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The Effect of Information on Health Risk Valuations

ALAN J. KRUPNICK
Resources for the Future, 1616 P Street NW, Washington, DC 20036

MAUREEN L. CROPPER*
Department of Economics, University of Maryland;
Resources for the Future, 1616 P Street NW, Washington, DC 20036

Abstract

This article examines the effect of familiarity with chronic lung disease on people's willingness to pay to reduce their risk of contracting chronic bronchitis, and on their willingness to increase their risk of auto death to reduce chronic bronchitis risk. We find that persons who have a relative with chronic lung disease are willing to give up more income to reduce their risk of chronic bronchitis than persons with no first-hand knowledge of the disease; however, their willingness to increase their risk of auto death to reduce their risk of chronic bronchitis is no different, on average, than persons with no first-hand knowledge of lung disease. This suggests that responses to risk–risk tradeoffs may be more stable than responses to risk–income choices.

Key words: morbidity valuation, chronic lung disease

Considerable effort has been devoted to valuing small changes in risk of death, both through compensating wage studies (Thaler and Rosen, 1976; Dillingham, 1985; Marin and Psacharopoulos, 1982) and through survey approaches (Jones-Lee, Hammerton, and Philips, 1985; Smith and Desvousges, 1987; Gerking, DeHaan, and Schulze, 1988). Similarly, much attention has been devoted to the valuation of acute illness and its attendant symptoms (Berger et al., 1987). However, an important category of health benefits—reductions in the risk of contracting a chronic disease—has only recently received attention from researchers.[1] One approach to valuing such risks, developed by W. Kip Viscusi, Wesley Magat, and Joel Huber (1991), is to question respondents about their willingness to 1) trade income for reductions in risk of chronic disease, and 2) trade increases in risk of instantaneous death for reductions in risk of chronic disease. This is

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done using a computer-interactive survey in which respondents compare alternative risk–income or risk–risk bundles until a point of indifference is reached. Risk–income choices provide direct estimates of willingness to pay (WTP), while risk–risk choices can be converted to dollars using the value of a statistical life.

The use of this approach to value the risk of chronic disease raises two questions that do not arise in valuing risk of death. The first concerns the amount of information respondents may have about the disease they are valuing. Whereas death is something most persons have considered, the chronic disease they are being asked to think about may be unfamiliar to many respondents. One view on the matter is that persons who are unfamiliar with a disease cannot give valid and reliable answers to WTP questions. An alternative view is that citizens are often called upon to vote on issues about which they are imperfectly informed; therefore, valuing an unfamiliar disease is no different from other public decisions.

A second question concerns what should be traded for reductions in chronic disease risk. Viscusi, Magat, and Huber (hereafter, VMH) argue that respondents should find it easier to make tradeoffs between risk of chronic disease and risk of death than to trade off risk of chronic disease for dollars. The risk–dollar tradeoff often involves the response that people will not subject themselves to increased risk even if dollar compensation is forthcoming (Kunreuther and Easterling, 1989). Furthermore, the risk–income tradeoff has the disadvantage that it compares dissimilar objects.

We have attempted to shed light on these questions by administering the VMH survey, which elicits values of reductions in risk of chronic bronchitis, to persons in the Washington, DC area who have a relative with chronic lung disease.[2] This allows us to test the effect upon responses of familiarity with the risk in question and to see whether this effect is different for risk–risk and risk–income trades. We test the effects of familiarity on responses in two ways. First, we examine whether mean WTP, conditional on a vector of respondent characteristics (age, income, marital status, etc.), varies between two groups—one with no particular familiarity with chronic lung disease (VMH's sample), and the other composed of relatives of persons with chronic lung disease (our sample). One might, for example, expect that persons familiar with the disease in question would be willing to pay more to reduce their risk of getting it than persons unfamiliar with the disease. Second, we test whether familiarity alters the variance of responses, conditional on respondent characteristics. One might expect that familiarity would reduce the variance in responses if the latter reflects random noise.

We find that, conditional on respondent characteristics, the variance of responses is no different for persons familiar with the chronic illness in question than for persons unfamiliar with chronic lung disease. The large variance of responses within each sample drives this result. We also find that familiarity appears to have no effect on mean responses when one risk is being traded for another. However, persons who have a relative with chronic lung disease are willing to forgo more income, on average, to reduce their risk of chronic bronchitis than persons who are less familiar with the disease. This may reflect the fact that responses to risk–risk tradeoffs are more stable than responses to risk-income tradeoffs.

The stability of risk–risk vs. risk–income responses is also tested by seeing how sensitive each response is to the description of the commodity valued. Specifically, we compare WTP in order to avoid an abstract case of chronic lung disease with WTP in order to avoid a case of lung disease "like the respondent's relative's." As in testing the effects of familiarity, we find no differences in the answers to risk–risk tradeoffs, but find, even after correcting for the severity of their relative's disease, that persons are willing to forgo more income to avoid a case of lung disease "like their relative's" than they are willing to forgo to avoid an abstract case of lung disease.

Our results suggest two conclusions: 1) responses to risk–risk questions may be less sensitive to changes in the description of the commodity valued than responses to risk–income questions; and 2) at least for chronic lung disease, familiarity with the disease valued has no effect on responses, provided that the respondent is trading one health risk for another.

This article is organized as follows. In section 1, we review the theory underlying the risk–risk and risk–income tradeoffs in the VMH questionnaire. Section 2 describes the remainder of the questionnaire and our modifications to it, as well as the characteristics of the VMH respondents and our respondents. The results of the two surveys are presented in section 3, including tests of the effect of familiarity on responses.

1. The theoretical model

1.1. Risk–risk tradeoffs

The purpose of confronting respondents with risk–risk and risk–income tradeoffs is to elicit their WTP for an exogenous change in risk of chronic disease, i.e., the rate at which they are willing to trade income for lowered chronic disease risk. The risk–risk tradeoffs (termed trade 1 and trade 2) are based on a model in which there are three health states: death in an auto accident (D), having a chronic disease (C), and being healthy (H). Utility in each state is a function of income, I, and the state itself; therefore, utility conditional upon being healthy is $U(\mathrm{H}, I)$. Letting X denote the probability of having a chronic disease and Y the probability of accidental death, expected utility is given by

$$E(U) = XU(\mathrm{C}, I) + YU(\mathrm{D}, I) + (1 - X - Y)U(\mathrm{H}, I). \tag{1}$$

The individual's WTP for a marginal change in X, i.e., the rate at which he is willing to trade I for X holding expected utility constant, is the difference in utility between being healthy and having a chronic disease, divided by the expected marginal utility of income,

$$-\frac{dI}{dX} = -\frac{\partial E(U)/\partial X}{\partial E(U)/\partial I} = \frac{U(\mathrm{H},I) - U(\mathrm{C},I)}{\partial E(U)/\partial I}.^{3} \tag{2}$$

To estimate equation (2), one can make use of the relationship between WTP for a change in the probability of chronic disease and WTP for a change in the probability of death,

$$-\frac{dI}{dY} = -\frac{\partial E(U)/\partial Y}{\partial E(U)/\partial I} = \frac{U(\mathrm{H},I) - U(\mathrm{D},I)}{\partial E(U)/\partial I}. \tag{3}$$

By substituting equation (3) into equation (2), it is clear that WTP for a change in chronic bronchitis risk equals WTP for a change in risk of death times the ratio of the utility gained from avoiding chronic bronchitis to the utility gained from avoiding death,

$$-\frac{dI}{dX} = -\frac{dI}{dY}\frac{U(\mathrm{H},I) - U(\mathrm{C},I)}{U(\mathrm{H},I) - U(\mathrm{D},I)} = -\frac{dI}{dY}t. \tag{4}$$

This ratio, denoted t, is just the slope of the individual's indifference curve in X–Y space (see figure 1),

$$-\left.\frac{dY}{dX}\right|_{E(U) = \bar{U}} = \frac{U(\mathrm{H},I) - U(\mathrm{C},I)}{U(\mathrm{H},I) - U(\mathrm{D},I)} = t. \tag{5}$$

Thus, if one can find two bundles (X_A, Y_A) and (X_B, Y_B) that yield equal expected utility, t can be computed as $(Y_B - Y_A)/(X_A - X_B)$.

To estimate dI/dX, dI/dY may be obtained from compensating wage studies and t elicited using the series of paired comparisons described in section 2.

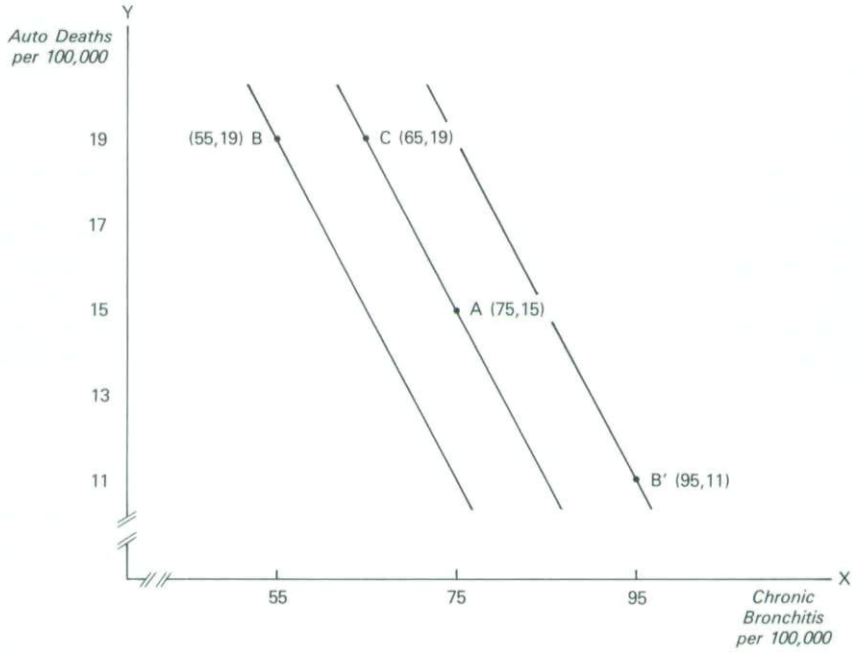

Figure 1. Indifference map for chronic bronchitis–auto death tradeoff.

1.2. Risk–income tradeoffs

A disadvantage of the above procedure is that it requires extraneous estimates of the rate of substitution between income and risk of death. To avoid this, VMH also confront respondents with risk–income tradeoffs (termed trade 3). To see how these can be interpreted, suppose that the probability of accidental death is zero ($Y = 0$), and suppose further that the marginal utility of income is constant and independent of health state. Equation (1) then reduces to

$$E(U) = XU(\mathrm{C}) + (1 - X)U(\mathrm{H}) + \alpha I, \tag{6}$$

where α is the marginal utility of income. WTP for an exogenous change in X is still given by equation (2), where $\partial E(U)/\partial I = \alpha$. Suppose that the individual considers the risk–income pairs $(X_\mathrm{A}, I_\mathrm{A})$ and $(X_\mathrm{B}, I_\mathrm{B})$ equivalent, i.e., they yield the same expected utility,

$$X_\mathrm{A}U(\mathrm{C}) + (1 - X_\mathrm{A})U(\mathrm{H}) + \alpha I_\mathrm{A} = X_\mathrm{B}U(\mathrm{C}) + (1 - X_\mathrm{B})U(\mathrm{H}) + \alpha I_\mathrm{B}. \tag{7}$$

Equation (7) implies that

$$\frac{U(\mathrm{H}) - U(\mathrm{C})}{\alpha} = \frac{I_\mathrm{B} - I_\mathrm{A}}{X_\mathrm{B} - X_\mathrm{A}}. \tag{8}$$

Hence, given equivalent risk–income bundles, one can compute WTP for a change in X directly.

2. Survey description

2.1. Risk tradeoffs

To value chronic bronchitis risk using risk–risk tradeoffs requires finding two (X, Y) bundles that the respondent views as equivalent. To elicit this information, VMH have the respondent choose which of two cities he would prefer to live in, where the two cities differ only in their risk of death in an auto accident and risk of contracting chronic bronchitis. Initially the individual is confronted with two risk–risk pairs, shown in figure 1 as point A ($X_\mathrm{A} = 75, Y_\mathrm{A} = 15$) and point B ($X_\mathrm{B} = 55, Y_\mathrm{B} = 19$). (All risks are expressed as cases per 100,000.) If initially $(X_\mathrm{B}, Y_\mathrm{B})$ is preferred to $(X_\mathrm{A}, Y_\mathrm{A})$, then Y_B is held constant (at 19) and X_B is raised until the individual is indifferent between $(X_\mathrm{A}, Y_\mathrm{A})$ and $(X_\mathrm{B}^*, Y_\mathrm{B})$, shown in figure 1 as point C ($X_\mathrm{B}^* = 65$, $Y_\mathrm{B} = 19$). At that point, $t = (19 - 15)/(75 - 65) = 0.4$, implying a WTP for chronic-bronchitis risk reduction that is 0.4 of the WTP for auto-death risk reduction. A similar procedure is used to determine two equivalent (X, I) pairs.

In the VMH survey, each respondent is confronted with a series of three trades. Trades 1 and 2 both entail trading risk of chronic bronchitis for risk of auto death but differ in the initial bundles presented to the respondent. As shown in figure 1, the respondent is initially confronted with bundles A and B in trade 1 and with bundles A and B′ in trade 2. Thus, a respondent who prefers city A in trade 1 should prefer city B in trade 2, unless the initial conditions cause the interpretation of the risks to differ. If the individual is an expected utility maximizer, the value of t obtained in trade 2 should be identical to that obtained in trade 1. In practice, the two may differ because the individual's indifference curves are not parallel straight lines or because the individual learns about his preferences in the course of the survey. Trade 3 presents the subject with comparisons to elicit equivalent risk–income bundles.

2.2. The VMH questionnaire

VMH administered their questionnaire to 389 persons in a shopping mall in Greensboro, North Carolina. Prior to being confronted with the three trades, respondents were read a description of a case of chronic bronchitis, showed pictures of persons with the disease, as well as a breathing apparatus that is sometimes used by persons with chronic lung disease. Subjects began the self-administered survey by supplying information on personal characteristics, including smoking habits, exercise, health status, and feelings about avoiding 13 consequences of chronic bronchitis (on a 49-point scale). This was followed by a practice trade involving a dominant risk–risk tradeoff (i.e., where one city offers lower risks for both commodities than the other city) and the three trades described above. The survey ended with questions about insurance and income.

2.3. The Resources for the Future questionnaire

We administered a modified version of the VMH questionnaire to persons in the Washington, DC area who had a relative with chronic lung disease. Subjects responding to newspaper ads were eliminated for any of the following reasons: 1) they did not have a relative 21 years old or over with a chronic respiratory condition; 2) they themselves had a chronic respiratory condition; or 3) they were under 18 years old. Respondents received $25 for taking the computer-interactive survey. In all, 189 questionnaires were completed.

Each subject was randomly assigned one of two versions of the survey (I and II). The protocol and survey for version I were identical to those used by VMH, with the addition of a set of questions appended to the end of the survey.[4] These questions asked how familiar the respondent was with his relative's disease and also asked about the severity of the disease.

In version II of the survey, tradeoffs were elicited for risk reductions in a disease like that of the subject's sick relative. Therefore, the set of questions concerning the relative's disease was placed *before* the tradeoff questions. In addition, all questions referring to a "case of chronic bronchitis" were altered to read "a case of chronic respiratory disease

like your relative's."[5] Further, the respondents were asked whether they were concerned about possible loss of income and premature death, two possible effects of chronic respiratory disease that were explicitly excluded from the case description given to the VMH and the version I samples. Finally, respondents were asked if their relative actually suffered from any of the symptoms or exhibited any of the characteristics mentioned by VMH, or had suffered income loss or had died prematurely.

2.4. Descriptive statistics

Some respondents in our sample and in VMH's had difficulty answering the tradeoff questions. For example, some respondents indicated indifference between point A in figure 2 and a point such as D that is dominated by A. To eliminate such responses from the sample, VMH defined five types of inconsistencies (see the appendix for a discussion and analysis of inconsistencies) and excluded all responses to a given tradeoff that exhibited one or more of them. We used the same criteria as VMH to eliminate inconsistent responses from our sample.[6]

All variables used are defined in Table 1.[7] Table 2 describes the persons in our sample and in VMH's sample who responded consistently to trade 1. Comparing our version I sample to VMH's sample, there are many similarities and some striking differences in

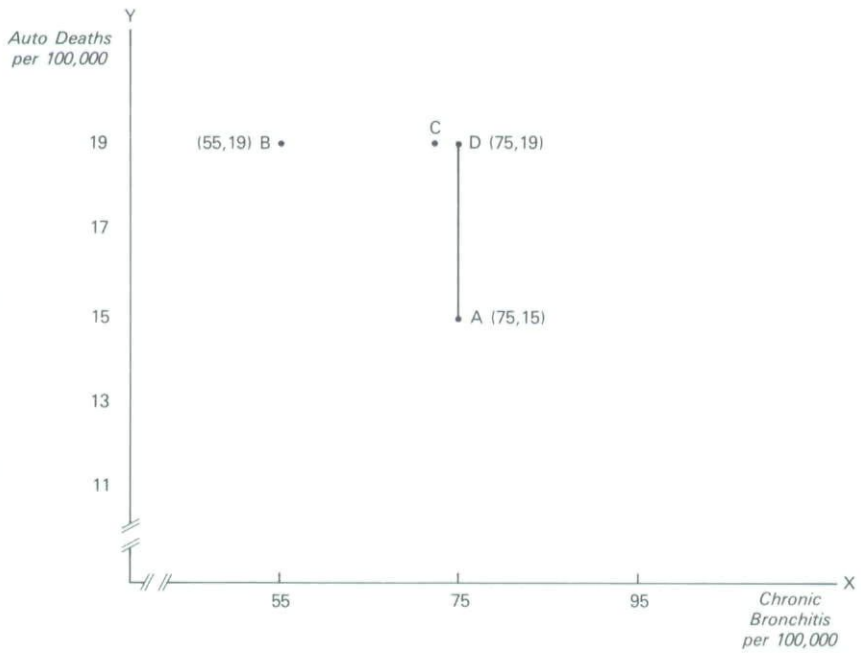

Figure 2. Illustration of inconsistencies 1, 2 and 4.

Table 1. Variable definitions

AGE	Age in years
AUTO_ACC	Friend or close relative lost in automobile accident Yes = 1 No = 0
BRSCORE	Severity of relative's breathing problems Range: 0–6
COLD	Respondent has experienced bad chest cold Yes = 1 No = 0
COUGH1	Relative has cough Yes = 1 No = 0
COUGH2	Time of day relative coughs A.M. = 1 Any time during day = 2 All day = 3
DK	Familiarity variable, sum of "Don't Know" answers on questions about relative's health Range: 0–6
DRIVER	Most often the driver when in automobile Yes = 1 No = 0
DUMMY	Flag for version I or version II Version I = 1 Version II = 0
EDUC	Years of education
EXERCISE	Hours of exercise per week
FAM	Self-assessed familiarity with relative's disease Scale: 1–49 1 = Not familiar 49 = Very familiar
HHSIZE	Number of persons in household HHSIZE = 5 for 5 or more persons
INCOME	Total combined household income in thousands of dollars
INSURANCE	Any member of family has over $20,000 in life insurance Yes = 1 No = 0
KIDS	Number of children under the age of 18 in household
LIVEWITH	Respondent lives with ill relative Yes = 1 No = 0
MALE	Sex of respondent Male = 1 Female = 0
MARRIED	Whether respondent is currently married Yes = 1 No = 0
MILES	Miles traveled in a year in thousands
PHLEGM1	Whether relative coughs up phlegm Yes = 1 No = 0
PHLEGM2	Time of day relative coughs phlegm Morning = 1 During day = 2 Both = 3
RDIED	Whether relative died prematurely because of his respiratory disease Yes = 1 No = 0 (set = 0 for version I subjects in pooled model)
RELHOSP	Whether relative has been in the hospital for respiratory disease in the previous year Yes = 1 No = 0
RLOSEINC	Whether relative has lost income as a result of his respiratory disease Yes = 1 No = 0 (set = 0 for version I subjects in pooled model)
SEEOFTEN	How often respondent sees relative, in contacts per year If respondent lives with relative SEEOFTEN = 365
SEETALK	Sum of visits and phone contacts per year

Table 1. (continued)

SELFRISK	Whether respondent feels at greater than average risk of chronic lung disease because of relative's disease Yes = 1 No = 0
SEVSUM	(For version II only) Relative's severity as sum of symptoms (set to 0 for version I subjects in pooled model) Range: 0–15
SMOKE	Respondent is current or former smoker Yes = 1 No = 0
SMOKER	Respondent currently smokes Yes = 1 No = 0
TLKOFTEN	How often respondent talks to relative, in contacts per year
WHEEZE1	Whether relative sounds wheezy Yes = 1 No = 0
WHEEZE2	Whether relative sounds wheezy when he has a cold
WORK	Whether respondent currently works outside the home for pay Yes = 1 No = 0
VOC1AVE(2)(3)	Implied mean value of a statistical case of chronic disease, (trade1), (trade2), (trade3)
VOC1MED(2)(3)	Implied median value of a statistical case of chronic disease, (trade1), (trade2), (trade3)

respondent characteristics. Because many respondents in our sample were students, the average age was lower, as was the percentage married. Household size and income are larger for our sample, possibly due to differences in incomes in the Greensboro, NC area versus Washington, DC and to the relatively large proportion of our sample drawn from the University of Maryland staff and student body. More important, persons in the VMH sample, perhaps because of their ages, are more familiar with auto death and, by driving more miles per year, are more at risk from auto death than persons in our sample—a fact that widens the relative differences in familiarity between the two samples for trades 1 and 2. By contrast, the samples from our versions I and II are very similar to one another in all respects.

Table 2 also contains mean and median estimates of the WTP for chronic-disease risk reductions. For trades 1 and 2, we use $2 million as the value of a statistical life. With this arbitrary assignment, if a subject indicates indifference to the initial subtrade of any of the three trades, the implied value of a statistical case of chronic lung disease (VOCL) is $400,000, with the highest possible implied VOCL being $8 million and the lowest possible VOCL being $10,000. Median VOCLs are substantially less than mean VOCLs, with versions I and II estimates generally exceeding the VMH estimates.

3. The effect of familiarity on risk–risk and risk–income tradeoffs

To examine the effect of familiarity with chronic respiratory disease on the value of risk reductions, we compare the responses of our version I sample with the responses of VMH's sample.[8] Due to differences in sample characteristics, it is necessary to estimate

Table 2. Means and standard deviations of variables for VMH, version I and version II samples

Variable	VMH		Version I		Version II	
AGE	32.02	(10.92)	25.04	(9.91)	24.36	(8.08)
AUTO_ACC	0.50	(0.50)	0.35	(0.48)	0.32	(0.47)
BRSCORE			2.70	(1.80)	2.60	(2.12)
COLD	0.34	(0.47)	0.34	(0.48)	0.43	(0.50)
COUGH1			0.73	(0.45)	0.67	(0.47)
COUGH2			1.86	(1.23)	2.04	(1.18)
DK			1.53	(1.59)	0.86	(1.12)
DRIVER	0.83	(0.37)	0.58	(0.50)	0.51	(0.50)
EDUC	14.02	(2.42)	14.65	(1.88)	14.33	(1.81)
EXERCISE	3.36	(2.64)	3.23	(2.60)	2.88	(2.33)
FAM			2.86	(0.97)	2.95	(1.01)
HHSIZE	2.70	(1.18)	3.46	(1.12)	3.70	(1.17)
INCOME	36.8	(19.7)	56.56	(30.05)	53.26	(25.30)
INSURANCE	0.66	(0.47)	0.61	(0.49)	0.53	(0.50)
KIDS	0.58	(0.97)	0.44	(0.93)	0.53	(0.76)
LIVEWITH			0.29	(0.46)	0.32	(0.47)
MALE	0.53	(0.50)	0.40	(0.49)	0.41	(0.50)
MARRIED	0.48	(0.50)	0.16	(0.37)	0.16	(0.37)
MILES	14.9	7.5	12.34	(6.77)	10.78	(6.83)
PHLEGM1			0.57	(0.50)	0.55	(0.50)
PHLEGM2			1.48	(1.24)	1.41	(1.29)
RELHOSP			0.48	(0.50)	0.40	(0.49)
SEEOFTEN			132.87	(162.86)	140.24	(163.93)
SEETALK			275.20	(318.65)	289.40	(320.90)
SELFRISK			0.34	(0.48)	0.38	(0.49)
SEVSUM			13.00	(0.00)	6.47	(3.29)
SMOKE	0.53	(0.50)	0.43	(0.50)	0.32	(0.47)
SMOKER	0.36	(0.48)	0.26	(0.44)	0.15	(0.35)
TLKOFTEN			142.33	(156.24)	149.16	(157.33)
WHEEZE1			0.81	(0.40)	0.90	(0.31)
WHEEZE2			2.07	(1.13)	2.13	(1.01)
WORK	0.77	(0.42)	0.66	(0.48)	0.65	(0.48)
VOC1AVE[a] ($millions)	1.36		1.34		1.76	
VOC1MED[a] "	0.64		0.53		1.33	
VOC2AVE[a] "	1.23		1.60		1.88	
VOC2MED[a] "	0.53		0.80		1.60	
VOC3AVE "	0.93		2.08		1.84	
VOC3MED "	0.46		1.07		1.07	
N						
Trade1	248		77		72	
Trade2	254		76		68	
Trade3	111		70		64	

models for each sample that predict the response to trades 1, 2, and 3 as a function of respondent characteristics.

Table 3 provides the regression results for the three trades.[9] For trades 1 and 2, the dependent variable (following VMH) is $\ln(t)$, the natural logarithm of the ratio at which the individual is willing to substitute risk of chronic bronchitis for risk of death.[10] For trade 3, the dependent variable is the natural logarithm of the rate at which the individual substitutes risk of chronic bronchitis for income. In both our sample and the VMH sample, we cannot reject the null hypothesis that the vector of slope coefficients is zero (0.05 significance level) for trades 1 and 2. This is not surprising: the variables in table 3 very likely have similar effects on the respondent's valuation of the utility of not dying ($U(\mathrm{H}) - U(\mathrm{D})$) and on the utility of not contracting chronic bronchitis ($U(\mathrm{H}) - U(\mathrm{C})$); thus they have little effect on the ratio of the two.

In trade 3, where income is traded for a reduction in chronic bronchitis risk, the vector of slope coefficients for our sample is significantly different from zero at the 0.01 level; however, few individual coefficients are significantly different from zero. This may be due to the small sample size. As reported in section 4, one third of the explanatory variables are significant when the version I and version II samples are pooled. Of the variables that are significant in table 3, it appears that women, people with children, and persons who never smoked are willing to pay more to reduce their risk of chronic bronchitis than men, persons without children, and smokers.

To test hypotheses about the effects of familiarity on responses, we compare the predicted mean and variance of responses to each trade, conditional on the variables in table 3. We use a generalized Wald test to determine whether the regression model estimated from the VMH sample and the model estimated from the version I sample (using identical variables) provide statistically different predicted mean tradeoff estimates conditional on mean values of the independent variables (we use the means of each sample in turn). Using the subscript 1 to refer to our sample and the subscript 2 to refer to VMH's sample, the test statistic is

$$W = \frac{\mathbf{C}'(\hat{\beta}_1 - \hat{\beta}_2)}{[\mathbf{C}'((X_1'X_1)^{-1}s_1^2 + (X_2'X_2)^{-1}s_2^2)\mathbf{C}]^{0.5}} \tag{9}$$

Where $\mathbf{C}$ is a vector of means of the independent variables and $(X_i'X_i)^{-1}s_i^2$ is the variance-covariance matrix for sample i.

The Wald test results clearly reveal that only in trade 3 are the mean values placed on chronic bronchitis risk statistically different between the two samples. When trading chronic-bronchitis risk reductions for income, those familiar with the disease reveal a significantly higher mean WTP for chronic-bronchitis risk reductions.[11] However, when trading such risk reductions against auto-death risk reductions, no significant differences in WTP are observed.[12] One hypothesis is that those familiar with this disease feel more strongly about reducing their risks of both chronic bronchitis and auto death. Therefore, their tradeoffs are not much different than the trading ratios of those unfamiliar with chronic bronchitis. Another hypothesis, for which some support is provided below, is that answers to risk–risk trades are more stable than answer to risk–income trades.[13]

Table 3. VMH—version I: unconditioned familiarity tests

	Trade 1				Trade 2				Trade 3			
	VMH		Version I		VMH		Version I		VMH		Version I	
	Coef.	|*t*-ratio|	Coef.	|*t*-ratio|	Coef.	|*t*-ratio|	Coef.	|*t*-ratio|	Coef.	|*t*-ratio|	Coef.	|*t*-ratio|
INTERCEPT	−1.55	2.76	−1.05	0.62	−1.12	1.60	−0.52	0.27	−0.19	0.15	0.92	0.57
MALE	−0.19	1.28	−0.01	0.03	−0.45	2.50	−0.05	0.12	−0.10	0.32	−0.63	1.86
MARRIED	−0.06	0.37	−0.16	0.30	−0.31	1.52	−0.30	0.47	0.14	0.45	−0.09	0.15
KIDS	−0.02	0.18	0.05	0.27	0.10	0.91	0.24	1.19	−0.02	0.10	0.50	2.47
HHSIZE	0.03	0.32	−0.33	1.88	−0.08	0.80	−0.51	2.40	−0.18	1.13	0.16	0.89
EDUC	0.02	0.68	0.11	1.08	−0.00	0.08	0.07	0.60	0.11	1.54	−0.00	0.04
INCOME	−0.08	2.28	0.07	1.37	−0.00	0.05	0.15	2.25	0.11	1.56	0.04	0.66
AGE	0.01	1.31	−0.02	0.92	0.00	0.08	−0.03	0.98	0.01	0.61	0.03	1.31
SMOKE	−0.16	1.11	0.19	0.67	0.05	0.27	0.38	1.13	0.10	0.36	−0.95	3.21
WORK	−0.13	0.80	−0.32	1.02	−0.07	0.34	−0.41	1.06	−0.10	0.28	−0.20	0.60
EXERCISE	0.06	2.16	0.09	1.29	0.06	1.68	0.08	0.83	−0.02	0.39	0.09	1.33
COLD	−0.37	2.59	−0.61	1.92	0.01	0.06	−0.62	1.57	−0.28	0.93	−0.26	0.77
DRIVER	0.32	1.76	0.22	0.69	0.13	0.54	0.11	−0.31				
MILES	0.11	1.14	−0.13	0.59	0.19	1.57	0.09	0.34				
INSURANCE	0.14	0.91	−0.15	0.48	−0.12	0.64	0.16	0.40	0.29	1.04	0.47	1.49
AUTO_ACC	−0.06	0.42	0.18	0.61	0.05	0.28	0.33	0.94				
F_2		1.76		0.85		1.05		0.96		0.94		2.97
R		0.10		0.17		0.06		0.19		0.10		0.39
N		248		77		254		76		111		70
WTP ($millions)												
VMH Means	0.77		0.55		0.61		0.62		0.46		1.06	
VI Means	0.69		0.78		0.66		0.76		0.46		1.12	
Wald Test: VMH Means		−0.61				0.07				2.33[a]		
Version I Means		1.33				0.97				2.48[a]		

[a]Significant difference in mean values for chronic bronchitis risk between the two samples.

An additional way in which familiarity may affect responses to trades 1–3 is by altering the variance of responses. If we interpret the error term in each equation in table 3 as representing random noise in respondents' answers, it is plausible that the variance of this error term is larger when respondents are unfamiliar with the commodity being valued. To test this hypothesis, we examined for each trade the difference between the estimated variances of the error terms in the two models. This difference is asymptotically normally distributed (Schmidt, 1976),

$$s_1^2 - s_2^2 \sim N(\sigma_1^2 - \sigma_2^2, 2\sigma_1^2/N_1 + 2\sigma_2^2/N_2), \tag{10}$$

where $\sigma_1^2 - \sigma_2^2 = 0$ under the null hypothesis.

For each of the three trades in table 3, the null hypothesis is accepted at conventional significance levels; hence, we must conclude that the variance of responses is unaffected by familiarity with chronic lung disease.

It is interesting to compare these results with those of Coursey, Hovis, and Schulze (1987). In their study, the authors compare willingness to accept compensation (WTA) for tasting a bitter but nontoxic substance (sucrose octa-acetate or SOA) with WTP to avoid tasting the substance. Although the focus of the article is on the effect of repeated trades on the disparity between WTA and WTP, the authors also examine whether persons who have tasted a small amount of the substance have WTPs (or WTAs) that differ significantly from those of persons unfamiliar with the substance. Based on four groups of eight persons, the authors find that tasting a few drops of SOA had no statistically significant effect on WTP or WTA, a finding similar to our finding for risk–risk trades.[14]

4. Abstract vs. concrete commodities and willingness to pay

As noted above, half of the persons in our sample were asked to value the risk of getting a case of lung disease "like their relative's" rather than the abstract case of chronic bronchitis described by VMH. In this section we examine the effect of this change in the disease description on the mean value of responses to trades 1, 2, and 3.

There are two reasons why mean responses to versions I and II of our questionnaire might differ. One is that the severity of the case of chronic bronchitis described by VMH and valued in version I differs from the severity of the relative's disease valued in version II. The other is that in one case the respondent is valuing an abstract case of lung disease and in the other a case with which he is more familiar.[15] Because of emotional involvement with the relative (for version II subjects) or difficulty grasping the severity of an abstract case description (for version I subjects), one might expect persons answering version II of our questionnaire to have higher responses to trades 1, 2, and 3 than persons answering version I.

To test this hypothesis while holding constant the severity of the disease valued, we estimated regression equations for trades 1, 2, and 3 using our combined samples. The results are reported in table 4. Our method of controlling for the severity of the disease is to include the variable SEVSUM, which is the number of symptoms of chronic lung

Table 4. Selected regression results for pooled data from version I and version II with familiarity and severity variables, VMH-consistent samples

	Trade 1		Trade 2		Trade 3	
	Coef.	|*t*-Ratio|	Coef.	|*t*-Ratio|	Coef.	|*t*-Ratio|
INTERCEPT	−1.65	1.37	−2.50	1.83	−0.46	0.37
MALE	0.19	0.81	0.07	0.24	−1.05	4.09
MARRIED	−0.36	0.96	−0.32	0.73	−0.26	0.65
KIDS	0.13	0.90	−0.21	1.32	0.30	1.78
HHSIZE	−0.17	1.41	−0.02	0.18	−4.7E−03	0.04
EDUC	0.17	2.46	0.13	1.66	0.03	0.37
INCOME	3.8E−06	0.99	2.9E−06	0.64	7.6E−06	1.71
AGE	−0.03	1.75	−6.9E−03	0.36	0.02	1.36
SMOKE	0.21	0.99	0.21	0.85	−0.85	3.56
WORK	−0.17	0.77	−0.40	1.50	0.12	0.50
EXERCISE	0.04	0.85	0.02	0.27	0.07	1.32
COLD	−0.09	0.43	0.07	0.28	−0.09	0.36
DRIVER	−0.08	0.34	0.01	0.05	—	—
MILES	−5.1E−06	0.31	2.4E−06	0.13	—	—
INSURANCE	−0.02	0.08	0.07	0.28	0.64	2.75
SELFRISK	−0.05	0.24	−0.20	0.77	0.39	1.59
AUTO_ACC	−0.18	0.84	−0.07	0.29	—	—
SEVSUM	−0.05	0.74	0.05	0.63	0.18	2.69
RDIED	0.18	0.30	−0.11	0.17	−0.84	1.44
RLOSEINC	−0.09	0.23	0.30	0.67	−0.66	1.51
DUMMY	−0.08	0.15	−0.68	1.05	−1.13	2.02
LIVEWITH	7.9E−03	0.03	0.02	0.08	0.36	1.40
F	0.88		0.63		3.52	
R-SQR	0.13		0.10		0.36	
N	145		140		130	

disease that characterize the disease being valued. For version II respondents, SEVSUM is the number of symptoms that the respondent reports his relative as having. For version I respondents, SEVSUM = 13 (the highest value that the variable may attain), based on the description of the case of chronic bronchitis in the VMH questionnaire.

In addition to including SEVSUM, the regressions in table 4 include five other variables that do not appear in table 3. The variable DUMMY (= 1 if the respondent answered version I of the questionnaire) captures the abstract nature of the case valued. SELFRISK indicates that the respondent views himself as being at higher than average risk of developing chronic lung disease. RDIED and RLOSEINC indicate, for persons answering version II of the questionnaire, that their relative died prematurely as a result of his disease (RDIED) or suffered a loss in income (RLOSEINC). These variables are set equal to zero for persons who answered version I of the questionnaire, since premature death and income loss were not part of the case of chronic bronchitis described by VMH. LIVEWITH indicates that the respondent lives with his relative; this variable is included to control for degree of familiarity with the disease.

The regressions reported in table 4 are similar to those in table 3 in the sense that the vectors of slope coefficients in the trade 1 and trade 2 regressions are not significantly different from zero. This null hypothesis is, however, rejected in the trade 3 equation, in which seven individual coefficients have the expected signs and are significantly different from zero at the 0.05 level (one-tailed test). As in table 3, women, persons with children, and persons who have never smoked are willing to pay more to reduce their risk of chronic lung disease than men, persons without children, and smokers. WTP increases with income, and is higher for persons who purchase life insurance.

We now ask whether reductions in risks of contracting an abstract case of chronic lung disease (the VMH chronic bronchitis description) are valued less than such risk reductions for a concrete case of chronic lung disease (the subject's relative's), holding severity constant. This is equivalent to testing the hypothesis that the coefficient of the sample dummy variable (DUMMY) is zero.[16] Table 4 indicates that there is evidence for an abstract-specific case effect for trade 3 (a negative sign on DUMMY indicating that version I tradeoffs were below those of version II), but very weak evidence for this effect in trades 1 and 2. This supports our findings above that the results of risk–risk tradeoffs appear to be more stable than the results of risk–income tradeoffs.

5. Conclusions

If average WTP responses elicited by contingent valuation (CV) studies are insensitive to familiarity with the commodity being valued, then it does not matter whether such commodities are valued by informed or uninformed individuals. Our results show that CV studies with tradeoffs posed between risks and income may be subject to a familiarity effect, but that such an effect appears to be absent from the indirect risk–risk approach developed by VMH to value chronic bronchitis risk.

The stability of risk–risk vs. risk–income responses is further supported by a second test. We find, when controlling for disease severity, that there is no difference in mean responses to risk–risk tradeoffs between persons who valued an abstract case of chronic bronchitis and persons who valued a case of chronic lung disease "like their relative's." By contrast, persons valuing a disease "like their relative's" were willing to forgo more income to reduce their risk of lung disease than people who were valuing an abstract case of lung disease.

Appendix. Definition and treatment of inconsistent responses

The large number of inconsistent responses to both the VMH survey and our modifications to it raises questions about the ability of persons to answer the tradeoff questions. In this appendix, we examine these inconsistencies in some detail. VMH identified five inconsistencies, which we explain as follows:

1. Preference for dominated city. The subject kept favoring a given city on each subtrade, even when it exhibited (on the last question) the identical risk in one dimension

(say chronic bronchitis) and a higher risk in the other (auto death). In terms of the indifference map of figure 2, this inconsistency involves a subject preferring point D to point A, even though A dominates D. This implies that the subject's indifference curve through A must pass through a point to the right of D, implying that it is positively sloped.

2. Indifference to dominated city. This problem is the same as inconsistency 1 except that the subject was at a point of indifference on the last subtrade, even though one city was preferable to the other in one dimension and equivalent in the other. For example, the subject was indifferent between points A and D in figure 2.

3. Flip-flop. When exhibiting inconsistency 1, the respondent was automatically asked to start the tradeoff over. The second time through, the respondent began by favoring a different city than he had favored before. This inconsistency involves revealing an indifference map as shown in figure 1 (for the initial choice of city B), followed by the revelation of a map that would place the bundle at city A on the isopleth nearer the origin.

4. Last-ditch switch. The subject preferred a city until the next to the last possible subtrade and then switched on the last subtrade to the other (now dominant) city. While such behavior is not technically inconsistent, it makes computation of the tradeoff impossible. In terms of figure 2, the subject does not actually reveal a point of indifference with city A, revealing instead only that he prefers a point like C to the bundle at city A (but not a bundle like D with the same chronic bronchitis risk but higher auto death risk than city A).

5. Continuous indifference. The subject is indifferent between cities for all subtrades. The indifference map implied is a "thick" indifference curve for all the risk values presented.

Table 5 provides inconsistency counts by inconsistency type and trade for version I and VMH samples. Two results are important. First, inconsistency types 4 and 5 predominate. Second, the percentage of subjects with inconsistencies is far lower for version I subjects than for the VMH subjects. In version I, 43 of 95 subjects (45%) gave at least one

Table 5. Inconsistency counts and percentage of total sample for version I and VMH samples by trade

Inconsistency	Trade 1 (%)		Trade 2 (%)		Trade 3 (%)		Any trade (%)	
Version I								
1	1	(1)	1	(1)	3	(3)	4	(4)
2	0	(0)	3	(3)	4	(4)	7	(7)
3	0	(0)	2	(2)	0	(0)	2	(2)
4	13	(14)	6	(6)	10	(11)	21	(22)
5	4	(4)	7	(7)	8	(8)	18	(19)
Any	18	(19)	19	(20)	25	(26)	43	(45)
VMH Sample[a]								
1	17	(9)	12	(6)	12	(6)	30	(15)
2	13	(7)	6	(3)	7	(4)	23	(12)
3	5	(3)	6	(3)	10	(5)	18	(9)
4	26	(13)	23	(12)	29	(15)	45	(23)
5	15	(8)	21	(11)	19	(10)	37	(19)
Any	76	(39)	68	(35)	77	(40)	124	(64)

[a]VMH Questionnaire A only

inconsistent response in at least one trade. For VMH, the overall inconsistency rate was substantially greater—64% had at least one inconsistency on at least one trade. On any given trade, the inconsistencies were fewer. In version I, between 19% and 26% of the subjects had at least one inconsistency, while for VMH, between 34% and 40% of the subjects gave at least one type of inconsistent response in a particular trade.

We note that inconsistencies 2 and 4 above may not be true inconsistencies but may simply reflect strong preferences for one of the commodities being traded. Individuals strongly preferring a commodity are more likely to prefer the city favoring it until just before that city becomes dominated by the other city, thereby committing inconsistency 2. Likewise, individuals with strong preferences are more likely to commit inconsistency 4, which is not an inconsistency, implying rather that such individuals require an even higher chronic bronchitis–auto death tradeoff than the maximum tradeoff available in the computer program.[17]

To test whether the familiarity effects are being reduced by systematically dropping subjects strongly preferring either commodity being traded, we added subjects with inconsistencies 2 and 4 back into the sample and assigned them the maximum or minimum t, as appropriate. Then we repeated the analysis discussed in the body of this article. We found that average WTP estimates for chronic-disease risk reductions rose for all the samples. The regressions generally were less able to explain variation in the tradeoffs than they were for the VMH-consistent samples. However, the basic results of our analysis of the VMH-consistent samples were unchanged: predicted estimates of average WTP differed between the two samples for trade 3 only.

The second important result in table 5 is the higher rate of inconsistencies for the VMH sample relative to the version I sample. One obvious explanation for the difference is the dissimilar survey environments. Our subjects were in an environment more conducive to concentration. They were administered the survey in a quiet room with a person present to answer their questions. The VMH survey was administered in a room in a shopping mall, and not all subjects were given exclusive attention. In addition, because our subjects had to make a special trip to take the survey and were getting paid, they may have treated the survey more seriously.

The extent of what might be termed the "mall" effect cannot be tested with the data at hand. However, some further indication of the lack of attention among subjects in the VMH sample can be obtained by comparing the frequencies with which subjects in either sample made the same mistakes in subsequent trades. Figure 3 provides a Venn diagram for inconsistency 5 (subject is indifferent to all subtrades) for each sample to illustrate the idea.

Consider the version I sample. Of the four people who gave at least one type 5 inconsistent response in trade 1, none made this mistake again on subsequent trades, and only one of the seven who made this mistake on trade 2 made this mistake again on trade 3. This suggests that learning was occurring. Contrast these results with those from questionnaire A of the VMH sample. Of the 15 people with this inconsistency on trade 1, nine of them made the same mistake on trade 2, and four of these made this mistake on all three trades. Also, an additional six subjects made the same mistake on trade 2 and trade 3 (but not trade 1). Similar, if less dramatic, differences in inconsistency patterns across trades exist for the other types of inconsistencies. The implication of these findings

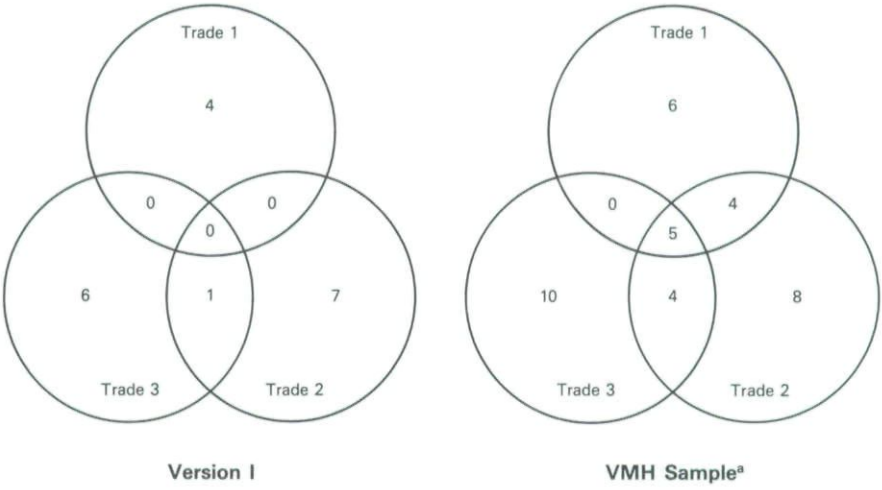

Figure 3. Venn diagram of inconsistency 5, by trade, for version I and VMH samples.

is that future versions of this survey should be administered in environments more conducive to concentration.

Notes

1. A public health or air pollution control program that will reduce the incidence of chronic disease in a population is typically viewed as reducing the probability that persons in the population contract the disease. The appropriate measure of benefits of such a program is the sum of individuals' WTP to reduce their risk of contracting the disease.
2. Viscusi, Magat, and Huber administered their questionnaire to a sample of persons in a Greensboro, North Carolina shopping mall.
3. Equation (2) assumes that $dY/dX = 0$ and $dZ/dX = -1$, i.e., a decrease in X, the probability of contracting chronic bronchitis, increases the probability of being healthy, rather than the probability of dying (Y).
4. VMH used several versions of their questionnaire. Of relevance to our study are questionnaires A and C. Questionnaire A contains the same tradeoff questions as our version I. Questionnaire C contains tradeoff questions corresponding to our trade 1 and trade 2.
5. The descriptions of chronic bronchitis offered to respondents taking version I were not given to those taking version II.
6. We estimated probit equations to explain inconsistent responses to the tradeoffs using income, education, and demographic variables; however, we could not reject the null hypothesis that the vector of slope coefficients was significantly different from zero at conventional levels.
7. A full set of descriptive statistics and a correlation coefficient matrix involving all variables for both version I and version II is available from the authors.
8. Since some of the subjects in the VMH sample "knew of someone" with chronic bronchitis, we tested whether this variable significantly explained differences in tradeoffs made by VMH subjects. It did not.

9. The results of the VMH sample represent our analysis of VMH's data. These results differ from those reported in VMH (1988) in two respects. First, we have corrected minor errors that were made by VMH in classifying inconsistent responses. Second, we have added certain variables to the regression equation that do not appear in VMH's table 16. These include WORK, COLD, INSURNCE, and SELFRISK, and for trade 1 and trade 2 only, DRIVER and MILES.
10. At the bottom of table 3, predicted responses to trades 1 and 2 have been converted to dollars using a value of a statistical life ($-dI/dY$) of $2 million.
11. The higher cost of living in Washington, DC compared to Greensboro, North Carolina might explain a portion of the larger average WTP of the Washington, DC-based version I sample. However, the portion is small. Cost of living indices for Greensboro are only about 10% lower than those for Washington, DC.
12. A referee suggested that this was caused by the high variance in risk-risk responses. We note, however, that the absolute difference in the mean responses between the two samples is small—less than 15%—not just small relative to the variance of responses.
13. It is interesting to note that while familiarity with chronic lung disease, in the sense of having a relative with the disease, affects mean WTP to reduce one's risk of contracting chronic bronchitis, frequency of contact with one's relative has no apparent effect on WTP. We tried several variables in the version I regressions that measure the respondent's degree of familiarity with his relative's illness, including dummy variables to indicate the nature of the respondent's relationship to his relative, the number of times he visits the relative per month, and whether he lives with the relative. These variables generally were not significant at conventional levels.
14. We know of no other studies that examine the effect of familiarity with a commodity on respondents' valuation of it. Smith and Johnson (1988) find that cancer patients (or their survivors) attach more weight to sample information about radon in forming their perceptions of radon risk than do respondents in households without cancer patients. Their study, however, does not deal with risk valuation.
15. These statements assume that the version I subjects were able to respond to the abstract case of respiratory disease rather than to a case like their relative's. We tested this assumption by including variables measuring the severity of the relative's disease (frequency of coughing, wheezing) in the version I regression equations. These variables were seldom significant. We also included these severity measures in regressions estimated using version II data. In this case severity should influence WTP; however, severity variables were seldom significant in the version II regressions. This may indicate that severity is not being measured appropriately. However, these variables were constructed from standard questions taken from the British Medical Questionnaire.
16. A dummy variable-pooled model approach is used rather than the Wald test on the separate samples. The Wald test, which requires identical independent variables in the regressions to be compared, cannot be used because the unmodified SEVSUM variable equals 13 for all subjects in version I and, therefore, cannot appear in the version I regression. By pooling the two samples, we are assuming that the version I and II models share the same β coefficients and error structures.
17. Since the maximum trading ratio is four units of auto death risk for one unit of chronic bronchitis risk, some may argue that such a response is itself irrational and evidence that the subject did not understand the tradeoff task.

References

Berger, Mark C. et al. (1987). "Valuing Changes in Health Risks: A Comparison of Alternative Measures," *Southern Economic Journal* 53, 967-984.

Coursey, Don L., John J. Hovis, and William D. Schulze. (1987). "The Disparity Between Willingness to Accept and Willingness to Pay Measures of Value," *Quarterly Journal of Economics* 102, 679-690.

Dillingham, Alan E. (1985). "The Influence of Risk Variable Definition on Value-of-Life Estimates," *Economic Inquiry* 24, 227-294.

Gerking, Shelby, Menno DeHaan, and William Schulze. (1988). "The Marginal Value of Job Safety: A Contingent Valuation Study," *Journal of Risk and Uncertainty* 1, 185-199.

Jones-Lee, M. W., M. Hammerton, and P. R. Philips. (1985). "The Value of Safety: Results of a National Sample Survey," *Economic Journal* 95, 49–72.

Krupnick, Alan J. and Maureen L. Cropper. (1989). *Valuing Chronic Morbidity Damages: Medical Costs, Labor Market Effects, and Individual Valuations.* Final Report to EPA, Office of Policy Analysis.

Kunreuther, Howard and Douglas Easterling. (1990). "Are Risk-Benefit Trade-offs Possible in Siting Hazardous Facilities?" *American Economic Review* 80, 252–256.

Marin, Alan and George Psacharopoulos. (1982). "The Reward for Risk in the Labor Market: Evidence from the United Kingdom and a Reconciliation with Other Studies," *Journal of Political Economy* 90, 827–853.

Schmidt, Peter. (1976). *Econometrics.* New York: Marcel Dekker.

Smith, V. Kerry and William H. Desvousges. (1987). "An Empirical Analysis of the Economic Value of Risk Changes," *Journal of Political Economy* 95, 89–114.

Smith, V. Kerry and F. Reed Johnson. (1988). "How to Risk Perceptions Respond to Information? The Case of Radon," *Review of Economics and Statistics* 70, 1–8.

Thaler, Richard and Sherwin Rosen. (1976). "The Value of Life Saving." In Nester Terleckyj (ed.), *Household Production and Consumption.* New York: Columbia University Press for NBER.

Viscusi, W. Kip, Wesley Magat, and Joel Huber. (1991.) "Pricing Environmental Health Risks: A Survey Assessment of Risk-Risk and Risk-Dollar Trade-offs for Chronic Bronchitis," *Journal of Environmental Economics and Management* 21, 32–51.