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The Value of Statistical Life

A Contingent Investigation in China

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Abstract

Economic analyses of development projects and policies often involve assigning an economic value to changes in the risk of loss of human life. A typical term used in the economic analyses is the value of statistical life, which reflects the aggregation of individuals' willingness to pay for fatal risk reduction and therefore the economic value to society to reduce the statistical incidence of premature death in the population by one. Studies on the value of a statistical life have been extensively conducted in the developed world; however, few such studies can be found for developing countries. This paper presents a study that estimates individuals' willingness to pay for cancer risk prevention in three provinces of China. The results imply that the mean value of willingness to pay for a cancer vaccine that is effective for one year is 759 yuan, with a much lower median value of 171 yuan.

The estimated income elasticity of willingness to pay is 0.42. Using data on the incidence of cancer illness and death in the population, these willingness to pay figures imply that the marginal value of reducing the anticipated incidence of cancer mortality by one in the population is 73,000 yuan and an average value of 795,000 yuan, which are about six and 60 times average household annual income, respectively. The big difference between the marginal value and the average value of fatal risk reduction corresponds to a very low estimated elasticity of willingness to pay with respect to fatal risk reduction. This finding challenges the validity of previous studies of the value of a statistical life, which are mostly based on average willingness-to-pay values of mortality risk reduction.

The Value of Statistical Life: A Contingent Investigation in China

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1. Introduction

Economic analyses of development projects and policies often involve assigning monetary values to human lives, especially in the areas of public health, occupational safety, transportation, and environmental protection, where human lives can be significantly affected by a proposed project or policy change. As resources are finite, trade-offs between other resource uses and reducing risks to life are inevitable. In order to help make rational choices in these tradeoffs, a concept of value of a statistical life (VSL), as opposed to a specific person's life, has been defined and extensively studied[2]. VSL is an economic value which measures the break-even point at which society as a whole is willing to pay (WTP) in order to reduce the statistical risk of death.

Extensive VSL studies have been conducted in the industrialized countries, however, few studies on VSL can be found in the developing world. Almost all of the previous studies indicate that the VSL estimation results are sensitive to the sectors studied, the estimation methods employed, the risk reduction levels as well as the demographic and economic characteristics of the studied population. It is therefore very important to directly estimate VSL for a country of concern.

A significant number of earlier VSL estimates come from studies that measure compensating differentials for on-the-job risk exposures in labor markets. Since the 1990s, however, the contingent valuation (CV) method has been widely used to estimate the value of a statistical life. An individual's WTP for a specified death risk reduction can be elicited with a plausible CV scenario and a VSL can be estimated by dividing the WTP by the change in death probability. The advantage of the CV method over the traditional market approach is that a CV study can be flexibly designed even when no similar markets exist. This nature of the CV approach is especially important for the developing country context, because a good competitive market can hardly be found and data on risk and compensation are rarely available in most of the developing countries. However, the challenges in using the CV method to estimate VSL are enormous. Beside the conventional challenges in using CV method: questionnaire design, statistical analysis, strategic responses and elicitation method choices, etc., a particular challenge comes from the empirical finding that individuals may have difficulties in understanding a numeric probability change. Our analyses also show that the VSLs obtained from the previous CV studies which estimated WTPs for a couple of numeric risk reductions are incompatible with the theoretically defined marginal WTPs. These findings lead to suspicion of the validity and reliability of most of the previous CV studies for VSL estimation.

A contingent valuation study of health risk reduction was conducted in three provinces of China in 2000. A VSL can be calculated based upon the WTP information from that survey and the cancer morbidity and mortality data. In the CV survey, respondents are not asked to evaluate the abstract probability reduction as done in conventional risk valuation studies, which is usually a difficult task for the respondents to complete. Instead, they are asked whether or not they are willing to buy a cancer vaccine that is effective for one year. This CV scenario is easy to understand and is similar to a market transaction. WTP functions of risk reduction can be estimated with data of cancer morbidity and mortality, and a marginal value estimation of risk

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[2] A comprehensive literature review on VSL studies can be found in Miller (1999), Viscusi and Aldy (2003) and Australian Safety and Compensation Council (2008).

reduction can be produced, which is in sharp contrast to the average value estimation of risk reduction as done in a conventional contingent valuation study.

This paper is organized as follows. In the next two sections, we briefly present a literature review on WTP for mortality reduction and VSL estimation. The relationship between WTP for mortality risk reduction and VSL is developed in Section 4. In section 5, we present our contingent valuation survey. The econometric methods are illustrated in section 6, and the data and the estimation results are presented in section 7 and 8. VSL calculation and simulation are presented in section 9. We conclude the paper in section 10.

2. VSL Estimation Methods

VSL estimation methods can be categorized into two types.[3] The first type of methods measures the loss of direct income. One representative approach is the so-called human-capital method, which calculates the present value of future income forgone due to a premature death. These approaches however have two well recognized short-comings. First, they do not take into consideration the intangible impacts on individual and family well-being such as suffering and loss of leisure, therefore are often regarded as the lower bound of the social cost. Second, these approaches only focus on the active population but ignore the value of children and aged people.

The second type of approach measures willingness to pay or accept changes in human mortality risk. The principle of this type of methods is to use people's preferences as a basis for the measurement of increase (or reduction) in human well-being related to the reduction (or increase) of mortality risk (World Bank, 1998). As the "consumer surplus" from living can be many times higher than human capital, studies using the willingness-to-pay approach generally give a higher valuation of life than those using direct income losses. Using surveys in Taiwan and Los Angeles, Alberini and Krupnick (2000) found the WTP estimates gave values 1.61-2.66 times higher than the loss of direct income.

There are two ways of empirically estimating individuals' WTP for mortality risk reduction: the revealed preference approach, which can use compensating wage or consumer behavior data, and the stated preference approach, such as the contingent valuation method (Krupnick et al., 2002). The revealed preference approach often uses differences in wage rate to measure compensations that people require for differences in risk of dying or falling ill caused by occupational hazards. Viscusi and Aldy (2003) provide a comprehensive survey of compensating wage studies in the US and other countries. The recommended VSL figures range from 4 to 9 million dollars for the US case and 0.8 to 74.1 million dollars for other countries.

Besides the sensitivities of the estimation results to the studied sectors or markets, the VSL estimation with the revealed preference approach also suffers from some other serious limitations. First, in the labor market or durable goods consumption markets, inactive population, especially the elder people, cannot be included. Secondly, workers in the labor market may not be perfectly aware of the workplace risk. Thirdly, this approach also implicitly assumes that

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[3] A detailed introduction of the various approaches using the loss of direct income can be found in World Bank (1998).

people have no preference for certain profession choice, which is not true in some of the cases. Finally, many labor market hedonic studies also suffer from measurement errors. Workers within an industry or occupation group are typically assigned with the same workplace fatality rates, but in reality, the fatality rates can be quite different for different people even working in a same industry.

The contingent valuation (CV) method is a stated preference approach. It uses surveys to ask individuals to report directly their WTPs for a specified and hypothetical reduction of risk of premature death. An obvious advantage of the CV method over the hedonic price approach is that the former has more flexibility in choosing a population and a specific type of risk (Alberini and Chiabai, 2007). However, a well-behaved CV analysis is more demanding for technical expertise in questionnaire design, sample choice, treatment of responses, etc. The biggest critic of this method is that it is hypothetical, which requires a researcher using this method to undertake additional efforts to remind people of other related factors such as real budget constraints.

3. VSL Estimation in Developing Countries

Although numerous VSL studies have been conducted in the U.S. and other developed countries[4], there are few studies directly conducted in the developing world. Three types of efforts have been made in order to obtain a VSL estimate in a developing country: scaling, meta-analysis and direct estimation (Bowland and Beghin, 2001). The scaling approach adopts valuation estimates made in developed countries with calibrations based on income differences. However, the scaling approach is often problematic as per capita income level is not the sole determinant of VSL, because other factors such as regional economic and demographical characteristics and cultures can also affect VSL (Mead and Brajer, 2006). Besides, income elasticity is not constant. Chestnut et al. (1997) and Alberini and Krupnick (2000) indicated that in most of the cases, the VSL's income elasticity is higher for poorer people than for the richer one. The survey made by Viscusi and Aldy (2003) of the studies conducted in the developed countries revealed an income elasticity of 0.5 to 0.6 , while Bowland and Beghin (1998) found an elasticity of 1.8 for the developing countries studied.

The meta-analysis of VSL uses existing studies conducted in the industrialized countries to derive a VSL prediction function for developing countries, taking into considerations of differences in risk, income, human capital levels as well as demographics of a country. For example, Bowland and Beghin (2001) analyzed over 40 wage-risk studies conducted in the industrialized countries, and found VSL not only depends on income level but also on other factors such as average age, education level, coverage degree of social security system, and other social situation. Based on their estimation models and available data in Santiago, Chile, they predicted the cost of mortality due to air pollution for this South American city.

However, even the meta-analysis approach is still problematic to developing countries. Some specific factors in a developing country, such as distorted wages, cross-subsidy of public services, difficulties in valuing various homemaking services, high unemployment rates, are obviously contradictory with some implicit assumptions made in the original studies such as the

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[4] A summary table of the study results is presented in the appendix.

existence of a perfectly competitive labor market for a wage-risk hedonic study. In addition, these studies often have to ignore the potentially important roles played by age and health status in mortality risk reduction valuation (Krupnick et al. 2002; Arberini et al. 2004 and Hammitt and Liu, 2005). Given the fact that people living in different countries do not necessarily share the same demographical structures and health characteristics, the simple scaling principle or the independent-variable-based scaling principle do not permit us to include the differences existing in the original mortality risk between the countries. Chestnut et al. (1997), based on two paralleled CV studies in Bangkok and Los Angeles, revealed that the differences in the average increase in the incidence rate for certain respiratory diseases with the same percentage increase of pollution are incomparable between the two cities.

Obviously if it is feasible, it is always preferable to conduct VSL studies directly for a country itself. A small number of contingent valuation studies have been designed and carried out in developing countries to estimate VSL. Alberini et al. (1997), Alberini and Krupnick (2000), Hammit and Graham (1999), Hammit and Liu (2004), and Bhattacharya et al (2007) are a few examples. Only until very recently a couple of contingent valuation studies have been conducted in China to estimate VSL. Wang and Mullahy (2006) conducted a CV study in Chongqing to estimate WTP for reducing the risk of fatality due to air pollution and the value of a Chinese statistical life. Based on the face-to-face interviews of 550 individuals in 1998 with an open-end WTP question format backed by a bidding game in case of respondent's hesitation, a probit estimation and bootstrap process gives an estimate of medial WTP for saving a statistical life to be 286,000 yuan, or 34,458 US dollars. Hammitt and Zhou (2006) estimated WTP values for three health endpoints: cold, chronic bronchitis and fatality, based on an in-person interview conducted in 1999. The survey was carried out in three locations: Beijing, Anqing and the rural areas near Anqing. WTP was elicited by a double-bounded, dichotomous-choice format. Each respondent was asked whether she/he would purchase a treatment which provides a stated risk reduction at a specified price. After the two dichotomous-choice questions, the respondents were asked to state their maximum WTP for the risk reduction in an open-ended follow-up. Their estimations gave a sample-average median value of a statistical life ranging between 33080 yuan to 140590 yuan ($4000 to $17,000). Both studies only concentrate their surveys in a geographically limited regions, therefore the conclusion cannot be simply extrapolated to other regions, given the great regional disparities between different provinces. Both surveys related their mortality reduction WTP questions directly to environmental quality improvements. Although the studies reminded respondents to only evaluate their mortality risk reduction contributed by environmental quality improvements, the respondents might not have totally excluded from their valuation other benefits caused by pollution reduction. The vast differences in the estimation results call for further investigations.

4. Contingent Valuation of a Statistical Life

The linkage between a WTP for fatal risk reduction and VSL can be constructed from a life-cycle consumption model with an uncertain lifetime (Yaari, 1965; Sherpard and Zeckhauser, 1982; Cropper and Sussman, 1990). Following Alberini et al. (2004), the life-cycle model can be summarized below.

A person at the beginning of period j (age j) receives expected utility of V_j over the remainder of his lifetime.

$$V_j = \sum_{t=j}^{t=T} q_{j,t}(1+\rho)^{j-t} u_t(C_t) \tag{1}$$

$u_t(C_t)$ is the utility of consumption in each period t that this individual can receive. To get its present value, we can multiply it with the probability that the individual survives to that period $q_{j,t}$ and then discount it to the present at the subjective rate of time preference, ρ.[5]

In the life-cycle consumption model, V_j is maximized subject to initial wealth, W_j, and a budget constraint that reflects opportunities for borrowing and lending. The two cases usually considered are the case of actuarially fair annuities and the more realistic situation in which the individual can borrow and lend at the riskless rate r, but can never be a net borrower.

$$W_t = W_j + \sum_{k=j}^{t} \frac{y_k - C_k}{(1+r)^{k-j}} \geq 0 \tag{2}$$

Where y is income and C is consumption. We can use the life-cycle model to determine the amount of initial wealth that an individual would give up to reduce D_j, the probability that he dies during the current period. A reduction in D_j will increase the probability that the person survives to all future periods since, by definition, $q_{j,t}$ is the product of the probabilities that the individual does not die in all periods from j to t-1,

$q_{j,t} = (1-D_j)(1-D_{j+1}) \ldots (1-D_{t-1})$. *(3)*

The rate of substitution between D_j and W_j, which keeps the expected utility V_j to be constant, corresponds to the value of a statistical life for a person of age j, VSL_j,

$VSL_j = (\partial V_j/\partial D_j)/(\partial V_j/\partial W_j) = dW_j/dD_j$. (4)

dW_j represents the amount an individual is willing to pay for the reduction in D_j. VSL is the marginal value of a risk change, as defined in equation (4).

In contingent valuation studies on VSL, an individual is usually presented with a small risk reduction (ΔD), and a WTP for this small risk reduction is elicited. Because the proposed risk reduction is small, the VSL_j, as defined in equation (4), can be roughly equal to the average WTP of the risk reduction (Albrini et al, 2004); i.e.,

$VSL_j = WTP_j/\Delta D_j$. (5)

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[5] $q_{j,t}$ shows the mortality rates of the individual in the period from j till T. These mortality rates surely depend on the health situation of the individual at the beginning of the period j. Therefore, in certain sense, the $q_{j,t}$ should be personalized by the health status of each individual.

However, the contingent valuation estimates of VSL, which are based on equation (5), can have significant biases from the theoretically correct estimates as defined in equation (4). First, the proposed risk reduction in a CV study cannot be too small in order to be sensible to the respondents. Therefore the approximation of equation (5) to equation (4) can be a question in reality. Secondly, it can be a difficult task for a respondent to calculate his/her WTP for a small risk reduction. A systematic error may exist in a WTP calculation with an individual. Previous empirical studies find that the VSL estimates as defined in equation (5) are sensitive to the scales of the risk reduction proposed in CV studies. WTP estimates are found not proportional to the level of risk reduction. Krupnick et al. (2002), Alberini et al. (2004) and Alberini and Chiabai (2006) studied the VSLs for USA, Canada and Italy with the CV approach for two different levels of mortality risk reduction, with one to be 5 times the other, but found that the WTP is not 5 times high, and therefore different VSL estimates can be produced for a same sample of population.[6] Similar findings are also reported in Muller and Reutzel (1984), Vassanadumrongdee and Matsuoka (2005), Hultkrantz et al (2006), and Corso et al. (2001), Andersson and Svensson (2008), Bhattacharya et al. (2007), where WTP increases less than proportionally with the size of risk reduction. Hammit and Graham (1999) provided a synthetic analysis for the 19 CV studies published before 1995 that have employed more than one level of risk reduction in the surveys, and found that, although many studies did find an increasing trend of WTP with risk reduction, none of the 19 studies shown the proportionality between WTP and the proposed risk reduction. Persson et al. (2001) elicited WTP information for risk reductions of 10, 30, 50 or 99 percent of mortality risk for one year and provided a graphical relationship between WTP and absolute mortality risk reduction. They find that WTP is increasing with the level of risk reduction but the increasing rate is decreasing.

No theoretical studies have been found on the relationship of WTP with risk reduction. While a theoretically-correct functional form of WTP with respect to risk reduction is believed to be dependent on the utility function and the wealth function as presented in equations (1) and (2) above, one can project that it is an increasing function and to be concave when the risk reduction level is high enough due to the budget constraint.

To overcome the shortcomings of contingent valuation studies in estimating VSL as discussed above, it is logical to require researchers to estimate functional forms of WTP with respect to risk reduction and to derive a marginal WTP estimate of risk reduction. This study represents such an effort, where marginal WTPs are estimated and simulated with different WTP functional forms, and the results are compared with the average WTPs of risk reduction.

5. The Health Survey

In 2000, we conducted a household survey on public health and environment in three rural areas in China: Danyang (Jiangsu Province), Liupanshui (Guizhou Province) and Tianjin suburban. In-person surveys, where respondents complete the questionnaires with close guidance from enumerators[7], are conducted. About a half of the sample is workers who were working in local

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[6] In Alberini et al. (2004), the mean WTPs for 1/10000 and 5/10000 risk reductions are $370 and $466 in Canada, and $487 and $ 770 in the United States.

[7] The major intention is to minimize the potential interviewer bias. The interviewers read another copy of identical questionnaire to the respondents, but can not directly work on the questionnaire, and the respondents do not need to

township-village enterprises. One to three workers were randomly selected from each factory based on the worker name list and were invited for personal interviews. Another half of the sample is rural household heads, or farmers, who were interviewed in or around their houses. A list of communities was first randomly selected in the three municipalities, and a certain number of household interviews were assigned to each selected community. Teams of enumerators were sent to the communities, and the enumerators knocked the doors of the households selected and invited the heads of the households to participate in the interviews. If the heads of the households were not at home or refused to be interviewed, the neighbor households were then selected, until the total number of interviews in this community reached the target number.

The questionnaire was developed from a similar questionnaire previously employed in China, and was pre-tested in each of the municipalities. Special cares were paid to the WTP section of the questionnaire. Several group discussions and two pre-tests were conducted at each of the three study areas, focusing on the wording of the WTP questions as well as the price range. The survey was conducted by teams of researchers, professors and graduate students, and the survey teams were first trained by one of the authors of this paper, and then participated in the group discussions and the pre-tests of the questionnaire in order for them to fully understand the issue and to get familiar with the task before the formal surveys started. The final version of the questionnaire includes seven parts: personal characteristics, environmental perceptions and attitudes, local pollution control issues, pollution impacts on respondents and their families, household situation, health status, and finally the contingent valuation questions about cancer prevention.

The willingness-to-pay question on health risk reduction is posed in the form of cancer risk prevention. Aiming to obtain detailed information about the attitudes of each respondent toward the proposed cancer vaccine, we use a Multiple Bounded Discrete Choice (MBDC) format to check about respondent's WTP. This format combines two aspects of development from the traditional dichotomous choice (DC) WTP question. On one hand, it allows respondents to vote on a wide range of referendum thresholds, and on the other hand, a scale of "polychotomous choice" response options from "Definitely No" to "Definitely Yes" is also provided to allow respondents expressing their levels of voting certainty for the referendum at each price level. In this way, MBDC survey technique actually reinforces both quantity and quality of CV data[8].

The WTP question in our questionnaire is as follows:
    "Suppose there is a medicine that can prevent you from getting cancer for one year with one dose. There would be no side effects. But after one year, the medicine will fully stop functioning. With given quality and impact, the price of the medicine could be different. We would like to know the possibility for you to buy such a vaccine, with different prices, to make sure you would not fall ill of cancer for one year.

[8] For more discussions, see Wang and He (forthcoming).

Please note that, 1) different people have different probabilities to fall ill of cancer. Therefore, the likelihood that different people truly need the medicine is different. If a person will surely not get cancer in the next year, he may not need this preventive measure; and 2) with a given income, a person also needs to buy other goods and services such as food and clothes, and may spend money to prevent from other diseases.

We only want to know the likelihood that you would buy such a medicine, given the following list of prices, to make sure you would not fall ill of cancer in the next year. There is no right or wrong answers; we only want to know how you would react to the different prices. Please select one possibility under each price given below."

Price	Definitely not	Probably not	Not sure	Probably yes	Definitely yes
Free(0 yuan)					
10 yuan					
20 yuan					
40 yuan					
60 yuan					
90 yuan					
150 yuan					
200 yuan					
300 yuan					
500 yuan					
1000 yuan					
2000 yuan					
5000 yuan					
8000 yuan					
10000 yuan					
15000 yuan					

6. WTP Estimation with MBDC Data

MBDC format WTP data, offering rich information with extended bid price choices and multiple options of certainty levels, have been used in the past in a number of contingent valuation studies. Several of the studies employing the MBDC data, such as Alberini et al. (2003), implement an extension of the Random Valuation Model proposed by Wang (1997), which views the value that an individual attaches to any amenity (including market traded goods) as a random variable with an unspecified probability distribution (Shaikh et al. 2007). Following this logic, the data obtained from the MBDC format are several observations of an individual WTP distribution that is attached to the amenity in question. Wang and Whittington (2005) and Wang et al. (2004a) further proposed a CV approach called Stochastic Payment Card (SPC). This approach extends the MBDC format WTP question and directly elicits the numerical likelihood information of the respondents beside the verbal likelihood information. With this arrangement, we are able to directly estimate individual valuation distributions from the SPC data provided by the MBDC format questionnaire.

In this paper, we will use an alternative analytical strategy initially proposed in Wang and He (forthcoming) to estimate individual valuation distributions for cancer risk reduction. This new approach is based on the random valuation theory as described in Wang (1997) and Wang and Whittington (2005) and uses a similar data encoding strategy as used by Evans et al (2003). Subjective verbal likelihood responses given by MBDC respondents are first encoded into numerical likelihood data, or SPC data. Then the SPC data are analyzed to estimate individual valuation distributions, as did in Wang and Whittington (2005).

This new WTP estimation strategy suggests that an individual i may not know the exact value of his WTP for risk reduction but he does have some idea about the range of values in which it lies. When the proposed bid price comes out to be sufficiently lower (higher) than the value range, he will be relatively more sure about his positive (negative) answer, but when the bid price is located close or in the value range, he will be more unsure about his choice. So we can express an individual i's WTP for risk reduction, represented by V_i, as a random variable with a cumulative distribution function F(t). The mean value of V_i is μ_i, which represents the mean WTP of the individual i for the cancer preventive medicine, and the standard variance is σ_i. So we can write the WTP model as,

$$V_i = \mu_i + \varepsilon_i \tag{6}$$

where ε_i is a random term with a mean of zero. When given a price t_{ij} for the cancer vaccine, the probability for the person to say "yes" will be,

$$P_{ij} = Prob(V_i > t_{ij})$$
$$= 1 - F(t_{ij}) \tag{7}$$

Once P_{ij}, the probabilities for individual i to agree on the price t_{ij}, is known to a researcher, either by assigning numerical values to the verbal MBDC data or by directly asking individuals of their numerical likelihood information as did with the SPC approach, equation (7) can be estimated for each individual. The estimation model can be constructed as follows:

$$P_{ij} = 1 - F(t_{ij}) + \lambda_i \tag{8}$$

where the error term λ_i has a mean of 0 and a standard variance of δ^2. δ can be constant for a respondent i, but its value will be different for different respondents. P_{ij} is a dependent variable, which is the certainty answer chosen from "definitely yes" to "definitely no" by a respondent i at price j. P_{ij} will take values between 0 and 1, with the value approach to 1 meaning a higher certainty of accepting and the value approach to 0 meaning a lower certainty. These values can be viewed as a continuous variable. t_{ij} is an independent variable, which is the bid price proposed in the questionnaire. We can also consider t_{ij} as a continuous variable.

Assume a specific functional form for $F_i(\bullet)$, such as of a normal distribution, with a mean μ_i and a standard variance σ_i, i.e., $F(t_{ij}) = \Phi\left(\dfrac{t_{ij} - \mu_i}{\sigma_i}\right)$, then model (8) can be written as,

$$P_{ij} = 1 - \Phi\left(\frac{t_{ij} - \mu_i}{\sigma_i}\right) + \lambda_i \tag{9}$$

Assume λ_i also has a normal distribution. Then,

$$\frac{P_{ij} - 1 + \Phi\left(\dfrac{t_{ij} - \mu_i}{\sigma_i}\right)}{\delta} \sim N(0, 1).$$

and the log likelihood function is:

$$\text{Log } L_i = \sum_{j=1}^{J} \log \phi \left(\frac{P_{ij} - 1 + \Phi\left(\dfrac{t_{ij} - \mu_i}{\sigma_i}\right)}{\delta} \right) \qquad (10)$$

This is equivalent to a least square nonlinear estimation; δ has no influence on the estimation, as long as it's a normal distribution. With the log likelihood function (10), μ_i and σ_i can be directly estimated for each individual i with the MBDC data.

Once μ_i is estimated for each individual, models can be constructed and estimated to analyze its determinants. One simple example is to have the following linear functional form:

$$\mu_i = \beta 0 + x_i'\beta + e_1 \qquad (11)$$

where x are personal specific characteristics. βs are coefficients to be estimated; e_1 is a random errors.

7. Survey Data Analyses

7.1 WTP Responses

1,933 respondents accepted to be interviewed. 594 respondents did not give positive answers (i.e., a "not sure", "probably not" or "definitely not" answer was selected) at the price of zero, which may reflect that the respondents do not think they would need this preventive medicine. At the other end, 205 persons did not give negative answers (i.e., definitely yes, probably yes or not sure was selected) even at the highest bid price, 15,000 Yuan, which means that the price range did not cover the whole WTP range if people answered the questions honestly.[9] 838 respondents have their WTP located in the price range. Two respondents have cancer so the preventive medicine is not meaningful to them. 135 respondents did not fully complete the questionnaires, and 146 respondents gave some unreasonable answers to the likelihood questions, such as giving a higher acceptance probability for a higher bid price[10]. Those responses would have been corrected by the enumerators if it is a traditional in-person interview. Table 1 summarizes the statistics of the responses.

7.2 Characteristics of the Respondents

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[9] Almost all members in the focus group and pre-tests believed 15,000 Yuan to be more than the highest possible WTP for a medicine preventing cancer for one year. But apparently, some people may have very high WTP for such a medicine if they give honest answers.

[10] This may make sense in reality if people believe that a higher price means a higher quality.

Table 2 reports the descriptive statistics of the respondents in three categories: 1) 594 respondents who give negative answers at the zero bid (no demand); 2) 205 respondents who are positive even at the highest bid (extremely high demand), and 3) 838 persons whose WTPs are covered by the bid range (normal demand). The sample statistics are given in the third column. The stars marked in the first three columns indicate the significant difference of the variable from the category 3, which will be used in the following econometric analysis.

In Table 2 we can see that the observations in category 3 with normal demand share very similar statistical characteristics with the whole sample. The only variable that seems to have a significant difference is the income uncertainty in future 5 years. When there are statistical differences between the subsamples, we generally believe these differences are logical: people who have answered negatively at the zero bid generally have lower income level, fewer cases of cancers observed in their families and relatives, lower degree of trust or need for such a medicine. People reporting positive answers at the highest bid, on contrary, have much higher income level, more frequent cases of cancers observed in their families and relatives, high degree of trust or need of such a medicine. These findings are further supported by the Probit analyses reported in Table 3, where the probability for a respondent to report a negative answer at zero bid and the probability for a respondent to report a positive answer even at the highest bid are modeled, with respect to the respondents in category 3 whose WTP is covered by the payment range. The statistically significant independent variables are family income (and the future income uncertainty for the case of negative answer at the zero bid), relatives diagnosed with cancer, and the two dimensions of perception measurements of people on the preventive medicine: trust and need. However, other socio-demographical variables, such as age, sex, profession, health habits and religion, etc., do not show significant differences. This implies that the survey respondents do base their WTP answers on their payment capacities, their real needs and trust in the medicine.

7.3 WTP Response Statistics

The frequencies and the percentages of WTP responses of the whole sample (including all of the three categories) are presented in Tables 4-1 and 4-2. Based on Table 4-2, inverted stochastic demand curves for the whole sample can be drawn. Tables 5-1 and 5-2 show the frequency distribution and the percentage distribution of responses of respondents with normal demands. As shown in Table 5-1, the percentage of "definitely yes" answer is decreasing fast from 70.29% at the price of zero to less than 0.2% at the price of 8000 yuan. While the percentage of "definitely no" answers increases steadily with the price offered, from 0% at price of zero to about 87.7% when the price increases to 15000 yuan. In total, over 37% of the responses are uncertainty responses (probably yes, not sure, probably not) which happen between the prices of 90 and 1000 yuan. This indicates that the respondents have relatively important uncertainty in their WTPs. This, to certain degree, justifies the use of MBDC format and reveals the existence of individual WTP distribution.

8. WTP Estimation Results

8.1. Individual WTP

To estimate the mean WTP, μ_i, for each of the 838 respondents whose WTP distribution is covered by the MBDC price range, we conduct maximum likelihood estimations with normal distribution functions as shown in equation (4). All redundant answers at the two ends of the payment card, i.e. those "definitely yes" answers at the prices below the highest price where a "definitely yes" answer is given and those "definitely no" answers at the prices above the lowest price where a "definitely no" answer is given, are deleted. After doing so, each respondent has 2 to 11 answers getting into the maximum likelihood estimation.

The benchmark encoding strategy for the verbal likelihood data is to use 0.999 for "definitely yes," 0.75 for "probably yes," 0.50 for "not sure," 0.25 for "probably no," and 0.001 for "definitely no".[11] Wang and He (forthcoming) tried other encoding strategies and found the estimation results were relatively stable if a symmetrical encoding strategy was used. The same conclusion is drawn in Evans et al (2004). In the following discussions only the results based on the benchmark encoding strategy will be presented.

The distributions of the estimated mean value of individual WTP (μ_i) are given in Table 6-1. The mean WTPs vary from 0.27 to 11,872.18 Yuan, with a sample mean of 759 yuan (or, 5.6% of sample average household annual income) and a medium value of 172 yuan.

8.2. Average WTP for Risk Reduction

With the estimated individual WTPs and the expected cancer risk reduction for each individual, an average value of cancer risk reduction can be calculated for each individual, and a sample mean value can be obtained. This sample mean value corresponds to the VSL estimate in a conventional contingent valuation study for mortality risk reduction. The morbidity-based average value of risk reduction is corresponding to a lower bound of VSL and the mortality-based value corresponding to an upper bound. The reason is that the cancer morbidity risk is always higher than the cancer mortality rate: falling ill of cancer does not necessarily mean dying, but not falling ill of cancer means that the individual will not die of cancer. The morbidity-based average value is in fact the value of cancer, which should be lower than the value of life. The WTP divided by individual's expected value of cancer mortality corresponds to an upper bound of VSL, as the WTP obtained in our survey does not only include the WTP for avoiding death caused by cancer but also include WTP for avoiding suffering and medical expenditures that may be caused by a cancer.

The mean value of the morbidity-based average value of cancer risk reduction is estimated to be 0.89 million yuan, while the median is 0.18 million yuan, for the group of respondents with a normal demand of cancer vaccine. The mean value of the mortality-based average value of cancer risk reduction is 1.97 million yuan and the median value is 0.39 million yuan[12]. The

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[11] The values of 1 and 0 cannot be used for the answers of "definitively yes" and "definitely no" because a normal distribution function is assumed.

[12] The results here are only for those respondents with a normal demand of cancer vaccine whose WTP is covered by the payment card. Those who do not need a vaccine as described in the survey cannot be included in the analyses. This is a shortcoming of such a study, which is similar to the hedonic wage studies that cannot include those people

distributions of the average value of risk reduction by age and sex are presented in Tables 6-2 and 6-3. In general, a female values more than a male. A younger person values more than an older person.

8.3. WTP Determinants

The estimated WTP means, μ_i, can be further analyzed with a simple robust OLS regression on log WTP, as shown in equation (11), in order to see how the demographical, economical, social and health characteristics of a person can affect his/her WTP. The estimation results are reported in Table 7. The regression gives consistent results for almost all of the variables. People having higher family income, with better education, having relatives diagnosed with cancer, having less future income uncertainty, having regular health check-ups, have relatively higher WTPs. The WTP is also positively associated with the degree of trust and subjective judgment on the need of the medicine. The income elasticity of WTP is found to be around 0.42, which is slightly lower than the estimate provided by Viscusi and Aldy (2003) which is about 0.5 and 0.6 for U.S. studies. Table 7 also gives the detailed coefficients and their significances for the age-, sex- and region-related variables. We do not find significant coefficients for the continuous age variable, which may be due to the fact that the correlation between age and WTP is not a simple linear one. But we do observe dummies of some age-ranges having interesting, significant coefficients. In Jiangsu, younger people are willing to pay more, and males are willing to pay more than females. The opposite is found in Tianjin and Guizhou, where old females are willing to pay more than old males and younger people. In general, males in Jiangsu are willing to pay more; old males in Jiangsu and old females in Tianjin and Guizhou are willing to pay the most, and old males in Tianjin and old females in Jiangsu are willing to pay the least.

8.4. Sample Selection

The empirical results of the WTP model presented in Table 7 can be used to project an average WTP of the whole sample by substituting the values of the independent variables of all respondents into the model. The average WTP is estimated to be 439 yuan with a standard deviation of 546 yuan. The average risk of cancer is 15.5/10000, and the morbidity-based average value of cancer risk reduction is about 283,000 Yuan. The average cancer mortality rate is 9.32/10000, and the mortality-based average cancer risk reduction is about 471,000 yuan. These estimates are lower than the estimates presented in section 8.1. One reason is that the WTP model used is in log term and therefore the average WTP projected by the model is compatible with the geometrical mean, rather than the algebra mean. When the WTP is in log terms, those large values in WTP play less influence in the mean estimation. When a linear WTP model is used, the estimates are compatible with the results for an average person presented in last section. This indicates again that the final outcomes are very sensitive to the choices of models if WTP models are used to project the final estimates.

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who are not involved in the labor market studied. Those respondents with extremely high demands of the vaccine, whose WTP values should be higher than 15,000 yuan, are not included in the estimation either. So the estimates obtained here are conservative ones.

While the log WTP models can significantly under estimate the final values, they can be employed to assess the potential biases that may be caused by excluding those outliers in our sample. The average WTPs can be projected for the groups of people with no demand as well as extremely high demand by the empirical WTP model. The results are summarized in Table 8. Higher VSL estimates are obtained when those people with extremely high demands are included, just as expected. When the empirical WTP model, which is estimated with the sample with a normal demand, is applied to the whole sample, the VSL estimates are slightly lower than but very close to the ones obtained with the normal sample.

9. Marginal Value of Risk Reduction

In our study, WTP functions of risk reduction can be constructed and estimated, because the level of risk reduction for each respondent is different. As discussed before, the risk reduction in our study is the cancer morbidity and mortality rate that each individual is facing. The estimated WTP function of risk reduction can be used to simulate the marginal value of risk reduction, as shown in equation (4), which is a theoretically correct valuation. The estimated WTP function of risk reduction can also be used to simulate the average value of risk reduction, as defined in equation (5), which is an approximate value given by a conventional contingent valuation study. The results can be compared.

The estimated relationships between WTP and risk reduction are presented in Table 9-1 for cancer morbidity rate and in Table 9-2 for cancel mortality rate. The cancer morbidity data are region-, sex- and age- specific, but the cancer mortality data are available only at the national level[13]. The individual cancer morbidity rate and mortality rate are found to be significant determinants of their WTP for the risk prevention. This implies that our respondents do have a reasonable judgment of relative cancer risk and do base their WTP answers on the risk judgment.

The results of six modeling strategies are presented in Tables 9-1 and 9-2. In model 1, the WTP is forced to be proportional to the risk reduction; i.e., WTP=a*RR, where RR is risk reduction and a is the coefficient which is individual specific. In theory, when risk reduction is very small, this should be the case. The marginal value and the average value of risk reduction with model 1 are the same, and the estimation result are 226,700 yuan for morbidity risk and 282,843 yuan for mortality risk for an average person, who takes the sample average values for all related variables in the model except WTP and RR.

In model 2, the WTP model is specified as WTP = a*RR + b*RR^2. The log likelihood test shows that model 2 is a significant improvement over model 1. Income turns out to be a significant variable. For an average person, the marginal value of cancer is 353,138 yuan and the average value of cancer is 433,119 yuan. For mortality risk reduction, the marginal value is 810,879 yuan and the average value is 572,023 yuan.

In model 3, it is assumed that individuals may have errors in judging their WTPs, and this error is determined by individual characteristics. The model is specified as WTP = a*RR + c.

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[13] The national-level cancer morbidity data are used for the respondents in Guizhou as the data for Guizhou are not available.

According to the log likelihood values, model 3 is a significant improvement over model 1, however, the marginal value estimate is much lower with model 3 and even negative for mortality risk.

In model 4, individual errors in both risk reduction judgment and WTP calculation are considered. The model is specified as WTP= a*RR + b*RR^2 + c. The results are much better according to the log likelihood values. The significant variables include the risk reduction, the square of the risk reduction and the personal characteristics. For an average person, the marginal value of cancer is estimated to be 68,410 yuan and the average value of cancer is estimated to be 514,386 yuan. For mortality risk reduction, the marginal value is 72,616 yuan and the average value is 794,692 yuan.

Model 5 tests the overall significance of including the interactions of risk reduction with personal characteristics, and it is found that the interaction is not significant.

Model 6 gives another version of model 5, but the dependent variable in model 6 is log WTP; i.e., log(WTP) =a*RR + b*RR^2 + c. The interactions of risk level with personal characteristics are also tested, which did not show a significant improvement. The marginal value and the average value of cancer are estimated to be 29,208 yuan and 110,801 yuan for an average person respectively. The marginal value and average value of mortality risk reduction are 25,787 yuan and 183,385 yuan respectively. Because the dependent variable is in log term, the values estimated are corresponding to the medial value of the WTP in the sample.

In general, the results presented in Tables 9-1 and 9-2 are consistent, but the model performance presented in Table 9-2 is lower than that presented in Table 9-1. It is understandable because the results presented in Table 9-2 are for mortality risk reduction which is only based on a national-level dataset that has no variation between regions.

Model 4 and 6 are the best among the alternative models. Model 4 in Table 9-1 gives a value of cancer of 68,410 yuan with the marginal value approach and 514,386 yuan with the average value approach. Model 4 in Table 9-2 gives a VSL of 72,616 yuan with the marginal value approach and 794,692 yuan with the average value approach. One can see a tremendous difference between the results obtained from the marginal value approach and the average value approach.

Our results are in contrast to those results previously obtained in China. Wang and Mullahy (2006) provided an estimate of medial WTP for saving a statistical life to be 286,000 yuan in 1998, and Hammitt and Zhou (2006) provided a sample-average medial value of a statistical life ranging between 33,080 yuan to 140,590 yuan in 1999. Our results are for the year of 2000. The medial value of statistical life is estimated to be 395,694 yuan with the simple average approach and 183,385 yuan with the log WTP model. With the marginal value approach, the VSL is estimated to be 72,616 yuan for an average person. With the average value approach, the VSL is estimated to be 794,692 yuan for an average person based on the WTP modeling result and1.97 million yuan based on a simple sample average.

In order to see how the estimation result changes with the level of risk reduction, we conduct simulations based on the modeling results of models 4 and 6. Presented in Table 10 are the simulation results of cancer morbidity risk reduction[14]. Individual characteristics are fixed at their sample average values. The simulations show that the average values of risk reduction are always higher than the marginal values. At the risk reduction level of 1/1000, the WTP model gives an average value of 11.4 times the marginal value, and the log WTP model gives an average value of 5.3 times the marginal value. The marginal values do not change much when the risk reduction is small. However, the average value is decreasing dramatically along with the increase in risk reduction. This is consistent with the empirical findings that higher VSL estimates are found when lower risk reduction levels are proposed in contingent valuation studies.

10. Discussion and Conclusion

In this paper, we present a study on the value of statistical life (VSL) in China which uses data on cancer morbidity and mortality observed in China and information on willingness-to-pay (WTP) for cancer risk prevention that was collected in a contingent valuation study conducted in three areas of China in 2000. The cancer risk information is age, sex and region specific, which can be mapped with the respondents' characteristics to produce an estimate of cancer risk for each of the respondents. WTP for cancer risk reduction is elicited with a hypothetical cancer vaccine that can prevent a person from getting cancer for one year.

With the conventional CV approach, the mean value of individual VSLs based on the cancer mortality data is estimated to be 1.97 million yuan, or 150 times of average household annual income, which is 13230 yuan for our sample. Because the WTP in the study is more than for avoiding death, the value can overestimate the VSL. This estimation can also be significantly affected by a small group of individuals who value lives extremely high. This mean value is reduced to about 800,000 yuan, or 60 times of the average household annual income, when it is calculated by the sample mean WTP divided by the sample mean cancer mortality reduction (759*10000/9.5). This is equivalent to the total WTP divided by the total lives saved, which is more relevant to policy analyses. However, the former approach is more compatible with the VSL definition, which is based on an individual's WTP for risk reduction.

VSL can also be projected with the empirically estimated WTP models by substituting the mean values of the characteristic variables into the models. The average value approach gives a VSL estimate of 795,000 yuan, or 60 times of the average household annual income[15]. The marginal value approach gives a VSL of 73,000 yuan, which is about 10 times lower than the estimate obtained with the average value approach. As the marginal value approach is a theoretically correct approach, this sharp difference provides a strong challenge to the validity of the average value approach, which has been used widely in previous contingent valuation studies of VSL. Also note that the WTP function of risk reduction in this study is estimated with cross-individual data which is based on the variations in WTP and level of risk reduction between individuals. It

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[14] As discussed before, the modeling results with cancer mortality are poorer than those with cancer mortality. But the simulation conclusion is the same for both the mortality model and the morbidity model.

[15] See table 9-2, model 4.

is not clear how the function will change if variations in WTP and risk reduction level for a same individual are also included in the empirical estimation.

While the projected mean WTP should not be statistically significantly different from the sample mean value if WTP is used as dependent variable, other types of models may produce significantly different results. In this study, a log WTP model is estimated and used to project the individual WTP values, and the projected mean WTP as well as the projected VSL are significantly lower than the values directly estimated from the sample. With a log WTP model, a VSL of 26,000 yuan is obtained with the marginal value approach and a VSL of 183,000 yuan is obtained with the average value approach[16]. These results challenge the validity of the benefit transfer approach which intends to transfer the (modeling) results of a study site to a policy site, because the choice of models can significantly affect the final estimations.

The estimates provided above are only from the part of sample where people have a normal demand of cancer vaccine. The WTP responses collected with the Multiple-Bounded Dichotomous Choice (MBDC) format do offer a significant amount of outliers which cannot be reasonably modeled. Those people with extremely high demands and those people with no demand of the vaccine are excluded in the final estimates. However, further analyses show that those outliers are reasonable responses. Those outliers can significantly affect the final estimation results, and may not be able to avoid in a future study of such type, especially for those people with no demand in cancer vaccine. This shortcoming is similar to the hedonic wage approach, which does not work for those who does not present in the studied labor market. However, the potential biases caused by excluding the two types of people from the final estimation may not be that serious in this particular study, as the WTP projection with the whole sample does not give a sensible difference from the part of sample with normal demands of the proposed cancer vaccine.

The survey was conducted in the year of 2000, and the VSL should have changed significantly as the income of Chinese families has significantly changed. The WTP models estimated in this study can be used to adjust the estimates. The survey was conducted in three areas of China which have a wide range of economic and geographical coverage. However, the sample area only covers rural areas and small towns; big cities are not included. If one believes that people in the urban areas of China value reducing risks to human lives higher, the estimates presented above would be biased downward. Therefore, the estimates presented in this paper may be conservative.

One unique design feature of this risk valuation study is that people are asked to value a cancer vaccine, rather than to value a specific number of risk change, which is found to be difficult to understand by the respondents, as used in a conventional risk valuation study. Our approach, while being more realistic and plausible to the respondents as it offers a reasonable market choice, runs risk that the respondents might not know what the cancer risk reductions are and therefore their WTP might not be sensitive to the cancer risk reduction they are facing. However, the modeling results on WTP and the estimated cancer risk show that this has not been a problem in this study; people's WTP are significantly correlated with their expected cancer risk reduction.

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[16] See table 9-2, model 6.

The results of this study reveal that a person who is richer, better educated, doing regular health checks, facing lower future income uncertainty, having relatives diagnosed with cancer, having a higher degree of trust in medicine, or feeling a higher degree of need for the medicine, has a higher WTP in general. VSL estimates are higher for women than men and are higher for younger people. They are also different for different regions in China.

Even though this study can help to provide a better understanding of WTP for risk reduction and VSL, as one can see from the analyses above, this study cannot give a conclusive result for VSL that can be used for policy analyses in China. This study also challenged the validity of some of the previous CV studies on VSL, such as Wang and Mullahy (2006) and Hammitt and Zhou (2006). A more systematic research on VSL is warranted.

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Table 1. Statistics of Survey Responses

Category	Definition	Number of respondents
1	Normal Demand: WTP value covered by the bid price range from 0 to 15000 Yuan	838
2	No Demand - don't need the medicine even at price of zero	594
3	Extremely High Demand - need the medicine even at the highest price of 15000 Yuan	205
4	With missing values or disordered answers	281
5	Age<16	2
6	Cancer patients	13
7	Total number of respondents	1933

Table 2. Descriptive statistics of major variables

Variable	Whole Sample (mean value)	No Demand (mean value)	Extreme High Demand (mean value)	Normal Demand				
				Mean	Obs	Std. Dev.	Min	Max
Social and demographical characteristics								
Worker (1=worker; 0=otherwise)	0.499*	0.463***	0.607*	0.533	838	0.499	0	1
Male (1=male; 0=otherwise)	0.706	0.746**	0.7679*	0.699	838	0.459	0	1
Age (years)	36.820	38.695***	35.000*	36.323	838	10.746	16	77
Education (1=Secondary school or higher; 0=otherwise)	0.938	0.912*	0.976*	0.931	838	0.254	0	1
Married (1=married;0=otherwise)	0.840	0.887***	0.762*	0.827	838	0.379	0	1
Religion (1=yes; 0=no)	0.091	0.101*	0.095	0.080	838	0.271	0	1
Economic characteristics								
Income (household income last year, yuan)	13230	12614**	24411**	13397	838	8495	600	70000
Yuncertain (1=not sure about future income; 0=otherwise)	0.160**	0.195***	0.071*	0.134	838	0.340	0	1
Physical and health characteristics								
Rcancer (1=relative diagnosed with cancer; 0=otherwise)	0.095	0.071°	0.202***	0.088	838	0.284	0	1
Smoking (1=yes;0=otherwise)	0.421	0.465*	0.405	0.421	838	0.494	0	1
Healthcheck (1=Regular check-up; 0=otherwise)	0.382	0.359	0.417	0.374	838	0.484	0	1
Perceptions about the preventive medicine								
Need (1=do not need the medicine at all, 2=somewhat, 3=need)	1.814	1.606***	1.952*	1.856	829	0.766	1	3
Length (1=expected length of the preventive effect 1=less than 1 year; 2=1year; 3=longer than 1 year)	1.574	1.594*	1.829***	1.539	831	0.652	1	3
Trust (1=not at all trust in the medicine; 2=somewhat. 3= totally trust)	2.067*	1.922***	2.250***	2.104	836	0.527	1	3
Regional dummies								
Guizhou	0.310**	0.290***	0.254***	0.353	838	0.478	0	1
Tianjin	0.352**	0.273**	0.327	0.309	838	0.462	0	1

Note: The stars are to indicate the statistical significance of the differences from respondents in category 7, based on the student T test.. *** represents a significance for 1%; ** for 5%; * for 10%.

Table 3. Determinants of Extreme Demands for the Medicine

	Equation for No Demand (Probit: 1=no demand even at price of zero; 0= normal demand)	Equation for Extremely High Demand (Probit Model: 1=yes at the highest price; 0=normal demand)
	-0.000	-0.023
Age	(0.03)	(1.59)°
	0.220	0.068
Male	(1.32)	(0.21)
	-0.198	0.285
Worker	(1.47)	(1.08)
	0.367	-0.149
Married	(1.79)*	(0.40)
	0.075	-0.275
Smoking	(0.49)	(0.91)
	-0.171	1.898
Income	(1.67)*	(6.70)***
	0.066	0.207
Education	(0.23)	(0.27)
	-0.413	0.521
Rcancer	(1.50)°	(1.57)°
	0.485	-0.173
Yuncertain	(2.93)***	(0.37)
	0.058	-0.068
Healthcheck	(0.41)	(0.26)
	0.278	0.208
Religion	(1.24)	(0.48)
	-0.386	0.613
Trust	(3.41)***	(2.47)**
	-0.423	0.082
Need	(4.55)***	(0.51)
Tianjin	1.353	-0.714
	(6.54)***	(2.43)**
Guizhou	1.370	-1.713
	(6.50)***	(3.79)***
Constant	0.394	-20.948
	(0.37)	(7.01)***
Observations	1380	913

Absolute value of z statistics in parentheses.* significant at 10%, ** significant at 5%; *** significant at 1%

Table 4-1. Statistics of WTP Responses: Frequencies of the Whole Sample

Price	Definitely not	Probably not	Not sure	Probably yes	Definitely yes	Total
0	427	78	89	303	740	1,637
10	480	91	94	379	593	1,637
20	518	93	105	357	564	1,637
40	545	100	133	353	506	1,637
60	582	118	149	347	441	1,637
90	618	140	162	329	388	1,637
150	682	169	196	275	315	1,637
200	732	188	203	231	283	1,637
300	786	205	199	192	255	1,637
500	852	216	183	173	213	1,637
1000	981	196	163	136	161	1,637
2000	1,059	197	155	111	115	1,637
5000	1,13	196	141	88	82	1,637
8000	1,183	185	122	77	70	1,637
10000	1,232	161	120	59	65	1,637
15000	1,248	151	115	59	64	1,637
Total	**13,055**	**2,484**	**2,329**	**3,469**	**4,855**	**26,192**

Table 4-2. Statistics of WTP Responses: Percentage of the Whole Sample

Price	Definitely not	Probably not	Not sure	Probably yes	Definitely yes	Total
0	26.084	4.765	5.437	18.509	45.205	100
10	29.322	5.559	5.742	23.152	36.225	100
20	31.643	5.681	6.414	21.808	34.453	100
40	33.293	6.109	8.125	21.564	30.910	100
60	35.553	7.208	9.102	21.197	26.940	100
90	37.752	8.552	9.896	20.098	23.702	100
150	41.662	10.324	11.973	16.799	19.243	100
200	44.716	11.484	12.401	14.111	17.288	100
300	48.015	12.523	12.156	11.729	15.577	100
500	52.046	13.195	11.179	10.568	13.012	100
1000	59.927	11.973	9.957	8.308	9.835	100
2000	64.692	12.034	9.469	6.781	7.025	100
5000	6.903	11.973	8.613	5.376	5.009	100
8000	72.266	11.301	7.453	4.704	4.276	100
10000	75.260	9.835	7.330	3.604	3.971	100
15000	76.237	9.224	7.025	3.604	3.910	100
Total	49.843	9.484	8.892	13.245	18.536	100

Table 5-1. Statistics of WTP Responses with Normal Demand: Frequency

	Definitely not	Probably not	Not sure	Probably yes	Definitely yes	Total
0	0	0	0	249	589	838
10	41	11	14	320	452	838
20	71	15	29	297	426	838
40	92	27	56	291	372	838
60	120	49	76	278	315	838
90	153	70	89	262	264	838
150	205	100	127	213	193	838
200	251	121	133	170	163	838
300	297	142	128	135	136	838
500	358	158	110	113	99	838
1000	477	145	84	71	61	838
2000	553	145	71	43	26	838
5000	621	145	46	19	7	838
8000	672	136	19	9	2	838
10000	720	113	4	1	0	838
15000	735	103	0	0	0	838
Total	5366	1480	986	2471	3105	13408

Table 5-2. Statistics of WTP Responses with Normal Demand: Percentage

	Definitely not	Probably not	Not sure	Probably yes	Definitely yes	Total
0	0.000	0.000	0.000	29.714	70.286	100
10	4.893	1.313	1.671	38.186	53.938	100
20	8.473	1.790	3.461	35.442	50.835	100
40	10.979	3.222	6.683	34.726	44.391	100
60	14.320	5.847	9.069	33.174	37.589	100
90	18.258	8.353	10.621	31.265	31.504	100
150	24.463	11.933	15.155	25.418	23.031	100
200	29.952	14.439	15.871	20.286	19.451	100
300	35.442	16.945	15.274	16.110	16.229	100
500	42.721	18.854	13.126	13.484	11.814	100
1000	56.921	17.303	10.024	8.473	7.279	100
2000	65.990	17.303	8.473	5.131	3.103	100
5000	74.105	17.303	5.489	2.267	0.835	100
8000	80.191	16.229	2.267	1.074	0.239	100
10000	85.919	13.484	0.477	0.119	0.000	100
15000	87.709	12.291	0.000	0.000	0.000	100
Total	40.021	11.038	7.354	18.429	23.158	100

Table 6-1. Distribution of the Estimated WTP with Normal Demand

Variable	Obs	Percentile	Centile	[95% Conf.	Interval]
Wtp	835	0	0.269	0.269	0.269
		10	11.326	6.776	15.400
		20	39.322	31.794	46.897
		30	69.673	60.000	84.881
		40	120.869	97.512	130.716
Mean :	758.8494	50	171.544	150.103	200.253
Stand. Err.	1586.139	60	255.959	221.416	312.481
		70	468.126	398.388	549.162
		80	879.748	746.574	1147.648
		90	2108.107	1793.560	2488.585
		100	11872.180	11872.180	11872.18

Table 6-2. Average Value of Risk Reduction by Sex

Variable	Sex	Obs	Mean	Std. Dev.	Min	Max
Morbidity	Male	576	856,576.3	2168075	131.2368	2.20e+07
	Female	249	954,089.4	1865910	438.253	1.42e+07
Mortality	Male	576	1,725,847	4212262	203.2255	3.45e+07
	Female	249	2,519,660	4948185	753.1705	3.70e+07

Table 6-3. Average Value of Risk Reduction by Age

Variable	Sex	age	Obs	Mean	Std. Dev.	Min	Max
Morbidity	Male	15-44	415	1,131,665	2495159	517.131	2.20e+07
		45-54	116	179,377	325070.7	217.702	2287034
		55-64	36	71,487	102289	131.2368	388329.4
		65-74	8	45,707	60048.31	216.3856	147747.7
		75+	1	180	.	180.0348	180.0348
	Female	15-44	213	1,062,087	1984652	1633.342	1.42e+07
		45-54	30	326,019	609848.5	438.253	2803215
		55-64	5	278,312	319122.8	37641.95	662462.8
		65-74	1	171,591	.	171591.3	171591.3
		75+	0	.	.	.	.
Mortality	Male	15-44	415	2,302,021	4831718	825.3475	3.45e+07
		45-54	116	298,932	605489.8	414.5512	4355004
		55-64	36	99,493	146848.8	203.2255	601343.5
		65-74	8	61,381	78463.8	336.9885	194385.4
		75+	1	247	.	247.2682	247.2682
	Female	15-44	213	2,854,431	5264090	4593.689	3.70e+07
		45-54	30	545,312	1031117	753.1705	4817534
		55-64	5	531,069	620468	59732	1260051
		65-74	1	386,661	.	386661.3	386661.3
		75+	0	.	.	.	.

Table 7. Determinants of WTP with Normal Demand (Robust Regression on Log (Mean WTP)

Variables	Coefficients		
worker	-0.094		
	(0.66)		
married	-0.011		
	(0.06)		
smoking	-0.190		
	(1.26)		
Log(income)	0.418		
	(3.99)***		
education	0.621		
	(2.26)**		
Rcancer	0.355		
	(1.42)		
Yuncertain	-0.385		
	(1.71)*		
Healthcheck	0.292		
	(2.02)**		
religion	0.023		
	(0.10)		
trust	0.339		
	(2.38)**		
need	0.187		
	(2.05)**		
Region-, age- and sex-specific dummies	**Guizhou**		
	Tianjin		**Jiangsu**
age15_44_male	-0.007	**Reference**	0.886
	(0.03)	**--**	(3.98)**
age45_55_male	0.464	-0.087	0.686
	(1.71)	(0.18)	(2.39)**
age55_65_male	-0.294	0.123	0.045
	(0.54)	(0.14)	(0.07)
age65plus_male	-1.774	No Obs.	1.830
	(2.10)**	--	(2.06)**
age15_44_female	-0.205	0.119	0.158
	(0.77)	(0.47)	(0.42)
age45_55_female	0.085	No Obs.	0.264
	(0.17)	--	(0.32)
age55plus_female	1.578	2.296	-0.666
	(2.64)***	(3.10)***	(2.23)**
Constant	-0.688		
	(0.69)		
Observations	816		
R-squared	0.12		

Robust t statistics in parentheses, * significant at 10%, ** significant at 5%; *** significant at 1%

Table 8. Average Value of Risk Reduction Based on Projected WTP

	Normal demand	Extremely high demand	Normal+high demand	Whole sample
Mean WTP Projected (Yuan)	439.4	546.0	460.2	411.7
Mean cancer morbidity (1/10000)	15.5	14.3	15.3	15.7
Mean cancer mortality (1/10000)	9.3	8.2	9.1	9.5
Average Value of morbidity (Yuan)	283,273	382,548	301,424	261,446
Average value of mortality (Yuan)	471,442	664,767	505,530	431,596

Table 9-1: WTP Function of Cancer Morbidity Risk Reduction

Model (Dependent Variable)	Model 1 (WTP)	Model 2 (WTP)	Model 3 (WTP)	Model 4 (WTP)	Model 5 (WTP)	Model 6 Log(WTP)
Risk Reduction	1.705	19.808	13.939	74.795	5.990	0.023
	(0.18)	(0.90)	(1.18)	(2.21)**	(0.99)	(3.17)***
Risk Reduction^2		-0.328		-0.782	-0.065	-0.0002
		(1.06)		(2.00)**	(1.47)	(3.18)***
risk_worker	1.319	-5.571	-0.186	-6.850		
	(0.23)	(0.53)	(0.03)	(0.43)		
risk_smoking	-3.868	-11.533	-4.281	-15.086		
	(0.69)	(1.31)	(0.69)	(1.10)		
risk_fincome	-0.000	-0.001	-0.000	-0.001		
	(1.12)	(2.34)**	(0.60)	(1.02)		
risk_education	12.669	14.230	-4.153	-36.287		
	(2.11)**	(0.79)	(0.61)	(1.50)		
risk_Rcancer	8.794	19.533	-10.375	-28.900		
	(0.97)	(1.05)	(0.90)	(0.91)		
risk_uncertainty	-3.638	-8.494	4.346	18.219		
	(0.39)	(0.60)	(0.42)	(0.72)		
risk_health check	-9.162	-7.938	-4.964	2.853		
	(1.80)*	(0.86)	(0.91)	(0.20)		
risk_religion	21.435	17.468	20.942	24.437		
	(1.54)°	(0.70)	(1.26)	(0.63)		
risk_trust	7.553	20.635	-2.006	-6.548		
	(1.85)*	(2.52)**	(0.42)	(0.48)		
risk2_worker		-0.061		0.031		
		(0.36)		(0.16)		
risk2_smoking		0.057		0.096		
		(0.52)		(0.71)		
risk2_fincome		0.000		0.000		
		(2.41)**		(1.00)		
risk2_education		-0.185		0.336		
		(0.83)		(1.32)		
risk2_Rcancer		-0.230		0.358		
		(1.09)		(1.21)		
risk2_uncertainty		0.221		-0.250		
		(1.05)		(0.82)		
risk2_health check		0.088		-0.078		
		(0.65)		(0.45)		

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
risk2_religion			0.104		0.140	
			(0.46)		(0.47)	
risk2_trust			-0.147		0.103	
			(1.66)*		(0.78)	
Worker			-227.556	-160.414	-230.357	-0.049
			(1.65)*	(0.91)	(2.07)**	(0.35)
Smoking			178.560	254.001	80.636	-0.046
			(1.20)	(1.35)	(0.69)	(0.32)
Fincome			0.008	0.012	0.005	0.304
			(1.06)	(1.25)	(0.85)	(2.91)***
Education			312.897	761.388	149.948	0.652
			(1.36)	(2.94)***	(0.70)	(2.37)**
Rcancer			679.293	781.307	498.976	0.565
			(1.95)*	(1.68)*	(1.87)*	(2.30)**
Uncertainty			-198.846	-268.940	-156.097	-0.444
			(1.27)	(1.20)	(1.27)	(1.98)**
Health check			-1.315	-70.683	-70.971	0.234
			(0.01)	(0.40)	(0.65)	(1.68)*
Religion			-263.355	-334.927	62.958	0.071
			(1.14)	(0.92)	(0.28)	(0.28)
Trust			430.417	454.759	401.105	0.414
			(2.77)***	(2.24)**	(3.37)***	(2.93)***
Constant			-518.225	-1,144.424	-252.289	0.504
			(1.28)	(2.32)**	(0.85)	(0.51)
Observations	833	833	833	833	833	833
Log-likelihood	-7363.41	-7340.67	-7300.07	-7296.83	-7304.22	-1745.13
R-squared	-0.12	-0.07	0.03	0.02	0.03	0.05
Typical person's WTP-risk coefficient						
Constant	0	0	747.02	678.45	706.77	4.853
Level term	22.67	51.31	1.677	10.192	5.990	0.023
Squared term	0	-0.506	0	-0.106	-0.065	-0.0002
Marginal WTP (Yuan)	226,700	353,138	16,770	68,410	39,351	29,208
Average WTP (Yuan)	226,700	433,119	489,371	514,386	496,763	110,801

Robust t statistics in parentheses. ° significant at 15%, * significant at 10%, ** significant at 5%; *** significant at 1%.

Table 9-2: WTP Function of Cancer Mortality Risk Reduction

Model (Dependent Variable)	Model 1 (WTP)	Model 2 (WTP)	Model 3 (WTP)	Model 4 (WTP)	Model 5 (WTP)	Model 6 Log(WTP)
Risk Reduction	0.777	-0.886	7.579	32.562	2.481	0.020
	(0.07)	(0.03)	(0.59)	(0.92)	(0.33)	(1.84)*
Risk Reduction^2		-0.247		-0.321	-0.088	-0.0003
		(1.86)*		(0.59)	(1.08)	(2.02)**
risk_worker	4.511	-3.758	3.014	-0.776		
	(0.62)	(0.19)	(0.45)	(0.03)		
risk_smoking	-4.592	-13.559	-9.048	-21.485		
	(0.69)	(0.90)	(1.43)	(1.15)		
risk_fincome	-0.000	-0.002	-0.000	-0.001		
	(1.59)	(2.45)**	(0.99)	(0.84)		
risk_education	16.603	46.923	-5.069	-23.982		
	(2.06)**	(1.77)*	(0.62)	(0.76)		
risk_Rcancer	11.219	49.315	-10.449	-1.980		
	(0.95)	(1.45)	(0.92)	(0.05)		
risk_uncertainty	-6.441	-21.249	9.326	42.298		
	(0.56)	(0.63)	(0.95)	(0.93)		

risk_health check	-11.627	-28.990	-2.674	-10.501		
	(1.85)*	(2.03)**	(0.45)	(0.58)		
risk_religion	28.130	66.962	26.888	87.209		
	(1.53)	(1.34)	(1.54)	(1.43)		
risk_trust	10.119	36.900	0.313	6.796		
	(2.02)**	(2.90)***	(0.06)	(0.41)		
risk2_worker		-0.126		0.014		
		(0.31)		(0.03)		
risk2_smoking		0.061		0.155		
		(0.21)		(0.52)		
risk2_fincome		0.000		0.000		
		(2.63)***		(0.43)		
risk2_education		-1.163		0.084		
		(2.51)**		(0.17)		
risk2_Rcancer		-1.084		-0.079		
		(1.96)*		(0.12)		
risk2_uncertainty		0.807		-0.503		
		(1.23)		(0.62)		
risk2_health check		0.650		0.151		
		(2.18)**		(0.47)		
risk2_religion		-0.799		-0.858		
		(1.25)		(1.18)		
risk2_trust		-0.346		-0.045		
		(0.44)		(0.22)		
Worker			-271.764	-250.159	-241.520	-0.066
			(2.07)**	(1.56)	(2.15)**	(0.47)
Smoking			205.419	257.786	101.575	0.009
			(1.50)	(1.57)	(0.89)	(0.06)
Fincome			0.010	0.013	0.005	0.311
			(1.31)	(1.48)	(0.93)	(2.98)***
Education			224.738	482.622	98.078	0.585
			(0.91)	(2.37)**	(0.45)	(2.07)**
Rcancer			595.629	531.328	507.543	0.582
			(1.90)*	(1.43)	(1.91)*	(2.39)**
Uncertainty			-224.828	-340.606	-158.991	-0.452
			(1.69)*	(1.85)*	(1.29)	(2.01)**
Health check			-33.921	9.362	-67.210	0.229
			(0.26)	(0.06)	(0.62)	(1.64)*
Religion			-177.525	-431.596	54.066	0.061
			(0.91)	(1.70)*	(0.24)	(0.24)
Trust			401.842	368.080	403.771	0.425
			(2.82)***	(2.19)**	(3.40)***	(2.99)***
Constant			-330.964	-599.908	-164.013	0.602
			(0.87)	(1.51)	(0.53)	(0.61)
Observations	833	833	833	833	833	833
Log-likelihood	-7378.16	-7350.87	-7099.72	-7295.66	-7304.20	-1748.22
R-squared	-0.14	-0.08	0.05	0.06	0.04	0.06
Typical person's WTP-risk coefficient						
Constant	0	0	785.886	738.3830	762.3307	4.9817
Level term	28.2843	81.0879	-0.9486	11.8542	2.4805	0.0199
Squared term	0	-1.2815	0	-0.2464	-0.0882	-0.0003
Marginal WTP (Yuan)	282,843	810,879	-9,486	72,616	8,366	25,787
Average WTP (Yuan)	282,843	572,023	833,824	794,692	834,589	183,385

Robust t statistics in parentheses. ° significant at 15%, * significant at 10%, ** significant at 5%; *** significant at 1%.
R=9,3194, WTP=180,2293,

Table 10. Simulation of Marginal and Average WTPs of Risk Reduction

Risk Reduction (1/10000)	WTP Model (Model 4)		Log WTP Model (Model 6)	
	Marginal Value (Yuan)	Average Value (Yuan)	Marginal Value (Yuan)	Agerage Value (Yuan)
0	59,900	+∞	29,469	+∞
0.1	59,770	70,736,835	29,485	12,841,895
0.5	59,250	14,194,975	29,549	2,591,993
1	58,600	7,126,950	29,624	1,310,790
5	53,400	1,470,190	30,035	286,044
7.5	50,150	997,385	30,109	200,724
10	46,900	760,170	30,032	158,064
15	40,400	521,330	29,401	115,300
20	33,900	400,285	28,103	93,677
40	7,900	210,592	16,342	58,364

Table A.1 Cancer incidence rate
(per 10,000 a year, average of 1993-1997)

Age ranges	National average		Jiangsu		Tianjin	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
TOTAL	24.78	19.38	25.69	13.54	24.52	20.49
0_4	1.28	0.90	0.62	0.20	1.41	1.18
5_9	0.97	0.78	0.88	0.56	1.01	1.14
10_14	1.06	0.79	0.76	0.53	1.29	0.63
15_19	1.11	0.84	0.77	0.55	1.34	0.76
20_24	1.33	1.59	1.15	0.83	1.29	1.88
25_29	2.03	2.47	2.92	1.55	1.62	2.80
30_34	3.67	4.68	8.23	3.98	2.84	4.81
35_39	7.11	8.65	18.64	7.96	5.03	7.19
40_44	12.93	13.14	31.65	16.42	11.09	11.03
45_49	19.57	19.10	45.55	22.13	19.92	17.71
50_54	28.94	24.62	43.69	23.39	31.68	26.58
55_59	40.84	34.88	59.83	27.73	40.44	44.30
60_64	75.68	53.77	93.69	39.65	76.38	64.52
65_69	112.53	69.40	114.45	48.66	123.23	80.11
70_74	151.01	89.10	134.68	55.79	178.94	98.49
75_79	164.10	97.63	149.87	72.04	183.12	107.65
80_84	153.46	92.79	102.43	40.19	182.95	99.55
85	106.89	79.35	--	--	130.89	78.41

1. Data Source : Data for Tianjin and Jiangsu come from Parkin, D.M., S.L. Whelan, J. Ferlay and H. Storm (2005). Cancer Incidence in Five Continents, Volumes I to VIII. International Agency for Research on Cancer and the World Health Organisation. IARC CancerBase No 7, Lyon, 2005. Website : http://www-dep.iarc.fr/
2. Data for national average are calculated by authors according to the IRAC database.

Table A.2 National average cancer mortality rate[1] (per 10,000 persons)

Age rage	1991		1995[2]		2000	
	male	**female**	**male**	**female**	**male**	**female**
15-44	3.12	2.00	3.26	2.00	3.29	2.13
45-54	22.32	12.62	23.49	13.19	24.3	14.14
55-64	56.23	28.33	48.97	25.41	47.7	26.30
65-74	104.27	53.10	93.18	38.10	104.89	51.58
75+	128.24	67.84	126.99	67.29	135.39	67.39

1. the data for 1991 and 2000 come from Yang, L., DM Parkin, LD, Li, YD, Chen and F. Bray (2004): Estimation and projection of the national profile of cancer mortality in China: 1991-2005. British Journal of Cancer (2004) 90, 2157-2166.
2. The data for year 1995 is projected by authors. We suppose a linear growth for both the cancer incidence and population between 1991 and 2000.
3. This data also used in mortality rate estimation reported in table 7.

Table A.3 Province-specific cancer incidence rate used in estimation
(per 10000 persons)

Age ranges	National average		Jiangsu		Tianjin	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
15_44	5.20	6.09	10.484	4.995	4.205	5.210
45_55	23.55	21.39	44.730	22.668	24.800	21.446
55_65	58.13	44.45	75.832	33.466	58.331	54.173
65_75	128.46	77.78	122.593	51.193	145.114	85.854
75+	151.92	93.35	116.020	51.852	174.414	97.546

1. calculated directly by authors from the IRAC database f with a less precise age-classification.

Table A-4 Ranges of VSL estimates by countries, 2006 USD

	No. of studies	Health	Occupation safety	Transport	Environment	Other	Total	Mean	Median
Australia	17	0.9-2.2	2.2-21.1	1.3-5.4	0.7-5.3	1.1-13.1	**0.7-21.1**	**4.2**	**2.2**
Austria	5	---	1.9-9.8	---	---	4.0-9.8	**1.9-9.8**	**6.7**	**6.1**
Canada	17	2.0-6.7	0.6-5.8	0.5-30.5	---	2.7-10.8	**0.5-30.5**	**5.4**	**3.7**
Demark	2	---	---	1.0-1.4	---	4.9-6.5	**1.0-6.5**	**3.2**	**3.2**
Europe	1	---	---	4	---	---	**4**	**4.0**	**4.0**
France	2	---	---	1.1-26.6	---	3.8-5.4	**1.1-26.6**	**8.8**	**8.8**
Hong Kong	1	---	2	---	---	---	**2**	**2.0**	**2.0**
Japan	4	---	11.4-15	---	---	6.1-9.1	**6.1-15.0**	**11.9**	**13.2**
New Zealand	10	---	---	0.8-15.9	---	2.1-3.1	**0.8-15.9**	**5.2**	**3.9**
South Korea	6	---	1.0-1.9	---	---	0.5-1.0	**0.5-1.9**	**1.2**	**1.1**
Sweden	7	---	---	1.6-32.7	---	1.6-5.0	**1.6-32.7**	**5.9**	**4.2**
Switzerland	5	---	7.4-10.1	1.0-1.3	---	5.4-9.6	**1.0-10.1**	**5.0**	**5.7**
Taiwan	7	---	0.2-2.2	---	---	1.0-1.4	**0.2-2.2**	**1.3**	**1.3**
UK	26	---	1.6-8.7	0.7-25.2	23.3	1.0-30.7	**0.8-86.8**	**13.0**	**6.5**
US	117	0.2-8.7	0.4-24.4	0.15-37.7	0.8-10.1	0.7-31.4	**0.1-37.7**	**6.7**	**5.3**
Multiple	17	---	0.4-22.3	0.15-37.7	0.07-98.7	0.5-62.9	**0.1-98.7**	**9.9**	**5.6**
All	**244**	**0.2-6.5**	**0.2-86.8**	**0.15-37.7**	**0.07-98.7**	**0.5-62.9**	**0.1-98.7**	**7.0**	**4.9**
Mean	**---**	**3**	**8.2**	**5.9**	**8.3**	**6.3**	**7**	**---**	**---**
Median	**---**	**2.7**	**5.5**	**4**	**6**	**4.5**	**4.9**	**---**	**---**

Source: Australian Safety and Compensation Council (2008). The initial table is in Australian Dollar (2006 price). The authors have converted the VSL value into 2006 US dollar, with the corresponding historical exchange rate 1 Australian dollar=0.742302 US dollar.