to be measured and provides guidance to questionnaire construction and evaluation of responses. In Part II, we consider implications of the existence of many different types of child health effects. These suggest the need for not one, but several, types of CV investigation. In Part III, we stress, as prerequisites to CV field work, attention to child dose-response relations, need to distinguish between those who have experience with the child health effects asked about and those who do not, and need for focus groups in view of paucity of previous efforts to estimate child values. In Part IV, we consider major issues in the design of CV instruments as they pertain to child health. Topics include discounting, risk, bid anchoring bias from named bids and assumed payment vehicles, and response elicitation problems caused by embedding, scope, seriousness with which respondent feels answers will be taken known as the decisiveness issue, and decoupling. Alternative means of dealing with the problems, and the strengths and pitfalls of alternatives are considered. In the Appendix, we offer suggestive examples of CV interview modules.

I. The Components of Child Health Values

A. A Primer on the Own Value of Life Over Life

a. Need for Economic Theory

That sound theory is indispensable to contingent valuation work is axiomatic. If we are interested in the welfare of the child, then the child's well being over life is a first component of child value to be considered. Important previous CV work has estimated how values attached to survival to remaining years vary according to age of adult, as for example in Johanneson and Johansson (1997a), which questioned how young and old adults would value an extra year of life at the end of life. This type of work establishes the feasibility and usefulness of using CV to estimate health values for individuals at different ages. A need is to extend this work based on development of theory that evaluates investments affecting longevity. Child values rather than only adult values need to be considered, which raises a number of additional valuation issues that either do not arise or arise to a lesser extent with adults, and the work needs to be extended to morbidity.

The usefulness of economic theory in contingent valuation is at least four-fold. *First*, it structures the whole inquiry, indicating what questions should be asked and how they should be formulated. *Second*, answers of respondents can be checked for consistency with qualitative implications of theory. *Third*, attempts can be made to infer numerical values of parameters implied by respondents to check their reasonableness in relation to non-CV estimates of the parameters. *Fourth*, theory brings out the logic of the value of life which can be used to help the respondent think about answers before giving bids.

b. Mortality

i. Collapsing the Future to a Single Period

A certain amount of insight about the value of life over life can be gained from the one period formulation where expected utility is the probability of survival times utility that will be experienced if a person survives the period or

$$EU = P_s U(W,Z) \tag{1}$$

where P_s is the probability of survival and utility U stands in for utility that will be experienced in the rest of life. U is a function wealth W and shifters Z of the utility of wealth that may vary with age. To find how much wealth W would be given up to increase the probability of survival P_s, set the differential of expected utility to zero letting W and P_s change incrementally

$$dEU = P_s U'(W,Z)dW + U(W,Z)dP_s = 0 \tag{2}$$

The first right-hand side term is the change in utility resulting from a change in wealth and is the probability of survival times the marginal utility of wealth, or the expected marginal utility of wealth, multiplied by the incremental change in wealth. The second right-hand side term is the change in utility from a change in the probability of survival and is the utility of wealth multiplied by the incremental change in probability. Setting the sum of the two changes equal to zero shows what the change in wealth must be to leave the individual indifferent to the change in the probability of survival. Re-arrange (2) as a solution for dW/dP_s recognizing that it is negative since wealth is being diminished. The wealth change dW/dP_s is negative since a subtraction from wealth keeps the person as well off as before in face of an increase in probability of survival. To express as wealth that would be given up V, take the negative of the change in wealth, so that $V=-dW/dP_s$, giving

$$V = -dW/dP_s = U(W,Z)/P_sU'(W,Z) \tag{3}$$

which is the wealth the person is willing to pay to just compensate for a change in the probability of survival. The right most term of (3) is often referred to as the value of a statistical life. It is the expected utility gain from a one unit increase in the probability of survival divided by the expected utility loss from a one dollar decrease in wealth. The gain is the utility of life U(W,Z) times one for the one unit change in probability, and the loss is the probability that the loss will be realized P_s times the marginal utility of wealth -U'(W,Z)). While the units of measurement of survival probabilities in the expression imply that a one unit change in probability of survival is from zero to one, or from certain death to certain survival, the expression is applicable to incremental or strictly speaking infinitesimal changes in survival probability. (3) is appropriate for evaluating the actual small changes in probabilities taken by people in everyday life and by most policies taken to reduce risks of loss of life. Policies of concern are not from certain death to certain life but rather from a probability of survival which is usually quite high to a very slightly higher probability of survival. The monetary equivalent of lives saved by most policies is dW/dP_s as given by (3) times the small change in survival probability brought about by the program.

Multiplying and dividing by wealth W, (3) can be rewritten

(4) $$dW/dP_s = W/P_s\varepsilon$$

where $\varepsilon = U'(W)W/U(W)$ is the elasticity of utility with respect to wealth, i.e. wealth or percentage increase in utility from a one percent increase in wealth. (4) says that the value of a statistical life is proportional to W and inversely proportional to the probability of survival times the elasticity of utility $P_s\varepsilon$. If a person's earnings are $30,000 per year, an approximation to W as the present value of earnings capitalized at a 5% interest rate is $600,000. Given the high probability of survival of most persons, P_s may be approximated as unity in this example. Then from substitution into (4), an elasticity of utility ε of 10 gives a value of a statistical life of $6 million, which is on the order obtained from hedonic wage studies of earnings differentials people require to bear increased risk.

Using τ to denote age and V to denote dW/dP_s, (4) gives $V_\tau = W_\tau/P_s\varepsilon_\tau$ as the value of a statistical life at age τ, which may be differentiated with respect to τ and divided by V_τ to obtain

(5) $$(dV/d\tau)/V\tau = (dW_\tau/d\tau)/d\tau - (dP_s/d\tau))/P_s - d\varepsilon/d\tau)/\varepsilon$$

The percentage change in the value of life as age advances by one year is the percentage change in wealth minus the percentage change in probability of survival minus the elasticity of utility of wealth.

If ε is constant, $(d\varepsilon/d\tau)/\varepsilon$ drops out. Whether the value of life increases or decreases with age then depends on whether the percentage change in wealth exceeds or falls short of the percentage change in probability of survival. For adults, each year of advancing age reduces future earnings by the amount of earnings of the current year, while earnings in all future years become one year closer and are discounted less heavily. The latter effect may well outweigh the former in early years, especially when due to earnings rising with age the future earnings less heavily discounted are larger than present earnings. The effect may be reinforced due to other influences on utility Z noted in (1) whereby the child raising period increases the value attached to one's life because of feeling of responsibility toward dependents, consistent with the Johanssen and Johannasen (1997a) findings. Considering the entire life span, wealth might generally go up through working life and then decline during retirement when the dependent effect would also be lessened. Probability of survival declines, but only slightly so until very late in life. A likely course is for value of life to rise up to, say, middle age as retirement is approached due to increasing wealth. Wealth decreases after retirement, but eventually the decreasing probability of survival comes in as a significant positive influence on the value of life since it appears in the denominator of (4) and consequently has the negative effect in (5). The decreasing probability of survival could continue to increase the value of life until very advanced ages, when diminishing wealth could finally overtake its influence, leading to possible falls in the value of life in terminal years, especially for people bequeathing little wealth.

With regard to childhood, the wealth of the child consists primarily of the present value of earnings less education and rearing expenses. As the child grows older the present value of earnings grows because the adult earnings are discounted less heavily as they get closer in time. Assuming earnings during childhood are negligible, they are not a consideration. The increase in value of life with age noted above that is expected to occur at younger adult ages extends back to childhood.

Distinctions Between Value of Life, Utility of Life and Expected Utility of Life. From the multiplicative relation (3) giving the value of life $U(W,Z)/P_sU'(W,Z)$, the percent change in the value of a statistical life when age increases by one year is the sum of: the percent change in utility if one survives **minus** percent change in probability of survival **minus** percent change marginal utility of wealth. The percent changes in utility and marginal utility are in turn functions of percent change in wealth and percent changes that occur with age independent of wealth. If the utility function is separable in wealth and non-wealth influences, the percent changes in utility and marginal utility independent of wealth are identical and will cancel since they enter with opposite sign. For example, if the utility function is $U=aC^{1-\alpha}f(\tau)$, the percent changes $(dU/d\tau)/U$ and $(dU'/d\tau)/U'$ both equal $f'(\tau)/f(\tau)$ and cancel in the condition for percent change in value of life since one enters with positive and the other with negative sign. Combining the wealth effects on utility and marginal utility, the percent change in the value of life becomes the difference between the elasticity of utility and elasticity of marginal utility with respect to wealth **minus** the percent change in probability of survival. As shown by (5) if the elasticity of utility with respect to wealth is constant, the result reduces to the percent change in wealth **minus** the percent change in probability of survival.

The percent change in utility given survival as age advances by a year is the elasticity of utility with respect to wealth times the percent change in wealth **plus** the percent change in utility due to aging by one year at a given wealth level. The percent change in wealth is multiplied by the elasticity of utility with respect to wealth, which is likely to be a much smaller number than percent change in wealth multiplied by unity in the case of the value of life. Meanwhile, neither the elasticity of marginal utility with respect to wealth nor change in probability of survival enter.

The percent change in expected utility, which is the percent change in utility given survival **plus** the percent change in probability of survival, has the differences from percent change in value of life just noted for expected utility given survival, in addition to which the percent change in probability is added rather than subtracted as it is for the value of life.

Among the lessons from these distinctions are that one will have to be very careful in making statements about how value of life changes over life, so as not to be confused with changes in utility or expected utility, both in the framing of CV questions and interpreting results.

ii. Multi-period Models

Expected Utility in the Multi-Period Case. In extending work on how the value of life varies with age, one needs to go from the above model that collapses the future into one single period to an explicit multi-period model. Let the utility from a life year at future age t be $U(C_t,Z_t)$, where C_t is consumption of goods and services to which income is devoted and Z_t is a vector of other influences on utility varying with age t. $U(C_t,Z_t)$ here distinguishes utility in each future year in place of the single expression U(W,Z) used in (1) where the effect of all future years is collapsed into one term. In (1) wealth W is spread over consumption in all future years. The expected utility of remaining life at age τ is the sum of future utilities from τ onward as evaluated at τ giving as expected utility at time t

$$EU_\tau = {}_\tau\!\int U(C_t,Z_t)g(t-\tau)dt \tag{6}$$

where $g(t-\tau)$ diminishes the utility attached to future outcomes because of time preference. For a Ramsey rational individual who perfectly foresees future utility, the only reason for time preference is the possibility of not being alive in future periods. Future utilities are weighted by the probability of survival from t to τ. If the individual faces a time-constant instantaneous probability of death ρ, $g(t-\tau)$ becomes $e^{-\rho(t-\tau)}$. While reasons other than survival probability can contribute to time preference, the effect on utility of a health improvement that increases survival probability is to reduce time preference. Survival probability remains one of the contributors to ρ or to a more general form of $g(t-\tau)$, which provides the path through which increases in survival probability become translated into dollar values.

To consider what happens to the utility from remaining years of life with advancing age, differentiate (6) with respect to τ obtaining

$$dEU_\tau/d\tau=-U(C_t,Z_t)+\rho EU_t \tag{7}$$

derived assuming $g(t-\tau)=e^{-\rho(t-\tau)}$. The first term comes from the loss of the lower increment in the integration and represents the diminution in expected utility from having one less year of life to enjoy. The second term results from differentiating under the integral which moves utility from every future year one year closer. Each future year becomes more certain because one year of hazard that has to be endured to survive has been eliminated, acting to increase expected utility. Dividing (7) by EU_τ gives the percentage change in expected utility from remaining years of life from a one year increase in age

$$[dEU_\tau/d\tau]/EU_\tau=-U(C_t,Z_t)/EU_\tau+\rho \tag{8}$$

showing that whether expected utility decreases or increases with advancing age depends on whether the negative impact of loss of this year's utility as a percent of utility from remaining life exceeds or falls short of the rate of time preference which in the Ramsey case would be the instantaneous probability of death.

Value of Life in Multi-Period Case. While expected utility of remaining years of life or total utils considered in (6), (7) and (8) is interesting, our central concern is the dollars that will be paid for a change in probability of survival, just as in the single period model. Setting to zero the differential of (6) letting wealth W_τ and ρ change gives

$$(9) \qquad dEU_\tau = {}_\tau\!\int U'(C_t,Z_t)e^{\rho(T-\tau)}(dC_t/dW_\tau)dt \cdot dW_\tau$$

$$- {}_\tau\!\int U(C_t,Z_t)(t-\tau)e^{-\rho(t-\tau}dt \cdot d\rho = 0$$

where $U'(C_t,Z_t)$ is the partial of utility with respect to C_t and we have again assumed a constant rate of time preference $g(t-\tau)=e^{-\rho(t-\tau)}$. The effect on expected utility of the change in wealth in the first right-hand side term just offsets the effect of the change in survival probability in the second term. The change in wealth in this equation is the WTP for a change in survival probability and is the change in wealth necessary to compensate for an increase in the instantaneous probability of death leaving the individual at the same utility level. The negative sign for the second term arises because the increase in ρ decreases utility as reflected in the minus obtained when differentiating with respect to ρ since $de^{-\rho(t-\tau)}/d\rho=-(t-\tau)e^{-\rho(t-\tau)}$. The re-arrangement of the equation giving the ratio of the change in wealth to the change in probability of survival, or WTP expressed as the change in wealth needed to compensate for an increase in survival probability, is

$$(10) \quad dW_\tau/dP_s = -dW_\tau/d\rho = {}_\tau\!\int U(C_t,Z_t)(t-\tau)e^{-\rho(t-\tau)}dt \Big/ {}_\tau\!\int U'(C_t,Z_t)e^{-\rho(T-\tau)}(dC_t/dW_\tau)dt$$

Comparing value of life in the multi-period case (10) with that in the one period case (3), the numerator in (3) is the utility of living for the one period is seen to stand in for the sum of utilities of all future periods weighted by probability of survival in the multi-period case and is not really free of uncertainty at all. The denominator in (3) is expected marginal utility of wealth $P_sU'(W,Z)$ as compared to the denominator in the multi-period case (10) which is an expected marginal utility of wealth again weighting the future marginal utilities by probability of survival and further allocating a change in wealth at τ over the changes in consumption that are allocated over all future periods, as reflected in the dC/dt terms. For some purposes, it will be worth dealing with the extra complexities of the multi-period case to obtain further detailed insights.

To consider the multi-period case further, in the right-hand side numerator of (7), the τ in the lower limit of integration means that a year of utility is lost when age advances, acting to lower WTP. Within the integral the increase in τ in the $(t-\tau)$ term also lowers the numerator. However, the τ in $e^{-\rho(t-\tau)}$ has a positive effect due to drawing each survived year closer. Except for the $(t-\tau)$ term, the effect in the numerator is the same as the effect of age on expected utility. Thus the numerator should have a less rapid increase if increasing, or a more rapid decrease if decreasing.

In the right-hand side denominator, τ again appears in the lower limit of integration acting to decrease the denominator as age advances. Under the integral sign are effects that do not appear in expected utility of remaining years, namely the marginal utilities and the responses of consumption in different time periods to the change in wealth the individual gives up. The marginal utilities depend on the shape of the utility function. The changes in consumption depend on inter-temporal consumption allocation decisions. If one assumes rationality and a constant borrowing-lending interest rate, maximization of expected utility (6) with respect to C_t adding the

Lagrangian constraint $\lambda(W_\tau - {}_\tau\int C_t e^{-r(t-\tau)}dt)$ gives the well-known result $U'(C_t)=U'(C_\tau)e^{-r(t-\tau)}$ since λ is found to equal $U'(C_\tau)$. Consumption must increase continually to make the marginal utility of consumption fall at the rate of interest minus the rate of time preference, retarding the fall in the denominator with age. The results suggest the feasibility of further exploration of changes in the numerator and denominator of the multi-period value of life expression (10).

Predecessor literature using the life cycle model as it bears on the value of life includes Ng (1992) who presented numerical results for the value of life over life using a CRR utility function and other simplifying assumptions, in which the value of life peaked at a very advanced age, much later than the peak in expected utility. The analysis above provides a basis for further detailed exploration under a number of assumptions and for extending the analysis to child ages which Ng did not do.

In further life cycle work on mortality, the stringent inter-temporal assumptions of the Ramsey model could be relaxed, for instance, letting consumption more closely track income because of departures from a constant borrowing=lending interest rate. Defensive measures could be introduced and would be affected by changes in the probability of survival brought about by a program. If risks and effects of defensive measures are perceived accurately, the defensive measures in fact provide estimates of the value of life. Challenging cases to be investigated are those where perceptions are imperfect. Other possible complications include time varying ρ, changes in capacity for enjoyment over life and reciprocal altruism whereby at ages where children are dependent on the individual, the individual's valuation of his own life goes up because of support given to the child whose utility is of concern. Simple analytic solutions to these more extended formulations may not to be possible. However, qualitative insights emerge from them, and they are quite amenable to simulation.

c. Morbidity

A complication with morbidity models as compared to mortality models is that expected utility if a morbidity hazard is realized is not zero, as in the mortality case. Expected utility becomes a weighted average of probability of being healthy and probability of contracting a symptom, and the theory becomes accordingly more complex but remains tractable. The theory for the one period case was laid out in Berger et al. (1994) for use in CV estimation of morbidity values for adults. In the same volume Rosen (1994) developed elegant life cycle models encompassing both mortality and morbidity concerned primarily with the value of life extension. While specific expressions for the value of morbidity reductions by age were not presented, he emphasized heavily that the value of life and health are age dependent. His work provides a basis for extension to explicit expressions for value of morbidity by age and, from there, application to children.

d. Discount Rate

The discount rate is a separate issue from the value of life and health over life considered so far. The discount rate r figures in the above valuation expressions and is assumed to be known. Cropper and Sussman (1990) suggested that present WTP can be estimated as future WTP discounted by the consumption rate of interest defined as the marginal rate of substitution between present and future consumption $U'(C_t)/U'(C_{t+1})$. This result suggests that value of child mortality risk reduction could be estimated by finding the parent's surrogate valuation as an adult and using a possibly time varying $r-\rho$ to discount to the child's age. The major focus of the

Cropper and Sussman work, which also included inter-generational discounting not of concern here, was on the discount rate and not on the magnitude of the value of life as such though an algebraic expression for it was presented.

Regarding future work, we have already suggested that differences between borrowing and lending rate need to be distinguished. A person can ordinarily lend, when income exceeds consumption, at market rates of interest available on financial securities ranging from time deposits to equities. However, a parent making investments in a child's education and health may in effect lend to the child at the rate determined by the rate of return on investment in the child which ideally might be driven down to the market lending rate as the opportunity cost. The borrowing rate, when consumption exceeds income, may be determined by collateral such as real estate at low levels of borrowing, but the rate may rise rapidly if borrowing exceeds equity in financial collateral because the repayment depends on the borrowers return to human capital which is risky because of survival and health uncertainty and the difficulty of garnishing earnings. Empirically, household production studies may throw light on discount rates, the results of which could be used in or combined with contingent valuation studies.

B. Own Value and Parent Role Taking

We have so far considered conceptual issues in placing a value to oneself on one's own life and health, which is a first component of value to consider. We now begin to consider how to use the theory in the design of contingent valuation studies as applied to children's well-being. In estimating the first or own component of child value, the point immediately arises that children themselves are incapable of speaking adequately for themselves about their welfare over their lives. As we see it, the most practical approach is to have parents speak for them. For this component of value, one must ask a parent to undertake the challenging task of taking on the role of the adult that the child will become, giving opinions about what the adult who was the child will say was the wisest course that should have been taken when he or she was a child. As far as we know, this requirement for role taking is unique to child health valuation. Considerable experimentation is likely to be necessary to help respondents take on this role. In a survey instrument, needs for new types of warm up and explanation will certainly arise in addition to more than usual care in devising bid questions.

In addition to the problem of role taking, a reason the task is challenging is that discounting is involved. The parent may answer conjecturing what the child's willingness to pay (WTP) to avoid a symptom will be as an adult, which must then be discounted back to the child's age at present, either by the parent respondent or the researcher who must then find an alternative source of information about appropriate discount rate.

The task is further challenging because the parent must later in the interview be asked about the parent's valuation of child health for altruistic reasons, which is a separate source of value to be considered in the next section.

C. Value of Child Health to Family and Friends

A second component of child health value, to be added to the increase in the child's own welfare considered so far, is value of the child's health to other family members, principally parents. A major CV challenge is to induce parents to distinguish carefully between the values they express for a child's own value of health acting as a surrogate for the child as considered in the previous section and the value over and above this amount that they attach to the child's health. A desirable procedure would appear to give up front explicit instruction about the matter, with carefully constructed sequential questions that further make the distinction clear.

Value to parents includes several subcomponents, which should be called to the attention of respondents and possibly separated out for individual bids. The subcomponents include altruism due to appearance of child utility in parent utility function, warm glow due to the appearance of utility attached intrinsically to acts of giving and nurturing in parent utility function, and joy of parenting due to consumption utility of parenting appearing in parent utility function. The task of disentangling these subcomponents in bid elicitation would be daunting. The best hope may be to obtain a single bid for all of them, accepting them all as legitimate components of child health value.

From the foregoing positive subcomponents are to be subtracted costs to parents as bearers of uncovered medical expense and care giving. In the case of mortality, death of a child while still dependent brings a reduction in education, child consumption and other rearing expenses borne by parents.

While values to parents are surely the most important part of value of child health to family member, values to siblings, relatives and friends are also involved. An implication is that bid elicitation about sibling and relative values should be provided for in CV instruments. Since parents will be the primary interviewees, a feasible though not entirely satisfactory procedure is to ask parents to make conjectures about values that siblings, relatives and friends would express if asked.

D. Value of Child Health to Society at Large

The third component of child health value, to be added to the value to the child and value to family members, is value to those other than family members. Without knowing all children individually, people are concerned with the state of health of children generally in the population. After obtaining bids for the first two components, bids can be obtained for the third component making sure to carefully educate respondents about the distinctions between the three components.

II. Types of Child Health Effects

A. Symptom Distinctions: Acute versus Developmental, and Constant Risk versus Latency

One part of child health is everyday acute or short term symptoms ranging from colds to measles, many of which may be only tenuously caused by environmental pollutants. Exceptions are respiratory symptoms such as coughing, tearing and, of particular importance, asthma. A single CV questionnaire eliciting bids to avoid sick days, doctor visits or school days lost will at best throw partial light on WTP for avoidance of acute symptoms, inevitably being inadequate because of the variety of differences in pain and suffering associated with different symptoms. Even for acute symptoms, symptom-specific bids are needed.

Acute symptoms however are only a part, and perhaps not the most important part, of child health effects. Child cancer though much rarer clearly may have some roots in the environment, with smaller risks but far more serious consequences when contracted. Developmental effects such as stunted growth, brain damage and other sources of learning disabilities are further examples of long term effects during childhood. The symptoms differ greatly from more ordinary childhood symptoms, and much more attention is needed to helping respondents evaluate small risks. A different CV instrument could be needed for each disease.

Perhaps the most important child health effects of all occur when children become adults, either because a constant risk leads to a diminishing survival rate free of death or a debilitating disease with effects occurring into adulthood, or because of latency whereby there is relatively low risk during childhood with increasing risk from earlier exposure occurring during adulthood.

Inter-disciplinary effort including input from the medical profession will be required to specifically structure a meaningful differentiated CV approach. The major point is clear, however, that a series of different CV studies will be needed.

B. Mortality Versus Morbidity

As a review by Viscusi (1992, pp.45-68) brings out, the most prevalent value of life estimates are labor market studies. Some contingent valuation studies of the value of life have been carried out, with variable results. One approach to mortality effects, that tentatively seems appealing to us, is to estimate the value of life from labor market studies and use inferences from contingent valuation studies about discount rate to infer value appropriate to a child's welfare. Another approach is to frontally assault value of life in CV studies. Indeed if this is done asking about a reduction in child risk of a death from childhood disease that will occur in adulthood, the value of life and discount rate are rolled into one bid that the researcher in principle does not need to disentangle. Against this advantage is the burden placed on the respondent's mental calculation abilities which will undoubtedly be largely intuitive and thus more suspect in terms of accuracy.

Too sharp a distinction is sometimes drawn between mortality and morbidity, in that there is a tendency to consider the subjects separately. Death from disease is ordinarily accompanied by significant pain and suffering, as is clearest with cancer. The health costs include premature death and pain and suffering prior to death, both of which must be estimated. A significant part of a CV effort on child health therefore needs to be devoted to morbidity effects, even when fatal diseases are involved. The pain and suffering from the disease increases its costs, with the cost due to life shortening being at least a little reduced by the fact that the quality of life of final periods is not as great as if the individual were healthy.

C. Age of Child

Far more important than deciding the cut-off age at which a person is considered to be a child, sometimes put at 18, are distinctions between children of different ages, including negative age while still in the womb. Since children of different ages are affected differently by environmental exposures, different CV questions and perhaps even different CV studies, may be needed for children of different ages.

D. Environmental Versus Non-Environmental Health Effects

The fact that child health is affected by far more than environmental effects is one of the few considerations that helps to narrow studies focusing on the environment. For example, air pollution exposure will be of concern, but effects of nutrition may not be.

E. Direct Versus Indirect Environmental Effects

The effect of air pollution on child health is an example of a direct effect. The effect of air pollution on health of parent caring for the child, that diminishes the quality of care given, is an indirect effect. Systematization of indirect effects is needed, with provision for queries about indirect effects in CV instruments.

F. Lesson

CV estimation of child health appears eminently feasible and has marked advantages over other methods as brought out by Agee and Crocker (1998). At the same time, this section has indicated the need for an entire series of studies with careful investigation of how they should be structured in view of the variety of distinctions among health effects.

III. Prerequisites to an Adequate CV Investigation of a Disease

A. Dose Response Relations

Incorporation into the CV instrument of knowledge about dose response relations is particularly important in the case of risk reduction. Risk reduction queries need to be in terms of realistic risk reductions that would be brought about by a policy action. It is widely recognized that knowledge is particularly poor about the magnitude of most child health risks. In view of the difference in stage of biological development of children as compared to adults, damage from pollution differs. While children can throw off some common symptoms and diseases with less long lasting or ill effects than adults, they may be more susceptible to long term effects.

Non-CV attention is sorely needed to child dose response relations. While awaiting better knowledge, CV will need to assume general orders of magnitude being as realistic as possible. Ignoring the magnitude of risks, treating them cavalierly, or asking respondent to bid on risks that are out of the ball park, can importantly endanger the validity of CV estimates.

B. Recognizing the Importance of Respondent Experience

Because of the difficulty of visualizing and empathizing with symptoms with which a respondent has no experience, a case can be made that CV questionnaires be administered only to those who have experienced the symptoms or who intimately know people who have. To do so reduces the burden of defining the health commodity for which a bid is obtained. As a minimum, in a broader sample, experience with symptoms needs to be recorded in the interview process, followed by an analysis of how answers differ as between those who have experience with the symptom and those who do not.

C. Focus Groups

Continuation of the practice of having extended focus group experimentation prior to full field sampling is needed a fortiori in the case of child health. Focus group sessions ordinarily lead to substantial revisions of proposed questionnaires. In view of the new issues raised, revisions are likely to be even more substantial for child health.

IV. Issues in the Design of Child Health CV Instruments

A. Discounting

A typical way of estimating a discount rate in CV studies is to study differences in expressed values for a given commodity as affected by differences in future distance in time that the commodity will be consumed. The commodity considered is often lives saved. For example, intra-generationally, Johannesson and Johansson (1997a) compared values of people in their mid-thirties and in their mid-sixties for a mortality reduction in their mid-seventies, finding an implicit discount rate at 1.3%. Moore and Viscusi (1990) estimated discount rate based on labor market data, which is a source of discount rate outside a CV study that could be used to discount a parent's current valuation of a health risk back to age of child. CV studies of inter-generational discount rates include Cropper (1991), Johannesson and Johansson (1996) and Johannesson and Johansson (1997b). The techniques used in these various studies give ample precedent for inferring discount rates.

Questions arise as to how to use these techniques in child health CV work. Discount rates are needed for the three components of health value delineated in Part I. For discounting the first component, the child's own health value, the procedure of letting the parent speak for the child raises the question of what the rational discount rate for a child is. The child's observed behavior is likely to imply a very high discount rate but following our recommended approach is not to be used. A contender for an approach is to use adult discount rates either as inferred from questions to parents as part of the CV questionnaire using received techniques or simply using estimates from other studies.

For discounting the other two components of child health value, value to family and value to society, an inter-generational discount rate might be applied, since inter-generational distributional considerations enter.

B. Risk

The same problems of risk perception that confront CV studies of health risks to adults will confront child health studies. Viscusi (1992, chapters 6, 7 and 8) catalogs the many problems. We have already referred to the lack of scientific knowledge about child risk magnitudes. It goes without saying that extreme care regarding risk in the questionnaire is essential. We do not systematically review the possibilities here. As one example, Sloan, Viscusi, et al. (1997) applied the usual risk-money or direct payment of money for risk reduction to value multiple sclerosis, and they also applied risk-risk comparisons asking about mortality probability that would be accepted to cure a health condition, followed by use of value of life estimates from the wage literature to monetize the probability. The study also used a Bayesian formula and assumed a utility function form, combining the risk-money and risk-risk information, to correct for risk perception bias. A more elaborate chained approach combining responses to contingent valuation standard gamble questions is suggested in Carthy, et al. (1999) to break down response logic into manageable steps. Great care in providing heuristically appealing visuals for thinking about risk, requiring little mental effort, is to be recommended.

The literature on adult health effects thus supplies much precedent for handling risks that should be applicable to child health. One of our suggestions for possible CV questions in Part V offers a life path approach for eliciting bids where risk is important.

C. Bid Simplification and Avoidance of Anchoring

A tendency is often observed for respondents to value a symptom as what they believe the cost of a medicine is to treat the symptom. This is in fact correct if there is such a medicine and it will completely cure the symptom. On reflection, we believe it is simplest to remove dollar medical cost completely, obtaining bids for avoidance of symptom over and above medical costs. A simple procedure that is often true and in any case can be easily grasped is to tell the respondent that medical costs will be covered by pre-paid medical insurance with the premiums unaffected by the program. Viscusi follows a similar approach in asking respondents to bid on relief of pain and suffering only. We would add that bids on lost earnings also be obtained, as this can be an important part of value and in fact is seldom fully covered.

The literature on bid mechanisms in contingent valuation is long and still in flux. Some of our own hypotheses distilled out of bid mechanism experience in several studies in which we have been involved are as follows. First, iterative bidding which the interviewer initiates with a first bid suffers from respondent tendency to anchor to that bid. Second, the referendum approach whereby the interviewer asks yes-no questions about whether an amount named by the interviewer would be accepted encounters the same problem. Third, questions that convert payment into a vehicle such as a tax payment suffer from vehicle bias wherein the respondent is influenced by pre-conceived biases about the desirability or undesirability of the vehicle.

Fourth, asking the respondent to call out a bid on his or her own suffers from none of these problems and in our opinion deserves serious consideration.

Fifth, as another bid mechanism, we have had good results with a card game where, say, a dozen different bids ranging from ridiculously low to ridiculously high amounts are printed on playing card size pieces of cardboard. As the respondent watches, the interviewer shuffles the cards and picks them up with the values facing him that the interviewer cannot see, as in a game of fish. The respondent choose one of the cards from the interviewer's hand and either accepts it or discards it, proceeding until the value the respondent will pay is bracketed. The procedure convinces the respondent that the interviewer has no preconceived bid thought to be correct, and the involvement in the game seems to help get the respondent's mind off of thoughts that might lead to bias.

C. Embedding

Problems of embedding, where respondents value more than the researcher intends, extend to CV study of child health. Jointly produced goods appear most susceptible to embedding. If a CV questions asks about WTP for child health benefits resulting from environmental improvement, many respondents are likely to give an answer that includes benefits to adults; some may include aesthetic benefits and perhaps benefits of other public programs in their bids. Schulze et al. (1998) have considered several possibilities for dealing with embedding that should be applicable to child health. Mental models of joint products are of particular relevance to child health values. For example, if the respondent is asked "How much would you be willing to pay in extra taxes for an air pollution control program that will save your own four children 10 restricted activity days per year?", the respondent might reason that any such program will help all other children, and would also improve adult health, and would improve atmospheric visibility too; and because extra taxes mean more public goods in general, the children will benefit from improved school facilities. The example suggests that people will have different mental models; they will mix and match joint products and bid accordingly. If components of health values are asked sequentially--how much extra would you be willing to pay to extend the health benefits from your own children to include all children?--then embedding respondents will bid zero for the extra children because they have already been embedded in the initial response. Meanwhile, some respondents will accept the researcher's mental model and bid correctly. The problem is to disembed respondent answers where necessary and adjust the bids. Schulze et al. examine considerable evidence that the problem of mental models can not be completely overcome no matter how zealous the efforts are to increase context and convince the respondent to accept the researcher's point of view, though to do so to the maximum extent possible is indeed needed.

Crocker et al. (1998) argue that exchange institutions must be selected so as to elicit the respondent's underlying beliefs. Presenting a contingent market product in the language of the researcher's utility maximizing paradigm and expecting respondents to accept it will not work in many an perhaps most cases. In their examination of referendum contingent valuation, Green et al. (1998) find evidence of psychometric anchoring effects that can not be eradicated by questionnaire construction, leading them to a skepticism we agree with as to the usefulness of the referendum approach--will you pay some amount of dollars pre-specified by the interviewer for the commodity in question? We are thus not convinced of the arguments favoring using the referendum approach in the NOAA report.

D. Scope

The scope test proposed by the NOAA panel, wherein separate groups are offered programs of different scale as a check to see if the larger program receive large bids, is relevant to child health. Closely related to embedding, the scope problem is explained by Schulze et al. in terms of rapidly diminishing moral satisfaction, goods that are close substitutes, and mental models of joint products. Schulze et al. point out that the NOAA scope test is a between-group test and does not discriminate among individual respondents. Work by Schulze et al. employed a split sample and used follow up questions to detect embedding. They found that respondents who report little or no embedding tend to pass a scope test, while those who report substantial embedding tend to fail a scope test. By focusing on individual respondents, embedding problems can be identified and adjusted even when groups as a whole pass a scope test.

E. Decisiveness and Decoupling

Decisiveness means that the respondent's bids have a positive probability of influencing the adoption of a program. Decoupling means that if a program is adopted, its cost will be determined in a way the does not depend on the CV response. See Green et al. (1998, p.88), who argue that decisiveness and decoupling are necessary. The NOAA panel was less concerned, saying that "the respondent in a CV survey understands that the referendum is hypothetical; there is no implication that the tax will eventually be levied and the damage actually repaired or avoided. This suggests that considerable efforts should be made to take the question seriously..." (Arrow et al., 1993, p. 606). The panel does not give specific guidance on how to do this and does not include it in their guidelines or recommendations. We attempt to apply the analysis of Green et al. to child health valuation in our suggestive CV questions in the Appendix and include attention to the NOAA concern that respondents will have difficulty viewing the program being bid upon as isolated from other programs.

APPENDIX. ILLUSTRATIONS OF POSSIBLE CV QUESTIONS

A. Purpose of This Appendix

The number of issues discussed above is too voluminous to permit suggesting CV material covering all of them. In any case beyond, to develop a complete and refined CV instrument is too large an undertaking for the present paper. What we do in this part is to present illustrations of some possible modules of a CV instrument that attempt to grapple with some of the issues we have discussed. The material is offered tentatively to help make the issues real and to help in stimulating discussion.

We have started from the top down with the family, taking total value and breaking it down to various family members including the child. In retrospect, we might have started with the child whose heath is of concern and then built up adding on value to family members as was done in the theoretical discussion of Part I. We have not done as much with discounting or risk as we might and do not contend in any part of the material that these are the only approaches deserving consideration.

We first present set of questions that are independent of any specific environmental plan. It is the most abstract and hence simplest CV approach. Second, we develop a program-linked questionnaire that contains a good deal of descriptive realism that would be present in an actual EPA program under evaluation. Third, we briefly sketch a hybrid approach that combines elements of the first two versions. It may be most useful to evaluate programs in their earlier, formative stages.

Abstract Survey Format -- Introduction

The abstract survey version is similar to that in Tolley et al. (1994). It differs in being adapted to needs estimating child-health values, incorporating disembedding questions and using a card-game elicitation format to avoid anchoring instead of an iterative bid with starting point. Modules on budget consciousness, health evaluation, health status, defensive measures, and ranking of symptoms precede the CV questions, some of which are illustrated here.

In the abstract survey format to be considered first, there is no mention of environmental pollution, no mention of increased tax payments, utility bills or the like, and no mention of USEPA or other agency. These questions avoid a great deal of real-world institutional complexity. An advantage of this approach is that people are not prompted to think about taxes or utility bills, which may be too high already in their estimation, thus clouding the issue of health values. The questions do not allude to pollution, which can prompt respondents to vote on how they value the environment in general or to protest (with zero bids) what they see as bad behavior which should be paid for out of profits. An already complex and taxing questionnaire can thus be framed exclusively in terms of personal (and family) experience and behavior, and corresponding personal values.

We include some acute symptoms frequently associated with environmental pollution. We do not name diseases, only symptoms. We also include cancer as a long term health effect to be valued. We treat acute symptoms in a certainty context, though we cold have introduced a probability of symptom particularly for asthma. Risk in central in our consideration of cancer. Our approach to risk presentation is to face the respondent with the base-case probability of contracting cancer during an average lifetime. Thus the first probability the respondent faces is one of comfortable size, say 0.3. We then ask willingness to pay for a change in lifetime cancer risk commensurate with that associated with the pollutant. The pollutant, of course, is not mentioned in the abstract format. If the change in probability associated with environmental programs to be evaluated is too small for people to react to comfortably, the change can be magnified somewhat to induce comfort. Since no program is involved, no untruth has been conveyed to the respondent. Because several probability changes will presumably be presented to respondents, probably in a split sample, the curvature of the resulting bid curve should permit some reasonable interpolation to realistic probabilities. See Tolley et al. (1988) for an application of this approach to atmospheric visibility.

For cancer, life-path scenarios are used to define the contingent product. One scenario is the base case, where the respondent lives to an actuarially expected age. This is compared with column 1, the cancer path, to define the product. The respondent is told “You have say a 0.7 chance of getting column 3, the base case, and a 0.3 chance of getting column 1, the cancer case. Probabilities could be conveyed, for example, by a page with a thousand dots. Three-tenths are colored black, indicating base-case cancer probability, and seven-tenths red. A number of green dots could be added to convey the added cancer risk, prevention of which the respondent is asked to value. In a split sample, different groups of respondents are given different numbers of green dots, corresponding to different risks that generate a bid curve.

A "wheel of death" is used to help the respondent think about risk. It consists of a pie chart with areas corresponding to probabilities of different health outcomes and a spinner that will land on one of the areas when spun. The spinner is spun several times by the respondent, after which life path scenarios like those given on the second and third accompanying pages are presented to the respondent. The scenarios describe three age-specific health histories including asthma, cancer, and good health resulting in longer life.

Other approaches to risk could include dealing with hazard rates for cancer, which would affect the time at which cancer is contracted. If the probability that a pollutant causes cancer is constant through time, then the effect of a reduction in the constant probability on expected time to contraction of disease is a straight expectancy calculation akin to expected length of life in usual demographic work. If the hazard is more complex, with a latency period, then the probability of contracting cancer in near years may be affected little if at all but may rise sharply in later years. This is a uniform change in probability of contracting the disease through time and would require a still more complicated approach.

Focus-group work should include determining comfortable probability levels for this CV exercise. Larger-than-realistic probabilities introduce inaccuracy, but if a well-fitted bid curve can be derived, interpolation may warrant the tradeoff. Focus groups could also be used to experiment with questions based on hazard rate approaches to cancer, which we do not illustrate here.

Careful use of disembedding questions is important to getting a realistic scale of bids within programs. This in turn maximizes our chances of passing the external scope test advocated by NOAA (Schulze et al. 1998). As a way of dealing with the particularly severe potential for embedding in eliciting child-health values, we choose to start the bidding with health benefits to the family as a whole, and then ask what proportion of the bid pertains to the children, and then others. Disembedding questions are greatly simplified thereby. Another advantage of this approach is that if we view the parent-respondent as an agent for the children, then respondent's own health values, suitably discounted, serve as proxy for benefit values that will accrue to the children during their adult years. This may be a controversial interpretation, but it provides a benchmark against which other approaches can be compared.

A major tradeoff involved in using the abstract format centers mainly around the much-discussed issue of incentive compatibility. Green et al. (1988, p.88) state that there are three distinct aspects of an incentive-compatible CV protocol. They are elicitation frame, implementation frame and payment vehicle. The abstract or program-free approach makes use of only one of these aspects -- the elicitation frame. Our elicitation frame combines a symptom-ranking card game with the simple calling out of WTP bids. Frequent opportunities to revise rankings and bids gives our elicitation format the flavor of an iterative bid without a starting point. The anchoring problem associated with the iterative bid and referendum formats is thus to some extent avoided, while maximizing respondents' opportunity to research their own preferences. The other two aspects of the protocol are not appropriate to the abstract format.

Questionnaire Material -- Abstract Version

Hello. I'm ________________________ from the University of _____________. We are visiting with people in your area as part of a research project about risks to health. We have scientifically selected a sample of households to represent your area and your household has been chosen as part of the sample.

Are you the [male/female] head of the household?

[If not, ask to speak to the head and start over.]

Your opinions are very important and we hope you will help us. Please be assured that this is purely a research project and we do not represent any business or product. No sales call will result by your participation in this study. The information you provide us will remain confidential. The questionnaire will take about 30 minutes.

First I'd like to ask you some background question about your household.

How many members are present in your household?

Adults _____ Children _____

_____ _____

[Fill in age and sex on blank. Eg. 7, F]

How do you see your childrens' future income prospects?

____ Not as good as yours

____ About the same as yours

____ Better than yours

[Ask this question for kids as a group. Note any differentiation that respondent offers.]

The next few questions are about your general health. As you answer them, though, I would like you to think about the health of other members of your household, particularly your children.

A. Health Evaluation

[Interviewer: circle numbers.]

A-1. Would you describe your overall health as being

1. Excellent
2. Good
3. Fair
4. Poor

A-2. Please look at this card and tell me which statement best describes the control you have over your health.

[Interviewer: hand out card on ABILITY TO CONTROL HEALTH.]

1. There is little I can do because it is beyond my control.
2. I can do some things, but they have little effect.
3. My actions have moderate effect.
4. My actions have a great effect.

[Interviewer: take card from respondent.]

A-3. How often were you bothered by any illness, bodily disorders, aches, or pains during the last month?

Every day	1
Almost every day	2
About half of the time	3
Now and then, but less than half of the time	4
Rarely	5
None of the time	6

H. Health Status

Now we are going to talk about whether you have certain health problems and how they have occurred. Most people have difficulty remembering how many times they have experienced these problems, but it is important that you try to remember about how often you have had them. The health problems are listed on this card.

[Hand respondent Health Problem card.]

H-1. Which of the health problems on the card have you experienced in the last 12 months?

[For any health problem named, circle the number at the top of the column corresponding to the symptom. Remember to turn the page to complete each question.]

	Coughing Spells	Stuffed up Sinuses	Asthma

H-2. About how many days have

	you had this in the last 12 months?	___ days	___ days	___ days
H-3.	Which of these bothered you the most? 1 = most, 3 = least	_______	_______	______
H-4.	During the last year did this health problem cause you to miss 1 or more days of usual activity such as work, school, or work at home? Write H for housework, N for no activity missed, S for school, W for work away from home.	_______	_______	______
H-5.	About how many days of work or other usual activity did you lose because of this?	_______	_______	______
H-6.	Were there 1 or more days during the last year when this health problem caused you to greatly reduce your normal activities? Enter number of days.	_______	_______	______
H-7.	During the last year did you purchase any medicine for this health problem, either over the counter or with a prescription? Check for yes.	_______	_______	______
H-8.	About how much did you spend for this medicine?	$ _____	$ _____	$ _____
H-10.	During the last year did you visit a doctor, clinic, hospital, or other source of professional medical care for this problem? Enter number of visits.	_______	_______	______

H-12. About how much of this cost did you pay out of pocket? $ _____ $ _____ $ _____

H-13. [If workdays were lost in H-5] About how much earnings were lost because of workdays missed? $ _____ $ _____ $ _____

R. Ranking of Symptoms

In this next set of questions, I'm going to describe several symptoms of discomfort that are common to many people. The symptoms will not necessarily describe what you experience. I would like you to put yourself in the position of having these symptoms, however. Later on we're going to talk about a risk of cancer many years from now. But right now let's concentrate on the 3 symptoms.

I want you to suppose that your health in the next 12 months is going to be like it was in the past 12 months, except that you will experience 7 additional days of a given symptom.

First, we're going to talk about which of the symptoms you consider to be worst, and which you would be bothered by the least.

Everyone has experienced coughing. Please look at this card, which describes a particular coughing experience.

[Hand respondent coughing days card]

The card describes a day on which coughing occurs. You will cough about twice an hour in spells that last 10 to 20 seconds. You will feel the cough in your chest, but it is not severe enough to make you red in the face.

I am going to pause briefly to let you think about how much you would mind the 7 days of coughing.

Now suppose that, *instead of* having 7 additional days of coughing, you will have 7 additional days of sinus problems in the next 12 months. In other respects, your health will be exactly as it has been in the last 12 months.

A day of sinus problems is described on this card.

[Interviewer: hand respondent Days of Sinus Problems card]

You will have congestion and pain in your sinuses and forehead all day. You will be bothered by a feeling of stuffiness in your head, accompanied by sinus drainage in your throat. You will need to blow your nose every few minutes. You will have to breathe through your mouth most of the time.

Please think over how much you would be bothered by the 7 additional days of sinus problems and compare it to the 7 days of coughing. Think about which symptom you mind the least and which the most.

When you have decided, please tell me which bothers you more.

[Check one]

___ a coughing day
___ a day of sinus problems

Place that card under the other card.

[Wait for respondent to arrange cards]

Another problem that bothers people is asthma. Here is a card describing a day of asthma.

[Hand respondent card on Day of Asthma]

On this day, you will feel tightness in your throat and chest. You will begin to notice difficulty breathing. You will gasp and attempt to inhale more forcefully than is normal, attempting to get more air into your lungs. The harder you try, the worse your condition becomes. You wheeze, softly at first and then loudly. You inhale and exhale ever more rapidly. You feel panic, being afraid you will not get enough air. The attack last three hours, during which time you become physically exhausted. Finally you are so exhausted that you have to relax. You doze o sleep to recover.

Suppose that instead of either the coughing or the sinus problems, you will have 7 additional days of asthma, as described on the card.

Please rank the three symptoms. The question is which day bothers you the least, which the next least, and which bothers you the most. Place the three cards in the order you have decided on, the least serious on top.

[Interviewer: check to see cards are in proper order. If respondent has difficulty in ranking the days, read the following three indented paragraphs. If respondent has difficulty in ranking later on in the questionnaire, return and read these paragraphs. Otherwise, do not read the indented paragraphs to the respondent.]

> If there are symptoms that bother you the same, cards for those days should be next to each other in the deck. It does not matter which comes before the other.
>
> For example, if you don't care whether you have coughing or sinus problems, either of the two cards may be on top.

[Resume text if indented paragraphs were not read]

Thank you. I'm going to record your answers for use later. Let's keep the deck sitting there. We'll use it in a minute.

[Interviewer: record rankings on Tally Sheet.]

CV. Contingent Valuation -- Abstract Format

Now I want to ask you how much it would be worth to you to avoid the symptoms we've just talked about. In addition to the symptoms, we are also going to ask you to value the avoidance of a small risk of cancer many years from now. Notice our Tally Sheet, which we will use to record all your bids. **[Show respondent Tally Sheet]**

<u>Tally Sheet</u>

	Asthma	Cancer Risk
1.	$ _______, for entire family per year	
2.	$ _______, for children in family per year	$ ______ (one payment)
3.	$ _______, for self per year	$ ______ (one payment)
4.	$ _______, residual, if any, for other family members per year	
	[Check 1 = 2 + 3 + 4. Adjust if necessary.]	
5.	$ _______, children close to your family	$ ______ (one payment)

6. $ _______, all other children in U.S. $ ______ (one payment)
7. $ _______, TOTAL BID for asthma symptom reduction. $ ______ TOTAL (one payment) for cancer-risk reduction

[Check 7 = Σ 1-6.
Check to see if total is satisfactory.
Check to see if 1-6 are in desired relationship.
Revise as necessary.]

It shows you all the kinds of questions I will ask you about the three symptoms. Keep in mind as you answer individual questions that the total value you express will include all these parts. As we go along, you will be able to revise your bids to keep the total where you want it and to keep the parts in the right relationship to one another.

I have a deck of cards here where each card has a money amount written on it that you might or might not be willing to pay for the symptom reductions that we are asking about. Some of the numbers are really large, others quite small. We will shuffle the deck and deal the cards one by one. Please say yes if you would pay that amount for symptom reduction; say no if you wouldn't.

The first question pertains to your entire family, and refers to asthma. Would you be willing to pay the amount on this first card I've drawn at random from the deck to prevent 7 extra days of asthma? [If appropriate] And remember your expenses for these symptoms were H-8 + H-12 + H-13 for _____ symptom days. So you would be saving about $ _____ in out-of-pocket expenses. You should take account of this in your answer.]
[Deal cards repeatedly from deck. Record highest "yes" $ _____ .]
[If zero bid, probe for protesting.]

Your highest "yes" card is $ _____. Should we record that number as your bid, or would some other number be better?

Yes ____ . Value $ _____. per year.
No ____ .

Some people tell us it is difficult to think about paying to reduce just one health problem. Would you say that the dollar amount you stated your household would be willing to pay is: (Circle number)

1. Just for the Stated Health Program
2. Only for Yourself Instead of the Entire Family
3. Somewhat for People Outside Family
4. Somewhat for the Better Health and Somewhat a General Contribution to Environmental Causes
5. Basically a Contribution to All Environmental or Other Worthwhile Public Causes
6. Other (Please specify) ________________________________

About what percent of your dollar amount is just for the better health we just described? (Circle percent)

NONE SOME HALF MOST ALL

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Adapted from Schulze et al. (1998)

Next, lets focus on the value of preventing the 7 days of asthma <u>for your children</u>. Let's deal the deck again.

[Shuffle and repeat the card gam approach as long as it is meaningful to respondent. At some point, respondent may get the idea and be willing just to call out his bids. Record highest "yes". $ _______ .]

[If zero bid, probe for protesting, if necessary.]

Your highest "yes" card is $ ______. Should we record that number as your bid, or would some other number be better?

Yes ______. Value $ _______. per year.

No ______.

Next, I want you to think about the portion of your family bid pertains to <u>yourself</u>. Now let's recall your family bid and what's left over. Tell me how much of what remains pertains to yourself, leaving as much as you want for [your husband, wife, other adult household member].

Value for self $ _______ per year.

As you think about this, you might want to consider altering the family bid, or rearrange the amounts apportioned among your kids, yourself, and others.

[Changed values, if any]

Family $ _______. per year.

Children$ _______. per year.

This takes care of your family. We now move to values outside your immediate household. Here we're going to focus exclusively on kids. Are there any children outside your immediate household that you feel especially close to?

Yes ______. How many? ______.

No ______. Move to next section

How much would be willing to pay to reduce the symptoms (three symptoms, 7 days for each child) for these children?

WTP $ _______. per year.

[Elicit bid again. Card game may have spent its usefulness by now. This is a focus group question.]

A last question on the symptoms. Let's consider all children in the U.S. How much would you be willing to add to your bid to prevent extra symptoms for all these extra children?

WTP: $ _______. per year.

Let's look at the Tally Sheet. Do you wish to change any of the bids you've made so far?

[Record change, if any]

Now lets look at the cancer risk to your children during their lifetime. Here I have an illustration of some typical life paths.

[Show respondent life-path sheet]

Column 3 shows a person living out an average life span. Column 1 shows a typical life path of a person who contracts cancer. Suppose there are three chances in 10 that a person will contract cancer over the course of life and 7 chances in 10 that the person will live a normal life span. Imagine that your children face these prospects, but that there is an extra 0.05 probability -- an extra 5 chances in 100 that they might contract cancer at age 50. Let's look at this diagram to help get a better idea of the risk we're talking about.

[Hand respondent cancer-risk sheet.]

There are 70 black dots, representing normal life span and 30 red dots representing chances of contracting cancer. [Interviewer point to cancer path on life-path sheet.] The cancer risk we're talking about is represented by the 5 extra green dots shown in this diagram.

[Interviewer show second sheet of dots.]

Do you have any questions about this?

What would you be willing to pay now to prevent this extra risk of cancer to your children at age 50? Suppose that your children, when adults, will have adequate health insurance. Assume that they will also have adequate sick leave or workers' compensation to cover lost earnings. So, what we're asking you is how much would be willing to pay to spare your adult children the extra risk of pain and suffering from cancer.

I have a second set of bid cards here. Let's deal the cards.

[Shuffle and deal as before, unless respondent objects that it's not necessary.]

Record highest "yes" $ _____. (one payment.)

[If zero, probe for protesting.]

Again, I'd like to note that people sometimes find it difficult to think about paying to reduce just one health problem. Would you say that the dollar amount you stated your household would be willing to pay is:

(Circle number)

1. Just for the Stated Health Program
2. Somewhat for Pecuniary Expenses
3. Somewhat for Other Members of Your Family
4. Somewhat for People Outside Family
5. Somewhat for the Better Health and Somewhat a General Contribution to Environmental Causes
6. Basically a Contribution to All Environmental or Other Worthwhile Public Causes
7. Other (Please specify) ____

About what percent of your dollar amount is just for the better health we just described?

(Circle percent)

NONE		SOME			HALF			MOST		ALL
0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Adapted from Schulze et al. (1998)

Now I'd like to repeat the cancer-risk question to you. But now we're talking about your own risk. What would you be willing to pay to prevent the additional 5 chances in 100 of contracting cancer?

10 years from now? ___ [whichever is greater. check.]

At age 50? ___

[Interviewer show the two sheets of dots again.]

WTP: $ _____ . (one payment)

Let's keep our eye on the Tally Sheet as values are completed. Feel free to make changes any time you want to.

Next, what would you be willing to add to your bid to get cancer-risk reduction for children who are close to you and your family?

WTP $ _____ .(one payment)

Lastly, let's consider all the rest of the kids in the U.S. What would you be willing to add to get the cancer-risk reduction for them?

WTP $ _____ .(one payment)

Total WTP to remove cancer risk

WTP $ _____ .(one payment)

Cancer -- Quality Adjusted Life Year Approach

Let's look at the cancer-risk question from a somewhat different point of view. Here is a card with a line drawn on it that is scaled from 0 to 1. [Interviewer hand card to respondent.] The number 1 corresponds to our column 3 situation -- long life with good health. The 0 number stands for sudden death in the immediate future. Now let's take another look at our cancer-risk life path in column 1. [Interviewer hand first life-path sheet to respondent.] I'd like you to mark the line between 0 and 1, where you think the cancer-risk life path would put a person on the quality-of-life scale. Let's look again at the sheet that illustrates the increased probability of cancer in the future. [Interviewer hand respondent second page of dots.]

Do you have any questions about this?

[Discuss, as necessary]

Please mark the line on the quality-of-life scale where you feel the cancer risk falls.

[Respondent mark line]

Now lets consider the lower level of cancer risk that we discussed earlier.

[Interviewer hand first life-path sheet to respondent.]

Please mark the line to show how much the prevention of increased cancer risk improves the quality of life. The improvement will be reflected in the size of the interval between the two marks.

Any questions?

[Respondent marks the scale.]

Here's a second quality-of-life line to rate the three symptoms we discussed earlier, thinking about your children's quality of life. Recall our discussion of 7 days per year of the three symptoms. Let's use the marker labeled "1" to compare. How much below "1" would 7 days of the three symptoms place your children?

[Respondent mark the line]

Now, if we put the two lines together, we can compare the effects on quality of life from the cancer risk and asthma. We can also see how big the relative improvements are in the before and after situations.

Looking at them together, do your responses reflect your judgment about the relative importance of the illnesses and the before and after situations? Feel free to change them in any way you like. Respondents often use their erasers a lot in this part of the survey.

[Record changes.]

We have now almost come to the end of this long exercise. Before we leave it, though, I would like to take another look at your bid card and quality-of-life lines to see if there are any values you would like to change. You could adjust the total amount, or adjust the relative size of the individual entries.

[New bids go here, if any]

Thank you. Do you have any questions about the questionnaire? If so, we can go over any part of it you like. If you'd like to think about it some more, we could meet again in a day or two to repeat any or all of the questionnaire so that it really reflects the way you feel about the program. The importance of the program and the fact that you are one of a small number of citizens in our representative sample made it important to do as good a job as we can.

Program-Linked Survey Format -- Introduction

The second narrative develops a program-linked CV for child-health values. In reality, a real program would be described. The program we describe here, however, is a purely hypothetical one, made up to illustrate some of the main features of this type of questionnaire construction. The material from the first narrative, prior to the CV questions, is partly interchangeable with the second narrative. As with the abstract questionnaire format, embedding is stressed as perhaps the main challenge to the valuation of child health. Incentive compatibility is the reason for introducing the program. Program-linked questionnaires utilize all three aspects of the Green et al. CV protocol. In addition to the elicitation frame, they provide a program to be decisive about, and they raise the real possibility that payment will be required. Implementation frames should be decisive, according to Green et al., which means that respondents should know that their bids have a positive probability of determining whether a program will be implemented. The authors recommend that the payment vehicle be decoupled, which means that respondents' bids be dissociated with amounts they would actually have to pay if the program is implemented.

If the researcher decides to stress the incentive-compatibility potential of contingent valuation, then it is necessary to describe in some detail the actual program, the agent responsible for abatement, and the method by which payment will be made. Some idea of program cost is often conveyed in program-linked surveys, but it can be wondered whether this practice would produce anchoring. We elect not to include any program-cost detail. There may be uncertainties, on both the benefit and cost sides, concerning the program. These should be conveyed, as succinctly as possible. The CV product itself, however, should be made quite precise, so that everyone is encouraged to bid on the same thing. (Clear definition of the CV product is, of course, essential to any CV approach.)

All of this requires a good deal of descriptive realism and interview time, much of which will no doubt be evocative in a variety of ways to many respondents. Zero protest bids are one common result of CV program characteristics that respondents object to. These must be probed. Tax-financed government programs offer fertile grounds in which embedding problems can grow. Considerable care must be given to disembedding questions. Of course, protest and embedding are problems for abstract questionnaires as well, but abstract questionnaires would appear to offer fewer promptings in those directions.

We believe that program-linked CV has some serious additional shortcomings for the elicitation of child-health values compared to the abstract approach. A program description could state that children on average would experience say 5 fewer symptom days per year and that the average severity is such and such, according to best available knowledge. With sufficient knowledge about program effects, it could describe the extent of variability and elicit values in the tails of the distributions. But in the absence of this degree of detailed knowledge, only point estimates of average symptom-reduction values could be elicited.

The abstract format, by contrast, could simply postulate say 1-day, 7-day, and 30-day symptom reductions, and elicit their values. Responses would provide the basis for an estimated bid curve, relating willingness to pay to a range of symptom reductions and background explanatory variables.

Another disadvantage of this program-linked approach is that CV probably must be focused on population aggregates rather eliciting values at the household level. It would be different to tell a respondents that the child's symptoms could be reduced from 15 days per year (information already acquired) to an expected 8 days per year, or even to give the respondent a reasonable probability distribution. Using the abstract format and knowledge of household symptom endowments, one could ask "What would 5 days relief be worth?" In the case of relatively light symptoms, certainty-oriented questions are useful, and there's no problem of a lack of knowledge about program effects at the household level.

Questionnaire Material -- Program-Linked Version

Several of the modules in the Abstract and Program Linked Version are very similar. These include Health Evaluation, Health status; Ranking of Symptoms. The only modification to these parts in the program-linked version are that the P-reduction program is mentioned in the Health Status section and a day of symptoms is used rather than 7 additional days, because the program-linked version asks for values of symptom <u>reduction</u> in the CV section.]. The description of the contingent product and the bid questions differs in the program-linked version and are as follows:

Description of Program

A program is currently being planned to reduce pollutant P concentrations in the air. The plan is required to meet standards that USEPA is establishing in order to achieve health benefits that scientific research has determined will result from better air quality. These benefits are the symptom reductions we have just discussed. Benefits also include reduced risk of cancer which might occur after many years of exposure to P cancer. All citizens stand to benefit from the program. Children and other sensitive groups are likely to receive greater benefits.

We are seeking to find how much value citizens place on the value of health improvements that result from better air quality. You're household is one of 800 in several areas of the country being interviewed. Your views, therefore, will be an important part of the sample that represents the values of the U.S. population. Because of the small number of households being interviewed the importance of your views will be similar to the vote of a representative or senator in the U.S. Congress, rather than, say, your vote in a presidential election. P reduction is costly, and our concern is whether the citizens believe it to be worth the cost. The basic atmospheric science of P reduction has largely been put in place during the last half dozen years of so. The technology needed to make the science work is not as well developed, however. Also, the management practices that will be used to reduce program cost are still developing. Consequently, we don't have precise knowledge of the cost of P reduction at present. Sources that produce P include electric utilities, automobile drivers, and people who cut their lawns with gasoline-powered lawn mowers, among others. If the P-program is enacted, it will be paid for by increased prices of heating fuel, gasoline, and some other price increases.

We would like to know what your household would be willing to pay each year for the program. Your bid is important to the overall result. The higher your bid the more likely the program will be enacted, because a higher bid increases the average bid for the 800 people in our sample. The higher average bid makes it more likely that the value people place on the program will justify the cost. If, of course, you don't see that much value to the program, then a low bid for your household reduces the likelihood that the program will be enacted.

Before you state your valuation of this program, there is one additional point we would to make. It is that all households are not equally able to pay for an environmental program. Some are a lot wealthier than others, and in reality they will actually pay more for the program than households that are less well off. In short, it is unlikely that your household will end up paying the amount you give as your stated value.

Do you have any questions about what we've just talked about?

CV. Contingent Valuation

Notice our Tally Sheet, which we will use to record all your bids.

[Show respondent Tally Sheet]

Tally Sheet

	<u>3 Light Symptoms</u>	<u>Cancer Risk</u>
1.	$ ______. for all children in U.S., per year.	$ ______ to reduce cancer risk to all children. One payment.
2.	$ ______. Own children per year	$ ______ to reduce cancer risk to own children. One payment.
3.	$ ______. Other children who are close to you, per year.	$ ______ to reduce cancer risk to other children who are close to you. One payment.

[Check 3 = 1 + 2 in both columns. Is total satisfactory? Check to see if 1-3 are in desired relationship. Revise as necessary.]

It shows you all the kinds of questions I will ask you about the three symptoms and the cancer risk. They are all parts of the benefits the EPA program is expected to produce. Keep in mind as you answer individual questions that the value you express for the program will include all these parts. As we go along, you will be able to revise you bids to keep the total where you want it and to keep the parts in the right relationship to one another.

Now I want to ask you how much you would be willing to pay to get the benefits of the pollution-control program. Our focus is on the benefits that children in the U.S. would get from the program, immediately and throughout their lives.

Right now there are about n children in the U.S., 18 years old or less. On average, each child could be expected to experience (5) fewer days each year of the symptoms we have just looked at, according to best available knowledge. Some children will get less benefit. These would be kids who get less than average exposure to pollutant P, and those kids who resist its effects because they are in very good health. Others will get more that average benefit because they live in areas of high exposure to P, or because poorer health makes them more sensitive to P exposure.

If people are exposed to P for many years, they are at a higher risk of cancer than they would be if P were removed from the air. I will describe the illness with you in a moment, and also the increased chances of getting it if P is not removed from the air. We will also discuss the value to you of reducing this risk. [Interviewer point to cancer column on Tally sheet.]

How much would you be willing to pay to reduce all three symptoms by an average of 5 days per child for all children in the U.S.?

I have a deck of cards here where each card has a money amount written on it that you might or might not be willing to pay for the program. Some of the numbers are really large, others quite small. We will shuffle the deck and deal the cards one by one. Please say yes if you would pay that amount for the program; say no if you wouldn't. Think about the children in your own household, other children you feel close to, as well as all kids in the U.S. Your bid is for all children in the U.S.

[Shuffle deck and deal cards. Record highest "yes." $ _______ .]

[If zero bid, probe for protesting.]

Your highest "yes" card is $ _______ per year. Should we record that number as your bid, or would some other number be better?

Yes _____. Value $_______ per year.

No _____.

Some people tell us it is difficult to think about paying to reduce just one environmental problem. Would you say that the dollar amount you stated your household would be willing to pay for child-health improvement is: (Circle number)

1. Just for child-health improvement
2. For adult-health benefits of the program
3. For health benefits not related to the program
4. Somewhat for the child-health program and somewhat a general contribution to all environmental causes
5. Basically contribution to all environmental or other worthwhile public causes
6. Other (Please specify) ____

Q13 About what percent of your dollar amount is <u>just</u> for the stated child-health improvement program? (Circle percent)

NONE		SOME			HALF			MOST		ALL
0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Source: Based on Schulze et al. 1998

We realize it's difficult to guess how much the program might benefit your own family and those close to you. But could you tell us about how much of your willingness to pay is for your own children and those that are close to you?

Own children $ or % _____ .
Other children who are close $ or % _____ .

Let's look at the Tally Sheet that summarizes your bids. Are there any you'd like to change?

[Enter changes]

[The cancer-risk CV questions are almost the same as in the abstract format from here to the end of the CV section. The only differences is that the green dots on the cancer-risk sheet show a <u>reduction</u> in cancer risk.

Hybrid Survey Format -- Introduction

A conclusion that can be drawn from the comparison of abstract vs. program-linked CV surveys is that there are tradeoffs in the choice between the two methods. Program-linked contingent valuation is feasible when environmental programs are fully formulated or at least in a fairly advanced state of preparation. But is contingent valuation useful to health policy only when specific programs are in an advanced stage of development? We argue that CV can be profitably employed in the early stages of policy making, before programs have begun to take shape. For example EPA might wish to employ CV to help make a decision on policy priorities. A full-blown policy-linked survey is then not possible; one can't lie to respondents about programs. But because program thinking is already part of the policy process, it should be possible to exploit some of the incentive-compatibility features of the program-linked survey while taking advantage of the stronger points of the abstract format. We propose some language to help direct the development of a hybrid form of CV survey that could be useful in this context.

Hybrid Survey Format -- CV Narrative

There are concerns about cancer risk arising from years of exposure to pollutant P. A group of researchers from the University of __________________ is exploring the desirability of reducing the air pollutant P. One of the health benefits expected from reduced P pollution is reductions in the risks of cancer that can occur after many years of exposure.

We have chosen a random sample of households . . . .

It isn't known yet how much it will cost to reduce P pollution. We have at this time only an approximate knowledge of the extent of cancer-risk reduction as more and more P is taken out of the air. What we plan to do in this interview is ask you how much you would value various amounts of cancer-risk reduction. These risk reductions are expected to be in the range of actual risk reductions as P pollution is reduced.

The higher you value these risk reductions the more likely it is that a P reduction program will be enacted. [Continue to establish decisiveness.]

Also I want you to understand that wealthier households will pay more for P reduction than less wealthy households . . . . [Continue to establish decoupling.]

Proceeding to the bids:

> Now consider what it would be worth to you to get the benefits from the pollutant P reduction program, focusing first on values to the entire family. We want to get a combined value for all the symptoms and diseases together.
>
> Note that a disease like cancer involves medical expenses, loss of earnings and pain and suffering. In your answers, suppose that medical insurance is good enough to cover all the medical expenses. Suppose also that sick leave and disability and unemployment insurance provided by employer are generous enough so that no lost earnings occur. If the idea of having no lost earnings makes things too unrealistic for you, please give me a separate estimate of how much you think lost earnings would be. What we want to get down to is how much you would be willing to pay solely to avoid pain and suffering from the disease.
>
> What is the most you would be willing to pay to reduce the risk of pain and suffering associated with the cancer scenario from X to Y (probabilities to be specified by the interviewer based on best available information about dose response relations):
>
> WTP 1: $____
>
> How much of this amount pertains to you and your wife and not to other family members?
>
> WTP 2: $____
>
> Next consider the cancer risk your child will face as an adult because of pollutant exposure early in life. Suppose that cancer sets in at age 50, a long time from now. Again suppose that there will be full coverage of medical expenses and that there will be no lost earnings (or state amount if you believe there be lost earnings). We could ask your child what the benefit to him would be now for the prospect of better health as an adult, but he is unlikely to have the judgment to answer accurately, especially since children under 18 tend to be impatient and may discount the future benefits more heavily than if they were able to reason with more maturity. Therefore, we are asking that you answer for the child. Please try to put yourself in the place of your child when grown, and imagine what he would say it should have been worth to him when he was a child to reduce the risk. What is this amount?
>
> WTP 3: $____

Finally, we wish to consider how much of the bid for your entire family is for other family members who may feel bad about the child's illness or who may suffer from lack of attention due to parents caring for a sick brother or sister, and the like. Extend your bid to include what you think would be paid by relatives who know the child, as well as friends whose feelings would be affected by the child's sickness.

WTP 4: $____

A benefit that may be worth something to you that we have not yet considered is making children outside your family, everywhere in the United States, better off. How much would you be willing to add to your bid because children everywhere are made better off?

WTP 5: $____

A follow-up question as adapted from Schulze et al. (1998) deals with embedding:

Some people find it difficult to think about paying to reduce just one problem. Would you say that the dollar amount you stated your household would be willing to pay for reduced cancer risk is (circle number)

1. Just for the cancer risk reduction from the program
2. Somewhat for other causes of cancer
3. Somewhat for other illnesses
4. Somewhat for medical expenses
5. Somewhat for lost earnings
6. Somewhat for other worthwhile programs
7. Other (Please specify)_____________

If you answered that your bid was not just for the cancer risk reduction from the program, about what percent of your original bid was for the other effects?

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Question and Answer Period for Session III

Jenkins, Owens and Wiggins Paper

Kerry Smith, Duke University, asked whether the life of a bike helmet shouldn't be shorter than that assumed in the study. There is a difference between adult behavior and children's behavior here, in that adults don't replace bike helmets, whereas children outgrow helmets. Mr. Smith asked if Ms. Jenkins's assumption that adult helmets were replaced every four years (as recommended by manufacturers) was supported by any evidence. Ms. Jenkins replied that there are no data on actual replacement rates. Bill Harbaugh, University of Oregon, added that there is also an issue as to longevity because of misplacing helmets. His own experience is that his daughter often loses her bike helmet, and that he has to replace hers every six months.

Alan Krupnick, Resources for the Future, commented that the estimate of the value of a statistical life might be biased downward because there is not only a safety factor but a regulatory factor. In several states now, wearing bicycle helmets are mandatory for children of certain ages. The willingness to pay for safety may thus be less than the price of the helmet, but the desire to comply with the law might play a significant part in the decision to buy a helmet. Possibly a two-bid model would be appropriate for identifying the separate values.

Ellen Post, Abt Associates, wondered if the sample population used was a representative one. Bicycle helmets are often not purchased from poorer sectors of the population. Also, Ms. Post suggested that perhaps the best way to establish a baseline was to look at what the probability of buying a helmet would be in the first place (with respect to a respondent), and then measure how that person deviated from the predicted probability.

Ann Watkins, US EPA Office of Air and Radiation, commented that the costs may be an under-estimate of willingness to pay because like bikes, some helmets have to be replaced more frequently than others.

Richard Belzer, Washington University, commented that parents typically do not buy helmet with the expectation that their kids will wear the helmets all of the time.

Tim Bushnell, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, was concerned that helmet-wearing habits change over time, and that this may cause the value of a statistical life to change dramatically over a five-year period, for example.

Nick Bouwes, US EPA Office of Pollution Prevention and Toxics, pointed out that being a long-time bicyclist and bike commuter, and a long-time subscriber to Bicycling magazine, he considered himself an informed bicyclist but had no idea what the probability of an accident was, or what the reduction in probability is from his wearing a helmet. This suggests that the decision-making process is much cruder than that modeled in the paper.

Al McGartland, US EPA Office of Policy, pointed out that there are significant enforcement costs as well, with respect to both parents monitoring their children's behavior and authorities monitoring compliance with legal requirements of helmet safety.

Mr. Smith noted that the recently-begun National Recreation Survey, which queries respondents as to numerous recreational transportation patterns, presents an excellent opportunity to supplement studies similar to the present one, in that extensive data have been collected on leisure bicycling trips.

Harbaugh and Tolley and Fabian Papers:

Bryan Hubble, US EPA Office of Air Quality Planning and Standards, queried if there was a middle ground between the extremes of benevolent preferences, where parents wish to truly maximize their childrens' utility, and paternalistic preferences, where parents may be imposing their utility functions upon their children. Mr. Harbaugh replied that this was a reasonable possibility, but that the important thing about being a parent is having the advantage of knowing that their childrens' utility functions for safety will change over time. George Tolley, University of Chicago, wondered whether we, as adults, are able to put ourselves in the place of children.

Laurie Chestnut, Stratus Consulting, followed up on Mr. Hubble's question, citing the example of making kids do homework as parental altruism. This is not necessarily "paternalism." This is simply because parents have more information. Mr. Harbaugh agreed, likening the role of a parent to that of a social planner.

Mr. Krupnick asked if they were aware of studies of how parents give allowances to children. He cited as an example parents who give their kids $500 at the beginning of the year, and allow them the freedom to make their own spending decisions. Is this considered paternalistic or benevolent?

Sandy Hoffman, University of Wisconsin, cited Mr. Harbaugh's assertion that children are rational economic actors, and asked if the economic literature has looked at how children make economic decisions. Mr. Harbaugh replied that there has been very little work done by economists, but a significant body of work done by psychologists, although Mr. Harbaugh did not cite specific examples.

Clay Ogg, US EPA Office of Policy, commented that there are too many differences between children and adults, such that comparisons are difficult. The key is to find a good that is comparable between adults and children, so that relatively simple adjustments can be made. Mr. Tolley responded that children do indeed have some concepts of valuation that are similar to those of adults.

Ellen Post, Abt Associates, raised the issue of the appropriate sector of the population to be used for asking for valuations. Should we use the valuation of a crack addict parent? The model of a paternalistic parent may break down in such cases. Mr. Harbaugh responded that this is a sampling issue, and although other parents may not be paternalistic clearly Ms. Post was, and that these preferences are easily identified ex post. Ms. Post then added that this poses a moral problem, in that valuations are being made by third parties.

Mr. Chu raised the "trained seals" point raised by Reed Johnson the previous day – can we train children sufficiently so that they can respond to economic valuation exercises more rationally? And if we can, does that really help us measure the willingness to pay on the part of the larger population? Mr. Harbaugh agreed that this was a problem and noted that it still seems better to get adults to look backward than to get kids to look forward.

June 1999

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

PROCEEDINGS OF THE SECOND WORKSHOP IN THE ENVIRONMENTAL POLICY AND ECONOMICS WORKSHOP SERIES

--Session Four--

A Workshop sponsored by the
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Proceedings for Session Four, Thursday, March 25, 1999

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Household Environmental Protection and the Intergenerational Transmission of Human Capital

--Working Paper*--

PRESENTED BY:
Thomas D. Crocker
Department of Economics and Finance, University of Wyoming

CO-AUTHORS:
Mark D. Agee
Department of Economics, The Pennsylvania State University

* 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.

Household Environmental Protection and the Intergenerational Transmission of Human Capital

MARK D. AGEE
Department of Economics
The Pennsylvania State University
Altoona, PA 16601
USA
E-mail: mda4@psu.edu

THOMAS D. CROCKER*
Department of Economics & Finance
University of Wyoming
Laramie, WY 82071-3985
USA
E-mail: tcrocker@uwyo.edu

*Corresponding author

JEL classification: I12; J24; Q20.
Keywords: Human capital formation; endogenous environmental quality; intergenerational transmission.

ABSTRACT. The estimated discount rate of parents is used to test a choice-based intergenerational model of the contribution of environment to the cognitive skills of a child of a given endowment. A lower parental discount rate is shown to imply higher cognitive skills of the young child. In the context of the model, estimates also imply that environmental conditions and human capital formation are not separable. Lesser environmental quality raises the costs of human capital formation in children and lesser human capital reduces parents' demand for environmental quality. Environmental quality differences among families, just genetic differences, may persist across generations.

> *The difference of natural talents in different men is, in reality, much less than we are aware of; and the very different genius which appears to distinguish men . . .,, when grown to maturity, is not ... so much the cause, as the effect of the division of labor* (Smith, *[1776] 1937, p. 15*).

1. Introduction. The influence of human capital or knowledge about the laws of nature and the nature of man on economic growth and the evolution of income inequality receives increasing attention in both the technical economic literature, e.g., Levy and Murname *(1992)*, and in popular commentary, e.g., Murray *(1984).* Human capital is thought to be the primary engine of growth, the major component of wealth in developed economies, to be increased by and to increase the scope of markets, and to play significant roles in fertility choice, socialization, and migration. Little attention has been given, however, to how human capital can affect one's treatment of the natural environment or how this environment can mold one's accumulation and protection of human capital. Central to any attempt to deal with either of these questions is the extent to which intergenerational redistributions, especially from adults to young children, are influential. Since children do not vote and have only trivial assets or activities over which they can exercise substantial discretion, the practical aspects of the intergenerational redistribution issue revolve around the productivity of parental and social investments in environments that can affect a child's prospective human capital. Given that parents have limited resources, they must often make time and effort choices between their immediate consumption and the provision of environmental enhancements and protections that will advance a child's current health and adult prospects. When approaching adulthood the child takes what its parents, community, and genes have handed it and set its course for an adult life.

This study uses an unusual data set to estimate the relationship between the environmental protections that parents offer children and the intergenerational transmission of human capital. We focus on lead, a persistent micropollutant that has become ubiquitous in even remote environments and which is widely acknowledged in the biomedical literature to produce long-term cognitive skill deficits in young children who axe exposed to everyday ambient concentrations common to the world's urban areas (Smith et al., *1989).* Following Agee and Crocker *(1998),* the next section presents a simple model in which changes in parents' demand for own-consumption translate into changes in the environmental quality they provide their child, hence into changes in the benefits to them of building their child's human capital. The model hinges upon parents having imperfect access to capital markets in that they must either sell assets, increase parental market labor, or reduce household consumption to finance investments in their children which cannot be borrowed and made the children's future obligation. A third section describes the data we employ, while the fourth section presents empirical tests of model propositions. The connection we find between parents' own-consumption, their child's cognitive skills, and the child's environment leads us to conclude that environmental quality differences among families, just like genetic differences, may persist across generations.

II. **Parental Investments in Children's Cognitive Skills.** Consider a two-period, two generation lifetime setting in which the generations overlap each period. In period 1, parents with unified preferences derive utility

$$U(s_1, \alpha_1(n)nc_2) \tag{1}$$

in a weakly separable fashion from own-consumption, s_1, over their certain lifespans, and from the current health and thus the expected value, c_2, of the adult prospects in period 2 of their child. $U(\cdot)$ is twice differentiable and concave. So as to remove fertility decisions from the problem, we interpret the parents' number of children, *n,* to be predetermined. Diminishing marginal utility of children implies that parental first period altruism, α_1, is negatively related to child numbers (Becker et al., 1990). Parents have no favorites among their individual children, as is commonly assumed (Wilhelm, 1996). Children are passive with respect to their parents' consumption and investment decisions.

Parents maximize U(·) subject to the constraint

$$X + nc_2(Q_1; E_2) = p_1(Q_1)s_1. \tag{2}$$

The left-hand-side of (2) states that parents possess total exogenous money wealth, X_1, and the expected value, c_2, to them in period 2 of their children as adults. This expected value may include consumption support as well as the money equivalent of companionship and emotional support. On the right-hand-side , parents allocate this wealth and expected value between period 1 own-consumption, s_1, and the provision of environmental quality for their child. Greater parental provision of period 1 environmental quality, Q_1, progressively increases the unit value, p, of own-consumption such that $p' > 0$, and $p'' > 0$. In effect the quality of the child's environment and the parents' period 1 own-consumption are substitutes.

Q_1 is conditioned on whatever public goods society exogenously provides the child. Parents have no second-period earnings, but the presence of the second term, $c_2\ (Q_1; E_2)$, on the left-hand-side of (2) implies that the parents' lifetime wealth increases with the child's adult prospects.[1] $c_2\ (Q_1; E_2)$ is defined as

$$c_2\ (Q_1; E_2) \equiv w \cdot z_2\ (Q_1; E_2) + \varepsilon_2\ , \tag{3}$$

where z_2 is a continuous concave cognitive skill or adult prospect production function, w is the rental rate of these skills, and ε_2 is a stochastic term representing market luck. For simplicity, we assume w equals unity. E_2 is the child's exogenous phenotype, the autonomous background expression of the cultural, environmental, and the genetic attributes that the child inherits. We presume as a first approximation that these attributes are transmitted by way of a stochastic linear equation

$$E_2 = \lambda + \theta E_1 + v, \tag{4}$$

where λ denotes the child's community or social endowment (Coleman, 1988), θ represents the degree (or vector of degrees) of "inheritability" of the attributes, E_1, that the child's grandparents transmitted to the parents, and v measures unsystematic components in heritability. Expression (4) is presumed fixed over the child's lifespan and is shared in common with its siblings. Parents cannot invest in the child's endowment. In sum, $c_2\ (Q_1; E_2)$ implies that the cognitive skill impact of the child's inheritance is conditioned by the quality of the environment that the child's parents provide.

Parents' equilibrium levels of s_1 and c_2 obtained from the primal optimization problem in expressions (1) through (4) will vary with their demand, Q_1^*, for environmental quality**.** Substitution of Q_1^* into U (·) yields an indirect utility function

$$V = V\ (p_1\ (Q_1^*),\ nc_2\ (Q_1^*;\ E_2),\ X_1) \tag{5}$$

which follows from the primal result that parents produce that level of environmental quality which equates the money equivalents of their marginal utilities of consumption and their child's cognitive skills, given that the parents are wealth-constrained and cannot borrow for own-consumption and child investments and then make payments on these borrowings the child's adult obligations. Therefore expression (5) implies that parents invest in their child's environment until the marginal rate of return on this investment equals their substitution rate between own-consumption, s_1, and the child's adult prospects (see the Appendix). Becker and Tomes, (1986, p. S11) refer to this substitution rate as the parents' rate of discount for these prospects, $\rho \equiv (\partial U / \partial s_1)\,(\partial U / \partial Q_1)$, their "shadow cost" of investing in the child's environmental quality. As in Becker and Tomes, the parents' demand for environmental quality can then be written in terms of the parents' discount rate for developing the child's cognitive skills and hence the expected value of its adult prospects,

$$Q_1^* = Q_1^*(\rho(X_1; E_2, n); E_2) = Q_1^*(\rho(X_1; n); E_2).. \tag{6}$$

In expression (6), wealthier parents for whom the left-hand-side of (2) is relatively high apply a lower discount rate and consequently provide a better environment for their child, i.e., $(\partial Q_1^* / \partial \rho)(\partial \rho / \partial X_1) > 0$ Note that expression (5) requires $(\partial V / \partial p_1) p_1^{'} + (\partial V / \partial c_2)(\partial c_2 / \partial Q_1^*)\alpha_1(n)n = 0$ at equilibrium quality Q_1^*, implying that $c'_2 > 0$ since, by construction, $p_1^{'} > 0$, $\partial V / \partial p_1 < 0$ and $\partial V / \partial c_2 > 0$. Thus, increases in environmental quality increase the value parents attach to the child's cognitive skills.

To see the impact of a change in environmental quality upon parents' own-consumption, s_1, totally differentiate the Marshallian demand $s_1 (p_1 (Q_1), c_2 (Q_1; E_2, X_1))$ to obtain

$$\frac{\partial s_1}{\partial Q_1} = \frac{\partial s_1}{\partial p_1} p_1^{'} + \frac{\partial s_1}{\partial c_2} c_2^{'}. \tag{7}$$

This expression says that the demand for own-consumption arises from the impact of environmental quality provision upon the parental benefits of improving the child's adult prospects as well as upon the unit value of own-consumption. By construction, $p_1^{'} > 0,$ and by implication, $c_2^{'} > 0.$ Also, $\partial s_1 / \partial p_1 < 0,$ since an increase in unit value of own-consumption is consistent with a reduction in quality demanded. Given that the budget constraint in expression (2) makes parents' own-consumption and the child's adult prospects substitutes such that $\partial s_1 / \partial c_2 < 0$, it then follows that $\partial s_1 / \partial Q_1 < 0.$

Now consider how a change in the child's autonomous inheritance will affect parents' demands for own-consumption and hence their investment in their child's environment. Substitute Q_1^* from (6) into the parents' equilibrium level of own-consumption and differentiate to obtain

$$\frac{ds_1^*}{dE_2} = \left[\left(\frac{\partial s_1^*}{\partial p_1} \right) p_1^{'} + \left(n \frac{\partial s_1^*}{\partial c_2} \right) \frac{\partial c_2}{\partial Q_1^*} \right] \left[\left(\frac{dQ_1^*}{d\rho} \right) \frac{\partial \rho}{\partial E_2} + \frac{\partial Q_1^*}{\partial E_2} \right]. \tag{8}$$

The first bracketed term on the right-hand-side of (7) is the effect of any change in environmental quality upon parents' willingness to invest in developing the child's cognitive skills. Q_1^* must change as E_2 changes. The second right-hand-side term reflects the indirect and direct effect of a change in E_2 upon the parents' demand for environmental quality. Not surprisingly, parents' own consumption and children's endowments are indirectly linked through ρ *;* that is, constraints on financing investments in children introduce an accentuating positive effect of parents' wealth on children's adult prospects. [2]

III. **Data.** The foregoing model carries precise implications for the quality of the environment that parents choose for their children: they equate the marginal rate of return to investments in the child's skills to their marginal rate of substitution between own-consumption and the child's skills. Data on parents' equilibrium return rates for investing in these environments would thus enable us to distinguish the determinants among families of parental investments in their children and the distribution of skills among these children. We have no observed data on parents' equilibrium return rates for their children. However, in Agee and Crocker (1996), we use data on screening for children's body burdens of lead to estimate the discount rates that parents attach to investments in avoiding risks of their child developing long-term cognitive deficits from low-level lead exposure. This section describes the lead screening data and the Agee and Crocker framework used to estimate parental discount rates from this data. Together with information in the same data set on the assessed intelligence (IQ) of parents and children, these estimated discount rates allow us to test the foregoing choice-based, intergenerational model of the contribution of environment to the cognitive skills (as measured by assessed IQ) of a child of a given endowment.

The lead screening data. Our data were originally gathered for Needleman, et al. (1979; 1990). They involve observations on 256 children each from separate families in two adjoining Boston, Massachusetts area communities in 1975-78, and again in 1985. Each household had an own child who attended the first or second grades between 1975 and 1978. Thus these children were very unlikely to be old enough to reflect meaningfully about the effect of their cognitive development choices upon their parents' altruism toward them. Information on each child's medical history and current health status, and the parents' time allocations, employment, and a variety of personal characteristics was gathered in the 1975-78 survey. The lead content of shed teeth was used to measure each child's body lead burden. All sample children had a birth weight above 2500 grams, were discharged from a medical facility following birth at the same time as the mother, had not previously received medical treatment for lead-related health effects, did not have a history of noteworthy head injury, and were not retarded (i.e., IQ > 70).

While parents completed a Peabody Picture Vocabulary IQ Test (Dunn, 1959), their child was given the Wechsler Intelligence Scale for Children-Revised (Wechsler, 1974). We presume that cognitive skills are measurable without systematic error in terms of assessed intelligence (IQ). After completion of these IQ examinations, a child psychiatrist informed the parents of their child's lead status, its expected consequences, and medically appropriate courses of action for the child. Over the next few years, parents then had to make a choice between doing nothing for the child or investing in changing its environment, i.e., its lead burden. In 1985, the original data set was supplemented by information about 1985 parental wage levels and the medical treatments, if any, which the child had undergone in the interim.

Parents' Discount Rate. Agee and Crocker (1996) used parents' implicit valuations of children's reduced body lead burdens to infer the subjective discount rate parents apply to their children. The inferences were based upon an ex ante model of endogenous risk in which parents' perceived risk of their of their child developing lead-induced neurological deficits varied with parental choices of medical treatments and reductions of the child's exposures to lead in the home environment. Perceived risk represented a continuous measure over a real interval of perceived probability or expected severity of neurological deficits. For a reduction in perceived risk associated with a reduction, $\ell - \overline{\ell}$, of the child's body lead burden, ℓ, the parents' indirect utility function, $V(\cdot)$, was defined in annualized terms as

$$\overline{V} = V\left(Y_1 - \delta CS, \ell - \overline{\ell}, q\right), \tag{9}$$

where Y_1, is annual income, q is real prices, and δCS is the annualized Hicksian compensating surplus. δCS is the maximum income in annualized terms that parents are willing to forego in order to reduce perceived risks to their child while maintaining their original utility level, $\overline{V}$. The parents' rate of discount, ρ, generates an annualizing term, δ, equal to $\rho/(1+\rho)$.[3] A small reduction in the child's lead burden was thus valued in terms of the parents' annualized marginal implicit price of risk, P_ℓ. P_ℓ was obtained by totally differentiating (9) with respect to ℓ and setting the result equal to zero:

$$P_\ell \equiv -\left(\frac{dCS}{d\ell}\right) = -\frac{(1/\delta)(\partial V/\partial \ell)}{(\partial V/\partial Y_1)}. \tag{10}$$

Agee and Crocker (1996) estimate expression (10) by deriving an observable expression for the endogenous implicit price variable, P_ℓ, and by specifying $V(\cdot)$ with an indirect addilog utility function (Parks, 1969). The empirical version of (10) used the function,

$$\frac{1}{\delta} = (\text{INCOME, DADPRSNT, MOMAGE, MOMEDUC, DADEDUC, SEX, NUMCHLD}), \tag{11}$$

in log-linear form to explain differences in parental discount rates, where all right-hand-side variables were assumed determined prior to rather than contemporaneously with the parents' demands to reduce their children's body lead burdens. Annual parental income (INCOME), presence of the father in the household (DADPRSNT), the mother's age (MOMAGE), and educational attainments of parents (MOMEDUC, DADEDUC) combine to measure household differences in wealth. The child's gender (SEX) and number of siblings (NUMCHILD) measure sources of differences in parental altruism per child.

The adjusted R^2 for the estimate of (11) was 0.90, a coefficient which we presume to be large enough to allay the concerns of Bound et al. (1995) and Nelson and Startz (1990) about inconsistent estimates when the correlation between instruments and the endogenous explanatory variable is low. More parental income, maternal education, and presence of the father reduced the discount rate that parents applied to investments in their children's cognitive skills (see also Parsons and Goldin, 1989), while more paternal education increased this rate. Consistent with expression (1), no gender preference appeared. The parental discount rate increased with the number of the child's siblings.

Table 1 supplies descriptive statistics of sample parents' discount rate $\hat{\rho}$ calculated from the fitted values for expression (10). The mean implicit discount rate for the entire sample is 4.7 percent, with a 2.2 percent standard error. The table shows that sample parents with annual incomes below the 1979 U.S. median of $16,841 applied discount rates of approximately 7.2 percent on average, while those above the median applied rates of 3.2 percent.[4]

Children in families without a high school diploma were discounted at about 7 percent, while families with both parents having had at least some college were discounted at about 2.6 percent, which is fairly close to the Vicusi and Moore (1989) estimate of the long-term AAA bond rate of 3.2 percent.

IV. **Parents' Environmental Investments and Children's IQs.** In Section II the distribution across families of wealth and children's endowments determines the distribution of equilibrium parental investments for their children's environments. Substituting the Q_1^* in expression (6) into the cognitive skill production function in expression (3) yields

$$z_2^* = z_2^*(Q_1^*(\rho; E_2); E_2) = \varphi_2(\rho; E_2) \tag{12}$$

A linear approximation to this relation is

$$z_2 = a + b\rho + cE_2 + \eta_2, \tag{13}$$

where η_2 measures unsystematic components of the determinants of the child's cognitive skills. Our interest focuses on the marginal contribution to the child's cognitive skills of the systematic parent-child connections expressed in ρ, the discount rate that parents applied to their investments in reducing the child's body burden of lead. Given that parents apply a weakly positive discount rate and that increased child endowments raise the marginal productivity of parents' time and money expenditures on these environmental investments we expect our estimate of the *b* parameter to be negative.

The unobservability of E_2 complicates the straightforward estimation of (13). If E_2 is correlated with ρ, a failure to include some measure of E_2 would bias any estimate of the coefficient of ρ. We therefore postulate an incidental equation to describe the relation between the unobserved E_2 and an observable variable, the average of the assessed IQs of the child's parents (PARENTIQ). To derive this equation, we lag expression *(12)* by one generation and substitute from (4) to obtain (Behrman and Taubman, 1985):

$$\text{PARENTIQ} = A + BE_2 + \mu \tag{14}$$

where $A = a - (c\lambda / \theta), B = c / \theta, \ and \ \mu = b\rho_0 - (cv_2 / \theta) + \eta_1$ (0 denotes grandparents). This expression recognizes that a child does not inherit an IQ from its parents. Instead the child inherits a set of cultural and genetic attributes, as well as grandparent-to-parent nurturance. The expression of that inheritance, called the *phenotype* (the observable cognitive skills of a child), results from the interaction of the inheritance with current environmental influences. Expression (13) is therefore to be interpreted as the child's inheritance measured in terms of parental phenotype. Substitution of expression (14) into (13) yields

$$z_2 = \bar{a} + \psi \ (PARENTIQ) + \ b\rho + \bar{\eta}_2 \ , \tag{15}$$

where $\bar{a} = a(1-\theta) + c\lambda$, and $\bar{\eta}_2 = cv_2 - \theta(b\rho_0 + \eta_1) + +\eta_2$. However, since PARENTIQ and $+\bar{\eta}_2$ in expression (15) are correlated, the ordinary least squares (OLS) estimator of *b* and ψ will be biased and inconsistent. Specifically, if E_2 and ρ are negatively correlated, measurement error introduced by way of (14) will impart a downward asymptotic bias to *b* (Garber and Klepper, 1980). In effect, ρ will pick up some of the positive effects of E_2 which, because of measurement error, are not attributed to the PARENTIQ surrogate. As is well known, this same error will cause the estimated coefficient for PARENTIQ to be biased toward zero. Consequently, we interpret our estimates of *b* and ψ in Tables *2* and 3 as lower bounds on the true influences of the parental discount rate for body lead burden reducing investments and heritability of family endowments upon the development of a young child's cognitive skills.

Table 2 reports OLS estimates of expression (13) using assessed Full-scale and Verbal IQ scores as measures of children's cognitive skills. Both sets of estimates include as predetermined covariates the child's birth weight (BIRTHWT), length of hospital stay after birth (HOSPINF), order in which English was learned (ORDENGL), and number of head injuries (NUMHDINJ) to control for exogenous, strictly post-natal factors that do not influence p but which representative biomedical thinking (e.g., Needleman et al., 1990) believes are associated with differences in children's assessed IQ's. Also predetermined are the indirect influences in (11) which we postulate operate on IQ recursively through their effects upon the estimated discount rate, $\hat{\rho}$, that parents apply to investments in reducing their child's body lead burden. That is, as our analytical framework commands, we treat the parental discount rate as a price that intervenes between the child's cognitive skills and factors that, with little or no theoretical justification, nearly all cognitive skill studies maintain directly influence these skills. A dichotomous measure of whether the sample child's mother works outside the home (MOMWRKS) is also treated as predetermined. Some recent research suggests that the young children of working mothers develop cognitive skill deficits, e.g., Hill and O'Neill (1994).

In the first and third columns of Table 2, coefficients for the PARENTIQ and $\hat{\rho}$ covariates have the expected signs and provide statistically significant explanations of the variations in children's assessed Full-scale and Verbal IQs. For the intervals to which our sample refers, the table suggests that if parents' discount rates increase from roughly 3 percent to 7 percent (the average difference in Table 1 between lower and higher income and educated parent subsamples) the IQs of sample children decrease by about 3 points.[5] This can be compared to the 9 point decrease in PARENTIQ that is associated, on average, with a 3 point decrease in each of the child's Full-scale and Verbal IQ's.

Table 1 reports that the discount rate Agee and Crocker **(**1996**)** estimated which parents applied to investments in reducing their child's body lead burden increased slightly with this burden. Because parents were ignorant about its presence prior to the physician consultation **(**Needleman et al., 1979), this burden was part of the child's autonomous inheritance. In accordance with expression (8), one possible interpretation of these higher estimated rates is that a greater burden reduced parents' perceived effectiveness of investments in their child's cognitive skills, thereby increasing parents' propensity to consume and accentuating the effect that the inherited burden poses upon the child's adult prospects. The choice that parents made about own-consumption affected their child's environment and, in turn, the expected consequences of the environment affected their choices. Here we test the empirical validity of this interpretation. The alternative hypotheses are that only the autonomous body lead burden or only parents' investments and not the effect of autonomous lead upon the mix of parents' own-consumption and investments in reducing the child's lead burden as reflected in the parents' discount rate influenced the child's cognitive skills.[6] We now test these three distinct hypotheses by linearly approximating (12) as

$$Z_2 = \bar{a} + \psi\left(PARENTIQ\right) + b\rho + e\rho * \ell + \eta_2, \tag{16}$$

where ρ captures the willingness of the parents to invest in reducing the child's lead burden, ℓ represents its inherited body lead burden, and $\rho * \ell$ is the interaction between the parent-supplied environment and the inheritance. The second and fourth columns of Table 2 report OLS estimates of expression (16), again using Full-scale and Verbal IQs as measures of children's cognitive skills.

The coefficients for the discount rate and the body lead burden covariates in the second and fourth columns of Table 2 have the expected signs and provide qualitatively significant explanations of variations in the child IQ measures. We cannot therefore reject either the autonomous economy (discount rate) or the autonomous nature (body lead burden) conjectures. Note, however, that the term, $\hat{\rho}$ * PBHIGH, which represents interaction between the parental investments and the child's body lead burden is also significant.

For the interaction term, $\hat{\rho}$ * PBHIGH, lead is set equal to one and defined as high *(N = 195)* if the child's lead burden is in excess of *6* ppm. Otherwise the term is set equal to zero and defined as low *(N = 61).* The derivative

$$\frac{\partial\ Full\ Scale\ IQ}{\partial \hat{\rho}} = -1.54 + 0.85 = -0.69 \tag{17}$$

for high lead children, and the derivative

$$\frac{\partial\ Full\ Scale\ IQ}{\partial \hat{\rho}} = -1.54 \tag{18}$$

for low lead children suggest that low lead children are more sensitive than the high lead children to changes in the caregiving environment as registered in parents' discount rates. That is, neither the body lead burden nor the caregiving environment conjectures alone are sufficient to explain variations in the Full-scale IQs of our sample children. Similar results apply to their verbal IQs.

Agee and Crocker *(1996)* showed that the discount rates applied to children in this sample varied inversely with the parents' socioeconomic status or human capital stock. Elevated body lead burdens in this sample and in the general American population (Schwartz and Levin, *1992)* are associated with lower socioeconomic status. Hence, given that these associations are durable, natural conditions and human capital formation are not separable. Lesser environmental quality raises the costs of human capital formation and lesser human capital reduces the demand for environmental quality. Thus human capital differences are not so much the cause of environmental quality differences but are rather the intervening bridge by which parents' discount rates and all the economic factors and social ties which induce them are transformed into choices for different environments. Environmental quality differences among families, just like genetic differences, may then persist across generations if the factors that influence parents' discount rates are unchanged.

V. Conclusions. This paper qualitatively demonstrates that the discount rates which a set of American parents applied to own-investments in their young children's adult prospects influenced those children's cognitive skills. Construction and interpretation of the estimates is guided by an intergenerational utility maximization framework in which the development of cognitive skills is dependent in part upon the specific environment in which the skills are nurtured. Lower discount rates imply that parents make greater investments in improving their children's environments. Improved environments enhance the children's cognitive skills. The policy implications are plain: a high parental discount rate applied to environmental investments in children today implies that these children when adults will apply a high discount rate tomorrow, in the absence of some compensating activity. Given that higher cognitive skills lead directly to better adult prospects and indirectly to better prospects through increased learning and additional years of schooling, reduced parental incentives to nurture the cognitive skills of their children perpetuate lesser cognitive skills through the generations. Environmental differences among families, just like genetic differences, may persist across generations.

Some caveats are in order. First, if the parents' net rate of return to non-child (financial) investments is positively related to their earnings and education, our findings would be confounded by a price effect masquerading as a wealth effect. Second, the durability of the effects we have identified cannot be determined from our data. We do not allow differences in families' fertility decisions to appropriate the cognitive skills effects of the differences in their discount rate. Finally, the major limitation in our approach is that we cannot control for variations in cognitive skills that are not reflected in the IQ test scores we use as indicators of these skills.

Table 1. Acronyms, Definitions, Sample Means, and Standard Deviations

Variable	**Definition**	**Mean (Standard Deviation) (*N* = 256)**
Endogenous Variables		
FULSCLIQ	Age standard full-scale IQ measurement by the Wechsler Intelligence Scale for Children-Revised	104.88 (13.28)
VERBALIQ	Age standardized Verbal IQ measured by the Weschler Intelligence Scale for Children-Revised	101.87 (13.54)
Explanatory Variables		
$\hat{\rho}$	Parent's Implicit discount rate in percent for their child's cognitive development.	4.70 (2.2)
	(i) By household income:	
	Below 1979 U.S. Median (*N* = 256)	7.2 (2.8)
	Above 1979 U.S. Median (*N* = 256)	3.2 (.05)
	(ii) By education:	
	Both parents without H.S. Diploma (*N* = 49)	7.0 (.07)
	Both parents with some college or more (*N* = 21)	2.6 (0.7)
	(iii) By number of children:	
	One or two (*N* = 97)	4.3 (1.9)
	Four or more (*N* = 41)	5.0 (2.5)
	(iv) By body lead burden:	
	Low (*N* = 61)	4.3 (2.2)
	Moderate (*N* = 136)	4.7 (2.4)

	High (N = 59)	4.9 (1.9)
PBLEVEL	Dentine Lead level in arithmetic mean ppm over 3 shed teeth.	15.055 (11.99)
$\hat{\rho}$ * PBHIGH	Body lead burden in excess of a mean of 6 ppm taken over 3 shed teeth (1-yes, 0-no).	3.63 (2.83)
BIRTHWT	Subject child's birth weight in ounces.	116.84 (19.14)
DADEDUC	Father's education in grades completed as of 1978.	11.92 (2.57)
DADPRSNT	Father lives with the mother and child(ren); 1-yes, 0-no.	0.72 (0.48)
HOSPINF	Number of days subject child was in hospital after birth.	5.62 (7.17)
INCOME	Annual wage income of parents in 1980 dollars:1 = INCOME < \$7,000, 2 = \$7,000 $\leq$ INCOME < \$8,500…, 14 = INCOME > \$25,000.	8.73 (2.30)
MOMAGE	Mother's age in years in 1978.	30.24 (4.76)
MOMEDUC	Mother's education in grades completed as of 1978.	11.61 (2.17)
MOMWRKS	Mother works; 1-yes, 0-no.	0.81 (0.40)
NUMCHLD	Number of children in family in 1978.	2.94 (1.13)
NUMHDINJ	Subject child's number of lifetime head injuries.	0.07 (0.35)
ORDENGL	Order in which subject child learned the English language.	1.16 (0.59)
PARENTIQ	Mean parental IQ measured by the Peobody Picture Vocabulary Test.	110.83 (13.93)
SEX	Gender of the subject child; 1-male, 0-female.	0.50 (0.50)

Table 2. OLS Estimates of Child IQ Production Functions (N = 256)

Variable	Full-Scale IQ[a] (1)	(2)	Verbal IQ[a] (3)	(4)
Constant	69.48 (7.70)	70.23 (7.83)	73.09 (7.82)	73.82 (7.93)
$\hat{\rho}$	-0.77 (-2.04)	-1.54 (-2.87)	-0.76 (-1.95)	-1.51 (-2.73)
PBLEVEL	-0.17 (-2.04)	-0.23 (-3.25)	-0.18 (-2.74)	-0.24 (-3.31)
$\hat{\rho}$ * PBHIGH		0.85 (2.01)		0.84 (1.91)
BIRTHWT	0.05 (1.15)	0.05 (1.24)	0.06 (1.35)	0.06 (1.43)
HOSPINF	0.007 (0.60)	0.06 (0.53)	0.07 (0.61)	0.07 (0.55)
MOMWRKS	1.51 (0.79)	1.59 (0.83)	2.69 (1.35)	2.76 (1.39)
NUMHDINJ	-2.50 (-0.22)	-2.53 (-1.16)	-2.97 (-1.30)	-3.00 (-1.32)
ORDENGL	-0.51 (-0.22)	-1.07 (0.44)	-2.81 (-1.16)	-1.25 (0.49)
PARENTIQ	0.32 (5.55)	0.30 (5.29)	0.26 (4.45)	0.25 (4.20)
$\overline{R}^2$	0.18	0.19	0.15	0.16
X^2 (8)	58.01	62.15	49.37	53.09

APPENDIX

To show that parents invest in the child's environment until their marginal rate of return equals their substitution rate between own-consumption and the child's adult prospects, define the rate of return, 1+r, as

$$1 + r\,(Q_1; E_2) = \partial c_2 / \partial Q_1 \tag{A.1}$$

From expression (2) in the text

$$s_1 = \frac{X_1 + nc_2(Q_1; E_2)}{p_1(Q_1)} \tag{A.2}$$

which, when (A.2) is substituted into expression (1) of the text, means that the parents' primal optimization problem can be written as

$$\max_{Q_1} \; U(s_1(Q_1; E_2, X_1), \alpha, (n)nc_2(Q_1; E_2)) \tag{A.3}$$

The first-order-condition is

$$\frac{\partial U}{\partial s_1}\,\frac{\partial s_1}{\partial Q_1} + \alpha_1(n)n\,\frac{\partial U}{\partial c_2}\,\frac{\partial c_2}{\partial Q_1} = 0. \tag{A.4}$$

Rearranging (A.4), we get

$$\frac{\partial s_1 / \partial Q_1}{\partial c_2 / \partial Q_1} = -\,\frac{(\alpha_1 n)(\partial U / \partial c_2)}{\partial U / \partial s_1}, \tag{A.5}$$

or

$$1 + r = -\,\frac{(\partial U / \partial s_1)(\partial s_1 / \partial Q_1)}{(\alpha_1 n)(\partial U / \partial c_2)} = -\,\frac{\partial U / \partial Q_1}{(\alpha_1 n)(\partial U / \partial c_2)}. \tag{A.6}$$

FOOTNOTES

1. Moreover, we assume that parents recognize that children must have enough consumption to survive when they become adults. Formally, we deal with parents' concerns about their child's adult survival level of consumption, X_2^0, by supposing that $\partial U / \partial X_2 \to \infty \; as \; X_2 \to X_2^0$, and that $U(X_2)$ is undefined for $X_2 < X_2^0$.

2. Although imperfect access to capital market financing raises the positive effect of parents' earnings on children's adult prospects, Becker and Tomes (1986) show that this introduces a possible negative relation between the earnings of grandparents and grandchildren, such as is found in Wahl (1986).

3. See, for example, Hausman (1979, p. 35), and Viscusi and Moore (1989). The parents' present value of compensating surplus for a reduction their child's lead burden is

$$\frac{CS}{\{(1+\rho)[1-(1+\rho)^{-\tau}]\}},$$

where, τ is the perceived duration in years of the child's lead-induced health effects. Assuming that parents perceive the effects to be lifelong for their child and thus roughly infinite in duration, the above expression reduces to *CS/(1 + p).* Thus in annualized terms, parental compensating surplus is

$$\delta CS = \left[\frac{\rho}{(1+\rho)}\right] CS.$$

4. Relative to U.S. adults over age 25 (U.S. Census, 1982), sample parents have a higher mean number of years of schooling completed; 81 percent of sample parents completed high school and 16 percent have graduated from college compared to 1980 U.S. percentages of 66.3 and 16.3 (72.7 and 20.0 in Massachusetts). Sample households' median income of $17,000 is slightly higher than the 1979 U.S. median of $16,841.

5. This lower bound estimate fits well with existing social psychology research on class differences in assessed IQs. For example, in a sample of 261 adopted children, Scarr and Weinberg (1983) found that children with natural parents in the lowest third of sample parent educational attainments who were adopted by parents in the highest third of educational attainments scored an average of 6.7 points higher on IQ tests than did comparable children who remained with their natural parents. Likewise, children with natural parents in the highest third of sample parent educational attainments who were adopted by parents in the lowest third of educational attainments scored an average of 3.5 points lower.

6. In the child lead exposure literature, these hypotheses can be found respectively in Needleman et al. (1990), Milar et al. (1980), and Werner et al. (1968).

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Willingness to Pay for Reductions in Infertility Risks: A Contingent Valuation Study

--Working Paper*--

PRESENTED BY:
George Van Houtven
Research Triangle Institute

CO-AUTHORS:
V. Kerry Smith
(Department of Economics and Nicholas School of the Environment, Duke University)

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A Contingent Valuation Study

George Van Houtven
Research Triangle Institute
Research Triangle Park, NC

V. Kerry Smith
Department of Economics and Nicholas School of the Environment
Duke University

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1. Introduction

Millions of couples in the U.S. experience infertility every year—approximately 7-8% of married couples according to recent statistics. As the number of married couples, particularly those in the older age groups, has increased over the last few decades and with an increasing tendency for these couples to delay childbearing, the number of infertile couples and the demand for infertility-related medical services has increased steadily. Rough estimates suggest that, in recent years, as much as $2 billion is being spent annually on its diagnosis and treatment. One result of this trend has also been that more attention is now being focused on preventive measures to reduce the incidence of infertility.

Infertility is associated with a wide range of medical conditions, some of which are related to behavioral and environmental factors. Although it is inevitably linked to the aging process for women, many conditions that contribute to male and female infertility are inherently preventable. For this reason, as part the Healthy People 2000 initiative, government and other public health organizations have made reducing the prevalence of infertility one their primary objectives. The potential for chemicals in the environment to be a source of reproductive problems has also led agencies such as the Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA) to push for more active testing and surveillance of suspected endocrine disrupting chemicals. In spite of these public and private efforts and the growing sense of urgency surrounding this issue, relatively few studies have examined the value to the public of reducing the occurrence of infertility.

The purpose of this paper is to report on "research-in-progress" concerning household choices to reduce the risks of infertility and what these choices imply about the value of reducing these risks. More specifically, we report on the development and results of a pilot-scale contingent valuation survey that we have conducted as a means of evaluating how this methodology performs for measuring willingness-to-pay for reductions in infertility risks. The primary long-term motivation for this project has been to support the needs of environmental policymakers in evaluating the benefits of their programs, particularly those that are expected to have human reproductive health implications. Nonetheless, the implications of this research should be equally applicable to other policy areas affecting reproductive health. A related objective of this project has been to explore alternative models of household behavior as they relate to the separate preferences of individuals within a household and to examine what these models imply for nonmarket valuation in general. We use household choices related to infertility as one context for evaluating these models, and in this paper we discuss some preliminary results of this application. A more detailed discussion of this facet of our research can be found in Smith and Van Houtven (1998).

2. Infertility and Its Causes

According to the standard medical definition, infertility occurs when a couple who has not been using contraception does not become pregnant within at least one year. Based on data from National Survey of Family Growth (NSFG), which has become the primary source of information on infertility in the U.S., in 1995 approximately 7% of all married couples (and 12% of those who were not surgically sterile) were infertile. This is similar but slightly less than the NSFG's estimates of infertility rates in the 1980's, which were closer to 8%. These statistics contradict somewhat the notion of an infertility epidemic that has sometimes been portrayed in the popular media. Nonetheless, over the last twenty years, there have clearly been significant increases in both the range of infertility treatment options available to couples and in the demand for these services. Much of this trend can be attributed to the demands of an aging of the baby-boom cohort and a growing tendency to delay childbearing (Mosher and Bachrach, 1996). Approximately 1 million couples every year now seek professional medical assistance for infertility problems, and about half of these are eventually successful in conceiving a child.

Although the age of the female partner is clearly the single most important factor, infertility has been associated with a wide range of male and female medical conditions and to an even broader range of factors that contribute to each of these conditions. For women the most common conditions are problems with ovulation, blocked or scarred fallopian tubes, and endometriosis, whereas for men infertility is most often a result of abnormal or too few sperm. Overall, female and male conditions contribute equally to the prevalence of infertility in the U.S. population.

Many of these conditions are related to behavioral and environmental factors and are therefore inherently preventable (Gilbert and Weisberg, 1993). Sexually transmitted disease in particular is an important causal factor; however, diet, drug use, and stress have also been linked to infertility. In addition, a number of environmental toxicants have long been associated with adverse reproductive outcomes. In recent years, particular attention has been paid to a variety of compounds that are suspected to disrupt the functioning of human (and wildlife) endocrine systems, with one potential result of exposures being an increase in infertility rates.

3. Existing Estimates of the Value of Reducing Infertility

Despite the high demand for infertility services in the U.S. population and the potential for public policy to play a role in infertility prevention, relatively little attention has thus far been devoted to examining the value of reducing infertility. In 1987, the Office of Technology Assessment (OTA, 1988) estimated that expenditures for diagnosing and treating infertility totaled about $1 billion annually, and less formal estimates suggest that these expenditures have been closer to $2 billion in recent years (Colborn, Dumanoski, and Myers, 1996). However, it is likely that these estimates represent only a small fraction of the total welfare losses associated with the incidence of infertility. For example, they do not account for the less tangible losses incurred by those who decide not to pursue medical options, nor does it account for the time commitment and the pain, suffering, and often disappointment incurred by those who do.

Most, if not all, of the existing valuation studies related to infertility have focused on couples' or individuals' willingness to pay for infertility treatment, in particular for access to and use of advanced reproductive technologies such as in-vitro fertilization (IVF). Granberg et al. (1995) conducted a small scale survey of 40 couples seeking treatment at infertility clinics in Sweden and asked them to state the maximum they would be WTP for having a child. More than half indicated a WTP of more than $15,000; however, the small size and non-randomness of sample make it difficult to generalize these results. Also, it is unclear from the discussion to what extent "having a child" meant a certainty of success through IVF.

Ryan has conducted two similar studies in the UK and Australia. The first (Ryan, 1996) involved a contingent valuation survey of over 300 women using a fertility service in Sidney, Australia. Using a payment card approach, respondents were asked to state the maximum amount they would be WTP for a single IVF attempt. The mean WTP was about $3100 per attempt. Assuming an average success rate per attempt of 10%, this translates to roughly $31,000 for a "statistical" pregnancy. In the second study (Ryan, 1997) Ryan conducted a similar survey of over 450 women using a fertility service in Aberdeen, Scotland. In this case respondents were presented with a randomized bid and a dichotomous (take-it-or-leave-it) choice. The mean WTP per attempt was roughly $8000, implying about $80,000 per statistical pregnancy. Although the sample sizes were much larger than those used by Granberg et al., the ability to generalize these results is again hindered by the selection of the sample, which only involves individuals who are already seeking infertility services. Presumably, these are individuals with a relatively strong preference for increasing their chances of having a child.

To our knowledge, only one study has been conducted in the U.S. that measures individuals' values related to infertility. Neumann and Johannesson (1994) conducted a pilot CV study using a convenience sample of 231 individuals who were potential childbearers. Using a payment card approach, respondents were asked to state their WTP for IVF treatment. The question was framed in two ways—an *ex post* and an *ex ante* framework. The *ex post* framework was similar to the one used by Granberg et al. and Ryan, which asked respondents about their "out-of-pocket" WTP for IVF, *in the event* that they experienced infertility. In the *ex ante* framework, individuals were asked to assume that they did not know their fertility status and were then asked to state their WTP for insurance programs (one private and funded through premiums and another public and funded through taxes) that would cover IVF treatment. As has been argued by Gafni (1991) the *ex ante* insurance framework presents a more realistic "commodity" to respondents who generally do not pay the full cost of major medical interventions at the point of service. Based on responses to the *ex post* scenario and a 10 percent proposed success rate for IVF, average WTP for a statistical pregnancy was almost $180,000. This value is considerably higher than in the other studies, which is surprising given that the sample was not restricted to individuals who had already made active use of infertility services. However, it is possible that more hypothetical nature of the scenario had a positive effect on expressed WTP. Responses to the *ex ante* insurance question implied mean WTP for a statistical pregnancy that were an order of magnitude higher—$1.8 million1. Given the additional uncertainty that is inherent in the *ex ante* scenario, a higher is value compared to the *ex post* scenario is perfectly plausible (Schmalensee, 1972; Graham, 1981); however, there is little basis with which to judge the plausibility of the magnitude of this increase.

4. Study Objectives and Design

To study household choices related to infertility and to examine what these choices imply about the value of reducing infertility risks, we have developed and administered a pilot-level contingent valuation (CV) survey. Several features of this study distinguish it from previous research on infertility and, in some ways, from CV and non-market valuation research in general. Below, we highlight some of these differences as they relate to the objectives and design of the study.

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1 It should be noted that the WTP estimates were considerably lower – roughly $60,000 and $300,00 per statistical child for the *ex post* and *ex ante* scenarios respectively – when the success rates of IVF were proposed to be 25 percent to 100 percent.

Ex-ante prevention perspective. Perhaps the most important distinction between this study and the infertility valuation studies described above is that the "commodity" offered to respondents through our CV scenario is not linked to specific type of treatment for infertility (such as IVF). Rather, the scenario provides respondents with a means of reducing their future risks of experiencing infertility. In other words, it explores WTP for the prevention of infertility rather than for its treatment. In either case, respondents are provided with an opportunity to make a purchase that will ultimately increase their chances of successfully conceiving a child (i.e., to express their WTP for a "statistical" pregnancy). Like Neumann and Johannesson's private insurance scenario, our study focuses on *ex ante* WTP. Respondents are offered the opportunity to make state-independent payments (i.e., they must pay whether or not they ultimately experience infertility) to improve their chances of conceiving a child in the future. The difference lies in the fact that, through the prevention scenario of our study, respondents also have the opportunity to improve their chances of avoiding the physical, psychological, and pecuniary costs of experiencing and, in many instances, treating infertility. For this reason, the approach taken in our study is more relevant for evaluating the benefits of initiatives that help to prevent conditions or behaviors contributing to infertility.

Private risk reduction commodity. Although this research is motivated by a desire to understand the benefits of public programs to reduce infertility risks, we have developed a contingent valuation scenario that is based on a private good – a hypothetical medication – that helps individuals to avoid infertility problems. This is done to focus specific attention on individuals' WTP to reduce risks only to themselves and only for avoiding infertility.[2] In so doing, we are assuming the risk reductions through private and public means are perfect substitutes. One implication of using a private good scenario is that, to make it believable to respondents, they must have some discretion regarding when to use the good. Therefore, we must incorporate into the analysis a timing component to the decision.

Selection and recruitment of study sample. The characteristics of the sample drawn for this study also differ from those of previous studies. Given the resource constraints of the project and the resulting sample size restrictions, our objective was to recruit a demographically diverse set of respondents who were most likely to be in a position to seriously consider an opportunity to reduce their chances of experiencing infertility in the future. In other words, we wished to avoid targeting respondents for whom the decision would be less relevant or would be fundamentally

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2 Our primary concern was that a CV scenario based on a public risk reduction program would be "contaminated" by perceived ancillary benefits (such as other health improvements) from such a program or by altruistic considerations on the part of the respondent.

different. For this reason, we wanted to recruit individuals of child-bearing age who were in a long-term relationship with a partner of the opposite sex but who were also uncertain as to whether they would be able to successfully conceive a child. This is clearly a rather small subset of the population; therefore, the results based on this sample cannot be generalized to the US population as a whole. Nonetheless, because of the characteristics of the sample, it may be safe to assume that the implied average WTP for infertility risk reductions in this group represents an upper bound for the broader population's average WTP.

Resource constraints also precluded the recruitment of fully random sample within the criteria described above. Therefore, to recruit respondents for our pilot surveys, we used a mall intercept format. Although this provides what can be best described as a convenience sample, it still provides more of a randomized set of respondents than was used in the previous infertility studies described above3. The convenience nature of the sample again limits the ability to generalize the results of the survey, but we felt that it was appropriate for conducting pilot-scale surveys .

Household decision-making framework. Interviewing women who were in a relationship provided an opportunity to explore how her partner's characteristics and how the potentially joint nature of the decision might affect stated WTP. One important feature of a reduction in infertility risk is that, even within a private good setting, it has public good characteristics. That is, it confers benefits that are non-rival for the two individuals in a couple, provided that they both wish to have children. For this reason, it is important to consider the collective nature of the decision regarding whether to purchase a reduction in risk. The more traditional model of household decisionmaking (e.g., Becker, 1974), sometimes referred to as the "unitary" model, treats the household as if it has a common set of preferences. Households are assumed to maximize a single aggregate utility function subject to a single budget constraint. One implication of a simple unitary model is that households are assumed to pool their income. In other words, purchase decisions are not affected by *which* individual generates the income, only by the *total* income.

More recently, economists (e.g. Chiappori, 1988) have begun to challenge this perspective using "collective" approaches that disaggregate the household utility function and allow individuals' distinct preferences to play a role in household decision processes. Under the collective model, household expenditure patterns can depend on who brings in more of the income and how

3 For a summary of the literature evaluating the properties and implications of mall-intercept surveys, see Boyle et al. (1996).

preferences differ across individuals within the household. In part due to resource constraints of this study, we have only interviewed female partners. Nevertheless, we have collected information from this individual about the characteristics, preferences, and incomes of each partner. We use this to explore whether there is evidence of intrahousehold differences in preferences regarding childbearing and whether the distribution of earned income within the household has an effect on the CV purchase decision.

Computer-based survey instrument. The survey itself was conducted as a self-administered computer interview. The self-administered aspect of the survey was important because of the potentially sensitive nature of some of the questions. Using a computer-based instrument also offered several potential advantages. It allowed the some of the questions in the latter part of the survey to be conditioned on earlier responses (without forcing the respondent to follow complicate skip patterns), it helped to minimize item non-response, and it automatically tabulated responses. It may also have served to increase respondents' interest and involvement in the survey.

5. Background on Survey Development

The survey used in the analysis described below evolved through several stages of development and pretesting.

Clinical interviews. To understand the issues considered and information available to couples facing infertility risk we participated in five clinical interviews with patients at one of Duke Medical Center's Infertility Clinics. These interviews involved an information exchange between the patient (in three cases, couples) and the physician directing the clinic. The primary objectives of these meetings between the patient and the physician were to discuss sexual history, any past medical issues that might be related to infertility, any initial test results, and the treatment options.[4] While the set of people in the interviews were a selective sample of all couples who might experience infertility, they nonetheless identified a few generic issues relevant to any effort to elicit household preferences for reducing infertility risks. First, there was wide diversity in these couples' understanding of the clinical definition of infertility and the factors contributing to it. Second, some of the couples (or individual female patients) did identify concerns about individual and joint inconvenience associated with treatments. Finally, when both members of the couple were present for the interviews, both individuals seemed

4 Patients were at different initial stages in determining whether to proceed with infertility treatment.

actively engaged in the decision process even though the treatments (after initial diagnostic evaluations) focused primarily on the female members of each couple.

Focus groups. To evaluate the knowledge of infertility patterns and to investigate the extent of co-ordination in household decisions, a somewhat more random sample of couples was selected for two focus groups.5 Each meeting asked each participant to consider set of questions, and then to discuss their answers openly with the group. Four sets of issues were posed: (a) preferences about starting a family from each individual's perspective and their perceptions of their spouse's desire for children; (b) a series of questions intended to investigate how their households made allocation decisions; (c) knowledge of the factors associated with infertility; and (d) two closed ended contingent valuation questions about programs to reduce infertility risk.

The two meetings were organized somewhat differently for addressing the first two issues. The first focus group had both members of each couple seated beside each other and present for the full meeting. The second meeting (with a different group of couples) split each couple for the first half of the session, asked each member the same questions, evaluated discrepancies in these separately answered queries (during a short break), and then asked couples to discuss how they would resolve differences in their responses. Neither format offered substantive insight into how couples resolved decisions where their preferences seemed quite different. The responses to questions posed at the first focus group would have lead observers to conclude that there was a high degree of agreement in each couple, consistent with the "assortative mating" view of the "marriage market" (Becker [1981]]). While the second was also broadly consistent with this conclusion, there was also more evidence of differences in preferences and in strategies for making expenditure decisions in different households. Most couples did respond in ways that seemed to be consistent with the "income pooling" assumption of the unitary model of household decisionmaking.

Two additional findings emerged from these meetings that influenced the structure of our contingent valuation question. First, there was general agreement in the first group that public programs to reduce naturally occurring infertility risks would not be supported. Participants indicated that infertility was not a public concern. Even though infertility risks could be high for some groups, they indicated that private decisions for treatment were preferred to any public involvement in reducing the risk of infertility. Second, most couples had fairly strong interest in

5 The groups involved married couples who did not have children but were considering having children. They were recruited by a marketing research firm in Raleigh, NC from the Research Triangle area. They were conducted using the firm's focus group facility and video taped for a subsequent content analysis. Our summary is based on that evaluation. The first meeting on February 19, 1997 held six couples. The second on April 17, 1997 had five.

having children. However, the timing of childbearing was also an important consideration in any privately available program or medication that would reduce natural rise in infertility with the female partner's age.

Programming and pretesting of survey instrument. Based on the information from the initial interviews and focus groups, we developed a computer assisted survey. It was designed to be used in a mall intercept survey, where each respondent would answer an interrelated set of questions in private on a PC. The text of the questionnaire was programmed using Visual Basic. This allows the formulation of the stated choice question to be adapted in response to the information provided by each individual.   Two sets of pretests were conducted. One involved cognitive interviews with each of nine individuals (four females and five males) after they took the interview. A number of changes in the wording of questions, graphs, size of fonts, and colors used in the screens were made after the first pretest. A second informal pretest was also conducted with RTI employees to evaluate revisions to the questionnaire.

First pilot survey.   A preliminary pilot survey was conducted in late 1997 at regional malls in three cities: Charlotte, NC; Seattle, Washington; and Jacksonville, Florida.   Following the sample selection criteria described above, we recruited both men and women who met the following specific criteria:

- Currently in a long term relationship with a partner of the opposite sex
- *Female* partner in relationship between 20 and 35 years old
- No children from current relationship.

We completed interviews for 110 men and 73 women. For the purposes of this paper, we do not provide a detailed summary of the data or analysis from this initial pilot[6].   However, the structure and results of the first pilot are, in many ways, very similar to our second pilot survey, which we do describe in detail below. Also, we do note three fundamental areas of change that were made between the first and second pilots.

First, based on the focus groups and pretests, in both pilots we decided to convey the mechanism by which future infertility risks are reduced by describing a medication that would delay the naturally occurring increase in infertility risks that typically occurs as a woman ages (this is described in more detail below). For this reason, it was a private good that would benefit both

6 For an anlaysis of the first pilot survey data please see Smith and Van Houtven (1998) which can be acquired upon request from the authors.

individuals in a couple, but, to ensure credibility, it had to be a medication that the female partner would take. The results of the first pilot offered support for the conclusion that women were able to report meaningful choices in evaluating options to delay natural increases in infertility. However, the survey instrument did not appear to be effective with male respondents, who were asked to report whether they would be in favor of their *partner* taking the medication (at a specified monthly cost). This probably should not be surprising, given that both the source of the increase in infertility and the mechanism used to convey the delay focused on women. Consequently, we did not include male respondents in our second pilot.

Second, because of the private nature of the risk reduction commodity it was difficult not to allow the respondent some discretion regarding, not only *whether* they would take the medication, but also regarding *when* they would begin to take it. In the first pilot, respondents were presented with a dichotomous choice (yes or no) regarding whether to start taking the medication this year. To more directly address the timing dimension of the choice, in the second pilot respondents were given three fundamental choices – start the medication this year, start the medication in the future, or never start taking the medication. More details of the choice scenario in the second pilot are also described below.

Third, the results of the first pilot offered some evidence that would contradict the "income pooling" hypothesis of the unitary model of household decisionmaking. That is, the individual respondent's income appeared to be significantly more positively correlated than the remainder of total household income with the expressed willingness to purchase the medication. To more carefully test this hypothesis, the second pilot survey included more detailed questions regarding both the respondent's and her partner's earnings.

5. Description of the Second Pilot Survey

The second pilot survey was administered during the summer month of 1998 using mall intercept recruiting at four separate locations in the U.S.—Tampa, FL; Las Vegas, NV; Tulsa, OK; and Freeport, NJ. As shown in Table 1, a total of 188 respondents completed the survey. The mean age of respondents was between 25 and 26 years old, and their partners were on average two to three years older. Average household income was highest in the Freehold sample (almost $70,000) and lowest in the Tulsa sample (about $47,000).

The first section of the survey asked respondents about their (and their partner's) age, their relationship status, and the presence of children in the household to confirm that they met the desired criteria. It also inquired about their and their partners' desire and preferred timing for starting a family. Desire for children was measured using a five-point Likert scale varying from no desire to a "very strong" desire to have children in the future. Over 74 percent of respondents indicated a "strong" or "very strong" desire, and slightly less (71 percent) thought that their partner had a "strong" or "very strong" desire. 73 percent of respondents gave the same response for themselves and their partner. To explore their desired timing for childbearing, respondents were asked how many years into the future they and their partner would ideally wish to start a family. The average desired time until their first child was 2.9 and 2.8 years respectively for respondents and their partners. 72 percent of respondents gave the same response for themselves and their partner. These results are similar to the findings of the focus groups and the first pilot survey, which found a very strong correlation between partners regarding the strength of desire and desired timing of children, consistent with the "assortative mating" view of the "marriage market." With such a strong similarity of preferences between partners, it becomes less likely that one will find observable patterns to distinguish the collective and the unitary models of household decisionmaking.

The second section of the survey provided respondents with fundamental information about infertility and inquired about their perceptions. The meaning of the term "infertility" was described to respondents, and they were then asked to indicate (on a 1 to 7 scale from "not at all likely" to "very likely") their perceived likelihood of experiencing infertility in the next year if they were to try to have a child with their partner. Almost 63 percent of respondents gave values of 1 or 2, indicating that the perceived likelihood of present infertility was relatively low. To explore the determinants of these perceptions, these responses were analyzed using an ordered probit model. The only respondent characteristic that was found to be significant (at a 0.05 level) was the respondent's age, which, as expected, was found to have a positive effect on the perceived risk of infertility[7].

Respondents were then shown a series of informational screens describing the prevalence and primary risk factors associated with infertility. They were then asked to revise, if desired, their previous assessment of their perceived infertility risk. About 43% of respondents did revise their stated risk perceptions. Of those who did, more than twice as many increased rather than

7 The results of this regression are not reported in any more detail in this paper, but they are available upon request from the authors.

decreased their stated value; the average perceived rating increased from a score of 2.5 to one of 2.8.

Thereafter, respondents were provided additional information about the treatment of infertility (i.e., types, costs and success rates of treatment). This was followed by a graphical depiction of how average infertility rates increase with the age of the female partner. This is shown in Figure 1. To meet the objectives of the study it was important to carefully distinguish between *ex ante* reductions in future infertility risks and *ex post* treatment of infertility. This was confirmed through focus group discussions and one-on-one interviews that were used to pretest the survey instrument. Because infertility rates are so strongly and positively correlated with the age of a female partner, one way to portray a reduction in future infertility risk is by describing a reduction in the *rate of growth* of infertility risk through time (as opposed to an absolute reduction from the current baseline risk). For this reason we provided the information in Figure 1 to establish a baseline risk scenario.

The third section of the survey described the contingent valuation scenario. Respondents were asked to consider a potential decision; whether to purchase and begin to take a medication (on a weekly basis) that would help to prevent conditions that contribute to infertility and would, in effect, delay the increase in infertility risk for up to five years. Respondents were asked to assume that the medication was completely safe and would not cause adverse side effects. To illustrate the impact of the medication, they were once again shown the graph from Figure 1; however, this time a second trend line was superimposed on the graph to describe how the increase in infertility rates would be lower with the medication if they were to continue taking it indefinitely. Examples are shown in Figures 2a and 2b.

Because the impact of the medication depends on when one starts to take it, the computer-based design offered important advantages. First, it allowed each respondent to initially be shown a “with medication” scenario that corresponded exactly with her age (assuming she started taking the medication “within the next year”). Second, through a simple follow-up query (which could be repeated as often as desired), each respondent could examine the effect of selecting a different age to start the medication. This allowed the respondent to view new graphs, each one depicting a “with medication” scenario that corresponded to a different starting age. Seventy-one (almost 38 percent) respondents took advantage of this option.

The respondent was then asked to assume that the medication would cost a certain amount each month, but that it would not be covered by insurance. Seven monthly payment amounts ($10,

$16, $32, $48, $63, $125, and $300) were randomly assigned to respondents.[8] The respondent was then asked to choose between (1) starting to take the medication within the next year, (2) starting to take the medication sometime after next year, or (3) never starting to take the medication. The distribution of responses by bid amount are shown in Table 2. Roughly 20 percent of respondents indicated that they would begin taking the medication within the year and 25 percent indicated they would do so sometime thereafter.

Each of the 46 respondents who stated that they would begin taking the medication at a later date were asked *when* they would ideally begin to take the medication. The median response was to wait two years before starting the medication. Only 7 respondents indicated they would wait four or more years.

In addition to reminding respondents to consider their budget constraint, they were also asked to consider what their partner's role would be in the decision and to account for this in stating their choice. The purpose of this was to replicate as closely as possible what the household's purchase decision would be if indeed it would be a collective decision. As a follow-up to this, they were asked to describe what their partner's role would be in their choice by selecting from one of the following:

- We would make the decision together
- We would discuss the decision, but it is mine to make
- We would not need to discuss it, but I would consider my partner's wishes
- The decision is entirely up to me—my partner would not be involved

Sixty percent indicated they would make the decision together and 30 percent said they would discuss the decision, but it was hers to make. Only 9 percent of respondents indicated that their choice would be different if it were entirely up to them. This indicates that, for the most part, they did view the decision as a collective one involving both individuals in the couple and also that partners' preferences were expected to be consistent with one another.

The remainder of the survey was devoted to collecting socio-demographic information from respondents. Summary statistics for many of these variables have already been provided in Table 1. In addition to information on total household income, particular attention was focused on gathering wage earnings information for both the respondent and her partner. The sum of

[8] The bid amounts were selected based on focus group discussions and one-on-one pretests of the instrument.

annual wages for 1997 was on average \$55,600 (std dev = \$44,902). The ratio of the respondent's wage earnings to her partner's varied from 0 to 1 with a mean value of 0.4 (std dev = 0.23).

6. Analysis and Results

To estimate the average WTP that is implied by the discrete choice responses, we use a two-stage probit estimation which is based on a simple conceptual framework.

Conceptual framework for estimating WTP. We assume that a couple's maximum WTP for the risk reduction implied by the medication can be represented by a variation function (McConnell, 1990; Cameron and James, 1987) which includes a deterministic component and a random component:

$$WTP_i = s(\mathbf{X}_i) + e_i$$

The deterministic component s(.) is the mean variation function (the expected WTP) and is assumed to be a function of a vector of exogenous variables, $\mathbf{X}_i$ such as income and other individual or household characteristics. The random component, e_i, is assumed to be normally distributed with a mean of zero and a variance of σ^2.

Respondents are assumed to compare the offered price of the medication to their maximum WTP such that responding NO NEVER implies that price is greater than WTP and responding YES NOW implies that the price is less than WTP. For those who respond YES LATER, the monetary commitment is incurred beginning t years into the future (the number of years that these respondents indicated they would ideally wait before beginning to take the medication), so presumably its cost is discounted to the present (at an annual rate r). This response implies that the *discounted* price is less than WTP.

The probability of responding yes or no can therefore be expressed as

$$\text{Prob(NO)} = \text{Prob}(A_i \geq s_i(\ ) + e_i)$$

$$\text{Prob (YES NOW or YES LATER)} = \text{Prob}(A_i < s_i(\ ) + e_i)$$

$$\text{where} \quad A_i = PRICE_i \text{ if response is YES NOW or NO NEVER}$$
$$= PRICE_i * (1 + r)^{-t} \text{ if response is YES LATER}$$

Specifying the model in this way implies that there is an endogenous component to A_i ; that is, it depends in part on the yes/no response. To address this endogeneity we estimated a two stage probit model9.

Estimation results. The first stage regression, which is summarized in Table 4, uses ordinary least squares to predict A. To identify the model we need to assume a rate of discount, r. Results are shown for both a 3 percent and 5 percent rate. The explanatory variables include PRICE and a series of socio-demographic variables. As expected, the coefficient for PRICE is positive and very strongly significant. Although PRICE clearly explains a vast majority of the variation in A, two other variables are also significant (at a 0.10 level) are SOMECOLL and WORK. The negative effect of SOMECOLL suggests that those who were more educated would wait longer before starting the medication, thus lowering the present value of payment. WORK has the opposite effect, indicating that those who work more hours during a typical week would wait less. Neither of these variables are significant explanatory variables in a single equation probit model of the YES/NO response10; therefore, they are used as instruments and not included in the second stage probit regression. The R^2 value for both OLS regressions is greater than 0.99.

To test for the endogeneity of PRICE in a single equation probit model of the WTP responses, we included the predicted error from the OLS equation in the probit estimation. Using a t-test on the coefficient of the predicted error, we were unable to reject the null hypothesis of exogeneity.

The results of the first stage OLS regression were therefore used to predict values of A and to replace PRICE in the probit equation. The results of the second stage probit are shown in Table 5 for an assumed discount rate of 3 percent and in Table 6 for an assumed rate of 5 percent11. In support of the internal validity of the instrument, the predicted price variable (A) for the

9 Alternatives to the two-stage probit method are full-information maximum likelihood (FIML) are generalized method of moments (GMM) methods. All three yield consistent estimators; however, the two-stage model is computationally easier and tends to perform well, particularly when the first stage equation has a high R^2 value (Bollen, Guilkey, and Mroz; 1995).

10 A Wald test to test whether SOMECOLL and WORK are jointly equal to zero in a single equation probit (using PRICE as one of the explanatory variables) could not be rejected at a 0.05 level.

11 We have not corrected the standard errors to account for the two-stage approach; however, evidence suggests that such corrections make little practical difference for this type of approach (Bollen, Guilkey, and Mroz; 1995).

medication has a significantly negative effect on the purchase decision and household income HHINC has significantly positive effect. The coefficient on WAGEPART, however, is not significant, indicating that the distribution of income within the household did not affect the decision. That is, the likelihood of purchasing the medication did not increase (or decrease) significantly if the respondent earned relatively more of the household's income. Although it is not included in the specifications reported in Tables 5 and 6, interacting WAGEPART with a measure of the respondent's desire for children (relative to her partner's desire) did not alter this result. This suggested that, even if the respondent had a much stronger preference for children, earning more income relative to her partner did not increase the likelihood of purchasing the medication.

The coefficient for INFPROB is positive and significant -- those who felt they were more likely to experience infertility were more likely to purchase the medication at some point in the future. TIMEINR is also significant, indicating that the longer the respondent had been in the current relationship, the less likely she is to purchase the medication. Because individuals were only surveyed if they did not have children from their current relationship, this result may reflect the fact that those who had been in a childless relationship longer were less likely to want children. Somewhat surprisingly, the effect of CHLDTIM is also negative, indicating that the longer the respondent wanted to wait before having children, the more likely she was to say she would never purchase the medication. Given that the longer a couple waits, the more likely it is that they would experience infertility, it would seem that the medication would be more attractive to those wanting to wait. One explanation for this unexpected result may the that those wanting to wait longer for children also tended to have less of a strong desire for having children; therefore, larger values for CHLDTIM may also reflect a greater ambivalence towards childbearing.

The results summarized in Tables 5 and 6 can be used to estimate mean WTP for the medication and for the reduction in infertility risks that it entails. Because the first specification in the two tables contains a number of explanatory variables that were not significant, a second specification was estimated by dropping eight variables in each case. A likelihood ratio test of the null hypothesis that the coefficients for these variables are jointly zero could not be rejected at a 0.05 level. According to this second specification, the expected value of the variation function (mean WTP) can be expressed as:

$$E(s) = \mathbf{X}\beta$$

$$= \beta 0 + \beta 1{*}HHINC + \beta 2{*}WAGEPART + \beta 3{*}CHLDTIM + \beta 4{*}TIMEINR + \beta 5{*}INFPROB + \beta 6{*}MINORITY$$

Under the assumptions of the probit model,

$$\text{Prob (YES)} = \Phi[A{*}(1/\sigma) - \mathbf{X}(\boldsymbol{\beta}/\sigma)] = \Phi(A\alpha - \mathbf{X}\gamma).$$

Therefore, using the estimated coefficients, $\hat{\alpha}$ and $\hat{\gamma}$**,** from the probit model, mean WTP can be approximated by $\mathbf{X}\hat{\gamma}/\hat{\alpha}$. Using sample mean values for the variables in **X**, the estimated mean annual WTP for the medication is $324 ($317) assuming a 3 percent (5 percent) rate of discount.

Based on these results it is possible to develop preliminary estimates of WTP for reductions in infertility risks; however, this requires additional assumptions. The described effect of the medication is to delay the increase in infertility risks for up to five years, as long as one continues to take medication on a regular basis during this period. Therefore, the effect of the medication depends importantly on the age at which one starts to take it and on the number of years it is taken. For a typical couple (as described, for example, in Figures 2a and 2b), after five years of continually using the medication, their probability of experiencing infertility should be between 3 and 9 percent lower than it otherwise would be. After only 2 years the reductions vary between 1 and 4 percent, depending on the female partner's age. Total payments for the medication also depend importantly on how long it is taken for.

Assuming that the medication is purchased and taken for five years and that the discount rate is 3 percent (5 percent), an annual WTP of $324 ($317) for the medication translates to a total discounted WTP value of $1484 ($1371) for infertility risk reductions varying between 3 and 9 percent. This translates to a range of $165 to $494 ($152 to $457) per 1 percent reduction in infertility risk. If the medication is assumed to be taken for just two years, the annual WTP estimates translate to a range of $69 to $207 ($65 to $196) per 1 percent reduction in infertility risk. Finally, assuming that a percentage point reduction in infertility risk is equivalent to a one percent increase in conceiving a child, these values can be further translated into estimates of the value of a "statistical pregnancy." For the five-year scenario, the annual WTP estimates imply a range of values between $16,500 to $49,400 ($15,200 to $45,700) per statistical pregnancy. For the two-year scenario the values imply a range of $6900 to $20,700 ($6500 to $19,600) per statistical pregnancy.

It must be stressed that these values are very preliminary and are based on a relatively small and restricted sample. Furthermore, the implied values for infertility risk reductions are very sensitive to the underlying assumptions regarding the appropriate discount rate and the timing of the medication. However, compared to estimates of WTP for IVF, the implied values per statistical pregnancy are relatively low. Although the *ex ante* risk reduction scenario presented in this survey is most directly comparable to the insurance-based scenario used by Neumann and Johannesson (1994) the implied values are as much as 2 orders of magnitude lower.

7. Conclusions

Infertility issues have been attracting increased nationwide attention, and there is growing recognition that many of the conditions that contribute to infertility may be associated with behavioral and environmental factors that are inherently preventable. As more private and public resources are devoted to combating these factors, it becomes increasingly important to understand household choices related to the risks of infertility and what these choices imply about the value of reducing these risks. We have addressed this through a series of interviews, focus groups, and pilot scale surveys that have elicited individual's and couple's perceptions and preferences regarding future childbearing and the possibility that they may experience infertility problems.

Most of the evidence we have collected supports an assortative mating conclusion regarding childbearing preferences and decisions. That is, perhaps not surprisingly, individuals within couples have similar preferences regarding how strongly and when they wish to have children. and regarding infertility risks. We also found little evidence to contradict the income pooling hypothesis for the infertility decision we presented to respondents. Although household income was a found to be a significant and positive influence on WTP, there was little evidence that one partner's income had a stronger influence than another's. Taken together, these findings suggests that a unitary model of household decisions may be appropriate for analyzing infertility related decisions. However, it is important to stress that, with the exception of our small focus group sample, our evidence is based largely on *individual* reports regarding their own views and how they perceive their partner's views. It should also be noted that we did find some amount of disagreement between partners on these matters, which means that the collective model should by no means be rejected outright. Under ideal circumstances, information would be collected from both partners in a household in order to evaluate which factors influence whether a collective view of the household matters.

Analysis of responses to the CV scenario in our pilot surveys indicates that, with a female sample in particular, respondents provide theoretically consistent responses. This supports our findings from focus groups and pretests that respondents are able to understand the nature of the commodity being offered and to provide meaningful responses to the proposed scenario. These responses can also be used to derive preliminary estimates of mean WTP for the privately purchased medication and, hence, for infertility risk reductions in general. It is important, however, to interpret these results with caution. First, they are based on a relatively small convenience sample that is restricted to include individuals who are relatively likely to be in a position to seriously consider an opportunity to reduce their chances of experiencing infertility in the future. This is appropriate for the purposes of a pilot-scale study to evaluate the CV methodology as a way of eliciting preferences for avoiding infertility; however, it does limit our ability to generalize the results. Second, extrapolating the estimated annual WTP for the proposed private good to a more general WTP for reductions in infertility risks requires a number of assumptions regarding appropriate discount rates, timing of the medication, and the respondent's understanding or perception of how the medication would reduce the likelihood of infertility. With these caveats in mind, we estimate values for a "statistical pregnancy" that are considerably lower those estimated by the most directly comparable study (Neumann and Johannesson, 1994). Although the CV method shows promise as a means of estimating infertility values, more research will be needed to narrow the range of uncertainty regarding WTP for reductions in infertility risks.

Figure 1. Representation of Typical Baseline Infertility Risks

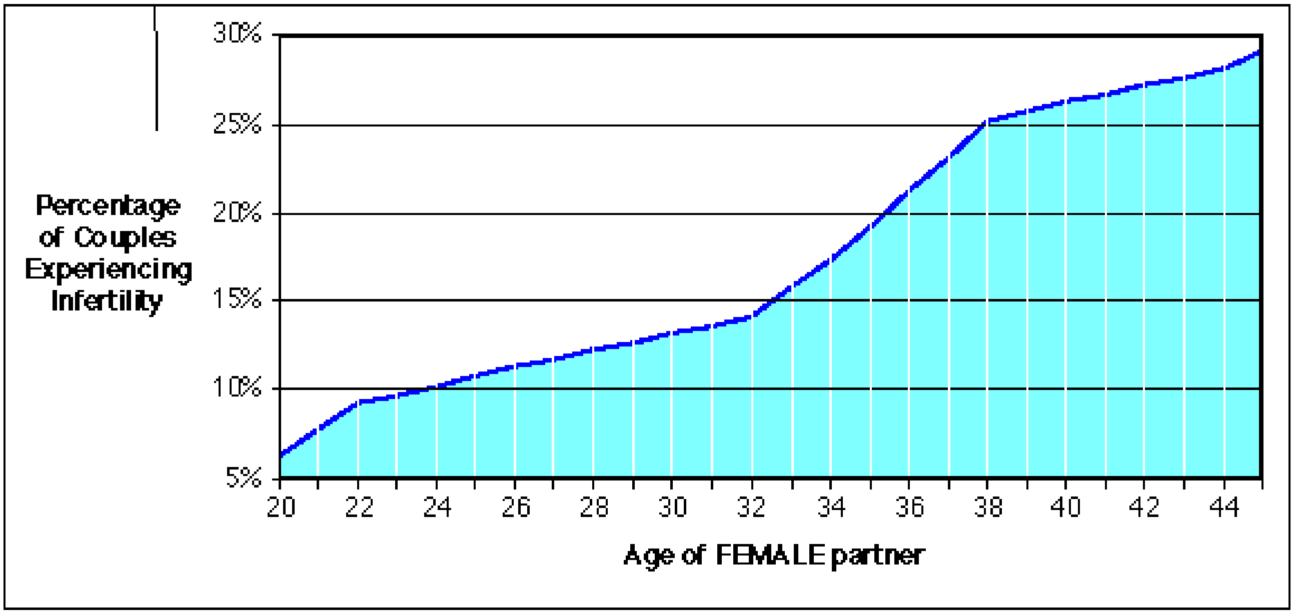

Figure 2a. Representation of Medication's Effect on Infertility Risks (starting at 25 years of age)

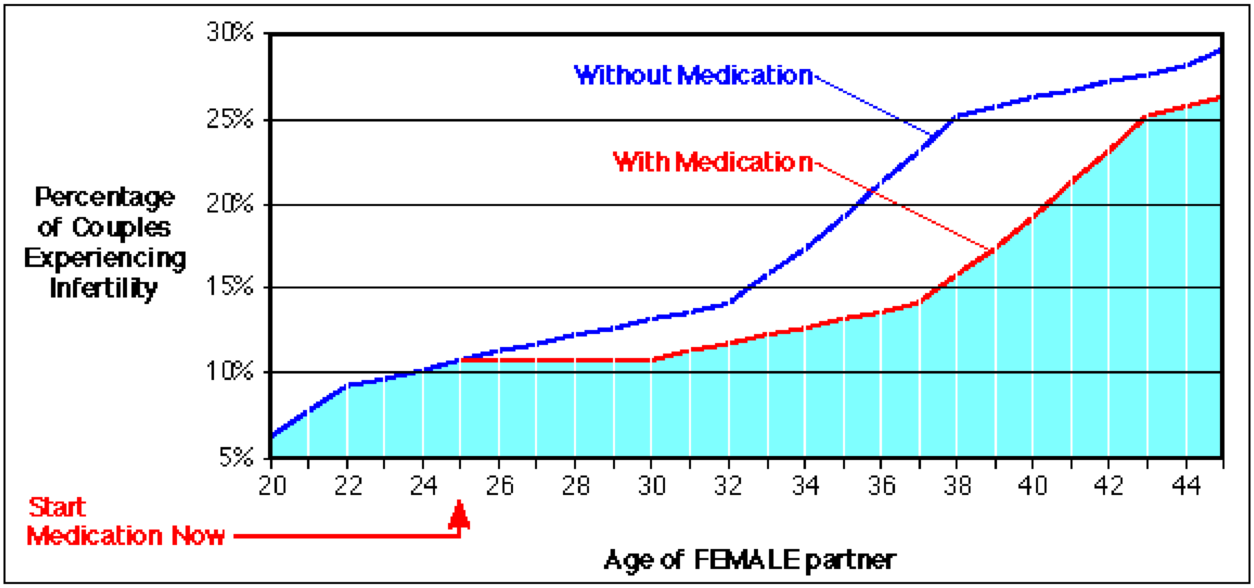

Figure 2b. Representation of Medication's Effect on Infertility Risks (starting at 30 years of age)

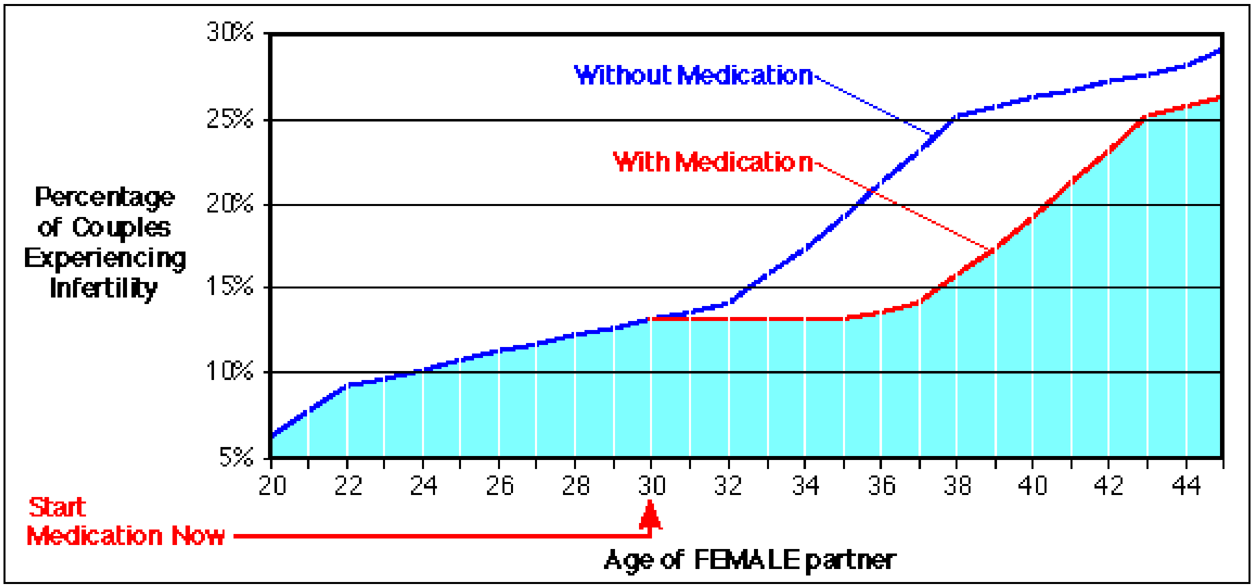

Table 1. Descriptive Statistics for Four Subsamples

Mall Location	Tampa, FL	Tulsa, OK	Las Vegas, NV	Freehold, NJ
Number of Observations	72	50	38	28
Continuous Variables	**Mean (Std Dev)**	**Mean (Std Dev)**	**Mean (Std Dev)**	**Mean (Std Dev)**
Age of respondent	25.53 (5.11)	25.88 (4.54)	26.87 (4.75)	24.64 (3.93)
Age of respondent's partner	27.94 (6.96)	28.64 (5.75)	29.47 (7.09)	26.61 (6.77)
Household income	\$58,854 (\$48,236)	\$47,347 (\$34,834)	\$54,079 (\$38,487)	\$69,259 (\$42,261)
Dummy Variables	**Percent = 1**	**Percent = 1**	**Percent = 1**	**Percent = 1**
Married	29%	48%	50%	21%
Minority	13%	26%	8%	29%
Beyond highschool education	78%	78%	76%	93%
Employed fulltime	61%	64%	58%	79%
Have health insurance	71%	74%	84%	64%
Ever experienced infertility	11%	14%	24%	11%
Partner ever experienced infertility	3%	4%	0%	4%

Table 2. Description of Variables Used in Analysis

Variable	Description
PRICE	Annual price of hypothetical medication (1998$)
HHINC	Household income in 1997 (1997$)
HHWAGEYR	Sum of respondent and partner's wage earnings in 1997 (1997$)
WAGEPART	Fraction of HHWAGEYR contributed by respondent
WORK	Number of hours of work per week at primary job
FULLTIME	=1 if work fulltime
TIMEINR	Number of years in current relationship
MARRIED	=1 if married
AGE	Age of respondent
CHLDTIM	Preferred number of years until first child
INFPROB	Perceived likelihood of experiencing infertility with partner (1-7 scale)
AUNT	=1 if respondent has nieces and/or nephews
SIBLINGS	Number of siblings
INSURED	=1 if respondent has health insurance
BELIEF	Strength of religious beliefs (1-4 scale)
MINORITY	=1 if respondent is not Caucasian
SOMECOLL	=1 if respondent has more than highschool education but not a bachelor's degree
COLLGRAD	=1 if respondent has bachelor's degree or beyond
TAMPA	=1 if survey location was Tampa, FL
TULSA	=1 if survey location was Tulsa, OK
VEGAS	=1 if survey location was Las Vegas, NV

Table 3. Purchase Decision Responses with Respect to Offered Price

	Number of Respondents in Each Category			
PRICE ($/mth)	**YES NOW**	**YES LATER**	**NO**	**All Responses**
$10	8	6	13	27
$16	12	6	12	30
$32	7	9	15	31
$48	0	8	7	15
$62	6	7	14	27
$125	0	7	25	32
$300	4	3	19	26
Total	37	46	105	188

Table 4. First Stage OLS Regression

	Dependent Variable: A[a]			
	3% Discount Rate		**5% Discount Rate**	
Ind Variable	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
PRICE	0.9928	328.928	0.9884	206.619
HHINC	-3.760E-05	-0.426	-6.170E-05	-0.441
AGE	0.3417	0.422	0.5191	0.404
MARRIED	-5.6490	-0.756	-9.0781	-0.767
MINORITY	-5.5568	-0.603	-9.1625	-0.628
WORK	0.3831	1.838	0.6072	1.838
SOMECOLL	-20.1029	-2.204	-31.8730	-2.205
COLLGRAD	-13.7691	-1.343	-21.7784	-1.341
CONSTANT	-12.0410	-0.600	-18.1500	-0.570
R^2	0.998		0.996	
N	188		188	

[a]equals PRICE/(1+ discount rate)^t where t is the number of years the respondent would wait to start taking the medication (t=0 for respondents who would start this year or never start).

Table 5. Second Stage Probit Analysis of Purchase Decision (assuming a 3 percent discount rate)

	Dependent Variable: whether to start medication			
	1 = YES NOW or YES LATER			
	0 = NO NEVER			
Variable	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
A	-2.436E-04	-2.559	-2.446E-04	-2.632
HHINC	6.220E-06	2.394	5.150E-06	2.131
WAGEPART	0.2078	0.402	0.1656	0.392
FULLTIME	-0.0193	-0.075		
CHLDTIM	-0.1418	-2.449	-0.1433	-2.607
TIMEINR	-0.1046	-2.283	-0.0819	-1.924
AUNT	0.2148	0.991		
SIBLINGS	-0.0437	-0.734		
INFPROB	0.1519	2.462	0.1618	2.713
INSURED	0.1768	0.724		
BELIEF	-0.0499	-0.545		
MINORITY	0.5243	1.868	0.4698	1.800
TAMPA	0.0384	0.122		
TULSA	0.4932	1.485		
VEGAS	0.4742	1.295		
CONSTANT	-0.3812	-0.695	-0.1399	-0.374
Log-L	-108.2502		-112.1409	

Table 6. Second Stage Probit Analysis of Purchase Decision (assuming a 5 percent discount rate)

	Dependent Variable: whether to start medication 1 = YES NOW or YES LATER 0 = NO NEVER			
Variable	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
DISCOUNTED PRICE	-2.455E-04	-2.566	-2.464E-04	-2.639
HHINC	6.220E-06	2.392	5.140E-06	2.13
WAGEPART	0.2087	0.404	0.168	0.396
FULLTIME	-0.0183	-0.071		
CHLDTIM	-0.1418	-2.449	-0.143	-2.608
TIMEINR	-0.1046	-2.284	-0.082	-1.925
AUNT	0.2147	0.99		
SIBLINGS	-0.0438	-0.735		
INFPROB	0.1521	2.464	0.162	2.715
INSURED	0.1767	0.723		
BELIEF	-0.0500	-0.545		
MINORITY	0.5236	1.865	0.469	1.796
TAMPA	0.0386	0.123		
TULSA	0.4932	1.485		
VEGAS	0.4747	1.296		
CONSTANT	-0.3825	-0.697	-0.141	-0.377
Log-L	-108.2305			-112.121

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WILLINGNESS TO PAY FOR CHILDREN'S HEALTH: A HOUSEHOLD PRODUCTION APPROACH

--Working Paper*--

PRESENTED BY:
MARK DICKIE
DEPARTMENT OF ECONOMICS
UNIVERSITY OF SOUTHERN MISSISSIPPI
SS BOX 5072
HATTIESBURG, MS 39406-5072
M.Dickie@usm.edu

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1. Introduction

Children are at greater risk than are adults from environmental hazards such as lead poisoning, pesticides, drinking water contaminants, and overexposure to solar radiation (USEPA 1996). Yet little evidence exists about how families respond to environmental threats to children's health, or about the economic benefits of risk reduction. More generally, significant gaps in knowledge remain about the value of reducing adult morbidity. In *The Benefits and Costs of the Clean Air Act, 1970-1990* (USEPA 1997), for example, many nonfatal health effects of air pollution are monetized using cost-of-illness procedures. The cost of illness includes medical expenses and foregone earnings but does not measure willingness to pay (WTP). One reason for the gaps in knowledge about the value of reduced morbidity is the difficulty of estimating the value with market data. Researchers often use primary data, but the cost of data collection usually results in small samples drawn from narrow geographic locations. Response rates often are low, and replication is relatively rare, raising questions about extrapolation to national benefit estimates.

This paper examines the use of a household production approach together with readily available, nationally representative data sets to estimate the value of reduced morbidity in children. Although joint production and unmeasured input prices hinder estimation of WTP in the household production model, and use of large secondary data sources limits the number of specific health conditions that can be valued, this approach nonetheless represents a cost-effective way to investigate several important questions related to children's health. Depending on the data set used, the approach supports investigation of how parents' choices and family characteristics affect children's health and household WTP for children's health. Also, the approach allows examination of rates of tradeoff between the health of different family members.

The next section of the paper presents a model of family resource allocation in which parents maximize family utility in part by making decisions concerning their own health and the health of their children. Section 3 examines prospects for implementing the household production model with several national data sets. Section 4 dicusses empirical estimation of the model, using preliminary data from the Panel Study in Income Dynamics Child Development Supplement, released in February 1999. Conclusions follow in Section 5.

2. *Model*

This section presents a model to highlight several key issues in children's environmental health. Concern about environmental health threats to children has arisen in part because, relative to adults, children may have greater exposure or be more sensitive to some pollutants; generally are less able to protect themselves against adverse effects of exposure; and on average have more remaining years of life and thus greater chance to experience delayed effects. Children differ from adults in several other respects that bear on modeling of health. Children are almost always members of multi-person households. Adult caregivers, typically parents, make important economic and health decisions on behalf of children. Previous empirical economic research underlines how important parents' choices are in determining children's health, and how parents' choices are in turn influenced by the inherent "healthiness" of their children (Corman, Joyce and Grossman 1987, Grossman and Joyce 1990, Pitt and Rosenzweig 1990, Rosenzweig and Schultz 1983). In addition to investing in health, parents invest in other forms of human capital, such as schooling, in order to improve their children's future opportunities. Finally, although children's time has no readily observable market price, it has alternative uses.

The model sketched below represents an attempt to illustrate effects of many of these features in a simple way. In the typology of Behrman et al. (1995) it is a "unitary" model with passive children – meaning that children comply with parental decisions, which in turn are made to maximize a single utility function representing the preferences of parents. Children are treated as identical, because the data to be used contain information on only one child, precluding investigation of variation in the characteristics of different children. The model can be generalized to allow for differences among children, however. A three-period version of the model is presented in which parents spend the first two periods raising children. Two-period models are common in the economic analysis of children, but a three-period model makes it easier to separate parents' time preferences from their altruism toward their children.

Parents in the model spend their healthy time working, enjoying consumption/leisure, and investing in their own health and in the health of their children. Children spend their healthy time enjoying leisure or investing in human capital (by attending school, for example). Parents' labor earnings and any asset income is divided between consumption, health investments and other investments in children's human capital, and savings.

Health investments are treated following the general approach of Grossman (1972) and Cropper (1981). Each person's stock of health H_{it} depreciates at an individual and time-specific rate d_{it} , but depreciation is offset by gross investments I_{it}. Thus

$$H_{it} = (1-d_{it})H_{i,t-1} + I_{it}, \qquad t = 0,1,\ i = p,c.$$

In this equation, the subscript *i*=*p*(parent), *c*(children). At time *t*=0, the initial level of health capital is $\overline{H_i}$. Gross investment in turn depends on market goods, time inputs, and exogenous factors $I_{it} = I_{it}(y_{it}, E_{it}),$ where y_{it} denotes a vector of inputs chosen by parents and E_{it} denotes a vector of exogenous factors influencing the effective rate of gross investment. A primary reason for investing in health is to increase the flow of healthy time, $h_{it} = \phi_{it} H_{it}$.

Parental utility is determined according to

$$U = U(Z_o, h_{po}, h_{co}, l_{co}; Z_1, h_{p1}, h_{c1}, l_{c1}; Q_2).$$

In the utility function, Z_t denotes parental consumption/leisure at time *t*, l_{ct} denotes children's leisure at time *t*, Q_2 denotes the final period's child "quality," and other symbols are previously defined. Child quality is an index of children's opportunities in life as influenced by parents' investments in children. In empirical applications quality often is measured by children's earnings or wealth, but conceptually it may be viewed as a broader measure of a child's future welfare. Children who are healthier and/or who have more schooling have greater opportunities when adults, and cash transfers or bequests from parents, if any, potentially also may boost child quality. Thus $Q_2 = Q(K_0, K_1, H_{c2}, B),$ where K_t denotes schooling or other human capital investments in period *t*, $H_{c2} = (1-d_{c2})H_{c1},$ and B represents a transfer of cash from parents to children (if any).

Resources available to maximize utility include parental earnings and any initial assets owned by parents. The "full wealth" constraint (see Grossman 1972 or Becker 1991 for details) is

$$R \equiv \sum_{t=0}^{1}(1+r)^{-t} w_t \Omega + A_0 =$$

$$C_p + nC_c + n(1+r)^{-1}B + \sum_{t=0}^{1}(1+r)^{-t}[Z_t q_{zt} + np_{kt}K_t + w_t(\Omega - h_{pt}) + nw_t(\Omega - h_{ct})].$$

In the budget constraint, r denotes the rate of interest at which parents can borrow or lend, and the sources of full wealth are w_t , the wage rate in period *t*, Ω , total time available within the period, and A_0 , initial assets. Full wealth is spent partly on consumption Z_t, whose full, or time-inclusive price is $q_{zt} = p_{zt} + w_t t_{zt,}$ where p_{zt} denotes the money price, and t_{zt} denotes the time required to consume a unit of Z. Full wealth also is spent on human capital investments in each of *n* children, purchased at the unit price p_{kt} . Also, C_i denotes the minimum total cost of producing any path of health capital for the parent (*i*=*p*) or children (*i*=*c*). Finally, time spent ill detracts from full wealth by reducing time available for market and nonmarket activities, where $(\Omega - h_{pt})$ denotes the time parents spend ill and $n\ (\Omega - h_{ct})$ denotes the total time spent ill by n children. Thus, the parental time constraint assumes that parents must care for sick children, and that no two household members are sick at the same time. (The model is easily modified to allow parent health and child health to have differential effects on parental time loss.)

A final constraint on maximization of household utility concerns children's time. Children's healthy time is divided between leisure and human capital investment: $h_{ct} = l_{ct} + K_t$.

The Value of Health Capital

In the equilibrium of the constrained utility maximization problem, the marginal value of health capital equals its marginal cost or supply price. Thus the value of parental health is

$$[(\partial U / \partial h_{pt}) / \lambda + (1+r)^{-t} w_t]\phi_{pt} = \partial C_p / \partial H_{pt},$$

where λ denotes the marginal utility of full wealth. The term in brackets on the left-hand side of this equation gives the value of a marginal increase in the flow of healthy time, which consists of its value as a pure consumption good plus its value in generating income or additional nonmarket production. For parents, then, the value of health capital equals its effect on healthy time ϕ_{pt} times the value of healthy time; in equilibrium this equals the marginal cost of health capital.

A similar equation gives the value of children's health capital in the initial period, where

$[(\partial U / \partial h_{c0}) / \lambda + nw_0 + \tau_0 / \lambda]\phi_{c0} = n(\partial C_c / \partial H_{c0}),$ and where τ_t denotes the marginal value of children's time in period t (which in equilibrium in turn equals

$\partial U / \partial l_{ct} = (\partial U / \partial Q)(\partial Q / \partial K_t) - \lambda(1+r)^{-t} np_{kt}$, or the value of the child's time input in producing future opportunities). The term in brackets measures the value to the family of a marginal increase in the healthy time of children. This value consists of the value of children's health as a pure consumption good, plus its value in reducing parents' time caring for sick children, plus the value of children's own time. Again, the value of health capital equals its effect on healthy time ϕ_{ct} times the value of healthy time; in equilibrium this must equal the marginal cost of health capital. The marginal cost or supply price in turn consists of foregone interest, plus depreciation less any capital gain (see Grossman 1972, equation (13) or Cropper 1981, equation (6)).

$$\partial C_i / \partial H_{i0} = (1+r)^{-1} \pi_{i0} [r + d_{i0} + \pi'_{i1}],$$

where π'_{i1} denotes the proportionate rate of change of π_{i0}, which in turn is the marginal cost of gross investment.

One difference between conditions for optimal investment in health of parents and children can be seen most clearly in the final period of child-rearing. In this period, the marginal cost of children's health capital is not equated to the value of its contribution to children's healthy time alone. Rather, the marginal cost is equated to the value of the contribution of health capital to healthy time, *plus* the value of its contribution to children's future opportunities in life:

$$[(\partial U / \partial h_{c1}) / \lambda + n(1+r)^{-1} w_1 + \tau_1 / \lambda] \phi_{c1} + (\partial Q / \partial H_{c1})(\partial U / \partial Q) / \lambda = n(\partial C_c / \partial H_{c1}).$$

Thus, parents account for the longer future which children have ahead of them, and the impact of health on the quality of that future, when making health investments in children.

Pollution and Willingness to Pay

Pollution can enter this model in several ways. To allow exposure to differ between parents and children, suppose that exposure, $X_{it} = X_{it}(\alpha_t)$, where α denotes ambient pollution. Exposure to some pollutants may cause only acute effects with no long-term health implications. In this case exposure could be viewed as reducing the flow of healthy time for a given stock of health: $\phi_{it} = \phi_{it}(X_{it})$, where $\phi_{it}'(X_{it}) < 0$. Alternatively, pollution may reduce the stock of health by reducing the rate of effective gross investment, $I_{it} = I_{it}(y_{it,} E_{it}, X_{it}(\alpha_t))$, or as in Cropper's model by increasing the rate of decay of health: $d_{it} = d_{it}(X_{it})$, where $d_{it}'(X_{it}) > 0$. Finally, a stock of pollution may accumulate, reducing health capital in all subsequent periods. Two of these possibilities are illustrated in the present paper: acute effects, and depreciation effects.

Willingness to pay (WTP) for reduced exposure in the initial period, for the case of purely acute effects $\phi_{it} = \phi_{it}(X_{it})$, is

$$[(\partial U / \partial h_{p0}) / \lambda + w_0] H_{p0} \phi_{p0}' = -(\partial C_p / \partial H_{p0}) H_{p0} \phi_{p0}' / \phi_{p0}$$

for parents, or

$$[(\partial U / \partial h_{c0}) / \lambda + n w_0 + \tau_0 / \lambda] H_{c0} \phi_{c0}' = -n(\partial C_c / \partial H_{c0}) H_{c0} \phi_{c0}' / \phi_{c0}$$

for children, where $H_{it}\phi_{it}' = \partial h_{it} / \partial X_{it}$ denotes the effect of exposure on the flow of healthy time, and thus measures how sensitive acute health is to changes in exposure. Thus, WTP equals the marginal value of healthy time, weighted by the sensitivity of healthy time to exposure. As shown in these equations, if all else is equal greater sensitivity implies a higher willingness to pay. Taken by itself, a greater sensitivity among children than among adults would increase WTP for reducing children's exposure relative to WTP for reducing adult's exposure. Likewise a lower ability to convert health capital into health time (ϕ_{it}) raises willingness to pay, as does a lower ability to offset the reduction in health time through greater investment in health capital ($\partial C_i / \partial H_{it}$).

If pollution affects the rate of decay of health, as in Cropper's (1981) model, then the impact of pollution in one period will continue to be felt in subsequent periods because of reductions in the level of health capital carried forward. At $t = 1$, for example, the WTP for a reduction in parental exposure is

$$[(\partial U / \partial h_{p1}) / \lambda + (1+r)^{-1} w_1] \phi_{p1} H_{p0} d_{p1}' = (\partial C_p / \partial H_{p1}) H_{p0} d_{p1}',$$

where $H_{p0} d_{p1}' = \partial H_{p1} / \partial X_{p1}$ denotes the impact of exposure on health capital. Thus, WTP for reduced exposure equals the value of health capital times the effect of exposure on health capital. For children, the corresponding expression is

$$\begin{aligned}&\{[(\partial U / \partial h_{c1}) / \lambda + n(1+r)^{-1} w_1 + \tau_1 / \lambda] \phi_{c1} + (\partial Q / \partial H_{c1})(\partial U / \partial Q) / \lambda\} H_{c0} d_{c1}' \\ &= n(\partial C_c / \partial H_{c1}) H_{c0} d_{c1}'.\end{aligned}$$

Again, the value of reducing exposure equals the impact of exposure on health capital times the value of health capital. In the case of children, however, the value of health capital includes effects on their opportunities or quality extending beyond the years of parental investment.

For both types of effects of pollution on health considered, then, WTP expressions depend on the value of health capital for a given household member. In environmental policy analysis, moreover, effects of exposure on health generally are estimated by health scientists, and economists are asked to provide a value for the resulting change in health. Thus the more important part of the WTP expressions above for economic analysis is the marginal value of health capital for parents or children.

This model supports theoretical and empirical investigation of three broad issues of importance in the analysis of children's environmental health. First, the model focuses on how parents' choices, such as investments in children's health and labor supply affect health outcomes experienced by children. Second, the model can be used to show how family characteristics, including available resources, family size and household composition, affect health outcomes experienced and WTP. Third, the model highlights determinants of any differences in WTP for improved health of various household members.

The last of these issues is analyzed below because it is likely to be the issue of the most immediate policy relevance. The simplest approach to valuation of children's health is benefits transfer, by applying to children existing values previously estimated for adults. Although some environmental hazards such as lead pose a limited threat to adults, many hazards potentially cause similar illnesses in adults and children, such as acute health effects of air pollution exposure, or risk of skin cancer from overexposure to solar radiation. To the extent the value of health is equal for adults and children, there is little need for special economic studies directed at valuing children's health, and the prospects for benefits transfer are improved. More generally, however, differences may exist between health valuations for adult and children, and the WTP expressions presented above indicate the sources of any divergences.

Valuing Health Across Persons and Time

As discussed previously, the key economic element of this model's WTP expressions is the value of health capital. One component of a comparison between the value of health capital for parents and for children is the marginal utility of healthy time. Parental preferences for healthy time of a parent and a child can be summarized by indifference curves showing alternate combinations of healthy time of each individual that would hold parental utility constant. Figure 1 shows the tradeoffs the parent is willing to make between his or her own healthy time and the healthy time of a child, within a period.

If the (absolute value of the) slope of the indifference curve is unity when the healthy time of the two persons is equal, then the parents' preferences could be described as neutral as between own health and child health. A steeper indifference curve, on the other hand, would indicate "selfish" preferences, or an intrinsic preference for parent over child health. Conversely a flatter indifference curve would indicate greater altruism toward children, or a preference for the child's healthy time over the parent's. Thus, the marginal rate of substitution between parent and child healthy time at the point of equal consumption of healthy time could be used to index the degree of parental selfishness or altruism in health preferences. In any of these cases, movements along an indifference curve which raise the healthy time of one household member while reducing it for another have the effect of boosting the relative marginal valuation of the healthy time of the person incurring the loss in health.

Preferences for current-period healthy time are only one determinant of the amount of health investment and the willingness to pay for health, however. For parental health, the other factors at work are the value of illness-induced losses in time available for market and nonmarket activities, and the marginal cost of health investment. For child health, the other factors at work are the value of time parents spend caring for sick children, the marginal cost of health investments, *and* the marginal value of health-related changes in the child's future opportunities. These health-related changes arise because better health increases the time the child has available for human capital investments (valued at $(\partial U/\partial Q)(\partial Q/\partial K_t)/\lambda$), and because a larger stock of health capital directly increases the child's future opportunities (valued at $(\partial Q/\partial H_{c1})(\partial U/\partial Q)/\lambda$).

Because of the value of children's health includes factors unique to children, even "selfish" parents, with an intrinsic preference for their own healthy time over their children's healthy time, might well prefer that their children enjoy more healthy time than the parents themselves enjoy. Parents with neutral preferences, as defined above, who would lose an equal amount of market and nonmarket time from their own or from a child's illness, would (given equal marginal costs for parental and child health investments), tend to prefer to increase their children's healthy time even at the expense of their own. This possibility is illustrated in Figure 2. The relative preference for child health would be stronger, the greater the value parents place on children's future opportunities

($\partial U / \partial Q$), the greater the productivity of children's time in schooling ($\partial Q / \partial K_t$), and the greater the effect of children's health capital on their future opportunities ($\partial Q / \partial H_{c2}$).

The model does not necessarily imply, however, that parents would value their children's health more highly than their own. If parents prefer consumption of their own healthy time over their children's healthy time, or lose more market or nonmarket time from their own than from a child's illness, of have a lower marginal cost for investing in their own health, then the value of parental health capital may exceed the value of children's health capital. Regardless of whose health capital is valued more highly by parents, the model highlights the determinants of differences in valuations.

A similar analysis can be performed to examine time-preferences for the health of parents or children. Specifically, the indifference curve diagram shown in Figure 1 can be drawn to show utility-constant tradeoffs between the health of a single individual in different periods. The slope of the resulting indifference curve would indicate the rate of time preference for healthy time.

The analysis also can be extended to investigate valuations of health across both periods and persons. In this case, the indifference mapping would be drawn to show utility-constant tradeoffs between, for example, a parent's healthy time now and a child's health time in the future. The slope of the indifference curve would reflect both time-preference and the extent of altruism for child health. Restrictions on the utility function, such as specifying lifetime utility as the sum of discounted within-period utilities, would allow time-preference to be disentangled from altruism.

Data

Ideal data to implement a health production function approach like the one sketched above would have several features. First, the data must include measures of health outcomes or risks experienced by at least one child. More complete data on health of other family members would allow estimation of tradeoffs, particularly between the health of a parent and a child. An economic approach is most easily applied if health outcomes, such as acute or chronic conditions experienced are measured, in addition to variables that measure behavioral responses to health outcomes, such as work loss or restricted activity.

A second requirement to implement the health production approach is measurement of behavioral choices that affect health. Use of medical care is a key input, and other inputs depending on the problem addressed. These would be as varied as time spent outdoors (exposure to ambient air pollution), smoking (especially maternal smoking), alcohol consumption (especially prenatal consumption by mothers), use of sunscreen lotion, actions taken to mitigate radon exposure, and use of water filters or purchase of bottled water. Many of these inputs are sources of joint production, in that they affect household utility in ways other than through their impact on health. Ideally the data would include inputs whose price can be measured and where joint benefits of using the input can be controlled.

A third type of data reflects exogenous factors affecting behavioral choices and health outcomes. These include economic factors like family income, wages, prices, access to medical care, insurance and sick leave coverage, as well as other factors like age, schooling, family size, health attitudes and knowledge, and environmental quality. In addition, a large, nationally representative sample with demographic diversity is helpful. If WTP for reduced pollution is to be estimated, then it must be possible to link households or individuals to measures of pollution or exposure, but this is not necessary to estimate WTP for reduced morbidity.

Few if any data sets have all of these desirable features. For adult morbidity valuation, most researchers have collected primary data. These data offer many advantages, including the ability to measure specific factors of interest, such as health outcomes and behaviors, attitudes, knowledge and beliefs, and exogenous factors. The location of respondents is known, making it possible to match them to measures of local environmental quality. Also, any valuation method can be employed, including stated preference methods.

Collecting survey data is expensive and time-consuming, however, which imposes several limits on the research. The number of studies that can be conducted, and the sample size of any given study are relatively small. Samples typically are drawn from one or two locations, and may have little demographic diversity. Response rates often are quite low. The cost also restricts the ability of other researchers to replicate results. Taken together, these factors limit the confidence that can be placed in extrapolations to national benefit estimates.

Using existing secondary data sets may offer the opportunity for cost-effective morbidity valuation, but these data also suffer from several disadvantages. Although some data sets measure specific acute or chronic conditions, others measure only behavioral responses to underlying conditions, such as work loss or activity restriction. Also, behavioral choices affecting health often are limited to major influences like use of medical care and smoking, and do not include behaviors that may be important to specific environmental risks like time spent outdoors. Assessments of health knowledge, attitudes and beliefs often are limited, and perceived risks are almost never measured. Confidentiality restrictions severely limit the ability to match survey respondents to local pollution measures. Valuation is limited to cost of illness or health production methods.

Nonetheless these data offer several advantages. The data are readily available at low cost. Replication is straightforward. Usually large, nationally representative samples are drawn, with demographic diversity. The data are extensively validated, response rates typically are high, and some surveys are ongoing, allowing changes to be tracked over time. Table 1 summarizes advantages and disadvantages of using primary data and secondary data from national surveys.

This section of the paper reviews prospects for estimating a household production model to value children's health using four large, national data sets. The three data sets most useful for applying the approach to children beyond infancy are (1) the National Health Interview Survey, (2) the Panel Study in Income Dynamics, and (3) the Medical Expenditure Panel Survey. The fourth data set discussed pertains to pregnancy outcomes and infant health. Brief descriptions of these and dozens of other public health data sources can be found in a recent compendium (US Public Health Service 1993).

National Health Interview Survey

The National Health Interview Survey (NHIS) is an ongoing survey of the health of the US resident, civilian, non-institutionalized population, in continuous operation since 1957. The NHIS is a nationwide survey with oversampling of blacks. A representative sample is drawn each week, and weekly samples are combined to form an annual sample. The 1994 NHIS includes 45,705 households consisting of 116,179 persons. The response rate was 94.1 percent.

The survey is a personal interview with adult household members who also report data on children living in the home. A core survey is administered to all respondents, and supplemental surveys on current health topics are administered to representative subsamples.

The core survey is repeated each year and collects basic health and demographic data. Health data collected include the presence of acute and chronic conditions, and disability days, including restricted activity, work loss, school loss, and bed days. The use of medical services, and the acute or chronic conditions responsible for the medical services, are recorded. Also measured are long term limits on activity from chronic conditions, and hospitalization experiences. Health data are collected for a two-week recall period, with an annual recall for more severe episodes of illness. Demographic data include age, sex, race and family income. Supplemental surveys in 1994 include access to care, and health insurance. The health insurance supplement includes premiums paid, as well as family annual medical spending.

The NHIS is useful for assessing the health status of the population or subgroups, epidemiological investigations, and the impact of some behavioral variables such as smoking and medical care on the health of family members. But it contains relatively little economic information. Family income is not measured by person or by source in the main survey, and has a high item non-response rate. Medical prices or time spent obtaining medical care is not measured, and the measure of annual household medical spending is not broken down by family member.

Medical Expenditure Panel Survey

The Medical Expenditure Panel Survey (MEPS) is the third in a series of national probability samples of health care use and expenditure. Its predecessors are the National Medical Care Expenditure Survey of 1977 and the National Medical Expenditure Survey of 1987. The MEPS substantially improves on the earlier intermittent surveys; it is a continuous survey of overlapping panels. Each year a nationally representative sample is drawn from respondents to the NHIS. Sampled households are interviewed six times to collect data over two calendar years. The first panel of 23,230 individuals living in 10,639 households was drawn from the 1995 NHIS, with data collection in 1996-1997. The overall response rate to the first wave of the MEPS was 77.7 percent (93.9 percent to the 1995 NHIS x 82.8 percent to the MEPS). Partial data collected for 1996 now are available.

The MEPS fills in the missing economic information from the NHIS: employment and earnings, and an hourly wage, are included. Health insurance data are collected, along with expenditures, and utilization. The survey includes four components. The Household Component is the subsample of the NHIS, with oversampling of blacks and Hispanics. The Medical Provider Component supplements and validates the utilization and expenditure information reported by respondents by collecting data from providers and pharmacies. The Insurance Component collects data from employers and unions and other establishments providing insurance to sample members, including data on insurance plans not chosen. Finally, the Nursing Home Component is a separate survey of nursing homes and residents.

The MEPS is likely to be the best source of data to implement the household production function, and a key source of cost of illness data as well. The data currently available are limited however. For example, data on health care use, health care expenditure, and household characteristics cannot yet be merged (until fall 1999).

Panel Study in Income Dynamics Child Development Supplement

In 1997 the Panel Study in Income Dynamics included a detailed supplement on children's well-being and development. The PSID is an ongoing panel started in 1968, with 6792 families in the core sample as of 1997. The data are widely used in economics. The Child Development Supplement was administered to 2394 PSID families, and data were collected on 3586 children 12 years of age and younger. The response rate was 88.2 percent. Data were collected on children's social and emotional well-being, their cognitive and behavioral development, and their health. Economic and demographic characteristics of families include income and wealth, the schooling, employment, hours and earnings of caregivers, and household size and composition. A cognitive assessment was administered to children, and surveys were administered to caregivers and to a teacher and school administrator.

Health status measures collected for children include a lifetime history of health, including birth weight, prematurity, immunization, and hospitalization experiences. Medical care expenditures and school loss days for the year preceding the survey were collected, along with data on health insurance coverage.

The PSID-CDS does not include as much specific detail on health status, presence of conditions, use of care, expenditures and insurance as does the MEPS or NHIS. But it does include the typical work loss and medical care variables, a great deal of economic information, and data on broader issues of children's development. Also, the data can be linked to family data in the larger PSID (although not yet to concurrent data from the 1997 PSID).

National Maternal and Infant Health Survey and Longitudinal Follow-up

Health production function models have had their most frequent successful application to children with respect to pregnancy outcomes – fetal death, gestational age, birth weight, and infant death (Corman, Joyce and Grossman 1987, Grossman and Joyce 1990, Rosenzweig and Schultz 1983) in part because the links between maternal behavior and infant health is clear. Micro data at the national level for studying infant health outcomes include the 1988 National Maternal and Infant Health Survey, and its 1991 Longitudinal Follow-up.

The 1988 data collection began with a sample of national records of live births, fetal deaths and infant deaths. Questionnaires were mailed to each mother named in the vital records. Over 18,000 mothers responded (54 percent of them in the live birth sample, 29 percent in the infant death sample, and 18 percent in the fetal death sample). The survey data are linked to the vital records. Data were collected on use of prenatal care, maternal smoking and alcohol and drug use before and during pregnancy, a history of pregnancies and outcomes for the mother, family income, and schooling and employment of the mother and father. For the live birth sample, additional data were collected on health inputs (medical care, vaccines) and illnesses during the first six months of life.

The 1991 Longitudinal Follow-up re-interviewed women from the 1988 survey, including all women with live births and samples of women with fetal or infant deaths. Response rates ranged from 82 to 89 percent, with over 8000 women in the live birth follow-up sample, and 1000 in each of the fetal and infant death samples. The fetal death and infant death surveys collected data on maternal health and any pregnancies since 1988. The live birth survey collected data on childhood injury, acute and chronic illness, and health inputs including smoking, use of alcohol and drugs in the household, immunizations, and pediatric care. Family income, sources of income, and health insurance data also were collected.

The 1988 NMIHS and 1991 LFU provide a rich source of data for infant and early childhood health. Effects of low birth weight on early childhood health, and more generally links between pregnancy inputs and outcomes to early childhood, can be investigated using these data.

4. Empirical Analysis

Empirical estimation of a household production model for children's health has been undertaken using preliminary data from the PSID-CDS released last month. The data have not been validated for final release, however, and cannot yet be matched to concurrent data on PSID families, current estimates are preliminary at best and inaccurate at worst. Therefore empirical results are not presented in this version of the paper.

5. Conclusions

Although children are at greater risk than are adults from several environmental hazards, little is known about how families respond to these hazards, or about the economic benefits of reducing hazards. There remain significant gaps in knowledge about adult health valuation as well, but the gaps are wider for children.

This paper has examined use of the household production approach together with data from large, nationally representative data sets to address some issues of children's health valuation. Although availability of only preliminary data precludes presentation of empirical results, the approach taken will support investigation of a number of key issues. These issues include: effects of family resources, size and composition on the value of children’s health; effects of parental resource allocations on children’s health; and estimation the relative value of children’sand parents health.

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Figure 1: Neutral Parental Preferences.
$(\partial U / \partial h_{ct}) / (\partial U / \partial h_{pt}) = -1$, when $h_{ct} = h_{pt}$.

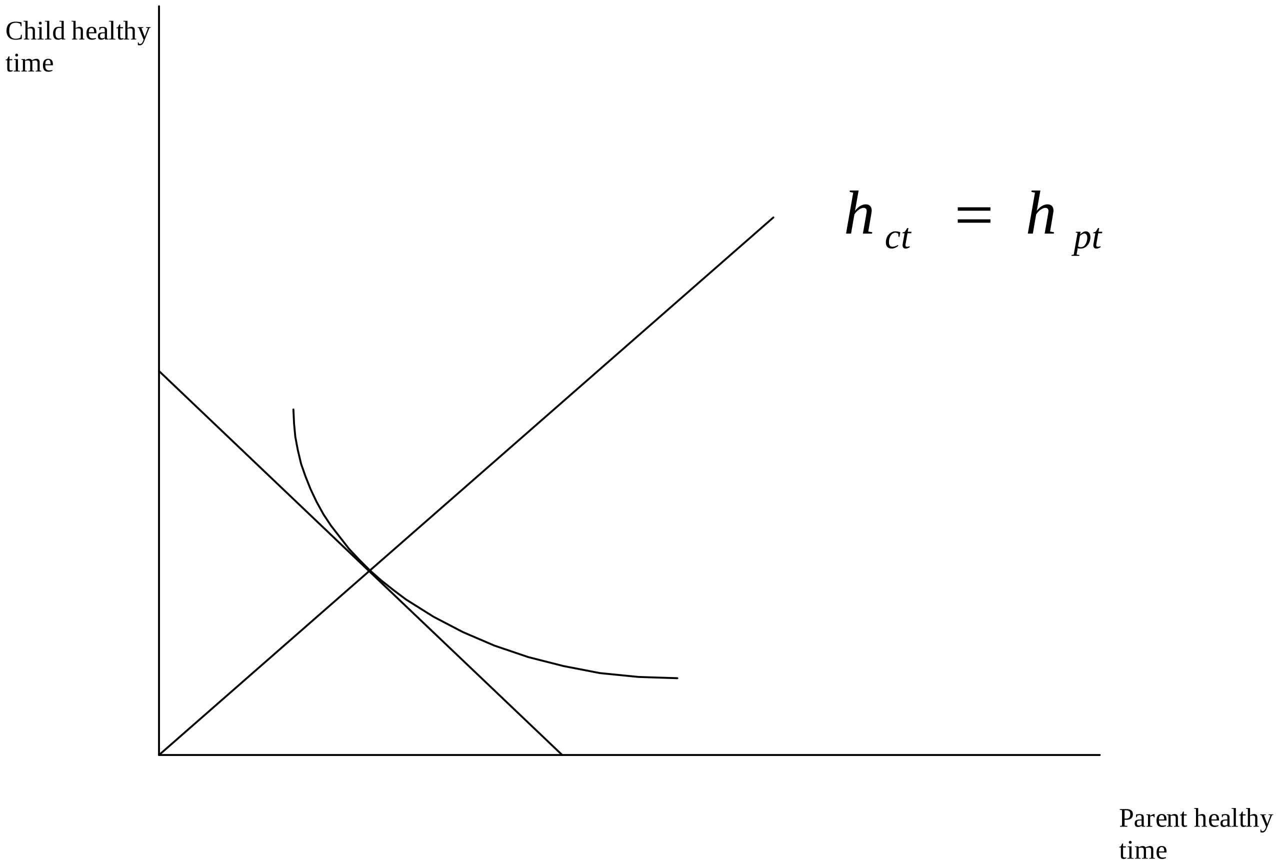

Figure 2: A Potential Health Investment Allocation, with Neutral Parental Preferences. The child consumes OC healthy days, which exceeds the parent's OP healthy days.

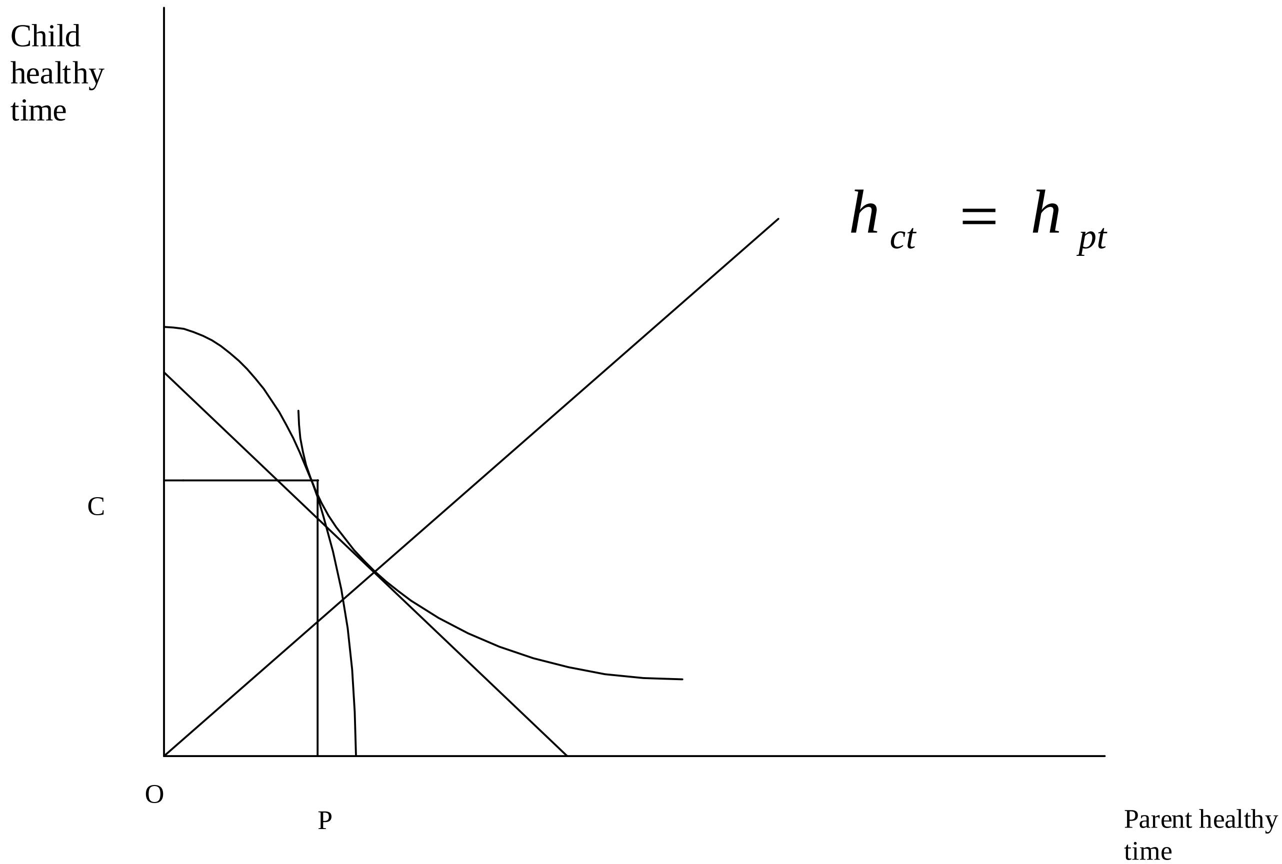

Table 1. Comparing Primary Data Collection and Use of National, Micro Data for Children's Health Valuation.

Attribute	**Primary Data Collection**	**Large National Data Sets**
Health Effects	Specific effects of interest	Broad measures of health or mixtures of health/behavior
Health-related behavior	Behaviors linked to specific effects of interest	Only most important health-related behaviors
Attitudes, information, beliefs	Can account for these	Little information on these
Location	Known	Confidential
Valuation Method	Any	Only COI or HPF
Cost	Expensive	Cheap
Sample Size	Small	Large
Geographic representation	Limited	National
Demographic diversity	Often limited	Diverse, minorities often over-sampled
Response rates	Typically low	High
Replication	Little opportunity	Available for replication
Repetition of survey	One-time	Sometimes ongoing

Discussion of Crocker and Agee Paper

by Jane Hall, California State University, Fullerton

Dr. Hall was unable to attend the conference.

Discussion of Van Houtven and Smith Paper

by John Horowitz, University of Maryland -- Summarization

Dr. Horowitz began his discussion by emphasizing the need to keep in mind the relevant policy question. That is, allowing people to abstain from voting or indicating that they would be willing to pay the stated amount but *later*, is a complicating issue because people are not afforded these options in real life. This is problematic because it is giving respondents an option that is not part of the underlying welfare model. EPA is considering implementing costly regulations now, and people will have to pay for it now. Although the authors of this paper dealt with this issue, their analysis was made more difficult by this issue.

Dr. Horowitz queried whether the bid responses were sensitive to the change in probability hypothesized in the survey, or whether they were sensitive to the description of the underlying problem contained in the survey. Dr. Horowitz noted that we usually have suspicions regarding the lack of sensitivity to the amount of change in probability, but there is not much that can be done to remedy that. Nevertheless, CV researchers should remain sensitive to the issue.

Dr. Horowitz's third point was a more general one regarding differences in baseline risks. The problem with fertility is that baseline risks change much more dramatically over time than mortality risks. A couple can be attempting to have children for a long time, and only after several unsuccessful attempts do they realize that they are in a higher risk group, in which case their willingness to pay can be expected to be much higher. The very large difference over time and cross-sectionally will have a very large effect on willingness to pay.

Dr. Horowitz also remarked that although Mr. Van Houtven's presentation did not reveal this, Mr. Van Houtven and Mr. Smith have spent a great deal of time thinking about the household decision-making process, and considering whether this is a collective decision-making process or a unitary decision, a matter that is at the crux of the work in this area.

Finally, Dr. Horowitz drew a parallel between the Van Houtven/Smith paper and the Crocker/Agee paper, in that they both deal with household production situations in which there is a public good substitution for a private good, which economic theory clearly predicts will result in some undersupply. This will make welfare calculations substantially more difficult.

Discussion of Dickie Paper

by Jason Shogren, University of Wyoming – Summarization

Dr. Shogren complemented Dr. Dickie on the groundwork that he had laid thus far, and commented that Dr. Dickie's model raises some interesting issues not yet addressed by the literature. Firstly, little is known about intra-household allocations, which differs a great deal from family to family, and inter-culturally. In some cases, the family attempts to balance out the opportunity sets for all the children, so that resources are allocated away from healthy children and towards needy children. Some cultures allocate resources to the first-born child. Knowing more about how these processes work is important for purposes of model specification. A related issue is how families mitigate against and adapt to problems. This is a separate question from the question of risk management.

A second point Dr. Shogren made was to suggest that state-dependent preferences may be important here, but not in the sense that it usually comes into play. It is possible that when one's children actually become sick, the marginal utility of money may change.

Thirdly, Dr. Shogren wondered what is known about the markets that currently exist, such as markets for health insurance and life insurance. Yet application of valuations obtained from these markets to valuation of children's health is not straightforward, because some parents wish to raise their children in a challenging environment, and limit their dependence upon inherited resources. This is a different kind of preference, which may also be important.

Fourthly, Dr. Shogren remarked that often economists attempt to decompose total values, while in the end, it is probably the total value that we are interested in. Thus, the effort to ascertain a special value for children may be misplaced, in that it is simply embedded in our own adult willingness to pay.

Finally, Dr. Shogren posed the question of what we know about the retrospective views of respondents? Does it indeed matter what children think about the opportunity set that they were given? Should their views matter in a retrospective sense? If the answer is yes, then perhaps children should indeed be entitled to value the opportunity sets that they are given prospectively.

Policy Discussion of Session IV

by Robin Jenkins, US EPA Office of Economy and Environment – Summarization

Dr.. Jenkins commented that all three of the papers asked relevant policy questions as far as EPA's Office of Policy and Office of Children's Health was concerned. With respect to the Agee and Crocker paper, the primary conclusion appeared to be that there may be a vicious cycle whereby children who grow up in a poor environment with many health risks grow up to become adults who tend to place a lower value on improving environmental conditions for their own children. The cycle is perpetuated by the passing down of a low discount rate. There are thus two possible policy options to break the cycle: (1) improving the environment for children, such as removing lead poisoning threats and decreasing second-hand smoke and even improving education, and (2) manipulate parents' discount rate, particularly by lowering the discount rates of parents who as children were exposed to high environmental risk. This may be particularly important in our culture, where the link between a child's adult development and the parent's utility is a weak one, at least more so than in developing countries. So, specific policy suggestions might be to provide parents with a tax rebate for enrolling their children in college, or perhaps as they progress through high school. Agee and Crocker themselves referred Dr. Jenkins to a paper that suggested reducing parents' opportunity costs of time in spending necessary time with their children, particularly caring for them when they are sick.

Another interesting implication of the paper is that parents' discount rate for themselves is not necessarily different from that applied to their children. In other words, those parents who undertake high risk behaviors themselves such as smoking of eating a high fat diet are more likely not to protect their children from environmental hazards such as lead poisoning. This suggests that the federal government may have a role to play to attempt to lower discount rates, perhaps by advertising campaigns discouraging smoking, encouraging radon mitigation, etc.

Thus, the larger question is whether or not society has a grand discount rate that we believe ought to apply to children, such that child-rearing which reflects a rate higher than such a grand discount rate might be considered neglectful or abusive. It is very difficult to think of the problem in this way, which is probably why we try to regulate in terms of the minimum quality environment. Government has recognized its limits in attempting to control childrens' environments, making sure that *schools* are smoke-free, lead-free and radon-free, implying that out of respect for individual rights, government is stopping short of imposing specific trade-offs upon everyone. In short, it is not surprising that when children grow up to be adults and have their own children, they mimic the trade-offs that their parents made. The larger policy solution is to attempt to remedy the growing income gap between rich and poor, because the discount rate gap will probably track the income gap.

Regarding the Van Houtven and Smith paper, Dr. Jenkins noted that the infertility risk issue was an issue of growing importance. Dr. Jenkins was surprised to hear that *true* infertility has not increased, in light of popular evidence that sperm counts are reported to be lower, and that there are more biological threats to fertility than previously. As a valuation issue, it seems that the value of a reduction in infertility risk is somewhere in between valuing a reduction of a risk in death and valuing ecosystem services, in terms of depth of study. But this is probably more difficult a task to value a reduction in risk of infertility than it is to value a human life. For example, the abortion debate suggests that we may not even be sure that a fetus is a human life. Nevertheless, it should not be surprising to find that the value of a statistical conception is worth less than the value of a statistical life. For example, there is probably some societal agreement that in cases where a choice must be made between an unborn baby and the mother, the choice is typically to save the life of the mother.

Dr. Jenkins wondered why the hypothetical medication scenario seemed to make it difficult for men to respond; could it have been because only women were hypothesized to be taking the drug? Perhaps if medication were hypothesized for the man, it would alleviate the respondent problems with men. Nevertheless, Dr. Jenkins complemented the medication scenario because it presents infertility in a fashion similar to what an EPA policy would implement. On the other hand, this does miss the "outrage" costs of environmental contamination. Dr. Jenkins indicated that as a respondent she would be willing to pay more first to do away with the associated injustice and second, to perhaps deal with broader concerns about what the implications are for other species and other natural processes.

With respect to the Dickie paper, Dr. Jenkins noted that Dr. Dickie is pointing out the advantages of large national data sets in estimating the value of health benefits, in that the researcher has better representation of the public, reproducible results and lower costs. From the policymakers' standpoint, there are more benefits. There are some surveys that are repetitive, so that one can track, over time, how specific health effects are valued, and observe trends. Also, national data sets better enable the researcher to make demographic delineations such as age. A third benefit is that we would avoid the "trained seal" problem that was referred to in an earlier session, in that people are not responding to very specific scenarios that are unnatural reaction.

Dr. Dickie's theoretical model points out two differences between children and adults. When a child becomes ill, a child not only loses her own time, but also the parents lose time caring for them. A second difference is that a child's illness may affect the child's opportunity set as an adult, as it robs the child of the opportunity to make choices regarding what her adult life might look like.

In conclusion, Dr. Jenkins complemented the relevance and quality of all three papers.

Question and Answer Period for Session IV

George Van Houtven, Research Triangle Institute, opened the session by acknowledging a comment made by Ms. Jenkins in noting that the terminology "value of a statistical life" was somewhat inaccurate with respect to his paper. As Ms. Jenkins pointed out, since their paper dealt with infertility risk instead of mortality risk, a more appropriate term might be "value of a statistical conception."

George Tolley, University of Chicago, commented that contingent valuation does not deal well with endogenous risk. Household production function models make strong assumptions about preferences in that risk-adjusting behavior is not accounted for. A second point made by Mr. Tolley was that the emphasis in this workshop thus far on soliciting values from *private* goods was problematic, in that it ignores the value of mortality risk reduction to society as a whole. That is, there is legitimately a public good aspect to mortality risk policy that should be measured as well.

Kerry Smith, Duke University, posed a philosophical question to the workshop participants regarding contingent valuation: is it more important to make certain that the question elicits a response to the precise policy question, or to make sure that the respondent understands the question clearly? There is a fundamental trade-off in that either a value is obtained for a specific policy, but at the cost of imposing strong assumptions, or a value is obtained for a commodity that the respondents understand but is not matched to a specific policy. This is true in the context of a production function, from which values are obtained but need to be identified back to a policy value of interest by imposing assumptions. Al McGartland, US EPA Office of Policy, suggested that one alternative may be to do a survey in the context of a household production function approach.

Thomas Crocker, University of Wyoming, expounded upon Mr. Smith's comment, pointing out that a deeper philosophical question pertains to the usefulness of economics in valuing non-market goods. If there is a well-established market basis for a commodity, then all standard economic axioms hold up well; if there is no market, however, the axioms are violated. When axioms are violated, we no longer know what "value" means, as there is no body of theory to deal with that situation.

Kim Thompson, Harvard School for Public Health, pointed out that environmental issues affect not only children's issues, but also ecosystem services. What would be useful is a single metric that combines the valuation of children and adults. For example, there may be some literature from the medical profession that combines valuations of children and adults, and the transferance of qualitative measures of risk.

Christina McLaughlin, US FDA Center for Food Safety and Applied Nutrition, commented that the Needleman estimate of the effects of lead exposure on IQ utilized by Mr. Crocker is unreliable because it added effects in a manner that led to double-counting, and hence probably over-estimated the effect of lead exposure on IQ. Also, Ms. McLaughlin questioned whether it was appropriate to use IQ as a measure of damages, which is itself of questionable accuracy. Mr. Crocker responded that he was aware of the controversy of the Needleman data, as he conducted a review of the study. Mr. Crocker and a colleague found that there were some coding errors, missing data and some questionable data analysis. These omissions might have led to an underestimation of the biomedical consequences of lead poisoning because it failed to take into account the opportunity cost of the mother's time (which was invested in inverse proportion to the opportunity costs), and also neglected to account for the improvement in the child's cognitive development problems resulting from the time invested by the mother. Using a Bayesian diagnostic analysis, Mr. Crocker and his colleague were able to show that the Needleman data was very accurate, once the omissions had been corrected. This is an example of how difficult it is to conduct this kind of analysis because of the need to account for how people adjust to adverse developments. On a second point, Mr. Crocker, acknowledged that while IQ is not a perfect measure, it is widely-accepted in the psychological community, and in fact is fairly accurate when used to evaluate young subjects.

Amalm Mahfouz, US EPA Office of Water opined that it was spurious to survey respondents on their willingness to pay for a reduction of risk outcomes that have not yet occurred, and apply these measures as if they had, giving rise to a general and inherent inconsistency in using ex post measures for ex ante situations. John Horowitz, University of Maryland, replied that the discounting literature addresses this issue to some extent. Mr. Smith further replied that even if the measures are not perfect, it is necessary to build a structure for things that we cannot observe and link them to things that we can observe. As is the case with social science generally, the only time we can conduct a perfect study is the situation where we do not need it, that is when the outcome is already known.

Ms. Thompson opined that benefit-cost analysis has not historically been very good at accounting for individual variability, and that researchers need to do a better job of dealing with variability on the individual level, and with violations of basic assumptions.

Richard Belzer, Washington University, expressed concern that very specific policy prescriptions were being made on the basis of very weak evidence. Mr. Tolley and others replied that "policy won't wait" for overwhelming evidence.

Concluding Remarks

by Jane Hall, California State University, Fullerton

Ms. Hall was unable to attend the conference.

Concluding Remarks

by Trudy Ann Cameron, University of California at Los Angeles

The conference organizers have asked me to distill some of the key issues from this conference, from my perspective, and to wrap up these two days of presentations and discussion by academics and policy-makers with a few summary remarks. I am both flattered and intimidated to be assigned this task.

It seems the most useful to organize my observations by issue, rather than to review individual papers in any formal order. The assigned discussants have already done an excellent job of raising important questions about the papers, and many helpful comments have cropped up in the discussion from the floor. I have noted names of speakers and commenters where I was able to identify them, but I also offer my apologies and my sincere gratitude to all those whom I have failed to credit explicitly.

• Subjective Individual Probabilities vs. Objective Actuarial Probabilities

I think the strongest general theme that cuts across almost all of the papers in this conference, either recognized or not, has been the problem of **subjective individual probabilities** versus **objective actuarial probabilities**. The former is what drives people's choices under uncertainty; the latter is what we can hope to affect via environmental policies.

The issue of subjective versus objective probability was raised explicitly by Robin Jenkins, who explained that their project (on valuing a statistical child's life based on bicycle helmet prices) assumed the two were identical. Subjective probabilities were also mentioned by George Van Houtven in his discussion of "private baselines" for respondents in his and Kerry Smith's survey study of willingness to pay for reductions in the risks of infertility.

We might wish to make policy based on science (objective probabilities), but individual people are going to make choices based on perceptions (subjective probabilities), and these choices are the only kind we can observe ex ante in order to infer the likely benefits from policy measures. Try as we might, via information provision, to get people to internalize our scientific objective probabilities, we can never know for sure that they have adopted these probabilities (we rarely even check). If we assume that they have, and model their WTP for risk reduction assuming that our objective probabilities are being used when they are not, we will be deriving biased estimates of willingness to pay for risk reduction.

• What They Don't Know Won't Hurt Them?

We need to know a lot more about people's **cognitive processes**. Perceived "risk" can be interpreted as the subjective probability of some adverse future outcome, in this case, some health endpoint. Subjective risks might be correct; sometimes, however, they are vastly out of line with reality, being either too high, or too low.

We also do not know enough about the **potential for manipulation** of individual subjective probabilities by information provision. What types of consumers are susceptible to having their individual subjective probabilities manipulated by authorities such as government scientists, the Surgeon General, environmental groups, or industry advertising? Does the **nature of the information source** matter? Does **the degree of susceptibility** vary across sociodemographic types? I've been exploring this on a pilot survey concerning expectations about climate change. The answer to both questions seems to be "yes."

In most applications, we have no way of knowing how individuals combine their own **priors** on risks with the information we provide on our surveys to generate a **posterior distribution** on risks that forms the basis of their response to our valuation questions. We usually assume, blithely, that their choices are based exclusively on what we have told them--that they completely discard their subjective priors and fully subscribe to the scenario we provide. The **credibility** of an information source seems to be a key determinant of how closely people attend to our scenarios in formulating their own conception of the good we are asking them to value. (Cameron, 1998). If we are less than credible, they will down-weight what we tell them and value some other "good" (consisting of health effect and probability), the precise identity of which is beyond our control.

• Risks are Not Point-Valued--They Are Distributions

Individual subjective mortality risks are probably not point-valued. Even if you inform respondents that the probability of death from a certain environmental hazard is 23 in 100,000, it is their prerogative to disbelieve you, and to instead formulate a response to your valuation question by using their *subjective* assessment of this probability. Their subjective assessment might possibly have an expectation of 23 in 100,000. But it might also be, say, normally distributed with 95% of the probability density falling between 3 in 100,000 and 43 in 100,000.

• Information Provision: Can We "Explain" some Problems Away?

In the Wednesday morning question period, the possibility was raised that manipulation of preferences by providing information about risks might increase utility by as much as the elimination of the risk. People's risk *perceptions* are presumably what matter to utility, not actual scientifically measured risks. Thus *subjective* risks are what drive choices in our WTP questions, yet *actual* risks are what can be manipulated by policy. If actual risks are "acceptable," whereas perceived risks are "unacceptable," then an information campaign may indeed do more to improve utility than eliminating the actual risk, particularly if the populace would remain unconvinced that the risk has been eliminated.

This leads us to the insight that there are tradeoffs between spending scarce environmental management resources on information programs as opposed to hazard mitigation programs. The tradeoffs will be a bigger issue in cases where the public has a uniformly poor understanding of actual risks. Willingness to pay to reduce environmental risks is a function not only of *expected* health endpoints (such as a 22/100,000 chance of an adverse outcome), but also of the degree of *uncertainty* about those endpoints. If willingness to pay for the same underlying reduction of threat could be reduced by 50% if people understood the scientific risks and believed them, then providing the information will result in an increase in social benefits of this amount. There may be some cases where an information program may represent the "highest and best" social use of management resources.

• Risk Communication vs. Risk Elicitation

A common thread in several papers was the challenge of communicating risk to survey respondents. Phaedra Corso's visual aids, Alan Krupnick's work, and George Tolley's "Wheel of Death" are good examples, as is the Van Houtven and Smith graphical profile of fertility risk. This is still too much of a "one-way street." Risk *communication* (i.e. the researcher explaining environmental health risks to the respondent) was the dominant concern. There was relatively little discussion of risk *elicitation* (i.e. the respondent conveying to the researcher the perceived environmental health risks upon which their choice behavior is based). The majority of papers in this conference did not address the possibility of empirical "slippage" between subjective and objective probabilities, and I believe that this problem is very important.

However, elicitation of subjective probabilities is a tough problem. Even many college sophomores at a prestigious public university cannot comprehend a relative frequency histogram at first, let alone draw one that summarizes their subjective probabilities regarding some event in a way that is consistent with their verbal description of these probabilities. This illustrates what survey researchers are up against with the general public. As researchers, most of us could express a probability distribution, but this is not an innate skill, it is learned form of expression.

It is worth noting that researchers who have studied the economics of aging have begun to address the problem of eliciting probabilities from subjects in their studies. Michael Hurd and Kathleen McGarry, for example, have had some success in asking samples of elderly people about the probabilities that they will live to age 70 or to age 80 (as opposed to asking them to specify their expected age at death). Facilitating the two-way flow of risk (probability distribution) information between researcher and subject is a vitally important part of the agenda in environmental health valuation research.

• Misguided Pursuit of a Single, Handy, One-Size-Fits-All VSL

Much of the discussion at the conference seemed to orbit around the problem of identifying "the" value of a statistical life. The observation that different studies have produced different values for this elusive quantity appears to be the source of some discomfiture. Admittedly, there is policy-making demand for a single number, like $5.8 million. One number could be remembered easily and universally applied. And it would be democratically appealing if everybody's life were to be valued identically. But I submit that there is no one number that can be universally applied.

Here, there are parallels to the discussion of "benefits transfer" versus "benefits function" transfer. We *do* want to explore how the choices that individual people make belie the values they place on marginal reductions in their own morbidity or mortality (and upon the morbidity and mortality of family members or broader society). But individual choices are constrained by income and prices. We need to estimate a VSL function that allows sociodemographic heterogeneity *and* controls for the nature of each chooser's constraints. Having estimated such a function, one could then counterfactually simulate the choices the individuals in the sample *might* have made, had everyone's constraints instead looked like those faced by the middle class (the median voter?). If the respondent's subjective understanding of the probabilities associated with health risks is part of the information set driving their choices from which we deduce the VSL, then we might also counterfactually simulate their VSL if these subjective probabilities were modified to reflect the objective facts about health risks.

• VSL *Functions* and Environmental Justice

Ellen Post asked how we could attribute a social value to the life of a "crack baby" based on its mother's observed choices relative to the child's health risks. Addictive behavior is an extreme case that has challenged economists for some time. Nevertheless, the question in a similar form can be applied to socioeconomically disadvantaged children in general.

Remember that **different choices** can stem from **different preferences** or from **different constraints**. Most basic economic theory also assumes full information (and zero transactions costs, etc., etc.). If it is *only* preferences that differ across individuals (perhaps according to sociodemographic groups), then economists are prepared to allow consumer sovereignty to prevail. If *constraints* differ across groups, however, an equity (distributional) issue arises. A persuasive social justice argument can sometimes be made that the amount of risk reduction that should be provided to everyone (as a public good) is the amount they would, on average, be "free to choose" if they all had comparable resources and perfect information.

• Diminishing Marginal Utility?

Phaedra Corso's paper went a bit too far in its demands that WTP be *proportional* to the size of the risk reduction that the survey stipulates. All that the economics requires (assuming perfect information—namely that respondents are answering the same question that you believe you are asking) is that "more should be better" if we are talking about a good, as opposed to a bad. There is no requirement of affine linearity. In fact, diminishing marginal utility is probably expected to be the norm, rather than constant marginal utility.

• Half-empty vs. half-full?

I'm sure it has come up before whether people respond to the absolute magnitude of two different levels of scope in risk analysis, or whether they interpret the information we give them in other ways. For example, some people who might worry about mortality risks might look at a reduction in risk due to a side-impact airbag from 20 in 100,000 to 10 in 100,000 as a 50% decrease in risk of **death**. But others, of a more optimistic bent, might think instead of the probability of ***NOT* being killed**, with or without a side-impact airbag. This probability will go from 99,980 in 100,000 to 99,990 in 100,000, which is a (10/99,980) *100%, or a 0.01000% (1/100%) increase in the probability of NOT being killed—a barely detectable improvement. We need to know more about what goes on inside people's heads as we feed them information. This takes us dangerously into the realm of cognitive psychology…but the detour is essential.

• **Non-response "Responsibilities"** (my current crusade)

Phaedra Corso is rightly pleased with her 76% response rate among households who were successfully recruited in the initial telephone contact of the phone-mail-phone survey. However, it is important to report how many valid residential telephones were simply not answered (e.g. answering machine used to screen calls; no reply). What are their characteristics? How many of those households with which voice contact could be established were not interested in participating in the sequence of surveys. What were their characteristics? Of the 24% who dropped out after the initial phone contact, what were their characteristics, and are they systematically different from the respondent group? If the individual's decision not to participate in your survey is in any way correlated with their WTP for risk reductions, then non-response bias can compromise your ability to scale your sample estimates to the general population.

The all-to-common strategy for dealing for non-response in this literature is to calculate and display marginal means of the distributions of sociodemographic variables in the sample and in the population. If these marginal means are not "too" different, it is presumed that non-response is "not a problem." But just because two groups of people (respondents and non-respondents) appear to be similar based on their observable characteristics does not mean they are similar based on their unobservables. Crucial unobservables such as "concern for the environment" (the salience of the survey's subject matter) can be what distinguishes a respondent from a non-respondent, even if their observable characteristics are identical. If the estimating sample vastly over-represents people with a high level of concern about the environment, WTP estimates from the sample will be misleading as a measure of mean WTP in the population.

All is not lost--provided the researcher retains some information about the numbers that were dialed randomly that were unsuccessful contacts, or about the zip codes to which unreturned questionnaires were sent. With luck it will be possible to map these telephone numbers back to geocoded information such as zip codes or census tracts. If this is the case, it will soon be possible (over the next year or so) to implement sample selection models based on zip code moment matrices for individual Census data by zip code (calculated from the 1-in-6 sample). One can approximate these models, using just the means, right now. We are working on preparing the necessary covariance matrices right now, with a proposal to the Bureau of the Census to process these data at UCLA's California Census Research Data Center. The local team seems enthusiastic; it will not take long to implement once approval has been gained.

• **Survey Experimental "Treatments" and Precision of Value Estimates**

"Treatments," such as alternative visual aids for risk communication, need not affect *only* the mean values of WTP. They can also systematically affect the precision (or variance) of WTP. Why do we want to pay attention to precsion? Precision is an important issue because it relates to how much data you need to collect before you can narrow to an acceptable width the confidence bounds on whatever unknown quantity you are trying to estimate. I believe it was Melonie Williams' point that "stated preference methods will be required; they are expensive, and we need to identify cost-effective survey modes."

Over the last few years, stated preference (conjoint) researchers have been devoting a lot of attention to the so-called "scale" issue in their random utility models. Value elicitation methods which provide for lesser error variances are preferred. However, these survey "treatments" may also have different effects on the point values of the utility parameters, not just on error dispersions. There may be tradeoffs. While experimentation with elicitation methods continues, we do not yet understand completely the nature of these tradeoffs. Phaedra Corso's study concerning alternative risk-communication methods (different visual aids), for example, looked only at the effects of these different treatments on point estimates of willingness to pay. Many researchers (and presumably funding agencies) will be intrigued about the effects of these alternative treatments on dispersions.

The decision of Alan Krupnick and his co-authors to use an abstract rather than a specific commodity stems from a comparison of the apparent consequences of using relatively more- or less-specific descriptions. In their experiments with commodity definitions, they had to trade off the problem of assumptions associated with specific "named" diseases against the problem of scenario rejection based on inadequate detail. A formal experimental design to quantify the exact nature of these tradeoffs would be very useful. It may or may not generalize to other applications, of course.

DeShazo and Fermo (1998) have conducted an assessment of complexity effects on the precision of WTP estimates from an assortment of conjoint instruments. They identify five different dimensions of complexity (including number of alternatives, number of attributes, within and across alternative measures of correlation among attributes, and so on). Each of these complexity measures is demonstrated to have statistically significant effects on the dispersion parameter in their random utility model. This research will be informative to researchers dealing with complexity in the description of mortality and morbidity risks.

• "Informed Consent" and WTP Questions; or, the Question of Trained Seals

Alan Krupnick pointed out that he wasn't too sure *how much* people should know about the good being valued before they are allowed to inform the government on policy. Do we want to consult the "person on the street"? Or should we insist that informants have at least some level of expertise with respect to the issue in question? Reed Johnson talked about the potential hazards of using "trained seals" to assess the typical behavior of seals in general.

George Tolley noted in his presentation that experience should matter to values. In work with Jeff Englin, I have certainly found that a respondent's past experience with the good to be valued has a systematic effect not only on *mean* WTP, but also on the *dispersion* in their WTP (e.g. values appear to be heteroscedastic with respect to past experience). Others have found, not surprisingly, that experience with food poisoning affects people's WTP to avoid it, as I recall. (Ready and Buzby? Kerry Smith? Hensen (in the UK).) With respect to the study reported by Phaedra Corso, did they think to ask if the respondent, personally, had ever been in an auto accident where they were injured? not injured? Had anyone in their immediate family been seriously injured or killed in an auto accident in the last 20 years? (This might of course be an omitted variable that is correlated with gender or with risk perception, that could be muddying the apparent coefficients of your models.)

• Endogenous and Exogenous Experience

In survey research, there are also two kinds of "experience" with the good to be valued. One is the kind that respondents have accrued on their own. The extent of their natural experience with an issue is an endogenous variable—it is a product of the same sorts of processes that contribute to the respondent's value of the good in question. Suppose we are talking about food poisoning. Whether or not you *have* experienced food poisoning in the past may have quite a bit to do with *how much you care* about avoiding food poisoning. The other kind of experience is the kind that survey researchers provide artificially on their questionnaires, for example, in the form of information or context for the respondents stated choices. Variations across individuals in the amount of this sort of experience can be randomly assigned, and is therefore exogenous. It is likely that BOTH types of experience will affect WTP distributions (not just means, but also dispersions).

• Now Tell Me Just Exactly *How* Willing Are You to Pay?

Just as people are likely to be uncertain about health risks, and to place greater or lesser faith in the information being provided to them by the government or by survey researchers, many people will be uncertain about their likely behavior in the hypothetical markets we employ in stated preference surveys. We need to capture this contingent choice uncertainty when we elicit valuation information.

Laurie Chestnut's discussion of Phaedra Corso's presentation brought up the issue of inviting respondents to indicate how confident they are in their answers. This can be done as a follow-up question, with the response modeled jointly and/or used as a control for the expected WTP (although with caution, because there are some econometric problems in "program evaluation models" employing two discrete variables).

There appears to be some promise in employing "multiple-bounded" contingent valuation questions, where "probability of being WTP," in several categories, can be employed in lieu of a simple yes/no response (which would be just two categories). The responses can then be modeled as an ordered logit or probit instead of a binary choice model. These responses can also be elicited at each of several bid values, providing a broader picture of preferences. Of course, "going back to the well" may times with each respondent invites the same sorts of problems faced by stated preference researchers (conjoint analyses) that require several choices from each respondent (e.g. fatigue, etc.)

• Nice Survey Research. Real Expensive… But We Have to Do Benefits Transfer Around Here?

It was valuable to have Melonie Williams remind us of the perennial government need to do benefits transfer. Mark Dickie raised the issue again on the second day. I believe that the method-of-moments ideas devised and demonstrated by Kerry Smith and his co-authors have great potential for helping us think rigorously and systematically about benefits transfer. This is the freshest "benefits transfer" insight in quite some time. It is going to be an essential strategy when we are trying to merge empirical evidence regarding different types of value estimates, all of which can be characterized as a different items on the menu of alternative utility-theoretic welfare concepts. The approach has much in common with the "calibration" strategy employed by one camp of modern macroeconomists.

• Oh, No! Have I Been Driving the Wrong Car for 18 Years?

Bill Schulze reported on a barely-off-the-presses pilot study concerning hedonic prices for auto safety as a function of family composition. The sample is 4000 single-car (unusual?) households in three classes: (a) with neither kids nor retired people present, (b) with kids, but no retired people, and (c) with retired people but no kids.

What Bill characterizes as a simultaneous equations problem is in fact a severe multicollinearity problem in the revealed preference data (which is quite a different kettle of fish). There is also an endogeneity problem in the *proxy data* he uses for the individual household's expected mortality rates by vehicle make/model/year. I am fundamentally troubled by the use of statistical fatality rates by vehicle type, even when controlling for the marginal means of driver characteristics and driving conditions within the sample of fatal accidents. I still don't think this gets around the fundamental endogeneity of vehicle choice.

Is there a better way to control for endogenous vehicle choices using Bill's current data? Observed average mortality rates by vehicle make/model/year are *not* the same mortality rates that would result if we randomly assigned people to different cars and observed fatality rates by make/model/year. People self-select their vehicles. Suppose everybody drove the same way, dealt with frustration the same way, had the same reaction times, the same visual acuity, the same driving experience and the same number of distractions while driving. Only then would the observed fatality rates per 1000 cars sold, for each make/model/year, be a good measure of the fatality risk of that vehicle type for a *randomly selected* driver.

I assume there exists a data set for the 1100 distinct types of automobile that includes total number sold, as well as another data set that records information pertinent to every traffic fatality of someone driving or riding in one of these vehicles. These fatality data are then grouped according to model/make/year, and marginal means are generated for the circumstances of the accident (including the characteristics of driver). To measure what he wants, however, Bill needs a random sample of vehicles and drivers, observed over a certain period. What he wants to model is the *probability* of a fatal accident as a function of the type of vehicle, controlling for the type of driver, etc.

The observable dependent variable would be a zero-one variable for each driver or driver-year that takes a value of zero if there is no fatality, and a value of 1 if there is. The explanatory variables would be type of vehicle, V (a very long list of dummy variables) , driver characteristics, D (age, gender, ability to deal with frustration, etc.) and behavior, B (e.g. drinking habits, seatbelt habits, night driving habits, etc.) and typical driving conditions, W (e.g. traffic, rainfall, storms, ice, etc.)

$$(0,1) = \beta_1 V + \beta_2 D + \beta_3 B + \beta_4 W + \varepsilon$$

But even this individual data would not get us around the problem of the fundamental endogeneity of vehicle type choice. Bill is in need of an unbiased estimate of the parameter(s) β_1. Even if these individual data were available, he would have to figure out how to instrument for vehicle type choice, perhaps by using other econometric vehicle choice models to construct a predicted choice probability to use as an instrument (that would be purged of correlation with the error term).

Surely vehicle manufacturers have attempted to discern consumer choices among vehicle makes and models as a function of vehicle attributes (possibly even safety) and sociodemographic characteristics of consumers. Consider Berry, Levinsohn, and Pakes' work. There is almost certainly something there that can be transferred to this study. Their random utility multiple choice models might even allow them to infer a marginal value of mortality risks at least as well as you can do with your data.

But again it comes down to whether actual science matters, or whether perceptions of risk matter…. Consider an alternative "take" on the problem of mortality risk data. Perhaps demand for vehicle safety is not based on *actual* safety, but on *perceptions* of safety, which might be drawn from just the sorts of data that I have just complained were problematic. People *think* they are buying safety when they purchase a Volvo. However, suppose the apparent safety of a Volvo is just an artifact of the unusually fastidious driving habits of the typical person who drives a Volvo—suppose the car itself is fundamentally no safer than a Corvette. The consumer is still paying a safety premium when they buy the car, even though the perceived safety is a figment of their imaginations.

But suppose a clean objective Mortality Risk variable could be obtained for each car, how should systematic variations in WTP for mortality risk be modeled as a function of family composition? The regression coefficient on the mortality risk variable is the quantity of interest. Render it a systematic varying parameter that depends upon a whole menu of family characteristics. And don't forget diminishing marginal utility—WTP for risk reduction should be *allowed* to vary with the amount of risk reduction if the data dictate this.

For the primary data collection, Bill might want to ask respondents directly about "what do you look for in a car?" People could be allowed to rank all the usual attributes of interest, including safety, speed, legroom, headroom, trunk space, style, reliability, color, warranty terms, proximity of dealership/service, and whatever other "important" features come out of focus groups. This might help us understand why some people value a car for its safety features, while others value the same car more for its size and comfort.

The key insight for Bill's team to keep in mind is that when the problem is one of multicollinearity—lack of sufficient orthogonal variation in the values of the regressor variables—then sometimes there is *absolutely nothing* that can be done to discern a precise estimate of the slope on one of the collinear variables. Even with 1100 different vehicles in the choice set, attribute space for cars is pretty sparsely populated. The available attribute combinations simply do not span all of attribute space. Suppose what we seek to know is the difference in WTP for a vehicle as a function of mortality risk, *ceteris paribus* (everything else held constant). If mortality risk never varies without other desirable or undesirable features being different as well, then the non-experimental data on vehicle attributes provided by the real market is not up to the task we require.

In these circumstances, however, additional data can sometimes be brought to bear on the problem. In this case, there will be an opportunity break the chronic multicollinearities in the actual data by resorting to contingent choice data. Create a hypothetical vehicle similar to the one a family chose, but different in just one key dimension; ask if they would have preferred that alternative. We had a similar problem with revealed preference valuation of water levels at Federal projects along the Columbia River system (Cameron, Shaw, Callaway, Ragland, and O'Keefe, 1996). Insufficient orthogonal variation across waters and over time led us to introduce contingent behavior components into our survey to identify crucial parameters.

There is one class of circumstances wherein multicollinearity in the observed data might not matter as much. That is when there *will never be* any independent variation among the multicollinear variables. Suppose it is technologically impossible to provide safety without also providing a heavier car, and that safety is a perfect linear function of vehicle weight. If nobody can ever consume more safety without also consuming more weight, then a change in vehicle safety will always produce a change in WTP that captures *both* the higher value of more safety and the higher value of more weight. This is a lucky thing if all we are trying to do is to predict WTP for different vehicles. Unfortunately, it does not get us anywhere if we are trying to isolate just the value of additional safety.

- **The Aggravations of Relying on Non-Experimental Data**

Most economists would agree that revealed preferences, as a source of information about environmental or health values, dominate stated preferences as an indicator of these same things. However, one insufficiently appreciated shortcoming of revealed preference data is that the conditions under which choices are observed were not established by orthogonal experimental design.

Consider the child IQ production function described by Tom Crocker and Mark Agee. Lead policy will pretty much affect ONLY lead levels in children, not their overall socioeconomic and physical circumstances. For valid ex ante predictions about the effect of lead reduction on child IQ levels, however, the correct "experiment" would have been to first remove all sources of lead from the environments of all children in a representative sample. Then, the researcher would have to randomly assign different amounts of lead to different children, so that lead exposure had no correlation with anything else about the child. Obviously, such a field experiment would be impossible (and unethical).

The consequence is that even with the best field data, it is ultimately the case that child IQ levels and body lead burden are jointly determined by the same vast and complex set of processes that have led to this child living in this place at this time. As an aside, I often explain to my econometrics students that since the world is a closed system, everything is endogenous…it is only a matter of degree. For each empirical problem we somewhat arbitrarily partition the continuum of variables into two groups and label one group (sometimes just one variable) as endogenous, and consider all the rest to be "exogenous."

It is worth remembering that despite the desirability of using revealed preference data for inferring health values, most revealed preference data from sources outside the laboratory are non-experimental and therefore vulnerable to this problem.

- **Finessing Subjective/Objective Probability by Assuming it is 1.**

Reed Johnson reported on a conjoint choice study of 400 Toronto respondents, inferring WTP to avoid for outcomes that would otherwise occur with certainty. There was not much about Reed's project that I would disagree with, at least based on his verbal description, since I have not yet had the opportunity to study the paper. I remain concerned, however, about the *ex post* nature of the values this study elicits. Individuals' subjective WTP amounts are often "option prices," in the sense of Daniel Graham's exposition about cost-benefit analysis under uncertainty. Individual option prices for uncertain future outcomes are fundamentally based upon subjective probabilities, and these option prices can be manipulated by manipulation of subjective probabilities. If you can alter someone's probability distribution over the health consequences that are being valued, you can alter their ex ante willingness to incur costs to avoid that particular consequence. Some of the remarks of both George Tolley and Jay Shogren kept me thinking about this option price issue.

Daniel Graham's original development of the theory of cost-benefit analysis under uncertainty (AER, 1982?) was in terms of **community risk** (i.e. objective actual probabilities, common to the entire community), rather than individual uncertainty. This is analogous to our dilemma about whether we should force people to acknowledge objective actuarial probabilities about an assortment of health endpoints, or whether we should allow them to employ (or just acknowledge that they *will* employ) their own subjective revisions to these "official" probabilities. Even if we choose to do the latter, there is an opportunity to counterfactually simulate what *would have been* their option price had their perceived subjective probabilities matched scientifically measured objective actual probabilities.

The policy question is emphatically NOT about health endpoints that occur with certainty. It is about uncertain future events. Reed has avoided the uncertainty problem in his study, but we cannot avoid it in policy-making. Thus his study is half of the answer to a policy question. A very important half, to be sure. But without an understanding of the subjective probability formation process, we do not yet have enough for determining ex ante willingness to pay for environmental health protection.

• Kids—And Example of the Economic Behavior of Other Species

In the late 1970's, I was greatly amused by demonstrations by Ray Battaglio of the economically rational behavior displayed by rats in the laboratory. It was somehow very satisfying to learn of the universality of the problem of making oneself as happy as possible when facing constraints, such as finite resources. Thus it is not surprising that Bill Harbaugh finds that any child old enough to recognize that candy and toys confer positive utility might be able to make rational economic choices. I am also greatly relieved to have my suspicions confirmed that even while some children can be observed to make apparently irrational choices some of the time, so will some adults, even Ph.D. economists (although the prevalence of errors declines in that order).

It occurred to me while listening to Bill's presentation that it would be intriguing to observe interpersonal variations in the frequency of economically irrational choices, perhaps over time, as well, and to see if there are any systematic determinants of this sort of economically anomalous behavior. Are the axioms of revealed preference violated more frequently when the individual is tired, or hungry, or distracted? Are there any traces of systematic sociodemographic differences? Clearly age and/or education seem to matter. What about other attributes? How about experience with the decision-making context? The types of goods being valued? Assumptions about the presence or absence of close substitutes? This inquiry would not, of course, immediately inform child environmental health valuation, but it appears to be a regression begging to be run, nevertheless.

• Opportunities for Combination of Data

I was greatly intrigued to learn from Mark Dickie that the Panel Study of Income Dynamics (PSID) Child Development Supplement (1997) data released last month might finally provide a reason for me to invest in learning how to work with the PSID. Over the last 15 years, dozens and dozens of labor economists have passed through UCLA giving seminars based on PSID data, yet I could never discern how this monstrous government panel data set might be of use to me and my research interests.

One thing that sparks my interest most is the possibility of linking these data, via internal-use geo-coding, to environmental quality data sets such as the Toxics Release Inventory or ozone attainment data, or other physical environmental data that might have a systematic effect on these children. Creation of such a data set would be immensely valuable. In particular, I have been trying to think of ways we might be able to seduce conventional labor economists into becoming interesting in children's environmental health issues. This PSID module might be a great opportunity. If economists primarily concerned with the valuation of environmental health could initiate a dialog with conventional labor economists by making creative use of special editions of the labor economists's own data sets, we might successfully expand the scope of interest in these topics. I will definitely be exploring this further!

- **Remembering that Other Groups Have Useful Ideas, Too.**

Near the close of the general question period at the end of the conference, Kimberly Thompson of the Harvard School of Public health suggested that economists should beware of re-inventing the wheel and should pay more attention to the large and growing inventory of medical research pertaining to child health effects. This is certainly a good idea. In the post-conference discussion, however, Jay Shogren noted that it would be immensely helpful if more researchers in the epidemiological community could be persuaded to include crucial economic variables in their studies. He brought up the point that public health researchers sometimes collect large national data sets on environmentally related disease, but fail to collect information about the degree of heterogeneity in indicators of socioeconomic status. This oversight can mean that a data set that would be of immense value is rendered almost useless for inferences about environmental health values. The omission of this key variable can mean that it is impossible to rule out "omitted variables bias" in the relationship between environmental conditions and health outcomes. The reason is that socioeconomic status is a key determinant of people's abilities to engage in averting behaviors with respect to poor environmental quality (e.g. to use air conditioners with filters, or to have bottled water delivered).

We can all learn from each other. That is what a conference like this one is for.

• Overall?

I found the presentations and discussions at this conference to be both interesting and provocative. It is invigorating to have so many researchers and policy folks, with common interests, engaged in discussion of critical basic research and its relevance for policy-making. It is cannot fail to be helpful to bring together both the producers and consumers of academic research to ensure that product development is on target with respect to its eventual uses. And it does not bother me at all that the presented papers span the entire spectrum of completeness. When a study is all finished, it is too late to make helpful suggestions for how it might have been done better.

It is misguided to think that "pure" academic research can proceed without reference to the value of the knowledge it creates from the point of view of society. As environmental and health economists, we have a moral responsibility to ensure that what we produce is useful—in the sense that it contributes to better decisions. Due regard for the policy implications of our work may not be the most highly rewarded dimension of our research when we are evaluated for promotion or salary increases, but it is what matters "in the real world."

The format and organization of this series of conferences is a great idea. I hope the policy folks will continue to make their voices heard. The two constituencies should be co-equal in this particular venue. Academics are accustomed to telling audiences how things work (we have had years of practice on our students). In this context, however, the policy folks have a responsibility to assert their views, *especially* when they conflict with what is being presented by researchers.

I would like to thank the conference organizers for inviting me to participate in this capacity. It is especially nice to have a really good reason to pay meticulously close attention to a complete set of conference papers. I learned a remarkable amount from my colleagues and from the policy-oriented participants. For me, a conference is always a success if I come away with new research ideas, which I have!