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Measurement of consumer–patient preferences using a hybrid contingent valuation method

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Abstract

This study introduces a hybrid, two-stage, contingent valuation method applied to asthma treatment. Respondents are initially offered a choice between hypothetical medications, implying a tradeoff between safety and efficacy. Stage two elicits willingness to pay (WTP) for an improvement along a single risk dimension. Estimates of the value of asthma control based on the initial risk tradeoff stage range from approximately US$1400 to US$2100 per year, assuming a US$6 million value of life. Analysis of the second-stage WTP responses yield estimates for the value of a statistical life of approximately US$9 million and for asthma control of approximately US$2200 per year. © 1997 Elsevier Science B.V.

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1. Introduction

Difficulties inherent in observing individual consumer--patient preferences with regard to health commodities have stimulated considerable interest in using stated

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preference techniques in health outcome evaluation. With varying degrees of success, approaches such as the contingent valuation method (CVM), which yields willingness to pay (WTP); the standard gamble and the time–tradeoff method, which yield quality-adjusted life years (QALYs); and general and disease-specific quality of life instruments, have been developed and applied to the measurement of health status. Each of these methods has its strengths and weaknesses in terms of theoretical validity, empirical reliability, and ease of implementation (see Johansson, 1995; Tolley et al., 1994; Johannesson and Jönsson, 1991; Torrance, 1986).

Rowe and Chestnut (1986) conducted an early contingent valuation study using a self-administered contingent questionnaire among 65 asthmatics in the Los Angeles area. They estimated a mean annual WTP of US$401.00 for a 50% reduction in 'bad asthma days' (37 day reduction) related to environmental (air) pollutants. Viscusi et al. (1991) developed a risk–risk tradeoff technique for valuing chronic bronchitis. They found a median implicit value of US$457,000 per case avoided. In a variation of that study, Krupnick and Cropper (1992) surveyed relatives of persons with chronic bronchitis to test for the effect of familiarity with the disease on stated values. They found a median WTP value for a statistical case of chronic lung disease of US$1.07 million.

The present study combines elements of these approaches in a two-step method for valuing an expected improvement in asthma. In the first step, respondents are offered a contingent choice between two bronchodilator medications that differ in terms of their probabilities of safety and of efficacy, a risk–risk tradeoff. The second step consists of a closed-ended CVM question concerning WTP for an improvement along a single risk dimension, either efficacy or safety. A survey was conducted to test this methodology using a convenience sample of asthmatics.

2. Risk–risk tradeoffs and WTP for morbidity and mortality risks

For individual utility maximizers, one can define an indirect utility function, V, over income, Y, prices (which will be suppressed), and health states, H. From an ex ante decision-making perspective, if there is uncertainty regarding the final health state, an expected utility function can be defined given the probabilities, p, of those outcomes. Assuming that individuals maximize expected utility, [1] this provides a basis for a measure of willingness to pay under conditions of risk and uncertainty (Jones-Lee, 1974; Freeman, 1993, Chap. 8).

[1] Marginal WTP expressions for changes in risks can be generalized when preferences take nonexpected utility forms as long as individuals maximize a well-behaved objective function, see Freeman (1993), pp. 251–256.

Consider the following option price (OP) formulation for a simultaneous change in two possible risks, p_1 and p_2, and income, Y (Viscusi et al., 1987):

$$\begin{aligned}
&(p_1+\alpha)(p_2+\beta)V^0(Y-\mathrm{OP},H^*)\\
&\quad+(1-p_1-\alpha)(p_2+\beta)V^1(Y-\mathrm{OP},H^{\mathrm{A}})\\
&\quad+(p_1+\alpha)(1-p_2-\beta)V^2(Y-\mathrm{OP},H^{\mathrm{R}})\\
&\quad+(1-p_1-\alpha)(1-p_2-\beta)V^3(Y-\mathrm{OP},H^{\mathrm{AR}})\\
&=p_1p_2V^0(Y,H^*)+(1-p_1)p_2V^1(Y,H^{\mathrm{A}})\\
&\quad+p_1(1-p_2)V^2(Y,H^{\mathrm{R}})+(1-p_1)(1-p_2)V^3(Y,H^{\mathrm{AR}}) \qquad (1)
\end{aligned}$$

where p_1 is the probability that the treatment will be effective and α is the change in that probability, p_2 is the probability that the treatment will be safe and β is its change, H^* is the state of full health, H^{A} is asthmatic, and H^{R} is side effects but no asthma. The best state is H^* where the treatment is effective and safe. The worst case scenario would be health state H^{AR}, which would be asthmatic with side effects.

If the side effect of the treatment is fatal, states H^{R} and H^{AR} would be equivalent. If we assume that no utility is received in the state of death, then $V^2=V^3=0$ and an option price for a reduction in either risk independently could be defined as

$$\frac{\partial \mathrm{OP}_1}{\partial p_1}=\frac{p_2(V^0-V^1)}{D(p_1,p_2)}>0 \qquad (2)$$

for morbidity risk and

$$\frac{\partial \mathrm{OP}_2}{\partial p_2}=\frac{p_1V^0+(1-p_1)V^1}{D(p_1,p_2)}>0 \qquad (3)$$

for mortality risk. $D(p_1, p_2)$ is the expected marginal utility of income across the four possible health states.

Eq. (3), which shows the WTP for an improvement of the odds in a lottery over life and death, can be rearranged and substituted into Eq. (2), the WTP for a change in morbidity risk, yielding the following expression,

$$\frac{\partial \mathrm{OP}_1}{\partial p_1}=\frac{p_2(V^0-V^1)}{p_1V^0+(1-p_1)V^1}\frac{\partial \mathrm{OP}_2}{\partial p_2}=-\frac{\partial p_2}{\partial p_1}\frac{\partial \mathrm{OP}_2}{\partial p_2} \qquad (4)$$

which expresses the WTP for an improvement in efficacy in terms of the tradeoff between the two risks, p_1 and p_2, and the WTP for a reduction in the probability of death. Having elicited the risk–risk tradeoff, one can apply known estimates of

the value of life (from implicit-market studies, for instance) as estimates of $\partial OP_2/\partial p_2$, and calculate WTP for a statistical case of asthma, without directly eliciting a risk–dollar tradeoff for asthma (Viscusi et al., 1991; Krupnick and Cropper, 1992).

3. Methods

Viscusi et al. (1991) and Krupnick and Cropper (1992) conducted computerized interviews involving iterated risk–risk tradeoffs leading individuals to a point of indifference between the risks of contracting chronic bronchitis and traffic fatality. We wished to develop an alternative methodology which would be feasible in a mail survey in which there is considerably less control over the response process than during an interview. In the mail format, it is difficult to condition iterations on earlier responses. In addition, because of concern with the effect of initial proposed risk levels on subsequent responses only, a single contingent tradeoff was presented to each individual. [2]

By varying the combinations of efficacy and safety across respondents, we can identify the rate of tradeoff between safety and efficacy for the sample (although not for each individual). As shown by Eq. (4), the safety–efficacy tradeoff rate can be used to infer the option price for a change in efficacy based on the option price for safety. There is an extensive literature on the value of safety, and based on an estimate of the value of a statistical life from implicit market studies (for a review, see Viscusi, 1993), it is possible to estimate the value of good asthma control.

In place of follow-up risk–risk questions, we substituted a contingent valuation question to elicit WTP along a single risk dimension. All respondents were asked whether they were willing to pay a given amount per month for drug C, which was maximally safe and effective (relative to A and B). In this way, respondents who had initially chosen drug A (the safer but less effective drug) were asked to state their WTP for an increase in the probability of a reduction in asthma symptoms. For those who had chosen drug B, drug C represented a reduction in the probability of a fatal adverse reaction. [3]

[2] Although we are not aware of any studies explicitly concerning starting-point bias in risk–risk tradeoff surveys, there is clear evidence of such a bias in contingent valuation surveys involving iterative monetary bidding (see Mitchell and Carson, 1989, Chap. 11 for a discussion of biases in CVM).

[3] To test for ordering effects, 25 respondents were presented with drug C that was minimally safe and effective but cheaper, and then asked whether they were willing to pay a premium for drug A or B. A dummy variable indicating this version of the survey instrument was not significantly different from zero in any specification tested.

To facilitate respondents' understanding of the valuation tasks and the commodities being valued, a major part of the survey instrument addressed the communication of the relevant risk concepts as well as testing of respondents' understanding and processing of the probabilities involved (Blomquist and O'Conor, 1995).

The survey was mailed to 216 adults with asthma in the US during January through March, 1995. Seventy of these individuals had volunteered to participate in clinical studies at the University of Kentucky College of Pharmacy. A smaller group of respondents ($n = 16$) was recruited through flyers distributed at local clinics and pharmacies in the Central Kentucky area. The third, and largest ($n = 130$), group of respondents was recruited via the Internet by posting a recruitment notice on the 'alt.support.asthma' newsgroup for asthma sufferers. Because of the difficulty and time required to fill out the survey, return packaging and postage was provided, and a stipend of US$10.00 per completed survey was offered to increase the response rate. Reminders were sent out after two weeks and, to the non-respondents, new copies of the questionnaire at four weeks. To conserve observations and ensure eliciting responses over the entire range of values in the sample, the survey was conducted in two waves. [4] Results of the first 20 questionnaires were examined and used to revise the bid values on subsequent questionnaires.

Of the 216 surveys mailed, 146 were complete and useable for this analysis. [5] Summary statistics concerning the individual demographic and health characteristics of the sample are provided in Table 1. Drug A was stated to have 80% efficacy and 4/100,000 fatality risk in all surveys. The efficacy of drug B was varied between levels of 85%, 90%, and 95%. The fatality risk of drug B was varied between levels of 6/100,000, 8/100,000, 12/100,000 and 16/100,000.

This small, convenience sample was predominantly healthy, white, and female. Age ranged from 19 to 77 years with a mean of 37 years. Probably because two-thirds of the sample were recruited from the Internet, the mean educational level of 16 years is high relative to the general US population, as is the mean annual household income of US$50,517. As this was a pilot study of the

[4] An initial pretest of the survey instrument was conducted by mail in October 1994 on an Internet sample of (alt.support.asthma) of 13 asthmatics. An open-ended bidding was used to elicit an appropriate range of threshold values based on a minimal sample size. A focus group was also conducted in November 1994, among graduate students attending a health economics seminar.

[5] Of the 216 surveys mailed, 177 were completed and returned. Nineteen (19) surveys involved scenarios describing a tradeoff between current and latent efficacy (rather than mortality risk) and are not analyzed here. Twelve (7.6%) of the remaining 158 respondents rejected the safety–efficacy/A–B tradeoff, and therefore were also unable to answer the WTP question. In addition, 10 respondents were not able to provide usable responses to WTP for drug C after choosing either A or B. There were a total of 22 missing observations (13.9%) to WTP. These item nonresponse rates are inclusive of those observations which were judged to be unreliable or protests based on follow-up questions.

Table 1
Summary statistics for asthmatic sample

Variable	Description		Frequency distribution				
Efficacy improvement	Increase in probability of efficacy relative to hypothetical baseline of 80%		5% 9	10% 46	15% 91		
Safety decrease	Increase in probability of fatal adverse reaction relative to baseline risk of 4/100,000	Immediate Latent	2/100,000 45 14	4/100,000 38 14	8/100,000 31	12/100,000 4	
General health	Self-rated health status: exellent = 1,..., poor = 5, (mean = 2.59)		Excellent 17	Very good 49	Good 60	Fair 17	Poor 3
Health relative to one year ago	Self-rated health status: much better 1,..., much worse = 5 (mean = 2.60)		Much better 22	Some better 45	Same 52	Some worse 23	Much worse 4
Other respiratory	Respiratory conditions other than asthma: none = 0, any other = 1 (mean = 0.45)		Yes 66	No 80			
Female	Male = 0, female = 1 (mean = 0.64)		Male 53	Female 93			
Non-white	White = 0, non-white = 1 (mean = 0.12)		White 129	Non-white 17			
Internet	Recruited through Internet, Internet = 1 (mean = 0.65)		Yes 95	No 51			
			Mean	Standard deviation	Min	Max	
Schooling	Highest grade completed in school		15.66	2.09	8	18	
Income	Household pre-tax income (US$)		50,517	33,439	2500	180,000	
Age	Year of birth–1995		36.74	12.59	19	77	
Symptom frequency	Individual symptoms in 4 weeks prior to survey		8.65	4.28	0	24	
Effect of asthma on QOL	Constructed by addition of QOL responses—higher rating indicates poorer quality of life		8.05	4.38	0	21	
Quality of good day	Rating of good day on scale of symptoms: 1 = no symptoms,... 7 = very severe		2.73	1.13	1	6	
Improvement days	Number of bad days avoided by control of asthma		55.3	53.58	0	248	
Treatment intensity	Intensity of current medication regimen		5.08	3.06	1	28	

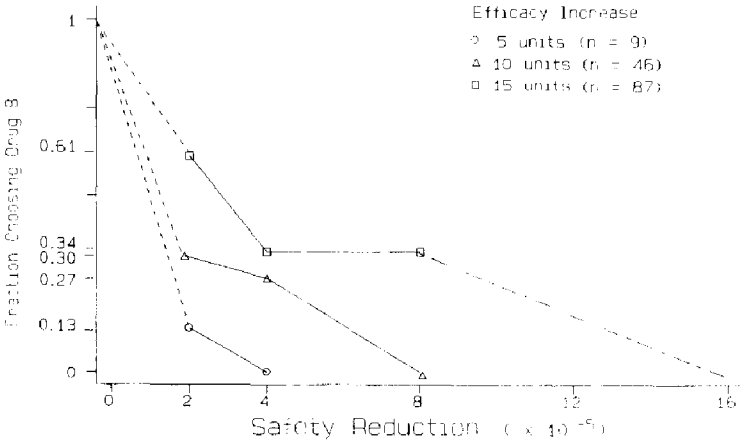

Fig. 1. Fraction of respondents choosing more effective–less safe drug.

methodology, the sample was convenience-based and not readily suitable for drawing inferences regarding the general population.

3.1. Results: drug choice, efficacy vs. fatality risks

Analysis of both sets of questions will utilize techniques developed for estimation of WTP from referendum contingent valuation survey data. One method, proposed by Kriström (1990), involves calculating the area under a nonparametrically estimated tradeoff curve, based on the proportion of respondents who were willing to accept the safety reduction in exchange for a given increase in efficacy.

Fifty-one out of 146 respondents (34.93%) chose the more effective but riskier drug B. Fig. 1 plots the proportion of respondents choosing drug B at three different efficacy levels. As the risk increases along the x-axis, fewer individuals choose drug B. However, for a given level of safety, the tradeoff curves shift outward as efficacy increases. The area bounded by each curve [6] represents the mean safety reduction respondents are willing to accept in exchange for the given level of efficacy increase. The ratio of these two values then yields an estimate of the mean rate of safety–efficacy tradeoff. Based on Fig. 1, these rates of tradeoff

[6] The estimate of mean WTP is derived from the area bounded by the survivor curve and will be sensitive to the x-intercept or 'choke price' for the goods. This is often referred to as the 'fat-tails' problem and is best dealt with through survey design by including in the bid vector values at which the proportion of acceptance will be zero. If the bid vector does not go high enough, as is the case for the 15-unit increase in efficacy, an intercept must be chosen ad hoc to estimate the mean. The y-intercept is less problematic, in that it seems reasonable to assume that the proportion of acceptance for a good will be equal to 1 ($\pi = 1$) at a bid of zero. The remaining issue affecting the mean estimates, then, is at what rate the survivor curve approaches the y-axis. In this study, we employ a simple linear interpolation between the proportion of acceptance at the lowest bid, π_1, and the y-axis at $\pi_0 = 1$. This is represented in Fig. 1 as a dashed line.

are 0.000250, 0.000240 and 0.000352, for the 5, 10, and 15 unit curves, respectively. These values, what Viscusi et al. (1991) refer to as death–risk equivalents, are essentially point estimates of the slope of an indifference curve between probabilities of asthma and death, and can be used to infer the value of a statistical case of asthma by multiplication with the value of a statistical life. For instance, for a value of a life of US$6 million, estimates of the annual value of asthma control would be US$1500, US$1440, and US$2112 based on the respective tradeoff curves.

The parametric method proposed by Hanemann (1984) and Cameron (1988) involves the inclusion of the bid level as an explanatory variable on the right hand side of a binary choice logistic regression. The estimated parameters are then used to fit a two-dimensional cumulative probability curve analogous to those in Fig. 1, and the mean valuation can be calculated as the area under the fitted curve evaluated at the means of the other explanatory variables.

Logistic regression results of the drug A vs. drug B choice are reported in Table 2. Model 1, which includes only the efficacy and mortality risk levels as explanatory variables, corresponds most closely to the non-parametric procedure. Although both risk coefficients are significant, the explanatory power of this model is low as demonstrated by the pseudo R^2 of 0.07. The addition of the square of the safety change and a dummy variable indicating whether the fatality was presented as immediate or latent improves the fit of the regression as a whole and of the individual risk variables. However, the ability of Model 2 to predict the correct choice does not increase above the 73% correct rate of the first model. The signs of the risk variables indicate that, ceteris paribus, respondents are more willing to accept drug B as its efficacy increases. Conversely, respondents are less willing to accept drug B as its safety decreases, but within the range of changes considered, this negative slope flattens out as the magnitude of the change increases.

The effects of asthma status and general health on the willingness to tradeoff safety for efficacy are reported in column 3. The first of these, 'improvement days', measures the magnitude of the improvement in asthma. The variable indicates the number of additional 'good asthma days' experienced when using an effective treatment measured relative to the respondent's current treatment. The positive and significant coefficient on this variable indicates that respondents are more willing to accept the more effective but dangerous drug B as the magnitude of the improvement, in terms of symptomatic days, increases. The presence of other respiratory diseases also affects the choice of the more aggressive therapy (drug B). Individuals with other lung diseases may perceive additional benefits from the bronchodilator therapy in addition to relief of asthma symptoms.

The coefficient on current asthma treatment intensity is also positive and significant, suggesting that those respondents who are currently using more types of medication and/or using medication with greater frequency are more likely to adopt the more aggressive treatment. This is reasonable to the extent that greater

Table 2
Logistic regression of drug A vs. drug B choice

Independent variable	Dependent variable: drug A or drug B (A = 0, B = 1)			
	Model 1	Model 2	Model 3	Model 4
Safety reduction ($\times 10^{-5}$)	−0.1496	−0.7127	−0.8683	−0.9133
	−(1.98)[a]	−(2.38)	−(2.38)	−(2.32)
Efficacy increase ($\times 10^{-2}$)	0.2225	0.2431	0.2647	0.3184
	(3.14)	(3.32)	(3.06)	(3.28)
Safety reduction squared		0.0506	0.0655	0.0688
		(2.04)	(2.14)	(2.11)
Latency (five years)		0.6874	1.1201	1.3184
		(1.45)	(1.98)	(2.18)
Improvement days			0.0102	0.0099
			(2.16)	(1.96)
Other respiratory			1.3823	1.4236
			(2.64)	(2.52)
Treatment intensity			0.1451	0.1970
			−(1.94)	−(2.29)
Symptom frequency			−0.1535	−0.1703
			−(2.39)	(2.31)
General health			−0.5776	−0.5021
			−(2.17)	−(1.73)
Health relative to one year ago			0.3918	0.4317
			(1.65)	(1.68)
Age				0.0085
				(0.39)
Female				−0.2855
				−(0.57)
Non-white				−0.5941
				−(0.81)
Married				−0.7185
				−(1.18)
No. of children in household				0.1528
				(0.51)
Schooling				0.0737
				(0.64)
Income (US$1000)				−0.0072
				−(0.97)
Internet				−0.6494
				−(1.21)
Constant	−2.9173	−2.1958	−2.7364	−3.9554
	−(3.02)	−(1.95)	−(1.62)	−(1.51)
Log likelihood	−87.53	−84.52	−66.19	−62.42
χ^2	13.87	19.88	42.96	48.36
Pseudo R^2	0.0734	0.1052	0.2450	0.2792
% Correct	72.86	72.86	75.74	77.04
n	146	146	136	135

[a]Ratio of coefficient to standard error in parentheses.

Table 3
Parametric estimates of safety–efficacy tradeoff rate

	Model 1	Model 2	Model 3	Model 4
Mean acceptable efficacy increase ($\times 10^{-2}$)	15.97	16.35	16.95	16.60
	(1.15)[a]	(1.19)	(1.48)	(1.22)
Safety–efficacy tradeoff ($\times 10^{-3}$)	0.2667	0.2606	0.2446	0.2506
(Δ safety[b]/Δ efficacy)	(0.02)[a]	(0.02)	(0.02)	(0.02)
US$3 Million	800	782	734	752
US$6 Million	1600	1564	1468	1504
US$9 Million	2400	2345	2201	2255

[a]Standard errors, in parentheses, estimated using Taylor series approximation, see Cameron (1988).
[b]Mean annual fatality risk reduction = 4.26×10^{-5} in columns 1 and 2 ($n = 146$); 4.15×10^{-5} for column 3 ($n = 136$); and 4.16×10^{-5} for column 4 ($n = 135$).

frequency of medication use indicates poor control of asthma symptoms. The negative coefficient on the variable measuring frequency of various asthma symptoms runs counter to this intuition. Such a result seems to indicate that those respondents with more severe asthma are less likely to choose the more aggressive therapy, holding constant the size of the improvement (in terms of number of symptomatic days). [7] This conclusion is supported by the negative and significant coefficient on current general health status, implying that those respondents with poorer health are less likely to accept the riskier, albeit more effective, treatment. Overall, the fit of the regression is improved with the addition of these variables. The pseudo R^2 increases to 0.25 and the rate of correct predictions increases to 76% in Model 3.

Results of a logistic model that includes various socio-economic variables are reported in column 4. None of these additional coefficients are significant independently, and a likelihood ratio test ($\chi^2(8) = 6.02$) fails to indicate that they are significant jointly. Results of the four models indicate that the effects of the risk variables on choice of treatment appear to be quite robust across specifications.

Estimates of the mean [8] increase in efficacy required to induce respondents to choose the drug with the higher mortality risk are reported in the first row of Table 3 for each of the four logistic models. Point estimates of the safety–efficacy tradeoff rate were calculated by division with the mean level of efficacy for the sample, and are reported in the second row of Table 3. The tradeoff values lie in

[7] If the variable, improvement days, is left out of model 3, the sign of the coefficient on symptom frequency remains negative but is no longer significant at ordinary levels.

[8] In Table 3, estimates of the mean efficacy increase required to induce respondents to choose a drug with a higher mortality risk are reported, instead of the mean increase in mortality risk at which respondents would choose a drug with greater efficacy. The inclusion of a fatality-squared term seemed to provide a better fit in the logistic model, but created difficulty in terms of estimating a mean or median fatality risk based on the Cameron approach.

the range of 0.00024 to 0.00027, corresponding closely to those obtained through the nonparametric method. Based on a value of life of US$6 million, these death–risk equivalents imply that respondents value the relief of asthma symptoms at approximately US$1500 per year.

3.2. Willingness to pay for drug C

Thirty-four of 56 respondents (60.71%) were willing to pay a premium to purchase a hypothetical drug which was safer but just as effective as its hypothetical alternative (see [3]). A recognized disadvantage to the closed-ended CVM format is that the information recovered from each respondent is diffuse, a problem which is amplified in the second stage of this hybrid approach. For instance, this subsample of 56 respondents was further subdivided into 4 levels of risk reduction and 5 dollar-bid levels. As a result, there are a number of cells that only contain one or two observations.

Despite the paucity of data in this pilot study, we are fortunate that the vector of proportions for the two unit risk reduction does decrease monotonically and contains at least three observations per cell. Based on this limited sample ($n = 26$) and assuming an upper limit of US$60.00 per month, the nonparametrically estimated mean WTP is US$19.83 per month for the two unit risk reduction, implying a value of statistical life of about US$11.9 million (US$19.83/month $\times$ 12 months/2×10^{-5}).

The results of ordered logistic regression of the intention to purchase the safer drug on the dollar bid and the change in safety are reported in the first two columns of Table 4. Column 1 represents a model analogous to the nonparametric estimation in which the effects of only the bid and safety change variables are analyzed. The model in column 2 includes variables controlling for individual health and socio-economic characteristics. As was the case with the risk tradeoff models, the inclusion of these variables improves the fit and explanatory power of the logistic regression. The full model in columns 2 is able to predict the correct 'yes–no' answer for 79% of respondents.

Two important tests of the validity of a CVM application are whether respondents respond to the stated bid, and the scope or magnitude of the change in the contingent commodity affects WTP. In the case of WTP for a safer drug C, the coefficient on the bid level is consistently of negative sign and significant in accordance with the expectation that as drug C becomes more expensive, respondents are less likely to express an intention to purchase it. The coefficients on the magnitude of the safety increase are positive and also significant in all specifications, indicating that respondents are more likely to pay a given dollar amount for drug C as the size of the safety benefit increases. In addition, the coefficient on income has the expected positive sign, although not statistically significant. Schooling appears to have a significant negative impact on the probability of

Table 4
Ordered logistic regression of intention to purchase drug C

Independent variables	Dependent variable: intention to buy drug C			
	Safety		Efficacy	
	Model 1	Model 2	Model 1	Model 2
Bid (US$/month)	−0.0352	−0.0601	−0.0345	−0.0635
	(1.93)[a]	−(2.62)	−(1.60)	−(2.35)
Safety increase ($\times 10^{-5}$)	0.2442	0.4650		
	(2.30)	(3.23)		
Efficacy increase ($\times 10^{-2}$)			0.0546	0.0537
			(0.86)	(0.70)
Latency (five years)		1.5205		
		(2.20)		
General health		−0.6982		
		−(1.70)		
Health relative to one year ago		0.1805		
		(0.57)		
Improvement days				0.0022
				−(0.46)
Other respiratory				−0.4201
				−(0.84)
Treatment intensity				0.0868
				(0.99)
Symptom frequency				−0.2166
				−(2.67)
Quality of life with asthma				0.1868
				(2.22)
Age		0.0172		−0.0258
		(0.81)		−(1.01)
Female		0.5776		0.2195
		(0.91)		(0.42)
Non-white		−2.6381		−0.6958
		−(2.04)		−(0.97)
Schooling		−0.4543		−0.1160
		−(2.83)		−(0.88)
Income (US$1000)		0.0109		0.0155
		(1.28)		(1.72)
Internet		0.8914		0.9308
		(1.32)		(1.55)
Constant	1.9811	8.3565	2.1274	4.3785
	(3.10)[b]	(2.41)	(2.52)	(1.88)
μ_1	1.828	2.4520	1.8277	2.0769
	(4.28)	(4.26)	(5.16)	(4.94)
μ_2	3.7793	5.0565	3.5937	4.3064
	(6.94)	(8.79)	(8.30)	(7.75)
Log likelihood	−68.59	−56.19	−101.62	−82.34
χ^2	7.80	32.59	2.82	30.17
Pseudo R^2	0.0538	0.2248	0.0137	0.1548
% Correct predictions	69.64	78.57	60.00	69.33
n	56	56	80	75

[a]Ratio of coefficient to standard error in parentheses.

purchasing the safer drug C, as does the dummy variable for race, indicating that non-whites are less likely to purchase the safer drug. [9]

One way to interpret the results in Table 4 is to use the technique of Cameron (1988) in reparameterizing the safety coefficient by division with the bid coefficient. The resulting parameter can be interpreted as a point estimate of the marginal WTP for a unit of safety increase in drug C. These WTP values (standard errors) are equal to 6.95 (4.12) and 8.31 (3.84) for the models in columns 1 and 2, respectively. Thus, for each unit of safety increase (1×10^{-5}), respondents are willing to pay between US$7.00 and US$8.00 per month. Aggregating these values in terms of WTP for a statistical life (WTP/month $\times$ 12 months/1×10^{-5}) yields an approximate value of life of US$8 to US$10 million.

Another approach in interpreting the logistic estimates is to estimate the mean valuation of drug C as the area under the fitted logistic cumulative probability curve. However, the linear model we have used implies that some respondents will have negative WTP. To avoid such a problem, we can truncate the distribution at zero when integrating (see Johansson, 1995). This approach seems reasonable in the present case since we are evaluating WTP for a private good, and the assumption of nonnegative WTP is consistent with economic theory. Estimates of mean WTP for a safer drug C, reported in the second row of Table 5, are about US$40.00 per month for Model 1 and US$28.00 per month for Model 2. Implied values of a statistical life, reported in the last row of Table 5, are calculated by dividing annualized WTP for drug C by the mean level of risk reduction (3.93×10^{-5}) and are about US$12 million for Model 1 and US$8 million for Model 2.

Forty-eight of 80 respondents (60%) were willing to pay a premium to purchase a hypothetical drug which was more effective but as safe as its alternative. Assuming an upper bound on WTP of US$45.00 per month, mean WTP based on responses to an offer of a 10 percentage point increase in efficacy is US$16.32 per month (US$195.84 per year). For a 15-percentage-point efficacy increase and assuming a US$60.00 upper bound, mean WTP was US$30.21 per month (US$362.52 per year). Dividing annual WTP by the size of the efficacy improvement, analogous to the calculation of the value of statistical life, yields estimates of WTP for good control of asthma of US$1958 to US$2416 per year.

Results of ordered logistic regression of the intention to purchase the more effective drug are reported in the last two columns of Table 4. The inclusion of various socio-economic characteristics and variables measuring asthma severity improve the fit of the model considerably, and the ordered logistic models in

[9] The coefficient on latency of the adverse effect is significant but of an unexpected sign. A small subsample of respondents received a variation of the survey in which the onset of fatal adverse effects was delayed through a five-year latency period. Analysis of the results of this subsample indicated that respondents seemed to interpret this type of fatality as being qualitatively different (more dangerous) besides occurring in a later period.

Table 5
Parametric estimates of WTP per unit

	Safety				Efficacy			
	Model 1		Model 2		Model 1		Model 2	
Mean WTP per unit change, based on scope coefficient[a] (US$/month)	6.95 (4.12)[b]		8.31 (3.84)		1.58 (1.83)[b]		0.85 (1.14)	
Mean WTP for drug C (US$/month)	39.72 (14.65)		27.61 (7.90)		37.43 (16.73)		28.16 (6.93)	
Mean WTP per unit change (US$/month)	10.11[c] (3.73)		7.03[c] (2.01)		3.06[e] (1.39)		2.33[f] (0.57)	
	Implied value of statistical life (US$ million)				Value of asthma control[e] (US$/year)			
	8.33[d] (4.94)	12.13 (4.47)	9.96 (4.61)	8.43 (2.41)	1896[g] (2196)	3667 (1639)	1020 (1368)	2800 (689)

[a]Scope coefficient is reparameterized by division with coefficient on the bid level (Cameron, 1988).
[b]Standard errors in parentheses using Taylor series approximation, see Cameron (1988).
[c]Calculated as mean WTP for drug C/mean annual risk reduction (3.929×10^{-5}, $n = 56$).
[d]Calculated as mean WTP per unit risk reduction $\times$ 12 months $\times$ 100,000.
[e]Calculated as mean WTP for drug C/mean annual efficacy increase (12.25×10^{-2}, $n = 80$).
[f]Calculated as mean WTP for drug C/mean annual efficacy increase (12.07×10^{-2}, $n = 75$).
[g]Calculated as mean WTP per unit efficacy $\times$ 12 months $\times$ 100.

column 4 predicts responses correctly about 69% of the time. The coefficients on the bid variable are of the expected negative sign in both models and is significant at the 5% level when the additional covariates are included.

The coefficient on the size of the efficacy increase is positive but insignificant in both regressions. Respondents who asked to value a change in efficacy were less sensitive to the scope of the improvement than were those who were valuing a change in safety. Another possible measure of scope, improvement days, consists of the number of additional nonsymptomatic days which the respondent estimated would result from 'good control of asthma' relative to their current condition. The coefficient on this scope variable was again positive but not significantly different from zero. The coefficient on quality of life with asthma, a variable which measures the strength of the (bad) effect which asthma symptoms have on a respondent's quality of life, was positive and significant in the ordered logistic model, suggesting that respondents with more severe asthma would be more likely to pay a given dollar amount for a greater probability of relief. However, the coefficient on symptom frequency is negative and significant. The socio-economic variables were jointly significant at the 10% level only, and income was the only independently significant (at the 10% level) variable in this model.

Again, these regression results can be used in two ways to estimate the value of an increase in the probability of efficacy of asthma medication. However, the estimates based on the scope coefficients, reported at the upper right-hand of Table 5, have very large standard errors. Estimates of monthly WTP for drug C, again assuming nonnegative WTP, are US$37.00 and US$28.00 and mean WTP per unit of efficacy is US$3.00 for Model 1 and US$2.33 for the full model. Aggregating these values in terms of WTP for 100% control yields estimates of about US$3700 per year and US$2800 per year.

4. Discussion and conclusions

In this paper we develop a hybrid, two-stage, contingent valuation instrument for the elicitation of economic values in multiple dimensions. This instrument is applied to the measurement of patients' values for improvements in the treatment of asthma. In the first stage, respondents choose between two medications, implying a tradeoff between safety and efficacy. In the second stage, WTP for an improvement along a single risk dimension (safety or efficacy) is elicited using a closed-ended CVM format.

In terms of theoretical validity, the instrument performed well. Parameters on the risk variables were, in most cases, robust and of expected sign and respondents appeared to be sensitive to the scope of the commodity improvements. Nonparametric estimates of the rate of safety—efficacy tradeoff for the sample range from 0.00024–0.00035, and parametric estimates based on a fitted logistic distribution yielded results in the lower end of this range. Parametric estimates for a value of a statistical life ranged from approximately US$8 to US$12 million. Willingness to

pay for complete asthma control ranged from about US$1000 to US$3700 per year.

Although the size and nature of the sample in this pilot study do not invite generalized inferences based on these estimates, the estimates of the value of asthma control were consistent whether elicited directly in dollar terms or implied through mortality risk tradeoffs. For instance, if the directly elicited US$8.5 million estimated value of life is applied to the parametric death–risk equivalent estimates obtained from the risk–risk tradeoff, the implied yearly value of asthma falls in the same US$2100 to US$2300 range which was obtained through direct dollar–risk elicitation. The value of life estimates were high but well within the range of values found in revealed preference studies (Viscusi, 1993).

One advantage of the two-stage approach relative to the standard binary choice CVM format is that more information can be extracted from each respondent without inviting the anchoring bias often attributed to sequential bidding games. From the respondent's perspective, the initial question in the form of a risk–risk tradeoff is less likely to influence the response to the subsequent closed-ended WTP choice. Another advantage is that, from the investigator's perspective, given some priority regarding the expected range of values, the dollar bid vector for the WTP stage can be conditioned upon the range of tradeoff bids proposed in the risk–risk section, permitting more efficient elicitation of WTP.

The task of measuring consumer–patient preferences is a difficult one. Any method will involve tradeoffs between theoretical validity, empirical reliability, and cost of implementation. The method proposed in this paper has a strong theoretical basis in welfare theory, captures elements of scope, and is understandable to respondents in a self-administered form. It shares the disadvantage of other closed-ended formats that information revealed by respondents is relatively diffuse. We believe that the inclusion of a second stage, which is conditioned upon first-stage responses, is a step in the direction of eliciting more information from each respondent in a self-administered format without inviting biases from anchoring, respondent fatigue, or other survey problems. Our results suggest that further efforts are warranted in integrating the various economic approaches to health risk valuation.

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References

Blomquist, G.C., O'Conor, R.M., 1995. Whose Willingness to Pay? A Policy Issue When Perceptions and Values Differ, presented in August, 1995 at the European Conf. on Health Economics in Stockholm, Sweden.

Cameron, T.A., 1988. A new paradigm for valuing non-market goods using referendum data. J. Environ. Econ. Manage. 15, 355–379.

Freeman, A.M. III, 1993. The Measurement of Environmental and Resource Values: Theory and Methods. Resources for the Future, Washington, DC.

Hanemann, M.W., 1984. Welfare evaluations in contingent valuation experiments with discrete responses. Am. J. Agric. Econ. 66, 332–341.

Johannesson, M., Jönsson, B., 1991. Economic evaluation in health care: is there a role for cost-benefit analysis?. Health Policy 17, 1–23.

Johansson, P.O., 1995. Evaluating Health Risks: An Economic Approach. Cambridge Univ. Press, London.

Jones-Lee, M., 1974. The value of changes in the probability of death or injury. J. Political Economy 82 (4), 835–849.

Kriström, B., 1990. A non-parametric approach to the estimation of welfare measures in discrete response valuation studies. Land Economics 66 (2), 135–139.

Krupnick, A.J., Cropper, M.L., 1992. The effect of information on health risk valuations. J. Risk and Uncertainty 5, 29–48.

Mitchell, R.C., Carson, R.T., 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. Resources for the Future, Washington, DC.

Rowe, R.D., Chestnut, L.G., 1986. Addendum to oxidants and asthmatics in Los Angeles: a benefits analysis. Environmental Benefits Analysis Series. Economics Analysis Division, US Environmental Protection Agency, Washington, DC.

Tolley, G., Kenkel, D., Fabian, R., 1994. Valuing Health for Policy: An Economic Approach. Univ. of Chicago Press, Chicago.

Torrance, G.W., 1986. Measurement of health state utilities for economic appraisal: a review. J. Health Economics 5, 1–30.

Viscusi, W.K., 1993. The value of risks to life and health. J. Economic Literature 31 (4), 1912–1946.

Viscusi, W.K., Magat, W.A., Huber, J., 1987. An investigation of the rationality of consumer valuations of multiple health risks. Rand J. Economics 18 (4), 465–479.

Viscusi, W.K., Magat, W.A., Huber, J., 1991. Pricing environmental health risks: survey assessments of risk–risk and risk–dollar tradeoffs for chronic bronchitis. J. Environ. Econ. Manage. 21 (1), 32–51.