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Tsuge, Takahiro
Kishimoto, Atsuo
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Takahiro Tsuge Atsuo Kishimoto and kenji Takeuchi

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An Integrated Framework for the Valuation of Mortality: Accident vs. Cancer vs. Heart Disease

Takahiro Tsuge^{*}, Atsuo Kishimoto^{} and Kenji Takeuchi^{*}**

Abstract

This paper develops an integrated framework for evaluating the reduction of several kinds of mortality risks using a Choice Experiment, which is one of a number of stated preference techniques. By this approach, we can distinguish marginal willingness to pay (MWTP) for the amount of risk reduction from that for the opportunity of risk reduction, and therefore calculate "pure" Value of a Statistical Life (VSL). The risks in our survey include the mortality risk by accident, cancer, and heart disease. The "pure" VSL is calculated to be 350 million yen (\$2.9 million). Furthermore, we analyze the influence of subjective risk perception and population characteristics of respondents on their MWTP. Estimated results suggest that it is unnecessary to adjust VSL according to the difference in the type of risks if VSL is adequately calculated by our approach. However, adjustments for timing of risk reduction and population characteristics are found to be essential for executing benefit transfer.

KEY WORDS: Choice experiment; VSL; risk perception; benefit transfer., cancer risk premium

^{*} Graduate School of Economics, Kobe University 657-8501 Kobe, Japan

^{**} National Institute of Advanced Industrial Science and Technology, Japan

1. INTRODUCTION

The Value of a Statistical Life (VSL) is a useful measure for public decision-making in the allocation of society's resources to projects or policies concerning mortality. While there is considerable consensus on its usefulness, the applicability of VSL to some policies is debatable. For example, measurement of VSL has relied mainly on the hedonic wage approach, which focuses on the relationship between wage and workplace safety.⁽¹⁾ The figures available from these studies may not be applicable to the policy that is currently under consideration, because characteristics of risks reduced by the policy and population who receive the benefit from the policy differ. Although stated preference approaches such as the Contingent Valuation (CV) technique have more flexibility concerning the type of risk evaluated and the number of stated preference studies are growing,^(2,3) there has not been a comprehensive comparison of various risk reductions that differ in type and amount of risk reduction.

The US EPA⁽⁴⁾ discusses the necessary adjustment when transferring VSL based on occupational accident to a policy concerning cancer risk. For this purpose, they formulated the value of risk reduction as a function of risk and population characteristics.

Risk characteristics are objective and subjective factors that might affect the VSL. They include the timing of death, the state of morbidity before death, and psychological factors such as dread and fear adjunct to the risk, voluntariness and controllability of the risk, and the public or private nature of the risk. Population characteristics are the socio-demographic nature of the population, such as age, income, and health status.

Since there could be substantial differences on these points among various kinds of risk, it is better to adjust the VSL obtained for a particular type of risk reduction when transferring those values to other types of risk reduction. The results of previous studies are available for such adjustment factors. McDaniels et al.⁽⁵⁾ asked respondents to state their willingness to pay (WTP) for 10 types of risk reduction by open-ended Contingent Valuation survey and explained variations in WTP by scoring questions for risk perception. Subramanian and Cropper⁽⁶⁾ used a pair-wise questionnaire of policy choice to examine the amount of risk reductions that can compensate the less preferred policy. However, no comprehensive study that treats all characteristics of VSL function simultaneously has been conducted. Consistent theoretical and empirical strategies are important because the results of stated preference study considerably depend on the instruments and mode of the survey.

In this paper, we developed an integrated framework for the valuation of several kinds of risk using a Choice Experiment (CE) methodology, which is one of a number of stated preference techniques. CE treats a commodity as a bundle of attributes, and derives the marginal valuation of each attribute separately. This feature enables division of risk reduction into several factors; type,

amount, and timing of risk reductions. Thus, we can calculate "pure" VSL based on the Marginal Willingness To Pay (MWTP) for the risk reduction. Furthermore, we analyzed the influence of subjective risk perception and population characteristics of respondents on their MWTP for the risk reduction. Through these examinations, we offer insight into the adjustment factor in utilizing the results of previous studies for evaluating current policy.

In the subsequent section, we explain CE methodology, examine its advantage for our research purpose, and explore its theoretical underpinnings. Next, we develop survey instruments and present an in-person interview for sample of Tokyo metropolitan residents. Following this, the empirical results are presented and discussed. The final section presents our conclusions.

2. VALUATION METHOD

2.1 Feature of Choice Experiment

The Choice Experiment (CE) is a technique that can infer people's preferences over some alternatives. It has been developed and applied in various fields where individual choice behavior is analyzed; marketing research, transportation research, environmental economics, and health economics.

In a CE, the analyst presents two or more alternatives to the respondents, and asks the respondents to choose the most preferable one among them. The alternatives are described as bundles of factors or their features. These factors are called "attributes" and the alternatives that are the bundles of the attributes are called "profiles". We can examine the attributes that influence the choice and the relative importance of each attribute through observation of the choice behaviors of respondents.

Since choice behavior is found in everyday life, typically in the form of shopping, respondents answer the questions of CE more easily than the questions of other stated preference techniques (e.g. rating, ranking, and pair-wise) that do not involve any choice behavior in decision making.

CE shares some advantages with CV. First, in a CE, we can use the hypothetical goods or policies as alternatives, so the respondent's preferences to those goods or policies can be observed. This is a very attractive feature over Revealed Preference techniques such as the Hedonic Wage approach where the range of mortality change is usually narrow and sometimes irrelevant to policy. Second, we can calculate the VSL based on the preferences of the general public using a CE whereas worker's preferences are elicited in the hedonic wage approach.

Furthermore, CE has an attractive advantage over CV. It can separately evaluate each attribute of the mortality reduction policies; type, amount, and timing of risk reductions. Thus, we can calculate "pure" VSL, based only on the MWTP to the "amount of risk reduction" attribute. We can also

calculate the VSL based on a particular type of risk from the results of CE.

CE has not been used in the field of economic valuation of the mortality reduction, though there are some applications of CV. We would like to explore how CE can be useful for eliciting people's WTP for the reduction of mortality and how it will become an important analytical tool in the field of risk analysis.

2.2 Theoretical Framework

The Random Utility Model is assumed for the utility of the individual. When the individual k choose the alternative i , we assume the following utility function.

$$U_{ki} = V_{ki}(x_{ki}, p_{ki}) + e_{ki} \quad (1)$$

Where, V_{ki} is the deterministic component that is the function of the attribute vector x_{ki} and the price p_{ki} of the alternative i , and can be interpreted as indirect utility function. e_{ki} is a random component that cannot be observed by researchers. The choice of alternative i over the other j ($j \neq i$) implies that the utility of that alternative (U_{ki}) is greater than that of the other (U_{kj}). Thus, the probability of choosing alternative i from the choice set C that consists of all the alternatives is,

$$\begin{aligned} P_{ki} &= \Pr(U_{ki} > U_{kj} \quad \forall j \in C, j \neq i) \\ &= \Pr(V_{ki} - V_{kj} > e_{kj} - e_{ki} \quad \forall j \in C, j \neq i) \end{aligned} \quad (2)$$

Assuming that the error terms e_{kj} and e_{ki} are *Gumbel*-distributed with scale parameter λ , as McFadden⁽⁸⁾ showed, P_{ki} is,

$$P_{ki} = \frac{\exp(\lambda V_{ki})}{\sum_j \exp(\lambda V_{kj})} \quad (3)$$

This model is called a conditional logit model. Scale parameter λ is usually standardized to one. To estimate the parameters of the deterministic component, maximize the following log-likelihood functions by a maximum likelihood method.

$$\ln L = \sum_k \sum_i d_{ki} \ln P_{ki} \quad (4)$$

Where, δ_{ki} is a dummy variable that takes 1 if the respondent k chooses the alternative i , and 0 otherwise.

MWTP for each attribute is obtained from the ratio of the estimated parameters of the attributes (β_n) and the price (β_p), if V is linear. For instance, the MWTP for one unit improvement of the attribute x_1 is obtained through the following calculation.

$$MWTP_{x_1} = \frac{dp}{dx_1} = \frac{dV/dx_1}{dV/dp} = -\frac{b_1}{b_p} \quad (5)$$

3. SURVEY

3-1. Instruments

The questionnaire consisted of the following parts. First, we explained the notion of the risk and stated the recent figures and the major cause of the death in Japan. For example, about 300 thousand, 140 thousand, and 40 thousand people die every year from cancer, heart disease, and accident, respectively. Second, we showed the graph of the relation between age and survival (Figure I), and explained that death is an unavoidable event and we are surrounded by the probability of death in everyday life. Third, we used a grid as a visual aid, so that the respondent understood the size of the mortality risk.⁽³⁾ Some of the 10,000 cells were colored to display low probability, e.g. 13 cells were colored to indicate a probability of 0.13%.

After the above explanation, the respondents move on to the questions of the CE. The respondents were asked to choose their preference from two hypothetical commodities that can reduce mortality risk, or to choose the “I do not purchase either” option.

The two hypothetical commodities differ in the type, the amount, the timing of risk reductions, and the price. The attributes and their levels used in CE are shown in Table I. Four types of risks (accident, cancer, heart disease, and general) are involved. *Accident* risk is explained as the risk of death due to an accidental event, such as transport accident, falling, drowning, suffocation, and poisoning by noxious substances. *Cancer* risk includes the risk of death due to cancer such as stomach cancer, lung cancer, and large intestine cancer. *Heart disease* risk is defined as the risk of death due to heart diseases, such as myocardial infarction and cardiac arrhythmias. *General* risk is

the risk of death due to a cause that the purchaser of the hypothetical goods does not know ex-ante. Accident, cancer, and heart disease are considered the major causes of death in Japan and are involved as specific attributes. General risk can represent the average image of all causes of death and assumed to be neutral to any kind of subjective perception of a specific risk.

"Price" is the financial burden of purchasing the hypothetical good to reduce the mortality risk. The individuals' utility usually decreases as financial burden increases, so that the coefficient of this attribute is expected to be negative. The level of "Risk Reduction" means how much mortality risk is reduced by the use of these hypothetical goods for 10 years. The sign of the coefficient of this attribute is expected to be positive. "Effect Starts" attribute means when the effect of the risk reduction starts. The expected sign for the coefficient of this attribute is negative, because individuals prefer current risk reduction rather than future risk reduction.

We prepared all combinations of the attribute levels as profiles and then randomly selected two of them to make the alternatives of hypothetical goods. We made choice sets by adding the "I do not purchase either" option to each two randomly selected profiles. An example of the CE questions are shown in Figure II. Each respondent was asked to answer 8 questions.

3-2. Descriptive Statistics

The data were collected using an in-person survey of randomly sampled residents of the Tokyo metropolitan area, which was conducted in September 2002, and resulted in 400 responses. A trained expert from a private research company was recruited for the interview.

Descriptive statistics on the socio-demographic characteristics of respondents are summarized in Table II. We selected samples evenly from the age groups above the age of 30 and evenly with gender. The average age and average income of sample group are higher than those in Japan. Composition of family, behavior of avoiding food risks (measure for the extent of risk aversion), experience of bereavement due to accident or cancer, and income can affect the preference toward mortality reduction. We analyze those effects on choice behavior, in a later section.

We also asked the respondents to rate their subjective perception of each risk by scoring it from 1 to 10. Incorporating these data in the analysis allows detailed examination of the cause of the difference in WTP for reduction of mortality.

The subjective rating of risk characteristics included *Voluntariness* (I am responsible for the cause of this risk), *Controllability* (Government policy can reduce this risk), *Dread<pain>* (Pain accompanies this death), *Dread<fear>* (This risk is terrible), *Severity* (The possibility of death is high), *Private Knowledge* (I know the cause of this risk well), *Public Knowledge* (Scientific knowledge of the cause of this risk is sufficient), and *Exposure* (I am exposed to this risk higher than others). An example question on risk perception is shown in Figure III. Table III shows the

descriptive statistics for the score of risk perception. Except for Controllability, all scores of cancer risk are highest among the three types of risk. This may suggest the existence of cancer risk premium.

4 MODELS AND RESULTS

4.1 Models

The following 7 forms of the indirect utility functions are examined. Note all index for respondents and alternatives are omitted.

$$V = b_1PRICE + b_2RISKREDUCT \quad ION + b_3ACCIDENT + b_4CANCER + b_5HEART + b_6TIMING \quad [\text{Model 1}]$$

Model 1 is the simplest linear model. *ACCIDENT*, *CANCER*, and *HEART* are the dummy variables for the type of risk. From the coefficients of the risk reduction and the price, we can calculate "pure" VSL that is based only on the marginal valuation of the amount of reduction. The coefficient of dummy variables for the risk type can be used to estimate the WTP for the opportunity to purchase each type of risk reduction, irrespective of the quantity change in mortality. We explain how these coefficients can be used to calculate VSL in next section.

$$V = b_1PRICE + b_2RISKREDUCT \quad ION / (1+r)^{TIMING} + b_3ACCIDENT + b_4CANCER + b_5HEART \quad [\text{Model 2}]$$

Model 2 is developed to estimate the individuals' discount rate r for future risk reduction. We can infer how much the individuals devalue later reduction of mortality risk using this model.

$$V = b_1PRICE + (b_2 + b_3ACCIDENT + b_4CANCER + b_5HEART)RISKREDUCTION + b_6ACCIDENT + b_7CANCER + b_8HEART + b_9TIMING \quad [\text{Model 3}]$$

Model 3 involves the cross terms of the risk reduction and the risk types. b_2 can be interpreted as the coefficient for the general risk, which is assumed as the base of the risk types. We can examine the difference of the valuation for one unit of risk reduction among different risk types from the

coefficients of cross terms.

$$V = (b_1 + b_2 INCOME) PRICE + b_3 RISKREDUCT \quad ION \\ + b_4 ACCIDENT + b_5 CANCER + b_6 HEART + b_7 TIMING \quad [Model 4]$$

$$V = b_1 PRICE + (b_2 + b_3 OVER70 + b_4 MARRIAGE + b_5 CHILD + b_6 NOBEEF \\ + b_7 DEADA \times ACCIDENT + b_8 DEADC \times CANCER) RISKREDUCTION \\ + b_9 ACCIDENT + b_{10} CANCER + b_{11} HEART + b_{12} TIMING \quad [Model 5]$$

Model 4 and 5 incorporate the cross terms of attribute variables and population characteristics variables in the utility function. This allows examination of the effect of the respondents' population characteristics on the valuation of the attributes. Thus, we can investigate the effect of the population characteristics on MWTP in the uniform utility function. Coefficients of each characteristic can be interpreted as marginal utility.

Model 4 includes the cross terms of the price and the income. We can examine whether there is a difference on the marginal utility of price by different income. In other words, we can verify if the higher the respondent's income is, the higher the WTP is.

Model 5 involves the cross terms of the risk reduction and population variables of the respondent. *OVER70* is a dummy variable that takes 1 if the respondent is over the age of 70 and 0 otherwise. *MARRIAGE* is a dummy variable that takes 1 if the respondent is married and 0 otherwise. *CHILD* is a dummy variable that takes 1 if the respondent has a child aged under 15 and 0 otherwise. *NOBEEF* is a dummy variable that takes 1 if the respondent has not eaten any beef since September 2001 and 0 otherwise. In Japan, Bovine Spongiform Encephalopathy (BSE) was first detected in September 2001, and attracted much attention through mass media, so that we can regard this variable as representing the degree of risk aversion by respondents. *DEADA* is a dummy variable that takes 1 if relatives or friends of the respondent had died due to accident and 0 otherwise. *DEADC* is a dummy variable that takes 1 if relatives or friends of the respondent had died due to cancer and 0 otherwise. We can investigate whether the marginal utility of risk reduction is affected by the population variables of the respondents. In other words, we can verify whether the WTP is dependent on those features of the respondents.

$$V = b_1 PRICE + b_2 RISKREDUCT \quad ION \\ + b_3 VOLUNTARIN \quad ESS + \dots + b_{10} EXPOSURE + b_{11} TIMING \quad [Model 6]$$

$$V = b_1PRICE + b_2RISKREDUCTION + b_3ACCIDENT + \dots + b_5HEART + b_6VOLUNTARINESS + \dots + b_{13}EXPOSURE + b_{14}TIMING \quad [\text{Model 7}]$$

$$V = b_1PRICE + b_2ACCIDENT + \dots + b_4HEART + (b_5 + b_6VOLUNTARINESS + \dots + b_{13}EXPOSURE)RISKREDUCTION + b_{14}TIMING$$

[Model 8]

Models 6 to 8 were formulated to investigate the effect of risk perception on WTP. Eight variables of perception are already explained in Table 2. These variables take the score of perception for a risk type that the respondent chooses as preferable. For example, if a respondent chose cancer risk reduction from the choice set, then the *VOLUNTARINESS* variables take the score that he/she answered for the perception question on *VOLUNTARINESS* of cancer.

In Model 6, respondents' risk perception data for each risk type is used instead of the risk type dummy. We attempted to decompose the types of risk to the characteristics of the risk by this model. On the other hand, Model 7 includes both risk perception data and risk type dummies. This formulation assumes that there is a common component of WTP for risk types, and a perception factor beyond that is reflected in b_5 to b_{13} . Model 8 contains cross terms of the respondents' risk perception data and the risk reduction term, so that we can examine whether the marginal utility of risk reduction is affected by the respondent's risk perception.

4.2 Estimation Results

Conditional logit models are estimated. Results of Model 1 to 5 are shown in Table IV, and those of Model 6 to 8 are shown in Table V.

All variables are statistically significant in the simplest model (Model 1). The sign of the *PRICE* is negative and that of the *RISK REDUCTION* is positive as expected. All the coefficients of the risk type dummies are significant, where the base of the risk type dummies is general risk. Significant coefficients of the risk type dummies show that the valuation of risk reduction policies varies with its risk type (later we discuss the size of this effect on VSL). Respondents prefer the measures for cancer the most and the measures for accident the least. *TIMING* is negatively significant, so that people prefer sooner risk reductions. We can infer the discount rate for the risk reduction is about

20% from Model 2.

In model 3, the cross terms of the *RISK REDUCTION* and the risk type dummies (*ACCIDENT*, *CANCER*, *HEART*) are not significant, though the *RISK REDUCTION* is positively significant. The result suggests that respondents might evaluate a unit risk reduction of any type of risk indifferently.

In Model 4, *INCOME_P* is positive and significant. This suggests that the higher the income, the higher the WTP.

In Model 5, *OVER70_R* and *DEADA_CANCER_R* are significant. The negative sign of the *OVER70_R* implies that people aged over 70 have lower WTP for risk reduction (0.2% lower). The positive sign of *DEADC_CANCER_R* suggests that respondents who had relatives or friends die due to cancer evaluate the risk reduction of cancer higher (62.3 % higher comparing to the other).

In Model 6, many of the risk perception variables are significant. However, comparing the Schwarz Bayesian Information Criterion (SBIC), a major criterion for the model selection, of Model 6 (3355.13) and that of Model 7 (3295.26), we judge that Model 7 is superior. The model decomposing the risk type only by the major risk perception variables turn out to be less persuasive.

In Model 7, *VOLUNTARINESS*, *CONTROLLABILITY*, *SEVERITY*, *PUBLIC KNOWLEDGE*, and *EXPOSURE* are positive, therefore measures for the risks with these subjective characteristics are preferred. Only *DREAD <PAIN>* has a negative sign, therefore measures for the risks with this subjective characteristic are less favored. Though this might be intuitively strange, people who attach the large weight to the pain may dislike the commodity that cannot ease the pain directly.

In Model 8, *VOLUNTARINESS_R* and *EXPOSURE_R* are positively significant. These results suggest that a unit reduction of the risks with these subjective characteristics is preferred. On the other hand, *DREAD <PAIN>_R* is significant and again has a negative sign.

4.3 Calculation of VSL

VSL is calculated by dividing WTP for a particular amount of risk reduction by the amount of risk reduction. When VSL is calculated from the WTP obtained from the Contingent Valuation survey, WTP for a particular amount of risk reduction is calculated by dividing the constant term by the coefficient of price. However, as the constant may contain both the utility of the amount of risk reduction and the *opportunity* of risk reduction, VSL calculated in this way might be biased.

With the CE method that can evaluate multi-attribute commodity, MWTP for the risk reduction is calculated from the coefficient of the risk reduction and the price. Thus, we can exclude the effect of other factors such as WTP for opportunity of purchasing risk reduction.

MWTP for the risk reduction in Model 1 is 35,335 yen, and 95% confidence interval obtained by the Monte Carlo simulation (1,000 times) is from 20,669 yen to 51,438 yen. VSL based on this

MWTP is about 350 million yen (\$2.9 million).

We can also calculate the VSL based on each type of risk by adding the WTP for the opportunity of reducing each type of risk to the pure VSL. However, WTP for the opportunity is unaffected by the size of risk reduction and its effect on overall VSL is very small. The WTPs for the purchase opportunities of accident, cancer, and heart disease are 0.68 million yen less, 0.19 million yen greater, and 0.36 million yen less than that of the general risk, respectively.

4.4 Discussions

Two points are worth discussing. First, we did not find any significance of the coefficient of cross terms of risk reduction and risk type in Model 3. People are willing to pay more for the larger risk reductions, but the amount is not different among the type of risk. On the other hand, there were significances of the risk type dummies without cross terms. Therefore, people might be willing to pay for the *opportunity* of purchasing some type of risk reduction, though this part is constant and does not have any relation with the size of risk reduction. As shown in the previous section, WTP for the opportunity is very small. There is a policy implication for benefit transfer: We should use the same VSL, irrespective of the type of risk reduction. However, the effect of other characteristics such as timing of risk reduction and population feature might be considerable and should be accounted when transferring the VSL.

US EPA ⁽⁴⁾ argues there is "cancer risk premium" and VSL should be adjusted with this factor, citing CV studies by Savage ⁽⁹⁾ and Jones-Lee et al. ⁽¹⁰⁾ However, CV technique cannot distinguish the MWTP for the amount of risk reduction from that for the opportunity of risk reduction. Therefore, it results in biased measure to multiply the whole VSL by cancer-premium weight taken from CV studies. We should calculate "pure" VSL that account the WTP for a specific amount of risk reduction, and add some premium on that if there is WTP for purchasing a specific type of risk reducing opportunity.

In Figure IV, the vertical axis is the total WTP, and the horizontal axis is the amount of risk reduction. OC is the total WTP curve for general risk reduction, and 1C is the "pure" VSL for general risk reduction. AD or AE is the total WTP curve for a specific risk, in this case cancer (assume AD is parallel to OC). The "pure" VSL for cancer risk reduction is BD or BE. We found in the estimation that a total WTP curve for cancer risk has the same slope with that of general risk (the curve was AD). OA is "cancer risk premium" in the WTP for the opportunity of risk reduction. The difference in the height of the curve between AD and AE is "cancer risk premium" in the WTP for the amount of risk reduction, though we did not found it significant in our data set.

The second noteworthy point comes from the models of the risk perception. From comparison of Model 6 and Model 7, we found Model 7 superior. This suggests that the risk of death due to

accident, cancer, and heart disease cannot be explained *only* by the eight representative risk perception factors. People share common evaluation beyond these risk perception factors, of the risk of accident, cancer, and heart disease. Furthermore, the result of Model 8 implies that the sensitivity of people to the risk perception can fluctuate the valuation of the same unit of risk reduction. As apparent from Model 3, even though these effects disappear when the risk type dummies are used for the cross terms with risk reduction, risk communication for people who are sensitive to subjective factors can further mitigate those fluctuations.

5. CONCLUSION

We developed an integrated framework for the valuation of several kinds of risk using a CE. Using this approach, pure VSL based on the MWTP for the risk reduction is found to be 350 million yen (\$2.9 million).

Timing of the risk reduction negatively affects the individuals' utility. The estimated discount rate is over 20%. These findings suggest that individuals prefer current risk reduction rather than future risk reduction.

Although we found that both the risk characteristics and the population characteristics affect VSL, the effect of the latter turn out to be important. Estimated results suggest that it is unnecessary to adjust VSL according to the difference in the type of risks, if VSL is adequately calculated according to our approach. One should note that this argument does not apply to the VSL obtained by CV that does not account for the differences of WTP for amount and opportunity of risk reduction. Finally, adjustments for timing of the risk reduction and population characteristics are found to be essential in executing benefit transfer.

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Figure I. Survival Curve (for male, the age of 35)

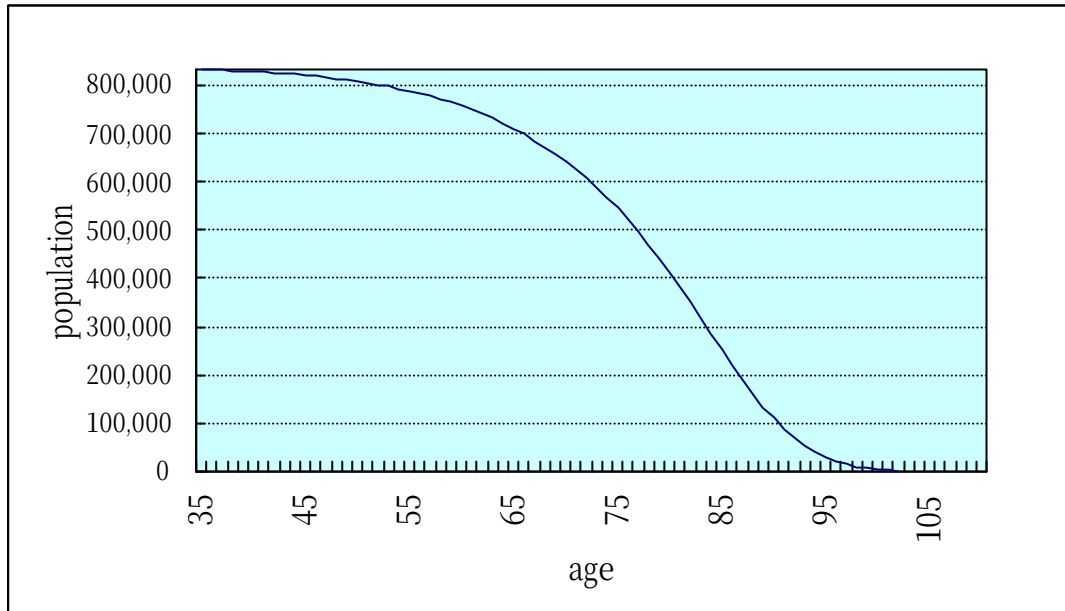


Table I. Attributes and Levels

Attributes	Levels			
Price (for 10 years)	80,000 Yen	150,000 Yen	580,000 Yen	850,000 Yen
Risk Reduction (for 10 years)	1/10,000	5/10,000	10/10,000	
Risk Type	Accident	Disease (Cancer)	Disease (Heart disease)	General
Effect Starts	Now	5 Years After	10 Years After	

FigureII. Example of Choice Sets

	1	2	3
Price (for 10 years)	80,000 Yen	850,000 Yen	I do not purchase either
Risk Reduction (for 10 years)	1 / 10,000	10 / 10,000	
Risk Type	Accident	Disease (Cancer)	
Effect Starts	5 Years After	10 Years After	

Table II. Descriptive Statistics for Socio-democratic Characteristics

	Mean (Standard Deviation) or percentage
Age	54.3 (14.15)
Female	50%
Married	86%
Has child under 15	29%
Have not eaten beef after BSE was detected in Japan	10%
Have relatives or friends who died due to accident	18%
Have relatives or friends who died due to cancer	58%
Income (10,000 Yen)	723.93 (329.16)

Figure III. Question on the Risk Perception (Voluntariness)

		I disagree → I agree									
I am responsible for the cause of this risk	Accident	1	2	3	4	5	6	7	8	9	10
	Heart Disease	1	2	3	4	5	6	7	8	9	10
	Cancer	1	2	3	4	5	6	7	8	9	10

Table III. Mean and Standard Deviation of Perception Score

	Accident	Disease (Cancer)	Disease (Heart Disease)
I am responsible for the cause of this risk: <i>Voluntariness</i>	5.17 (2.60)	5.56 (2.42)	5.21(2.47)
Government policy can reduce the risk: <i>Controllability</i>	5.68 (2.66)	4.96 (2.44)	4.50 (2.27)
Pain accompanies this risk: <i>Dread</i> < <i>Pain</i> >	7.49 (2.64)	8.52 (2.07)	7.68 (2.45)
This risk is terrible: <i>Dread</i> < <i>Fear</i> >	7.86 (2.63)	8.30 (2.30)	7.71 (2.60)
The possibility of death is high: <i>Severity</i>	7.05 (2.51)	7.50 (2.28)	7.03 (2.40)
I know the cause of this risk well: <i>Private Knowledge</i>	5.61 (2.63)	5.77 (2.33)	5.65 (2.37)
Scientific knowledge of the cause of this risk is sufficient: <i>Public Knowledge</i>	4.40 (2.53)	6.09 (2.40)	6.20 (2.30)
There is higher risk for me than others: <i>Exposure</i>	4.12 (2.22)	5.12 (2.36)	4.49 (2.34)

Note; Numbers in the parenthesis are standard deviations.

Table IV. Coefficients of Conditional Logit Models (Model1-Model5)

[400×8=3200 observations]

	Model1	Model2	Model3	Model4	Model5
PRICE(*10 ⁻⁶)	-0.849*** (-9.761)	-0.962*** (-11.207)	-0.867*** (-9.619)	-1.863*** (-9.510)	-0.843*** (-9.626)
RISK REDUCTION	0.030*** (4.362)	0.053*** (6.166)	0.036*** (3.480)	0.029*** (3.833)	0.061*** (3.997)
ACCIDENT_R			-0.007 (-0.336)		
CANCER_R			-0.007 (-0.410)		
HEART_R			-0.020 (-1.064)		
ACCIDENT	-0.580*** (-7.950)	-0.658*** (-9.147)	-0.558*** (-4.445)	-0.577*** (-7.126)	-0.531*** (-6.939)
CANCER	0.159** (2.321)	0.060 (0.912)	0.182 (1.732)	0.156** (2.058)	0.062 (0.766)
HEART	-0.309*** (-4.233)	-0.414*** (-5.969)	-0.216*** (-1.850)	-0.272*** (-3.391)	-0.301*** (-4.090)
R		0.210** (2.320)			
TIMING	-0.034*** (-5.247)		-0.035*** (-5.236)	-0.036*** (-5.098)	-0.032*** (-4.934)
INCOME_P(*10 ⁻⁸)				0.143*** (6.326)	
OVER70_R(*10 ⁻³)					-0.109*** (-7.907)
MARRIAGE_R					-0.016 (-1.074)
CHILD_R					-0.019 (-1.636)
NOBEEF_R					0.027

					(1.568)
DEADA_ACCIDENT_R					-0.026 (-1.062)
DEADC_CANCER_R					0.038*** (2.602)
SAMPLE	3200	3200	3200	2608	3192
LRI	0.0586	0.0583	0.0588	0.0636	0.0697

*** = significant at 1%, ** = 5%, * = 10%. Numbers in the parenthesis are t value.

r is the discount rate.

AUTO_R, CANCER_R, HEART_R are cross terms for RISK REDUCTIONS and ACCIDENT, CANCER, HEART, respectively.

INCOME_P is a cross term for INCOME and PRICE.

OVER70_R, MARRIAGE_R, CHILD_R, NOBEEF_R are cross-terms for RISK REDUCTIONS and OVER70, MARRIAGE, CHILD and NOBEEF, respectively.

DEADA_ACCIDENT_R is a cross term for RISK REDUCTION, DEADA and ACCIDENT.

DEADC_CANCER_R is a cross term for RISK REDUCTION, DEADC, and CANCER.

Table V. Coefficients of Conditional Logit Models (Model6-Model8)

[400×8 =3200obsrbvations]

	Model6	Model7	Model8
PRICE (*10 ⁻⁶)	-0.933 *** (-10.720)	-0.868 *** (-9.856)	-0.804 *** (-8.987)
RISK REDUCTION	0.027 *** (3.956)	0.031 *** (4.494)	0.013 (1.322)
ACCIDENT		-1.981 *** (-9.519)	-0.680 *** (-7.590)
CANCER		-1.399 *** (- 6.323)	-0.034 (0.393)
HEART		-1.772 *** (- 8.379)	-0.411 *** (- 4.737)
VOLUNTARINESS	0.052 *** (3.551)	0.086 *** (5.676)	
CONTROLLABILITY	-0.030 ** (- 2.105)	0.029 * (1.868)	
DREAD <PAIN>	-0.058 *** (- 3.234)	-0.033 * (- 1.693)	
DREAD <FEAR>	-0.021 (- 1.114)	0.016 (0.813)	
SEVERITY	-0.010 (-0.583)	0.034 * (1.891)	
PRIVATE KNOWLEDGE	-0.038 ** (-2.330)	-0.002 (-0.119)	
PUBLIC KNOWLEDGE	0.030 ** (2.011)	0.040 ** (2.353)	
EXPOSURE	0.111 *** (6.832)	0.115 *** (6.958)	
TIMING	-0.038 *** (- 5.880)	-0.034 *** (- 5.194)	-0.030 *** (- 4.381)

VOLUNTARINESS_R (*10 ⁻²)			0.682 *** (3.121)
CONTROLLABILITY_R (*10 ⁻²)			0.079 (0.372)
DREAD <PAIN>_R (*10 ⁻²)			-0.915 *** (-3.400)
DREAD <FEAR>_R (*10 ⁻²)			-0.153 (-0.543)
SEVERITY_R (*10 ⁻²)			0.392 (1.491)
PRIVATE KNOWLEDGE_R (*10 ⁻²)			-0.227 (-0.903)
PUBLIC KNOWLEDGE_R (*10 ⁻²)			0.065 (0.276)
EXPOSURE_R (*10 ⁻²)			1.134 *** (4.625)
SAMPLE	3200	3200	3200
LRI	0.0583	0.0787	0.0674

*** = significant at 1%, ** = 5%, * = 10%. Numbers in the parenthesis are t value.

VOLUNTARINESS_R, CONTROLLABILITY_R, DREAD <PAIN>_R, DREAD <FEAR>_R, SEVERITY_R, PRIVATE KNOWLEDGE_R, PUBLIC KNOWLEDGE_R, EXPOSURE_R are cross terms for RISK REDUCTION d each risk perception data, respectively.

Figure IV. The "pure" VSL

