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Risk Perceptions and Value of a Statistical Life for Air Pollution and Traffic Accidents: Evidence from Bangkok, Thailand

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Abstract

This paper presents results of two contingent valuation surveys conducted in Bangkok measuring individuals' willingness to pay (WTP) to reduce mortality risk arising from two risk contexts: air pollution and traffic accidents. Results from the risk perception survey disclose that respondents view the two risks differently. WTP to reduce air pollution risk is influenced by degrees of dread, severity, controllability and personal exposure, while WTP to reduce traffic accident risk is influenced by perceived immediate occurrence. Nevertheless, the value of a statistical life (VSL) for both air pollution and traffic accidents are comparable (US$0.74 to $1.32 million and US$0.87 to $1.48 million, respectively). This indicates that the risk perception factor alone has little impact on the VSL, a finding similar to previous studies using program choice indifferences.

Keywords: contingent valuation, value of statistical life, willingness-to-pay, air pollution, road traffic accident, developing country

JEL Classification: I18, D61, J17, J28

In most developed countries, governments recommend or require economic analyses of proposed regulations and public policies. Regulatory agencies, for example in the United States, United Kingdom, Canada, Sweden, and New Zealand, have been using value of a statistical life (VSL) estimates to evaluate the benefits of proposed environmental, health, and safety rules (see Viscusi and Aldy, 2003 for a comprehensive review of policy implication of VSL). In these countries, estimates of the value of reduced mortality risk often predominate the estimated total benefits. For example, more than 90 percent of the estimated total benefits of the Clean Air Act in 2010 comes from reduced mortality risk (U.S. EPA, 1999). It is in this regard that a reliable estimate of VSL is necessary to be able to perform a credible cost-benefit analysis for decisionmaking.

However, there is a dearth in empirical VSL studies especially in the area of pollution control. For example, the Environmental Protection Agency (EPA) guidelines for regulatory analyses (U.S. EPA, 2000a) recommended a VSL of $5.7 million (1995 US$), which is the mean value of 26 labor-market studies reviewed in Viscusi (1993). The lack of empirical

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VSL studies in the U.K. led the U.K. Department of the Environment, Transport, and the Regions to use the VSL derived from a contingent valuation (CV) study in which the road accident risk was $0.85 million (1995 prices, equivalent to US$1.4 million). Consequently, an ad hoc expert group under the U.K. Department of Health (1999) opposed the direct use of the road accident based VSL to the air pollution context. They proposed adjustments (both upward and downward) considering several factors. However, the group's VSL estimates range widely (from $2,500 to $1.35 million in 1995 prices), indicating that the estimates are highly uncertain.

This uncertainty in VSL estimates is caused by differences in risk contexts and at-risk population between the existing VSL studies and the actual policy contexts. For example, the risk context for the samples in labor market studies is seen as voluntary and routine exposure, rather than the involuntary and perhaps dreaded exposure to pollution. The samples in the labor market studies involve healthy, working-age adults while the population-at-risk from air pollution exposure largely concerns the elderly and those in poor health. The features given to the labor market studies also apply to the CV studies in the traffic accident context.

Several researchers and agencies have tried to adjust the existing VSL estimates (Revesz, 1999; U.S. EPA, 2000b; U.K. Department of Health, 1999). Revesz (1999) proposed adjusting the standard VSL used by the EPA for use in carcinogenic pollutants emission control by considering three risk attributes: involuntariness of the exposed, uncontrollability, and dread of having cancer. Relying on some empirical studies in the literature, Revesz suggested that the first two factors would lead to a doubling of the VSL, while the third would lead to another doubling. The U.S. EPA's Science Advisory Board (2000) still argue, nonetheless, that at present there is no sufficient theoretical and empirical basis to support the adjustment in the labor market based VSL. On the other hand, in the U.K. due to lack of empirical VSL studies in the air pollution context and reliable information to support adjustment in the road safety based VSL for air pollution, the Department of Health Ministers refrain from quantifying health benefits of air pollution reduction in monetary terms (Dunn, 2001).

Consequently, we have undertaken two CV surveys in Bangkok, Thailand to verify the effect of perceived risk characteristics on individuals' willingness to pay (WTP) for mortality risk reductions. The first survey measures individuals' WTP to reduce the risk of death brought about by air pollution induced lung diseases. The second survey measures individuals' WTP to reduce the risk of death brought about by traffic accidents. Both risk contexts are quite familiar to Bangkok residents but the degrees of these risk attributes as perceived by the public are expected to be different. In particular, we estimate WTP for a special medical health checkup in the air pollution sample and WTP for an optional safety device (either a frontal airbag or a side-impact airbag) in the traffic accident sample. The questions are constructed in a way that allows us to test whether WTP responses are sensitive to the magnitudes of different risk reductions. We also investigate the perceived characteristics of these two risks by incorporating risk-perception questions in the CV surveys.

Our study is different from previous program choices and WTP studies in that single risk valuation is used. In our CV survey, respondents were asked for their WTP to reduce mortality risk in either an air pollution context or traffic accident context. In this way, we can avoid possible misconceptions by respondents on the baseline risks given to multiple risk contexts, which are found to dominate the risk perception factors in previous studies (McDaniels, Kamlet, and Fischer, 1992; Beattie et al., 2000; Chilton et al., 2000). A direct comparison between air pollution based VSL and traffic accident based VSL can be used to verify the transferability of VSL between the two risk contexts.

This article is structured as follows. Section 1 provides a literature review concerning the effects of risk characteristics on WTP for mortality risk reduction. Section 2 describes the CV survey instrument, samples and survey implementation. Section 3 presents the results of regression analyses. Section 4 concludes the discussion.

1. Previous literature

Economists have developed a number of methodologies to measure the tradeoffs between quantitative risks and risk perception factors. The studies can be divided into two broad categories: (1) program choice indifference or priority ranking studies and (2) WTP studies. In the first approach, respondents are asked to choose a risk reduction program among alternatives and ranking safety programs (Mendeloff and Kaplan, 1989; Jones-Lee and Loomes, 1995; Subramanian and Cropper, 2000; Chilton et al., 2002). The latter approach directly elicits respondents' WTP for risk reductions and their perception on risk (McDaniels, Kamlet, and Fischer, 1992; Savage, 1993; Cookson, 2000).

Although psychologists recognize the importance of risk characteristics in explaining how people prioritize human health risks, these risk characteristics have been found to be non-significant in most studies using program choice indifferences. Mendeloff and Kaplan (1989) asked four samples to rank the relative priority of preventing deaths through eight programs. The results are mixed. Three samples valued preventing deaths due to air pollutants as more valuable than preventing immediate deaths by removing roadside obstacles. In contrast, two samples valued preventing deaths due to air pollutants as *less* important, while the other two samples rated these two programs quite similarly.

Subramanian and Cropper (2000) revealed that severity and personal exposure are significantly positively related to people preferences to life saving programs. Controllability is significant and has a negative sign. Voluntariness is found to be insignificant. A recent study, Chilton et al. (2002), estimated VSL in three contexts, railways, domestic fires and fires in public places, relative to the corresponding value for roads. None of the typical risk characteristics (e.g., dread, expert-knowledge, voluntariness and controllability) is significant, except the personal exposure variable and household benefits. However, as noted by the authors (as well as Beattie et al., 2000), the results of indifferences among risk trade-offs may be influenced by respondents' misconceptions on the baseline risk.[1]

The literature that explores WTP for different risk contexts is comparatively limited. McDaniels, Kamlet, and Fischer (1992) asked 55 respondents for their *household* WTP for safety programs that can reduce risk by 20%. The authors found that for more familiar hazards, individual WTP to reduce risk is most substantially influenced by the extent of respondents' perceived personal exposure to the particular hazard, whereas in the case of the less familiar hazards, the most important influences are levels of dread and the perceived severity of adverse consequences.[2]

Savage (1993) used a telephone survey asking 1,027 adults for their perceptions on four risks, commercial airplane accidents, household fires, automobile accidents and stomach cancer. The author found that WTP increases with the dread of the risk but declines with degree of knowledge people have about the risk they are exposed to. Although this study provides WTP estimates for these four risks, it does not measure individual WTP to reduce own risk. No information about the baseline risk and the magnitude of the risk reduction produced by the research were specified in the survey.

Cookson (2000) used four elicitation question modes: "priorities," "matching," "willingness to pay" and "relative monetary valuation" to investigate people's WTP on six areas of policy. Based on group discussions, voluntariness and controllability are important factors that participants considered in choosing or ranking policies but such is not the case for knowledge. The qualitative analysis of this study, however, limits the generalization of the findings.

2. Contingent valuation survey

The following sections describe survey instrument and implementation. Two combined CV and risk perception surveys were conducted in order to compare the VSL for air pollution and traffic accidents and to investigate the effects of risk perceptions on VSL.

2.1. Survey instrument

Unlike previous studies that elicit household WTP or ask WTP to reduce risk to the general population, respondents in this study were asked about individual WTP to reduce their own mortality risks, which is consistent with the economic theory of the VSL. Traffic accident risk is chosen to compare the resulting VSL and risk perception scores with those of air pollution risk. Similar to air pollution risk, traffic accident risk is a familiar risk context for most people, but it is generally viewed as having risk characteristics different from those of air pollution risk. Traffic accident risk may be perceived to be more voluntary, more controllable and have more immediate deaths.[3] In addition, traffic accident risk has often been researched in previous WTP studies (e.g., Viscusi, Magat, and Huber, 1991; McDaniels, Kamlet, and Fischer, 1992; Savage, 1993; Magat, Viscusi, and Huber, 1996; Beattie et al., 1998; Carthy et al., 1999; Persson et al., 2001).

The questionnaire begins with several questions about the respondent's view on their current health status (asking them to rate their health status as very good, good, fair, or poor) and the respondent's health history, whether they have ever been diagnosed with asthma, chronic cough, chronic bronchitis, high blood pressure, heart disease or cancer. These two questions are omitted in the traffic accident sample. Rather, respondents in the traffic accident case were asked for their mode of transportation. Then, the respondents were asked whether they have any health insurance in both of the two samples. The respondents in the air pollution group were further asked whether they have a regular health checkup (annual checkup).

The next question pertains to the type of risk the respondents were concerned with. In both risk groups, respondents were asked to rank the first three sources of risks that are of greatest concern to them. Seven common risks were provided: crime, food poisoning, air pollution, traffic accidents, job risks, pesticides/insecticides in fruits and vegetables, and water pollution. A blank space was provided for the respondents to fill in other risks that concern them. This question was designed to determine the respondents' attitude towards the source of risk and assess whether or not people who rank air pollution as their greatest concern will have higher WTP than others.

Before WTP questions were given to respondents, the questionnaire provided some explanations about the concept of "risk" and "death rate," accompanied by a table showing the death rate of Bangkok residents by causes of death. This aims to give respondents familiarity with the risk and awareness about mortality risks. To make the respondents familiar with the probability of dying and the visual aids, a simple probability test was introduced showing a risk ladder with two persons, A and B, located on the upper and lower steps of a ladder. Person A is located on a step higher than Person B, which implies a condition of higher risk (20 in 1,000) as compared to 10 in 1,000 where Person B is located. Respondents were asked accordingly: "which person do you think has a higher risk of death?"

The survey instrument was developed and refined through focus groups and a pre-test.[4] Information about the scenario of each risk and its corresponding WTP questions are provided in Appendix A. The scenario in the air pollution sample describes the health risks from exposure to particulate matter smaller than 10 micron (PM_{10}). We chose PM_{10} as the targeted pollutant because it is one of the pollutants of most concern in Bangkok and its main contributing source is from motor vehicles, (worsened by traffic congestion) which Bangkok residents are familiar with. The baseline pollution risk is annual deaths of 430 in 1,000,000. This figure is calculated based on a local concentration-response function estimated by Chestnut et al. (1998) together with the data of PM_{10} concentration levels and the natural death rate in 2002.[5] As for the road traffic accident scenario, the baseline risk of 150 in 1,000,000 for the year 2001 was taken from data on traffic accident deaths reported in *Thailand Public Health Report A.D. 2001* (Ministry of Public Health, 2003).

An annual medical health checkup was chosen as the payment mechanism by which pollution risk reductions would be delivered. It is presumed to be very effective in detecting any impairment in the respiratory system. In the case of traffic accidents, respondents were asked about their annual willingness to pay for installing either a frontal or side-impact airbag which would be effective over 10 years time. In both cases, the respondent was told that the payment mechanism is presumed to reduce his/her own risk of dying. This is because we wish to elicit individual WTP, which is an appropriate measure for cost-benefit analysis.[6] In addition, we selected private goods, rather than using tax or donations for public programs because public goods are found be to associated with some strategic biases (e.g., 'free riding' behavior) or warm glow effects on WTP responses.[7] Using private goods is thought to avoid a high number of protest responses due to doubts on the effectiveness of the programs.[8]

In view of the growing concern regarding the reliability of the CV method, especially the finding of inconsistencies in response to CV questions, a split-sample CV design was used in this study. Specifically, the survey instrument was designed to test the so-called "scope" and "ordering" effects in WTP responses. Scope effects refer to the phenomenon in which the WTP varies inadequately, which changes in the scale or scope of the item being valued (Hanemann, 1994). Findings of inadequate sensitivity to scope in health risk valuation studies is reported in Hammitt and Graham (1999) and Beattie et al. (1998). In turn, ordering effects are defined where responses to a given question vary according to the positioning of that question relative to others in the survey instrument (Powe and Bateman, 2003).

To test the sensitivity of WTP responses to scope (or probability of risk changes), all respondents were asked about their willingness to pay for two different annual risk reductions, namely 30 in 1,000,000 or 60 in 1,000,000. Furthermore, in order to test for ordering effects, respondents were randomly assigned to one of two sub-samples. Respondents in one sub-sample were first asked if they are willing to pay for a health checkup or an airbag that will reduce baseline risk by 30 in 1,000,000. In the second WTP question, risks were reduced by 60 in 1,000,000. Respondents in the second sub-sample were given the 60-in-1,000,000 risk reduction question first.[9] To increase respondents' understanding of small risk changes, we employed a visual aid-risk ladders, to illustrate the baseline risk and changes from it by undertaking the payment mechanism (a health checkup or an airbag) (see the Appendix).

In line with the NOAA Blue-Ribbon panel recommendation (Arrow et al., 1993), a dichotomous choice format was employed to elicit respondent's WTP. To improve the precision of the WTP estimates, follow-up questions to the dichotomous choice payment question, so-called "double-bounded dichotomous choice," formulated by Hanemann, Loomis, and Kanninen (1991) were used. Respondents were asked an initial dichotomous choice question: would they pay for the medical fee of taking a special health checkup at X price? Those respondents who answered "yes" were asked whether they would pay a higher price, and those who answered "no" were asked whether they would pay a lower price. Respondents who answered "no" in both the initial and follow-up questions and for both risk reductions (small and large risk reduction) were asked for the reason of refusal by selecting from one of five written reasons (if not applicable, they can write down their own reason).

The price of the health checkup, referred to as "the bid value," was varied across respondents. In this study, respondents were randomly assigned a price (bid value) from four predetermined values, 400, 800, 2,000 and 4,000 baht (or US$9.3, $18.6, $46.5, $93 respectively).[10] Some revisions were made in the structure of the WTP amounts available to the respondents, based on the responses from the pretest and the pilot survey. To avoid hypothetical bias in CV, respondents were informed to carefully consider their answer and their budget constraint.

Following the WTP questions, respondents were asked to indicate the extent of their agreement or disagreement with risk perception statements concerning air pollution risk and traffic accident risk. Respondents were asked to mark ✓ on the space below the heading "Strongly Agree," "Agree," "Not Sure," "Disagree," and "Strongly Disagree" after reading each statement. We adopted these kind of questions because they are often used in typical questionnaire surveys in Thailand and this kind of pattern is quite similar to the one used in Jones-Lee and Loomes (1995). The perceived characteristics addressed in this study include voluntariness, severity, controllability, dread, personal exposure, public exposure, immediacy, personal knowledge and knowledge to science or experts. The corresponding statements are described as follow:

Voluntariness: Whether [Air pollution/Traffic accident] risk will cause damage to me or not is up to me.
Severity: [Air pollution related illnesses/Traffic accident] can cause fatality.
Controllability: I can avoid being affected by [air pollution/traffic accident] with my own efforts.
Dread: I feel more afraid of dying by [air pollution/traffic accident] than other risks.
Personal exposure: [Air pollution/traffic accident] risk can happen to my family and me.
Public exposure: [Air pollution/traffic accident] can cause damage to the overall public.
Immediacy: [Air pollution/traffic accident] can cause actual damages immediately.
Personal knowledge: I know the causes of [air pollution/traffic accident].
Knowledge to science or experts: Regardless of my personal knowledge, I think there is enough research on the causes and impacts of [air pollution/traffic accident] risk.

The personal and public exposure factors were found to have positive effects on WTP in McDaniels, Kamlet, and Fischer (1992). The other seven risk attributes were used in Fischhoff et al. (1978) and other previous studies (Mendeloff and Kaplan, 1989; McDaniels, Kamlet, and Fischer, 1992; Savage, 1993; Jones-Lee and Loomes, 1995; Subramanian and Cropper, 2000; Chilton et al., 2002).

The final section seeks out the respondent's profile and subsequently two debriefing questions were asked. The first debriefing question pertained to the degree of certainty about the WTP responses. The second debriefing question tackled the respondent's understanding of overall information including the risk and probability concept and the given scenario.

2.2. *Survey implementation and sample*

The main survey was conducted in August 2003, employing eight undergraduate students (divided into four teams) to distribute and collect the questionnaire. The survey teams distributed a total of 1,080 questionnaires (680 for the air pollution sample and 400 for the traffic accident sample) to respondents living in 20 districts in the Bangkok metropolitan area.[11] In principle, the respondents should be recruited by telephone through random-digit dialing, however, due to budget constraints, respondents were stratified based on available information from the Bangkok Metropolitan Administration (BMA). Twenty districts were selected out of a total of 50 (approximately 40 percent) in the first stage of sampling. The districts were selected according to population density, the average family size in Bangkok and the distribution of number of districts in each zone.[12] The BMA has divided administrative areas into three areas: inner area (21 districts), middle area (18 districts) and outer area (11 districts). Selected sample areas were 9 districts for inner area, 6 districts for middle area and 5 districts for outer area.

Subsequently, random selection of some communities in each district using the list of communities registered with the BMA was made. The BMA has divided the communities into 5 categories: slum community, suburb community, real estate community, urban community and housing community. The survey teams were assigned to go to the selected communities in 20 districts (except the suburb community, which is located in low-density areas). Given these categories indicating rough income differentials among residents, the sample can be assumed representative of the population of Bangkok.

3. Analysis of the data and results

3.1. Data analysis

Both theory and evidence imply that the individual WTP (and hence VSL) may differ across circumstances (Cropper and Freeman, 1991). The value each person attaches to a small reduction in his/her probability of dying is likely to differ because of differences in underlying preferences, age, wealth, number of dependents, and level of risk to which he/she is currently exposed. Accordingly, an individual's WTP to reduce mortality risk in a given risk context depends on two dimensions as follows:

$$WTP = f(R, P) \tag{1}$$

where R refers to risk characteristics and P refers to demographic (or population) characteristics. In this study, R captures nine perceived risk characteristics often discussed in literature.

3.2. Characteristics of respondents

Out of 1,080 questionnaires distributed, 1,052 questionnaires could be collected (665 for the air pollution sample and 387 for the traffic accident sample). The number of complete answers (for both WTP and risk perception questions) is 630 for the air pollution group and 376 for the traffic accident group. After censoring the protest responses, the actual sample size used for WTP estimation and regression analysis is 524 and 301, respectively.[13]

Table 1 provides descriptive statistics of respondent profiles. The respondents' mean age in the air pollution sample is slightly higher than that in the traffic accident sample (43 versus 37 years). This is because the elderly were set as the targeted population in the air pollution case.[14] The mean of monthly household income of the two groups is almost the same, but higher than the average income (24,690 baht) of Bangkok residents in 2000

Table 1. Mean values of population characteristics.

Variable	Definition	Air pollution ($N = 524$)	Traffic accident ($N = 301$)
Age	Respondent's age in years	43.31 (14.11)	37.06 (10.62)
Male	1 if respondent is male, 0 if female	0.52 (0.50)	0.56 (0.50)
Education	School attainment in years	12.19 (5.84)	13.80 (3.78)
Family size	Number of people in household	4.63 (1.87)	4.40 (1.88)
Income	Monthly household income (Thai baht, 1 US$ = 43 bath)	30124.05 (19250.63)	33554.82 (19174.32)
	Monthly household income (median)	25000.00	25000.00
Voluntariness	1 if respondent stated "strongly agree" or "agree" to the statement, 0 otherwisea	0.64 (0.48)	0.70 (0.46)
Severity	1 if respondent stated "strongly agree" or "agree" to the statement, 0 otherwise[a]	0.69 (0.46)	0.77 (0.42)
Controllability	1 if respondent stated "strongly agree" or "agree" to the statement, 0 otherwise[a]	0.56 (0.50)	0.63 (0.48)
Dread	1 if respondent stated "strongly agree" or "agree" to the statement, 0 otherwise[a]	0.54 (0.50)	0.69 (0.46)
Personal exposure	1 if respondent stated "strongly agree" or "agree" to the statement, 0 otherwise[a]	0.83 (0.38)	0.88 (0.33)
Public exposure	1 if respondent stated "strongly agree" or "agree" to the statement, 0 otherwise[a]	0.76 (0.43)	0.69 (0.46)
Immediacy	1 if respondent stated "strongly agree" or "agree" to the statement, 0 otherwise[a]	0.33 (0.47)	0.66 (0.47)
Personal knowledge	1 if respondent stated "strongly agree" or "agree" to the statement, 0 otherwise[a]	0.76 (0.43)	0.85 (0.36)
Expert-knowledge	1 if respondent stated "strongly agree" or "agree" to the statement, 0 otherwise[a]	0.50 (0.50)	0.56 (0.50)
No insurance	1 if respondent reported that he/she does not have any kind of health or accident insurances, 0 otherwise	0.30 (0.40)	0.17 (0.38)
Most concern	1 if respondent ranked air pollution/traffic accident as of the most concern, 0 otherwise	0.26 (0.44)	0.30 (0.46)
WTP confidence	1 if respondent reported that he/she is very confident in his/her WTP answers	0.28 (0.45)	0.24 (0.43)
Failed test	1 if respondent chose "person B" (wrong answer) in the probability test, 0 otherwise	0.08 (0.28)	0.08 (0.27)

Note: Standard deviations are in parentheses.
a: 0 if respondent stated "not sure," "disagree," or "strongly disagree" to the given statement.

(National Statistical Office, 2003). In addition, the respondents' average years of education of about 12 to 13.5 years is higher than that of Bangkok residents (9.7 years). In the air pollution sample, about 30% of the respondents reported that they do not have any kind of health insurance. The result is consistent with national survey data reported by the Ministry of Public Health (2002, p.351) that in 2001, 29% of Thai citizens did not have any health insurance. The relatively low number of people not having any health insurance in the case of the traffic accident sample (17%) may come from relatively higher income and educational attainment levels in this sample.[15]

On debriefing questions, about 2.5% of the total sample in the air pollution sample and 2.4% in the traffic accident sample reported no confidence in their WTP answers. Only 1.4% in the air pollution sample and 0.8% in the traffic accident sample reported that they did not understand the overall information.

3.3. Effects of risk characteristics on WTP

The nine risk characteristics are coded as binary variables in the regression analysis. In each binary variable, responses as "strongly agree" or "agree" to the given statement (shown earlier in Section 2.1) are given "1", while, other responses ("not sure," "disagree," and "strongly disagree") are given "0". The mean and standard deviation of these variables are given in Table 1.

The results from maximum-likelihood log-logistic regressions are shown in Table 2 for air pollution risk and in Table 3 for traffic accident risk. In both air pollution and traffic accident cases, WTP responses for the same risk reduction from each sub-sample are pooled together. This pooled sample analysis is possible because no significant "ordering" effects were observed in sub-samples for both risk reductions.[16]

Specification 1 accounts for only bid value and risk characteristics, while specification 2 accounts for only bid value and population characteristics. Specification 3 includes both risk and population characteristics. In all specifications, the probability of saying "yes" to the WTP question is significantly related to the bid amount. A negative sign on the bidding price coefficient to the probability of "yes" response conforms to the economic theory that as the bidding price of the payment mechanism (a medical health checkup or an optional airbag) increases, respondents would be less likely to accept the proposed price.

Results from the regression analysis show that coefficients on controllability, dread, personal knowledge variables are statistically significant across model specifications in the air pollution context. The positive sign on these coefficients suggests that respondents who view the air pollution risk as having these three characteristics of risk are prone to state "yes" to the WTP question. McDaniels, Kamlet, and Fischer (1992) found similar effects of dread on WTP in their study for less well-defined risks, which included air pollution risk. On the other hand, voluntariness was not found to be not a statistically significant predictor of WTP. This result is consistent with previous studies (Mendeloff and Kaplan, 1989; McDaniels, Kamlet, and Fischer, 1992; Cropper and Subramanian, 1999; Chilton et al., 2002).

Table 2. Regression results from log-logistic regression analyses: air pollution risk ($N = 524$).

	Smaller risk reduction (30/1,000,000)			Larger risk reduction (60/1,000,000)		
Variable	(1)	(2)	(3)	(1)	(2)	(3)
Constant	7.25***	−0.07	−4.02**	7.96***	0.54	−1.37
	(14.50)	(−0.05)	(−2.14)	(15.54)	(0.36)	(−0.72)
Bidding price[a]	−1.18***	−1.21***	−1.26***	−1.20***	−1.22***	−1.27***
	(−19.09)	(−19.12)	(−19.12)	(−19.48)	(−19.49)	(−19.49)
Voluntariness	0.01		0.24	0.02		0.24
	(0.08)		(1.34)	(0.09)		(1.32)
Severity	0.12		0.01	0.28		0.20
	(0.67)		(0.04)	(1.52)		(1.09)
Controllability	0.33*		0.28	0.33*		0.26
	(1.96)		(1.62)	(1.94)		(1.49)
Dread	0.43**		0.45**	0.47***		0.51***
	(2.54)		(2.51)	(2.75)		(2.88)
Personal exposure	0.29		0.27	0.38*		0.36
	(1.28)		(1.16)	(1.65)		(1.52)
Public exposure	0.15		0.15	−0.12		−0.20
	(0.75)		(0.71)	(−0.61)		(−0.95)
Immediacy	0.15		0.29	0.03		0.12
	(0.85)		(1.55)	(0.16)		(0.68)
Personal knowledge	0.39**		0.46**	0.32*		0.34*
	(2.05)		(2.29)	(1.67)		(1.69)
Expert-knowledge	−0.29*		−0.13	−0.39**		−0.28
	(−1.67)		(−0.71)	(−2.22)		(−1.56)
Male		−0.13	−0.11		−0.23	−0.18
		(−0.79)	(−0.67)		(−1.41)	(−1.02)
Education		0.03	0.03		0.02	0.02
		(1.37)	(1.59)		(1.13)	(1.17)
Family size		−0.15***	−0.16***		−0.14***	−0.16***
		(−2.88)	(−3.00)		(−2.80)	(−3.15)
Income[a]		0.89***	0.99***		0.91***	0.98***
		(4.88)	(5.52)		(5.29)	(5.38)
Age		0.0003	0.10**		−0.01	0.03
		(0.05)	(2.51)		(−1.01)	(0.70)
Age square			−0.001**			−0.0004
			(−2.48)			(−0.88)
No insurance			−0.22			−0.32*
			(−1.28)			(−1.84)
Most concern			0.11			0.03
			(0.57)			(0.13)
Confidence on WTP			0.17			0.31
			(0.91)			(1.59)
Failed test			−0.17			0.16
			(−0.55)			(0.52)
Log likelihood	−751.96	−740.09	−722.09	−758.17	−746.44	−729.44
AIC	1525.92	1494.17	1486.19	1538.35	1506.88	1500.88

Notes: ***, **, and * represent statistical significance at 1, 5, and 10 percent, respectively.
t-statistics are in parentheses.
a: in logarithmic form.

Table 3. Regression results from log-logistic regression analyses: air pollution risk ($N = 301$).

	Smaller risk reduction (30/1,000,000)			Larger risk reduction (60/1,000,000)		
Variable	(1)	(2)	(3)	(1)	(2)	(3)
Constant	7.45***	0.85	0.16	9.44***	−0.44	−1.73
	(10.29)	(0.40)	(0.07)	(11.81)	(−0.20)	(−0.66)
Bidding price[a]	−1.09***	−1.12***	−1.14***	−1.27***	−1.34***	−1.38***
	(−14.44)	(−14.44)	(−14.37)	(14.79)	(−14.75)	(−14.65)
Voluntariness	0.19		0.13	0.43*		0.34
	(0.73)		(0.52)	(1.69)		(1.29)
Severity	−0.15		−0.05	−0.07		0.06
	(−0.59)		(−0.19)	(−0.27)		(0.21)
Controllability	−0.37		−0.34	−0.15		−0.18
	(−1.61)		(−1.43)	(−0.62)		(−0.69)
Dread	0.16		0.10	0.31		0.30
	(0.65)		(0.40)	(1.25)		(1.17)
Personal exposure	−0.32		−0.38	−0.54		−0.57
	(−0.94)		(−1.05)	(−1.49)		(−1.52)
Public exposure	−0.05		−0.10	−0.15		−0.13
	(−0.20)		(−0.41)	(−0.58)		(−0.49)
Immediacy	0.67***		0.67***	0.59**		0.62**
	(2.84)		(2.74)	(2.51)		(2.50)
Personal knowledge	0.24		0.18	0.14		0.12
	(0.73)		(0.55)	(0.44)		(0.36)
Expert-knowledge	0.08		0.12	0.09		0.03
	(0.34)		(0.50)	(0.39)		(0.10)
Male		−0.14	−0.13		0.11	0.13
		(−0.64)	(−0.57)		(0.48)	(0.54)
Education		0.04	0.03		0.05	0.04
		(1.20)	(0.78)		(1.64)	(1.10)
Family size		−0.06	−0.04		0.02	0.03
		(−0.86)	(−0.64)		(0.34)	(0.47)
Income[a]		0.65***	0.58**		0.95***	70.92****
		(2.75)	(2.45)		(3.90)	(3.66)
Age		0.01	0.08		0.00	0.10
		(0.58)	(1.19)		(0.07)	(1.46)
Age square			−0.001			0.00
			(−1.17)			(−1.53)
No insurance			−0.20			−0.17
			(−0.63)			(−0.51)
Most concern			0.25			−0.15
			(1.03)			(−0.58)
Confidence on WTP			0.33			0.27
			(1.24)			(0.98)
Failed test			0.55			0.48
			(1.37)			(1.09)
Log likelihood	−441.89	−440.53	−431.87	−412.36	−402.11	−394.64
AIC	905.78	895.06	905.74	846.72	818.22	831.28

Notes: ***, **, and * represent statistical significance at 1, 5, and 10 percent, respectively.
t-statistics are in parentheses.
a: in logarithmic form.

The coefficient on expert-knowledge is statistically significant and has a negative sign in the air pollution context. This result is similar to the findings in McDaniels, Kamlet, and Fischer (1992) and Savage (1993), implying that people are not prepared to pay for a risk perceived to be less well-known by experts or scientists.

The evidence on the positive sign of controllability variable in the present study is opposite to the findings in previous studies (Jones-Lee and Loomes, 1995; Subramanian and Cropper, 2000). One reason for the contrasting result is that previous studies refer to public programs to control the risk, while this study asked for individual or private risk reduction. When facing a public program, respondents may state higher WTP to support the program. In our scenario, people may think that they can avoid being exposed to motor vehicle emissions by, say, driving in an air-conditioned car or getting on an air-conditioned bus. Accordingly, respondents who took the view that they can avoid being exposed to air pollutants by undertaking some actions were willing to pay more for a given risk reduction. A positive sign on the controllability variable was also found in McDaniels, Kamlet, and Fischer's (1992) study.

As for the case of traffic accident risks (Table 3), the coefficient on the immediacy variable is statistically significant across model specifications. The positive sign implies that respondents tend to state higher WTP for risk that causes immediate damage rather than risk whose damage shows up later on in life. The coefficient on the immediacy variable, however, is insignificant in the air pollution sample. This factor may help explain why the VSL estimates for traffic accidents are higher (though only slightly) than VSL estimates for air pollution as shown later in Section 3.4. Besides the immediacy variable, voluntariness shows a statistical significance at the level of 10 percent in a model specification. This suggests that people who view that they are voluntarily exposed to the traffic accident risk are likely to give "yes" response to WTP questions.

It is noteworthy that this study does not intend to measure individual's WTP to reduce cancer risk, as in the Hammitt and Liu (2004) study. The baseline risk for air pollution risk described in this study was taken from the time-series based concentration response function (Chestnut et al., 1998) which represents acute mortality, not chronic or cancer mortality. The information about the risk of dying by air pollution induced diseases is given to respondents in general terms (i.e., respiratory diseases and lung cancer). No detailed information or specifications of the diseases were given.

3.4. Effects of respondent characteristics (and other factors) on WTP

Specification 2 for both magnitudes of risk reduction shows the effects of respondent (or population) characteristics on the likelihood that the respondent will agree on the proposed bidding price (i.e., the distribution of the underlying WTP). Specification 3 shows the result of the full model. In all specifications concerned, the negative and statistically significant effect of the bidding price variable is as hypothesized that the higher the price, the less likely a respondent would be to answer 'yes', other things equal. This finding lends credence to the plausibility of the WTP responses.

The income coefficient is statistically significantly related to the probability of a "yes" response to WTP questions. Income is the only demographic variable that is significant in the traffic accident sample. Consistent with the assumption that mortality risk reduction is a normal good, income is positively associated with WTP in all specifications. Coefficients on family size are significant in all specifications in the air pollution case. Respondents who have larger family size are less likely to respond "yes" as compared to those with smaller family size. This may be interpreted as; those who have more family members have limited spending opportunities. The positive effect of income and size of the household on WTP responses reveal additional evidence of the internal validity of the WTP responses (Alberini and Krupnick, 2003). Coefficients on male and education variables are insignificant in all equations. The coefficients of the education variable are positive in all specifications and almost significant in the air pollution sample for the smaller risk reduction (the p-value is 0.17 in specification 2 and 0.12 in specification 3).

When age enters the regression equations linearly as shown in specification 2, the effect of age on the probability of a "yes" response is insignificant in both risk contexts. However, when age enters the equations non-linearly (in quadratic form) shown in specification 3, we found a significant "inverted U-shaped" relationship between probability of acceptance and age for the smaller risk reduction in the air pollution sample. This finding is in line with the theoretical predictions of Shepard and Zeckhauser (1982) and empirical evidences reported in Jones-Lee, Hammerton, and Philips (1985), Johannesson, Johansson, and Lofgren (1997) and Carthy et al. (1999). The estimated coefficients of age and age^2 variables in the traffic accident are almost significant for the larger risk reduction (p-value is 0.13 for age and 0.12 for age squared variable).

The coefficient on the no insurance variable is statistically related to the probability of a "yes" response. The negative coefficients for people not having any insurance in almost all specifications suggest that non-insurance holders are less prone to respond "yes" to WTP questions. Although we expected that respondents who ranked air pollution (in the air pollution sample) or traffic accidents (in the traffic accident sample) as their greatest concern would be willing to pay more than other people, the coefficients on these two variables ("most concern") were found to be insignificant in all specifications. The coefficients on the "failed test" dummy variable show no correlation between people who failed the simple probability test (prior to the CV scenario and WTP questions) and the probability of "yes" responses.

The estimated coefficient on "confidence of WTP" is significant at a level of 10 percent for the larger risk reduction in the air pollution sample. The coefficients also have a positive sign in all specifications implying that respondents who express "very confident" in their WTP answers are more likely to respond "yes" to WTP questions. This result is consistent with the finding in previous studies (Johannesson, Johansson, and Lofgren, 1993; Li and Mattson, 1995; Ready, Whitehead, and Blomquist, 1995).

Before we move on to report the WTP and VSL estimates, it is notable from these regression results that only three explanatory variables (i.e., bidding price, immediacy, and income) are significant in WTP for traffic accidents. This might be a result of the relatively lower degree of familiarity by respondents with the payment mechanism. Compared to a medical health checkup in the air pollution sample, a frontal or side-impact airbag might be less well-known by some respondents, particularly to non-drivers. This may result in larger inconsistencies in WTP responses and a weaker relationship to their socio-economic circumstances. It is also possible that there are other factors, not included in this study, which may explain respondents' preferences. For example, media attention, occupational status, and household benefits, were found to be significant in Chilton's et al. (2002) study.

3.5. WTP and VSL estimates

The welfare measures, mean and median values, are estimated using conventional methods (Bishop and Heberline, 1979) from maximum-likelihood log-logistic models which are found to provide a better fit to the data than other models tested (Duffield and Patterson, 1991). The log-logistic model with the bid amount X in the logarithm yields the equation as follows:

$$\pi(X) = [1 + \exp(-\alpha - \beta_1 \log X - \beta_2 Z)]^{-1}, \quad X > 0. \tag{2}$$

where $\pi(X)$ is the probability that an individual will pay the bid amount, X and Z is a vector of population characteristics variables. The terms α, β_1 and β_2 represents unknown parameters to be estimated from the data. Because the log-logistic implies infinite mean, it was considered to be not consistent with the economic theory of utility maximization (Hanemann, 1984).[17] To generate a cumulative distribution function (c.d.f) that satisfies the consistency with theoretical constraints, we use truncating the distribution as suggested by Duffield and Patterson (1991) and Hanemann and Kanninen (1999). The truncation point is the maximum bid amount (8,000 baht), which is commonly used in most CV studies.[18] The truncated mean is given by:

$$WTP_{\text{mean}} = \int_0^{X(\max)} [1 - F(X)]dX \tag{3}$$

where $F(X)$ is the cumulative distribution function of WTP values in the population. The median is $F^{-1}(.5)$ and represents the largest amount that at least 50 percent of the population would be willing to pay. The distribution's parameters, $\hat{\theta}$, are estimated by maximum likelihood procedures. All models were estimated by using the GAUSS econometric software package.

The estimated median, mean WTP and the corresponding VSL figures are shown in Table 4. These are calculated from the full model without the age^2 variable.[19] The 95% confidence intervals derived from the Monte Carlo simulation are also given.[20] The median

Table 4. WTP and VSL estimates including corresponding income-adjusted values in 2003 US$.

	Air pollution ($N = 524$)		Traffic accident ($N = 301$)	
Risk reduction	30/1,000,000	60/1,000,000	30/1,000,000	60/1,000,000
Median WTP (95% confidence interval)	26 (23–30)	38 (33–43)	27 (23–33)	51 (43–60)
Mean WTP (95% confidence interval)	48 (44–55)	62 (57–69)	52 (46–61)	73 (65–82)
VSL from median WTP, million	0.87 (0.77–1.00)	0.63 (0.55–0.72)	0.90 (0.77–1.10)	0.85 (0.72–1.00)
VSL from mean WTP, million	1.60 (1.47–1.83)	1.30 (0.95–1.15)	1.74 (1.53–2.03)	1.22 (1.08–1.37)
Income-adjusted median WTP (95% confidence interval)	22 (20–26)	32 (28–37)	22 (19–27)	37 (31–43)
Income-adjusted mean WTP (95% confidence interval)	41 (38–47)	53 (49–59)	43 (37–49)	53 (46–59)
Income-adjusted VSL from median WTP, million	0.73 (0.67–0.87)	0.54 (0.47–0.62)	0.74 (0.63–0.90)	0.61 (0.52–0.72)
Income-adjusted VSL from mean WTP, million	1.37 (1.27–1.57)	0.88 (0.82–0.98)	1.43 (1.23–1.63)	0.88 (0.77–0.98)

Note: WTP and VSL estimates are computed from the full model without age-squares shown in the appendix.

and mean WTP to reduce risk of dying by traffic accidents are slightly higher than the median and mean WTP to reduce risk of dying by air pollution induced diseases. The median and mean WTP for a 30-in-1,000,000 risk reduction are estimated as approximately US$26 and US$48 in the air pollution context and US$27 and US$52 in the traffic accident context. The corresponding values for a 60-in-1,000,000 risk reduction are estimated as approximately US$38 and US$62 in the air pollution context and US$51 and US$73 in the traffic accident context.

The WTP estimates indicate sensitivity to scope in both the air pollution and the traffic accident samples. The results pass both internal (within-sample) and external (between-sample) scope tests. Here we reported the results from the external tests, which are more compelling than the internal tests.[21] The external scope test was based on comparing WTP for the first of two WTP questions presented to the respondents. Likelihood ratio tests for two different risk reductions shows the chi-squared statistic being significant at a level of 0.01 (Chi-square = 21.74; p-value < 0.00) for the air pollution sample. The likelihood ratio test for the traffic accident sample shows a similar result (Chi-square = 33.56; p-value $<$ 0.00). However, neither mean WTP nor median WTP increases in proportion to the size of the risk reduction.

The WTP values can be used to compute the corresponding value of a statistical life (VSL) by dividing annual WTP by the size of the annual risk reduction (30 in 1,000,000 or 60 in 1,000,000) as seen in Table 4. Because WTP is generally not proportional to the size of the risk change, VSL estimates are larger when calculated using WTP for the smaller risk change. The VSL for traffic accidents is slightly higher than the VSL for air pollution (both from median and from mean WTP). However, a significant caveat regarding this result is that the VSL for air pollution might be affected by perception of respondents that there is a latency period.

Given that aggregate WTP to reduce mortality risks is reflected in mean rather than median responses, we should report VSL estimates based on means. However, to the extent that there may be concerns about upward biases in responses to hypothetical questions, a more conservative approach might be to put equal weight on the median and mean responses and widen the range of VSL. Because we do not have a prior preference between the two magnitudes of risk reductions (30 and 60 in 1,000,000), we average the VSL estimates over these two risk reductions. Accordingly, the average VSL estimates for air pollution risk reduction are in the range of $0.74 million (median WTP) to $1.32 million (mean WTP), whereas the average VSL estimates for traffic accident risk reduction are in range of $0.87 million (median WTP) to $1.48 million (mean WTP). These results indicate that the VSL for air pollution is not significantly lower than the VSL for traffic accidents. The difference is even smaller when comparing the VSL estimates taken from the income-adjusted WTP.[22]

When compared to previous VSL estimates in other countries (all money values are converted to 1995 US$[23]), this study's ranges of VSL are much smaller than estimates for the U.S. and other developed countries. This study's VSL estimates for air pollution ($0.53-$0.94 million) are much lower than the current VSL figure ($5.5 million) used by U.S. EPA (U.S. EPA, 2000a) and the latest meta-analysis derived VSL estimates ranging between $5.06 and $7.00 million reported in Viscusi and Aldy (2003). Our VSL estimates are also smaller than two CV studies valuing environmental mortality risk reductions (Krupnick et al., 2002; Alberini et al., 2004). The VSL estimates for traffic accidents in the present study are also smaller than recent VSL estimates for the U.K. (Carthy et al., 1999) and Sweden (Persson et al., 2001).

Compared to studies in developing countries, our VSL estimates are also smaller than a series of empirical studies (either labor market or CV studies) in Taiwan (Liu and Hammitt, 1999; Fu et al., 1999; Hammitt and Liu, 2002, 2004). Hammitt and Liu (2002) estimated VSL taken from mean WTP ranging between $2.61 and $7.18 million, while the VSL taken from median WTP ranges between $0.47 and $2.05 million (Hammitt and Liu, 2004). Because this study, to our knowledge, is the first study valuing mortality risk reductions in Thailand, we compared our VSL estimates to a study that estimates VSL for Bangkok people based on benefit transfer approach. The most-referred-to-study, Chestnut et al. (1998), extrapolated the VSL for Bangkok residents from a range of the U.S. VSL estimates with some adjustment on income differences between U.S. and Bangkok. When converted to 2003 US$ (using Bangkok specific consumer price index), the VSL estimate of US$1.37 ($0.80-$2.78) million in the Chestnut et al. study is higher than the present study's income-adjusted VSL of US$1.12 ($1.04-$1.27) million. The difference between the adjusted U.S. VSL and the locally estimated VSL would be larger if the ratio of the GDP-PPP per capita between Bangkok and the U.S. is used instead (the adjusted U.S. VSL increased to US$2.28 [$1.33-$4.63] million).[24] Overall, the present study provides lower estimates of VSL than previous studies using benefit transfer approach.

4. Conclusions

This paper has explored the extent to which WTP and corresponding VSL for mortality risk reduction might be affected by public perceptions towards risk (particularly air pollution risk). Two CV surveys were conducted in the Bangkok metropolitan area. The first CV survey elicited individuals' WTP for reducing risk of death by air pollution induced lung diseases, while the second survey elicited individuals' WTP for reducing risk of death in road traffic accidents. Respondents were also asked about their perceptions towards the two risks using nine risk characteristics.

Based on mean values of the nine risk characteristics of the two risks, six characteristics of risk perceptions are statistically significant. Compared to traffic accident risk, respondents generally view air pollution associated risk to be less controllable, less severe, less dreadful, less immediate, and less known, but believe that the public is more exposed to this risk. Results from regression analyses suggest that people who view that being exposed to the air pollution is associated with a dread and that they are able to avoid the damage (controllability) to some extent tend to state "yes" to the WTP question. The perception of the individual about the risk personally exposed to the risk and the level of their personal knowledge towards the risk are also important factors. As for the case of traffic accident risk, WTP to reduce the traffic accident risk is influenced by immediate occurrence of damages from the risk.

Although these risk characteristics are found to be significantly related to WTP responses, the estimated WTP and corresponding VSL figures are not much different in these two different risk contexts. This finding suggests that risk perception alone may not necessarily count as a good reason to use a different VSL as has been sometimes suggested in policymaking. The findings from this study is consistent with the findings from program choice studies, that risk perceptions may have a small impact on people's preferences. This conclusion is reached even though no influence of different baseline risks of multiple risk contexts exists in this study (as we used separate risk valuations).

When we considered the effects of population characteristics, the income variable appears to have a high correlation with WTP responses in both risk groups. We also found evidence of an inverted-U shaped relationship between age and WTP that is in line with the theoretical predictions of Shepard and Zeckhauser (1982) and empirical evidences reported in Jones-Lee et al. (1985), Johannesson, Johansson and Lofgren (1997) and Carthy et al. (1999). This finding provides support to adjust VSL for age, at least in the sensitivity analysis. The results of this study require confirmation in other developing countries.

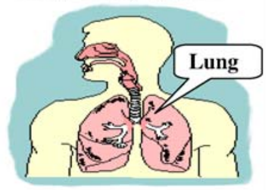
Appendix: CV scenario, WTP and risk perception questions

1. Air pollution questionnaire: CV scenario

SECTION C: AIR POLLUTION AND HEALTH RISK

Air pollution is one of many serious problems in Bangkok. It is worsened by traffic congestion. The main pollutants are small particulate matter, mainly from diesel vehicle exhaust. Small particulate matter can remain suspended in the air for a long time. If exposed to highly concentrated particulate matter, it can affect people's health.

Respiratory system



Small particulate matter can penetrate deep into lung tissue. The danger of inhaling small particulate matter is that it causes respiratory diseases including lung cancer and nervous system disorders. Since 1993, respiratory illnesses have become the leading cause of illness in Bangkok.

Recent research has found that long-term exposure to fine particulate air pollution can lead to heart disease and lung cancer mortality. The air pollution related death rate of people in Bangkok s **430 in 1,000,000 (430/1,000,000)**

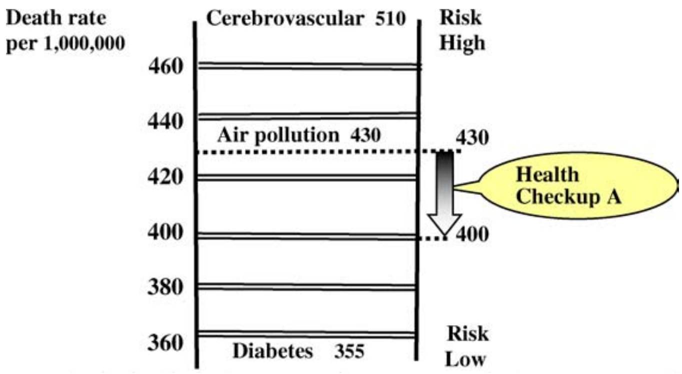
You can take some actions to reduce your risk of death due to air pollution. There are many ways to reduce mortality risk associated with air pollution, for example:

Wearing a mark	Regular health checkup	Improving the environment by planting trees
		

2. Air pollution questionnaire: WTP questions (for a smaller risk reduction)

   The following questions are hypothetical in order to find out your opinion on the reduction of air pollution associated mortality risk. **Please consider the following as if you were actually in the situation presented**.

6. Suppose there is a technological improvement in medical health checkups and there is a campaign for annual health checkups to reduce premature mortality risk associated with air pollution. Suppose now there is a health checkup program called Health Checkup A which can effectively detect any impairment in your respiratory system without any side-effects or pains occurring during the health checkup. If you take Health Checkup A annually, it will reduce your mortality risk **from 430 in 1,000,000 to 400 in 1,000,000.** (Look at the picture of the risk ladder below).



If you want to take this health checkup, you need to pay some medical fees. Are you willing to pay **400 baht per year** for taking Health Checkup A? We assert that this question is for academic purposes only, not for any marketing research. If you are willing to pay, you will loss some of your income that you could have spent for other things costing the same amount. (Please mark ✓ in the ☐)

☐ Yes Go to (1) below	☐ No Go to (2) below
(1) The medical fee has not been fixed, if the fee has increased to **800 baht per year**, are you willing to pay?	**(2)** The medical fee has not been fixed, if the fee has decreased to **200 baht per year**, are you willing to pay?
☐ Yes ☐ No Go to Q.8 (skip (2) on your right-hand)	☐ Yes ☐ No Go to Q.8

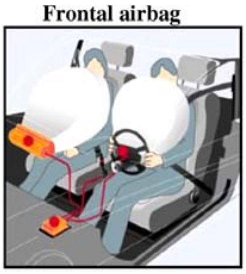
3. Traffic accident questionnaire: CV scenario

SECTION C: TRAFFIC ACCIDENT RISK

Thailand has the highest rate of road fatalities in the world (Bangkok Post, Feb.14, 2003). In Bangkok, about 700 people died in traffic accidents in 2001. This means people in Bangkok are facing a risk of death from traffic accidents at **150 per 1,000,000 population (150/1,000,000).** The government has now been implementing many measures to reduce the number of traffic accidents.

For yourself, you can reduce your risk of dying in traffic accidents by using or installing safety devices, for example, wearing a helmet every time you ride, or fastening seat belts and installing air bags.
Research had shown that using a seat belt and having an air bag reduces the risk of death by 68%.

Frontal airbag



Side-impact airbag

The following questions are hypothetical scenarios in order to know your view on reducing traffic accident risk through your decision to purchase airbags.

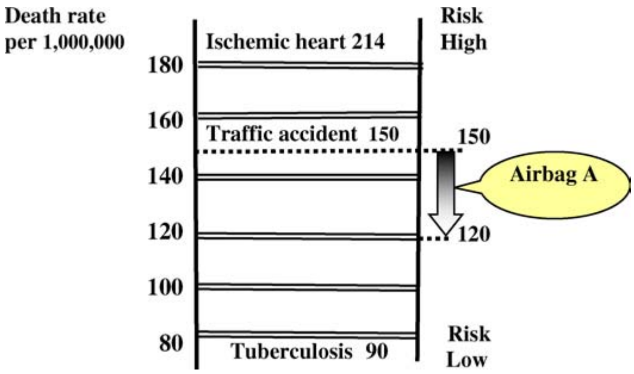
- If you own a car, please imagine that you are in a situation in which you are offered to have a frontal airbag installed in your car or
- If you already have one, please consider the side-impact airbag or think about installing an airbag when you want to buy a new car.
- For those who do not have car, please assume that you are buying a car and that you are offered to purchase the airbags.

Although the questions are hypothetical, we ask that you seriously consider them as if you were actually in the situation presented.

4. Traffic accident questionnaire: WTP questions (for a smaller risk reduction)

   The following questions are hypothetical in order to find out your opinion on reduction of traffic accident caused mortality risk. **Please consider the following as if you were actually in the situation presented**.

5. Assume there have been technological improvements on frontal and side-impact airbags for cars. Now there is new frontal airbag or side-impact airbag (here referred to as Airbag A) which is highly effective in protecting your body and head from impact against hard surfaces during a crash. If you install Airbag A, your risk of dying in a traffic accident will be reduced **from 150 in 1,000,000 to 120 in 1,000,000** as shown in the risk ladder below.



Airbag A can be used for **10 years**. Are you willing to pay **400 baht per year for 10 years** for this frontal airbag or side-impact Airbag A? We assert that this question is for academic purposes only, not for any marketing research. If you are willing to pay, you will loss some of your income that you could have spent for other things costing the same amount. (Please mark ✓in the ☐)

☐ Yes Go to (1) below	☐ No Go to (2) below
(1) The price of the airbag is not fixed, if the price has increased to **800 baht per year**, are you willing to pay?	**(2)** The price of the airbag is not set in stone, if the price has decreased to **200 baht per year**, are you willing to pay?
☐ Yes ☐ No Go to Q.6 (skip (2) on your right-hand)	☐ Yes ☐ No Go to Q.6

*We ask about the higher or lower price only in order to know your true willingness to pay

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Notes

1. Although respondents were told that each program would prevent the same number of deaths, a number of respondents appeared to be influenced by the idea that programs targeted at hazards with higher baseline risks would actually be likely to do more good than simply prevent 10 deaths.
2. However, WTP questions used in this study are open-ended formats, which are found to create some difficulty for respondents to answer to and are not recommended by the CV guidelines (Arrow et al., 1993). The WTP results may be influenced by the different baseline risk attached to the risk concerned. For example, a 20% reduction in annual fatalities represents 10,000 lives saved in car accidents but only one life in the case of workplace chemical hazards.
3. However, some characteristics are still controversial/ambiguous as reported in Cookson (2000) in that respondents often disagreed with one another about the relative degree of choice (voluntariness) and control involved in car accidents, food poisoning and railway accidents).
4. We conducted two focus groups (the first group was taken with 14 Thai graduate students in Hiroshima University and the second group was taken with 10 Bangkok residents from various ages and occupations) to check the understanding of respondents to the survey instrument and the small changes in risks. We also checked the degree of acceptance to the payment vehicles and the understanding of risk communication (risk ladder). After revising the survey instrument according to the comments from the focus groups, pretesting was conducted to check the appropriateness of the bidding prices and the understanding of questions and the CV scenario. We also checked the effectiveness of questionnaire distribution and observed the field implementation by eight undergraduate students. We used a reasonably large sample for the pre-test (182 observations for air pollution and 165 observations for traffic accident). About 90 percent of the questionnaires could be collected.
5. We used the middle value of the concentration-response function in Bangkok (1.2% change in natural mortality per 10 ug/m^3 of PM_{10}). Given the annual average of ambient PM_{10} levels of 57.8 ug/m^3 in 2002 as monitored by the Pollution Control Department and the natural death rate of 6.2 per 1,000 (Ministry of Public Health, 2003), the baseline risk per million is 430 ($0.0012 \times 57.8 \times 6200$).
6. We chose to elicit individual WTP because the appropriate measure of policy benefits for cost-benefit analysis is the sum of individual WTP for reductions in risk. The risk reduction is thought to be a private good, although in practice, the risk reduction from environmental programs is a public good. However, when people exhibit pure altruism, the maximization of net social benefits calls for equating the sum of individuals' marginal willingness to pay to reduce risks to themselves to the marginal cost of risk reductions. Private goods were used in the studies by Krupnick et al. (2002) and Alberini et al. (2004).
7. Strategic bias occurs when a respondent gives a WTP amount that differs from his or her true WTP amount in an attempt to influence the provision of the good. A free-riding effect may occur in that respondents underbid if they believe that they will actually have to pay or overbid if they believe they will not actually have to pay but hope to influence the provision of the good in question. Warm glow phenomenon occurs when respondents do not report real economic preferences but rather derive moral satisfaction from the act of giving per se (Kahnemann and Knetsch, 1992). Nunes and Schokkaert (2003) found the effects of warm glow on WTP for a natural park protection program.
8. However, private goods need to be set as appropriate as possible. Otherwise, it can cause a high number of protest responses due to doubts on its effectiveness on reducing the risk.
9. Although some researchers argue that people cannot understand risk reductions smaller than 1 per 1,000 (Krupnick et al., 2002), we believed that the x/1,000,000 risk change is a realistic outcome of a small air pollution reduction. The positive responses from the focus groups has increased our confidence in the use of the range of $\times$ per 1,000,000 risk changes. A similar magnitude of risk changes was used in Magat, Viscusi, and Huber (1996).
10. The exchange rate was 43 bath per US$ in August 2003 (Bank of Thailand, www.bot.or.th).

11. The subsample sizes were different because our aim is to estimate the WTP and VSL for use in the real policy analysis of air pollution controls (>500 observations). Budgetary considerations limited the use of sizable samples for both risk categories. Therefore, we decided to have a relatively large sample size for air pollution risk. Although the subsample sizes of the two risk categories were different, they were still large enough to reveal meaningful results.
12. Districts within three administrative zones (inner, middle, and outer zones) that have relatively high population density and average family size relatively similar to the average family size of Bangkok (of 3.6) were selected. Although we wished to stratify the sample by income levels of residents, unavailability of local data prevented us from using income stratification.
13. The protest responses were checked with a follow-up question for respondents who answered "no" to both risk changes and to the lower bidding prices in the follow-up WTP questions. The protest responses were those that answered any of these following reasons: (1) I don't believe that the stated risks applied to me; (2) I don't believed that the given health checkup (the airbag) can reduce air pollution (traffic accident) related mortality risk; (3) Not enough information about the health checkup and costs; and (4) I believe in the effectiveness of the health checkup (the airbag) but I don't think I should pay; government or firms should pay. The respondents who answered "I believe in the effectiveness of the health checkup (the airbag) but I can't afford it" are considered as legitimate answers (positive zero). These respondents have been kept in the sample. From total sample size, protest responses are about 17% in the air pollution sample and 20% in the traffic accident sample.
14. We tried to include the elderly in our air pollution sample as much as possible in order to test the effect of age on WTP. Age is an important issue for policy implication of VSL for environmental policies (see Krupnick et al., 1999). Because during field implementation, it was found that the student enumerators faced difficulty in getting the elderly to accept the survey instruments, the elderly sample was prioritized for the air pollution survey instrument only.
15. About 26 and 30% of the respondents ranked air pollution and traffic accidents respectively as their greatest concern. Since the questions asked are not common, the respondents were asked to understand probabilities and accept the WTP scenarios. In both samples, respondents who chose Person B (wrong answer) correspond to 8% for the total sample indicating a lesser understanding of the probability concept. Since the survey method is a self-administered questionnaire, explanations to those who answered incorrectly could not be provided. However, these respondents were still maintained in subsequent analyses, to check their effects on WTP. These samples were not dropped because only one probability test was asked and no correction was provided.
16. Based on likelihood ratio tests for simple models (accounting for only the bid value variable), WTP responses for each risk reduction drawn from the two sub-samples are not significantly different, except for the smaller risk reduction in the traffic accident cases. In the air pollution case, the likelihood ratio statistic is 2.33 (p-value = 0.127) for the smaller risk reduction and 1.37 (p-value = 0.243) for the larger risk reduction. In the traffic accident case, the likelihood ratio statistic is 5.96 (p-value = 0.015) for the smaller risk reduction and 2.68 (p-value = 0.101) for the larger risk reduction.
17. Economic theory implies that a person's maximum willingness to pay for an item is bounded by their income (Hanemann and Kanninen, 1999).
18. The truncation point is the maximum bid that is a small fraction of income. This may reflect the fact that if optimal consumption levels of other commodities are not zero, the plausible upper limit to the WTP distribution for any given resource will be well below individual income (Duffield and Patterson, 1991).
19. We chose to report WTP and VSL estimates from the full model without age-square because the quadratic function shown in Tables 2 and 3 (specification 3) generate quite high WTP estimates. The goodness of fit measures and the magnitude of coefficients of the full model without age-square is not so different from model specification 3. In addition, the resulting WTP is very close to the estimates computed from model specification 2 in Tables 2 and 3, in which only population characteristics variables were included and age entered the models linearly.
20. As suggested by Hanemann and Kanninen (1999), the Monte Carlo simulation simulates the asymptotic distribution of the coefficients, taking repeated random draws of coefficient vectors from this distribution and using them to generate an empirical distribution for the welfare measure, from which a confidence interval is computed.

21. In the internal test, a respondent may recognize the need for some degree of consistency between his/her responses to multiple WTP questions, while this is not the case in the external test.
22. In the air pollution sample, WTP may overestimate that of the general population by 14.6% for the smaller risk reduction ($0.16 \times 0.91 = 0.1456$) and by 14.08% for the larger risk reduction ($0.16 \times 0.88 = 0.1408$). In the traffic accident sample, WTP maybe overestimated by 18% for the smaller risk reduction ($0.30 \times 0.60 = 0.18$) and by 28.2% for the larger risk reduction ($0.30 \times 0.94 = 0.282$). Using the estimated income elasticity of the full model without the age squared variable, the WTP of the sample likely overestimates that of the general Bangkok population by about 14% for air pollution and 23% for traffic accident. By averaging over the small and large risk reductions, the income-adjusted VSL for air pollution ranges between $0.63 million (median WTP) and $1.13 million (mean WTP). The corresponding VSL for traffic accidents ranges between $0.67 million and $1.15 million.
23. Thailand's GDP deflator for year 2003 is the projected value taken from the National Economic and Social Development Board (NESDB); for Taiwan's GDP deflator we used an inflation index (1995 = 100) provided by the International Monetary Fund (IMF), World Economic Outlook Database.
24. Chestnut et al. used the ratio of GDP per capita in Bangkok to GDP per capita in the U.S. for the year 1995 and derived an adjustment factor of 0.3. This adjustment ratio is sensitive to the market exchange rate estimate of GDP per capita and may not reflect the purchasing power of the two countries. The per capita income ratio between Bangkok and the U.S. can be reduced from 0.3 in 1995 to 0.16 in 2001 as a result of the devalued currency after 1997. To account for the real domestic output of Thailand, we used a ratio of per capita income adjusted by parity of purchasing power (PPP). When comparing the figure to the GNP-PPP per capita of the U.S., the ratio of the GDP-PPP per capita between Bangkok and the U.S. is 0.52. By using this adjustment factor, the income-adjusted U.S. VSL has increased to US$2.28 ($1.33-$4.63) million, much higher than our empirical VSL estimates.

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