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Age, Health, and the Willingness to Pay for Mortality Risk Reductions

A Contingent Valuation Survey in Japan

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Abstract

A contingent valuation survey was conducted in Sizuoka, Japan, to estimate the willingness to pay (WTP) for reductions in the risk of dying and calculate the value of statistical life (VSL) for use in environmental policy in Japan. Special attention was devoted to the effects of age and health characteristics on WTP. We find that the VSLs are somewhat lower (103 to 344 million yen) than those found in the virtually identical survey applied in some developed countries. These values were subject to a variety of validity tests, which they generally passed. We find that the WTP for those over age 70 is lower than that for younger adults, but that this effect is eliminated in multiple regression. Rather, when accounting for other covariates, we find that WTP generally increases with age throughout the ages in our sample (age 40 and over). The effect of health status on WTP is mixed, with WTP of those with cancer being lower than that of healthy respondents while the WTP of those with heart disease is greater. The VSLs for future risk changes are lower than those for contemporaneous risk reductions. The implicit discount rates of 5.8–8.0% are relatively larger than the discount rate regularly used in environment policy analyses. This first-of-its-kind survey in Japan provides information directly useful for estimating the benefits of environmental and other policies that lower mortality risks to the general population and sub-groups with a variety of specific traits.

Key Words: willingness to pay, value of statistical life, mortality risk, contingent valuation, age

Contents

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I. Introduction

In many cost-benefit studies (USEPA, 1999), the bulk of the monetary benefits of environmental policies for the purpose of improving human health accrue to mortality reductions. Yet, these calculations are highly controversial, particularly the value assigned to a statistical life (VSL). These VSLs are mostly taken from the labor market literature and are often based on U.S. or European studies. They may be inappropriate for quantifying the benefits of environmental programs because they are not based on the WTP of elderly and/or ill persons, even though older and ill people are among the most likely groups to benefit from the reductions in pollution. They also do not address the WTP for future risk reductions, even though this is a feature of pollution control for carcinogens and perhaps conventional air pollutants.

Few countries have mounted any VSL studies, let alone ones that capture latency and the WTP of elderly or ill people. Therefore, it has become common practice to transfer such values, albeit with adjustments for income differentials across countries, from countries where such values have been estimated to those for which they have not. This practice has come under scrutiny because of concern that cultural and other differences will render such transfers meaningless. Some empirical studies have reinforced this notion (Krupnick and Alberini, 2000).

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There is particular concern about benefits transfer in Japan because of higher life expectancies there and a different cultural outlook with respect to old age.

Therefore, to inform cost-benefit analyses in Japan, research was undertaken to estimate the willingness to pay (WTP) of Japanese people for mortality risk reductions, including a focus on the elderly and ill and on both contemporaneous and latent effects. We conducted a contingent valuation survey in Sizuoka, Japan, in March 1999. This survey was based on a survey conducted in Hamilton, Ontario and throughout the United States as reported in Krupnick et al (2002) and Alberini et al. (2004a). A future paper will report on comparisons with those studies. This paper is limited to reporting on the Japanese results, following a format similar to that of the papers noted above.

This is not the first such study in Japan, however. In the survey by Yamamoto and Oka (1994) respondents were asked to value risk changes for drinking water. However, these risks were extremely small, leading to very large VSLs. Moreover, they presented an inappropriate scenario that death risk in drinking water will be eliminated.

The remainder of the paper is organized as follows. In Section 2, we discuss the necessity of a new contingent valuation study, detailing the nature of mortality risk reduction from environmental programs and the limitations of current estimates of VSL. We describe the survey design in Section 3 and its administration in Section 4. Section 5 describes the characteristics of our samples. Section 6 presents our results, including estimates of WTP for current risk reduction and future risk reduction, and Section 7 offers concluding remarks.

2. The Need for a New Contingent Valuation Study

2.1 The Nature of Mortality Risk Reductions from Environmental Programs

Epidemiological studies directly or indirectly indicate that benefits from environmental programs accrue mainly to elderly persons. In terms of human mortality effects, particulate matter (air pollutants) and carcinogens are considered some of the most significant substances to be regulated by environmental programs.

Particulate matter. In a rigorous study, Pope et al. (1995) and subsequent re-analyses (Krewski et al., 2000) evaluated the benefits from reducing atmospheric concentrations of particulate matter (PM10 and PM2.5) and showed that the majority of statistical lives saved were for persons over 65 years old. These studies make the common assumption that the effect of a change in pollution concentrations is proportional to baseline mortality rates. Because death rates are higher for older persons, this implies that the benefits of reducing exposure to air pollution accrue primarily to older people (Figure1).

Carcinogens. The toxicological studies that are used to quantify cancer risks provide only an estimate of lifetime cancer risk, rather than age-specific risk estimates. However, it is reasonable to assume that the age distribution of deaths from environmentally induced cancers follows the same pattern as cancer mortality rates from all causes. This implies that the mortality risk reduction benefits from reducing exposure to carcinogens are also concentrated among older people.

2.2 Limitations of Current Approaches to Valuing Mortality Risk Reduction

There are two ways to obtain empirical estimates of individuals' willingness to pay for mortality risk reductions: revealed preference studies and stated preference studies. Revealed preference studies mainly include compensating wage studies and consumer behavior studies (such as in the purchase of bicycle helmets and safer vehicles), and stated preferences studies consist mainly of contingent valuation studies. Each approach to measuring WTP has its advantages and drawbacks (Freeman and Myrick, 2003).

One significant advantage of revealed preference studies is that they are based on behavior, not hypothetical questions. A major problem for labor market studies is that the data reflect the wage risk premium of healthy, prime-aged adults. Moreover, people in the labor market usually do not know the increased risks they incur by taking a particular job. This problem is shared by consumer behavior studies, in which risk reductions from the use of safer products are unknown to the consumer. In addition, it is often difficult to separate objective risk measures from other attributes of the job or product examined.

Contingent valuation studies, in principle, can test whether individuals of all ages correctly perceive changes in mortality risks. Subjects are asked to value a commodity—a risk reduction—but the valuation questions must be posed in a manner that is meaningful to the respondents, and the respondents must be given adequate time to consider the choices. One measure of the success of a contingent valuation survey is if an external scope test is passed—when different groups of respondents are asked to value risk changes of different magnitudes, WTP should be statistically larger for the group reacting to the larger risk change. As a recent literature review by Hammitt and Graham (1999) demonstrates, however, few contingent valuation studies of mortality risks are designed for such a test and in those which are, most fail (e.g., Jones-Lee et al., 1985; Smith and Desvousges, 1987).

3. Survey Design

3.1 Development of the Survey Instrument

To estimate WTP for reductions in mortality risks that can be used to evaluate the benefits of many types of environmental programs, a survey must meet two requirements. First, it should ask older persons to value an immediate reduction in their risk of dying, as well as ask younger persons to value a *future* reduction in their risk of dying. Second, it should resolve the problems—in particular, insensitivity to scope—that have been encountered in previous surveys.

Although the survey instrument was modeled after that reported on in Krupnick et al. (2002), initial development of that instrument was aided by research in Japan, through pre-tests and a pilot survey conducted in 1998 in Tokyo. Subsequently, an initial survey was administered in Japan.

The survey instrument differs from others in the literature in several important respects. First, the target population is persons 40 to 75 years old, because it is only in middle age that risks of death from cardiovascular disease, respiratory illness, and cancer become significant in industrialized countries. Second, we ask people to pay for a product that will reduce their risk of dying, over a 10-year interval, by 5 in 1,000 and by 1 in 1,000. These risk changes correspond to annual risk changes of 5 in 10,000 and 1 in 10,000, respectively, which are in the range estimated to occur from reductions in air pollution. The use of 10-year intervals allows us to represent risks in terms of chances per 1,000, which can be displayed more easily in graphs and can be understood more easily than risks per 10,000.

Finally, the method of delivering risk reductions in our survey is a private good in an abstract scenario. This approach differs from that recommended by a National Oceanic and Atmospheric Administration panel (Arrow et al. 1993) for estimating nonuse values for ecological improvements, which counseled valuing the environment as a public good and using concrete scenarios. Capturing individual valuation is appropriate in a health context because individuals are used to making decisions about their health for themselves. Furthermore, to appropriately value health in a community context requires distinguishing between non-paternalistic and paternalistic altruism, because only the WTP of people holding the latter type of altruism should be counted (Harbaugh 1999; Jones-Lee 1992). We found the use of concrete scenarios to be problematic because some individuals viewed the scenario as not applicable to themselves and thus did not take the survey seriously. In short, our approach has the advantage of estimating a "pure" individual WTP for mortality risk reduction that can then be transferred to specific contexts associated with environmental policy in Japan. The challenge with this approach is to be sure that respondents understand and be comfortable with such an abstract commodity in the survey.

3.2 The Questionnaire

The questionnaire begins with some demographic questions and asks respondents about the health status and chronic disease history of themselves and their family. The second section introduces the concept of probability—the probability of dying or surviving—and poses simple practice questions to familiarize respondents with the idea. The main intent of this section is to clearly communicate probabilities and test their comprehension by respondents. We describe two cities, City A and City B. The cities are identical in every way except that in one city, 10 persons in every 1,000 of the respondent's age and gender will die over the next 10 years, whereas in the other, only 5 persons in every 1,000 of the respondent's age and gender will die. Then we show the subject a graph of the risks for one of the cities—with the risks represented using colored grid squares to convey probability—and ask him to identify which city it is. Finally, we ask, "If you had to move to one of the two cities, which city would you prefer, or are you indifferent between them?"

The third section presents respondents with age- and gender-specific leading causes of death and introduces common risk-mitigating behaviors, illustrative risk reductions, and qualitative costs. As noted above, one difficulty in asking people to value quantitative risk reductions is that even though people often engage in risk-reducing behaviors (e.g., they undergo cancer screening tests or take medication to reduce their blood pressure or cholesterol levels), they do not know how much these actions reduce their risk of dying. We present the effectiveness of common risk-reducing behaviors based on the statistics available and the extent of cost for those behaviors with abstract expressions such as very expensive, expensive and inexpensive

The fourth section communicates baseline risks for someone of the respondent's age and gender and asks her to accept this risk as their own for the purpose of the survey (the acceptance of the baseline risk is tested in debriefing questions). The fifth section elicits information about WTP for risk reductions of a given magnitude, occurring at a specified time, using dichotomous choice methods. As shown in table 1, in one randomly chosen subsample (Wave 1), respondents are first asked whether they would be willing to pay for a product or action that, when used and paid for over the next 10 years, will reduce baseline risk by 5 in 1,000 over the 10-year period. In the second WTP question, risks are reduced by only 1 in 1,000. In another subsample (Wave 2), respondents are given the 1-per-1,000 risk change question first.

This design permits both internal and external scope tests of the data. These tests involve comparing the WTP answers across the various questions, either within sample (the internal scope test) or between sample (the external scope test). The latter is by far the more important test and involves testing for a significant difference in WTP between the 5/1000 WTP from Wave 1 and the 1/1000 WTP from Wave 2.

The final series of dichotomous choice questions in both waves focuses on future risk reductions. The WTP questions are preceded by a question concerning the respondent's perceived chance of surviving to age 70. This question encourages the respondent to think about their future. A variety of surveys have shown that individuals are reasonably good at estimating future survival probabilities (Hamermesh, 1985; Hurd and McGarry, 1996) and are able to value risk changes occurring in the future (Johannesson and Johansson, 1996). The respondent is then told his gender-specific chance of dying between ages 70 and 80 and is asked, through dichotomous choice questions, his WTP each year over the next 10 years for a future risk reduction, beginning at age 70 and ending at age 80, that totals 5 in 1,000.

An extensive series of debriefing questions follows. These questions are meant to test for understanding of concepts in the survey, acceptance of various elements of the scenario and baseline, and other factors that could affect the credibility of the survey.

The debriefing questions are followed by a 36-question quality-of-life survey (Standard Form 36, or SF-36), which is used routinely in the medical community to gauge physical function and mental and emotional health states. The 36 health questions supplement those posed at the beginning of the interview and may be used to construct eight indexes of physical and mental health commonly used in the public health literature.

3.3 Payment Options

Table 2 presents the payment options presented to respondents. Within each wave, respondents were further randomly assigned to one of five groups. Each group was given a different set of bids. These bids were determined in line with the pilot survey conducted in Tokyo in 1998.

4. Administration of the Survey

We conducted the survey in the city of Shizuoka, Japan, in March 1999. The survey was administered on computer and used audio and visual aids to communicate both baseline risk of death and risk changes. In cultural and commercial respects Shizuoka is best described as "average" for Japan, considering its demographic and economic structure. Because of these characteristics, market researchers tend to choose Shizuoka as a region for their test marketing. It is located in the geographic center of the country and has a population of about 500,000 as of 2000.

As in the study in Canada and the U.S., about one-third of the respondents were aged 60 to 75, the remainder being 40 to 59, with equal numbers of men and women. The sample was chosen at random from the resident list of Shizuoka, with permission of the local government. The researchers then personally visited the selected people and asked them to participate in the survey. If they agreed, the respondents were asked questions shown to them on the researchers' laptop computers. The participants were offered a merchandise coupon valued at two thousands yen.

A total of 1,296 persons were initially contacted and invited to take the survey; 677 participated (an acceptance rate of 52.2%).

5. Sample Characteristics and Responses

5.1 Characteristics

Table 3 provides the descriptive statistics for the entire sample as well as for each wave. Respondents in the two waves were very similar: average age, 56; sex, roughly half male, half female; average schooling, 12 years; and mean household income, 6,400,000 yen (US$41,000). The percentage of female and the average of income of the sample are very close to those of the national average.

5.2 Health

The health status of the respondents is presented in Table 4. On average, only about one-fourth of the respondents reported any chronic disease (defined as asthma, bronchitis, emphysema or chronic cough, cancer, high blood pressure, or heart disease), even though the respondents were 40 or older. Statistics in Japan (Ministry of Health Labor and Welfare of Japan, 2000) revealed that those who recognize their illness are much fewer than those who are defined to be medically ill in terms of adult chronic disease—particularly for high blood pressure. About 52% of males at age 50–59 are medically classified as having high blood pressure but only 17% of this group in our survey say they have high blood pressure. This disparity may be explained by the definition of "medically classified," which may indicate a blood pressure threshold for being rated as having "high blood pressure" below that where symptoms are apparent. In this case, those who say they have high blood pressure may be the most severe cases. At the same time, only about 35% of the respondents rated their own health as excellent or very good compared with others of their age. This statistic can be compared to over 50% of respondents in the United States and Canada who feel this way. This low percentage for our sample may be attributable to a tendency in Japanese society to refrain from flaunting one's health status. On average, respondents reported believing that they expected to live 29 more years, which *is* consistent with Japanese health statistics.

About 72% of the respondents had supplemental health insurance coverage. Also, the physical functioning and mental health index scores from the SF-36 questions were 91 and 81, respectively. These compare quite favorably to the United States and Canada, where physical functioning scores were 78 and 81 respectively, and the mental health indexes were 77 and 76, respectively. These high scores also are evidence that people are reluctant to flaunt their good health status when asked directly about it.

5.3 Acceptance of the Product and Scenario

Respondents' acceptance of the risk reducing product and the scenario is presented in Table 5. More than 40% of respondents did not believe the baseline mortality risk presented to them. About two-thirds of those respondents thought their own death risks were lower than those presented in the survey. Roughly 40% of respondents had doubts about the effectiveness of the product. About 30% of the respondents thought about side effects and half of the respondents considered additional benefits (although only a small percentage say it influenced their vote). As for the payments, approximately 30% of the respondents did not consider whether they could afford payments and some respondents did not understand they would need to make the payment once a year for the next ten years. Some of these percentages exceed those of the U.S. and Canada samples. For instance, only from 20–25% of those groups didn't believe the risks applied to them. And almost double the percentage in the Japan study believed their risks were *higher* than what was given to them compared to the samples in the other countries. The other differences were less pronounced. Because of the large numbers of people questioning various aspects of the survey, we took special steps to address these issues (see below).

5.4 Understanding of Probabilities and the Choice Task

In table 6, the Japanese mathematical training shows itself in the answers to our probability test, where less than 6% got the simple probability question wrong the first time, compared to around 12% in the U.S. and Canada. On retest, the Japanese were under 1%, which the U.S. and Canada samples were between 1–2%. Also, Table 6 also provides information on questionable WTP responses. For instance, in an open-ended WTP question, at most 6 people gave an open-ended response inconsistent with that of their closed-ended response.

Given the information in table 6, we "cleaned" the sample through the following procedure. Individuals who chose the incorrect answer in both the first probability test and the second probability test (for confirmation) were dropped. Individuals who showed a preference for the higher risk of death in a test—that is, they preferred to live in the city with a higher mortality risk—were dropped if this preference was confirmed in the follow-up test. Individuals who answered the open-ended follow-up WTP question with an amount greater than the previous bid were dropped. Example: a person who said she would not pay 5,000 yen and would not pay 2,500 yen, but when probed in an open-ended fashion said 3,000 yen. Individuals who answered "Don't know" three times—in the initial payment question, in the first follow-up question, and in the open-ended follow-up question—were dropped. These respondents never indicated their WTP (although "Don't know" was treated as a "No" in principle, following Krosnick, et al. (2002)). These procedures resulted in dropping up to 64 respondents for Wave 1 and 61 for Wave 2.

6. Willingness-to-Pay

6.1 Methodology

The underlying econometric model is

$$\log WTP_i^* = X_i\beta + \varepsilon_I \quad (1)$$

where WTP^* is the underlying willingness to pay for a selected risk reduction; X denotes a vector of age, health, and other attributes; β is a vector of coefficients; and ε is an extreme value Type I error term. Effectively, equation (1) describes a survival time model based on the Weibull distribution. The log-likelihood function of the data is

$$\log L = \sum_{i=1}^{n} \log \{ F[(\log WTP_i^H - X_i\beta)/\sigma] - F[(\log WTP_i^L - X_i\beta)/\sigma] \} \quad (2)$$

where F is the type I extreme value distribution with scale σ, $WTPi^H$ and $WTPi^L$ are upper and lower bounds for WTP, and X is a vector of age, health, and other attributes with β as the corresponding coefficients. σ is the scale parameter of ε, as well as the reciprocal of the shape parameter of the Weibull distribution describing WTP. The scale parameter for the Weibull distribution is exp*(Xβ).* The Weibull had a better fit than other probability distributions[7].

6.2 WTP for Current Risk Reduction

Estimates of WTP and Implied VSL

The response patterns to the WTP questions are shown in Figure 2. For each initial bid value, the proportion of people willing to pay for mortality risk reduction is higher for the 5-in-1,000 risk reduction, a result suggesting that the external scope test will be passed. One would also expect that the percentage of people willing to pay a bid amount should decrease with the bid amount. While this is generally true for both risk reductions, we find that a slightly larger proportion accept the second-lowest bid (5,000 yen) than the lowest bid (2,500 yen), and for the 1 in 1,000 risk reduction, more accept the highest than the second-highest bid, although these effects are not significant. Otherwise, bid acceptance rates decline as bid amounts increase.

In Table 7 we report the estimates of median and mean WTP, which we estimate using the Weibull[8] distribution and the interval data model of equation (2). We focus on the first risk reduction valued by the respondent. In other words, WTP estimates for the 5-in-1,000 risk reduction are obtained from Wave 1, and those for the 1-in-1,000 risk reduction are obtained from Wave 2. The mean WTP for a 5-in-1,000 risk reduction from Wave 1 is 51,522 yen, and the mean WTP for a 1-in-1,000 risk reduction from Wave 2 is 34,408 yen. The median WTP for a 5-in-1,000 risk reduction from Wave 1 is 16,105 yen, and the median WTP for a 1-in-1000 risk reduction from Wave 2 is 7,595 yen. Note, however, that the mean values and to a lesser extent the median values do not seem to be very sensitive to question ordering. For instance, the mean VSLs from the 5 in 1,000 question from Wave I and from Wave II differ by only 3 million yen ($20,000). This occurs because of the long tail in the WTP distributions.

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[7] We tried the logistic, the log normal and the normal distributions. Compared to those distributions, the Weibull has higher log-likelihood and narrower disparity between medians and means.

[8] Mean WTP is $[(\sigma)\ \Gamma(1/\theta +1)]$ where θ is the shape parameter and σ is the scale parameter of the Weibull and $\Gamma(\cdot)$ is the gamma function. Median WTP is $(\sigma)\ [-\ln(0.5)]^{1/\theta}$.

The median estimates for the first question in each wave clearly pass the external scope test[9] (Table 8), but the mean estimates do not, although this may be due to the small sample, as their ratio is about 1.5 to 1. The Wald statistics on proportionality indicate that the median estimates pass the proportionality[10] test, but the ratio of 2.1 makes the test statistics questionable due to the high standard errors of our estimates.

Finally, we used the likelihood ratio test[11] to see whether the estimated distributions of WTP for the 5-in-1,000 and the 1-in-1,000 risk reductions were statistically different (Table 8). We found the two distributions of WTP were, in fact, clearly different.

The Influence of Rejection of the Product or Scenario

Because of the large numbers of respondents who did not accept one or more aspects of the scenario, baseline, or commodity, we estimated mean and median WTP by dropping such individuals (Table 9). Note that the effects of dropping individuals who questioned aspects of the survey are relatively minor. The exception is those who considered other benefits. Dropping them from the sample reduces WTP dramatically.

The Effect of Age, Health and Other Covariates on WTP

To determine the impact of age on WTP, we first divided the sample and fit equation (2) to four age groups: 40–49, 50–59, 60–69, and 70 and over. Table 10 shows the estimates of WTP of each age group. We see some differences, especially between the estimates of age 70-plus and

[9] The scope test checks whether median (mean) WTP from one independent sub-sample is equal to median (mean) WTP from the other sub-sample. The Wald statistic for this null hypothesis is distributed as a chi-square with one degree of freedom.

[10] The proportionality test checks whether median (mean) WTP from the 5 in 1000 risk reduction from one sub-sample is 5 times median (mean) WTP for the 1 in 1000 risk reduction from the other sub-sample. The Wald statistic for this null hypothesis is distributed as a chi- square with one degree of freedom.

[11] The difference of distribution of WTP is checked by likelihood ratio test. Λικεληιοοδ ρατιο $\lambda = L_{pooled\ sample} / (L_{sample1} * L_{sample2})$, $-2 \text{Log}\ \lambda$ is distributed as chi-square statistic with two degree of freedom.

those of other age groups. However, Wald test statistics and Likelihood Ratio tests on the difference of the estimates indicate that those differences are not statistically significant because each age group sub-sample has a large standard error (due to the small sample size).

We also divided the sample into two age groups (Table 11), finding that the 70 and over group compared to the other groups has a median WTP significantly lower—for instance, 8,018 yen in the 70 and older age group and 17,246 yen in the younger group. This difference is significant at the 5% level. However, the mean estimates do not differ statistically because of large standard errors. Still the mean estimates for the 70 and over group are the smallest, at $35,000, compared to $53,000 for the other group. Qualitatively the same median and mean results generally hold true for the 1-in-1,000 WTP responses, but the differences are not significant.

The above test permits all factors in the various age groups to vary, possibly hiding the age effect, if all other things were equal. A better test of the age effect is found running multivariate regressions, as in equation (2). In Table 12 we report five specifications intended to assess the construct validity of the willingness-to-pay estimates with respect to age, health, and other covariates for Wave 1.

We employ the age 70 and over dummy in Specification A for Wave 1 to examine the decline of WTP for those aged 70 and over. When it is the only variable in the regression, the age 70 and over dummy is significant with a negative sign. In Specification B, where we add health and other covariates to Specification A, the age effect disappears. At the same time, we find that the mental health score and the cancer dummy are negative and significant and the heart disease dummy is significant with positive sign. The former effect was found by Krupnick et al. (2000) for Canada, while most diseases were either insignificant or had a positive effect on WTP. In addition, we find years of schooling and natural log income (LN income variable) are positive and significant.

To further examine the age effect, in Specification C we substitute a continuous age variable for the age 70 and over dummy of Specification B, finding a small positive and significant association with WTP.[12] In Specification C, we see if these effects are robust to exclusion of respondents who “did not understand timing of payments.” This increases the age

[12] Most analyses do not find that WTP increases with age. One exception is Smith, et al (2004).

effect but eliminates the significance of the cancer effect, putting the health effect findings more in line with the Canadian results.

In Specification D we add dummy variables capturing the respondents' understanding of the questionnaire. As some of these variables may be considered endogenous, we do not rely on these results for calculating WTP. Nevertheless, as we expect, we find that those who "thought of side effects" had substantially lower WTP (by 48%) and that those who considered other benefits had substantially higher WTP (by 141%) that others. As seen in the Canada study, those who "did not consider whether he/she could afford payments" have lower WTP because such people are so negative about the scenario they don't get to the point of actually considering their income constraint.

To summarize the age effects, we find that a linear term for age is the most robust age variable in explaining WTP and that older people are willing to pay more for a mortality risk reduction. Figure 3 shows estimated WTP for 5 in 1000 current risk reduction of those who have mean age and income of each age group of the sample. In Figure 3, WTP goes up to about age 70 along age and declines a little after age 70, due to lower income of this age group. The decline in WTP at age 70 and over is much smaller than that directly estimated for this group (Table 10) because this age group has not only more illness and shorter years of schooling but also they tend not to think of other benefits (35%) compared to other age groups (53%).

Overall, we conclude that there is no evidence for a "senior discount" And that, if anything, the VSL actually rises as age rises.

6.3 WTP for Future Risk Reduction

Estimates of WTP and Implied VSL

In the upper part of Table 13, we report estimates of WTP for a *future* risk reduction starting at age 70 with the implied VSLs for Wave 1, Wave 2 and combined sample of Wave 1 and 2. Only those aged 40-60 were given this question. The results in Wave 1 and Wave 2 are quite similar. Therefore, we combined the waves in multivariate regressions as in equation (2) for four specifications, reported in Table 14. The Wave1 dummy variable in the four specifications is insignificant and indicates there are no ordering effects associated with whether the first WTP question asked was for a 5-in-1,000 risk reduction or a 1-in-1,000 risk reduction.

The appropriate comparison of WTP for a contemporaneous risk reduction and a future risk reduction requires querying the same sample. Hence, we also report estimates of WTP for a current risk reduction with implied VSLs based on the responses of the 40–60 age group in the lower part of Table 13. Comparing VSLs for a future risk change to those for a current risk change, the former is significantly smaller than the latter. The ratio is 2.3 for median WTP and 1.4 for mean WTP in the combined sample, thus passing an internal scope test.

The Effect of degree of Latency, Health, and Other Covariates on WTP

To examine the effect of age, health, and other covariates on WTP for future risk reduction (5-in-1,000) starting at age 70, look again at Table 14. The covariates used on Specifications A, B, C, and D in Table 14 are similar to specifications in Table 12. Specification A includes only a latency covariate (age 70 minus each respondent's age) and a Wave dummy. We find the latency covariate is significant and negative, meaning that respondents closer in age to the time the risk reduction takes effect value that risk reduction more. This effect holds up irrespective of specification changes. Quantitatively, in Specifications A, those who are one year older than others and WTP 8% more for the future risk reduction.

In Specification B and D we also add covariates for "How likely is it that you will live to age 70 (percentage chance)?" and "What health status do you expect at age 75." These covariates are negative and significant and plausible (and found in Alberini et al., 2004b), indicating that people who think their health will be better in the period during which the risk reduction will take place are willing to pay less for it and that people who are more likely to think they will die before getting the benefits of the future risk reduction are less willing to pay for it.

In terms of respondents' attribute variables, natural log income is weakly associated with WTP in Specifications C. A family chronic disease history is associated with a lower WTP at the 5% level in Specification C, but having a chronic disease today is not significant.

As for the dummy covariates for respondents' thoughts when answering the questionnaire, most are significant and in plausible directions.

Estimates of Implied Discount Rates

Since we have WTP for current risk reductions and WTP for future risk reductions, we are able to estimate the discount rate through comparison of those WTP estimates. However, directly comparing these estimates might neglect the nature of the commodity, that is the mortality risk might be valued differently depending on age. Therefore, we first project WTP for the current risk reduction if the respondent were 70, and then estimate the implicit discount rate using equation (2) and equation (3) below

$$\log WTP_{a,70} = \log\pi_{a,70} + \log WTP_{70,70} - \delta(70-a) + \varepsilon_I \quad (3)$$

where $WTP_{a,70}$ denotes estimated WTP of respondents at age a, $\pi_{a,70}$ denotes subjective respondent-assessed chance of surviving to age 70, and δ denotes discount rate to be estimated. $WTP_{70,70}$, is WTP for current risk reduction if respondent were 70, which is predicted based on the data of the first WTP question (5 in 1,000 reduction) of Wave 1 that did not have an order effect. We used Specification C of Table 12 omitting insignificant variables for the prediction.

In Table 15, we present estimates of implied discount rates. We find discount rates ranging from 5.8 to 8.0% (7% in pooled sample). The discount rate coefficients are strongly significant (P-value = 0.000). This finding mirrors results in Alberini et al. (2004) showing that the U.S. discount rate is around 4%, while the Canadian rate is about 8%.

7. Conclusion

Our survey is designed primarily to provide credible estimates of willingness to pay (WTP) for reductions in the risk of dying and calculate the value of a statistical life (VSL) in the context of mortality risk reductions associated with environmental policy in Japan. It follows a well-tested but novel survey approach applied in the U.S. and Canada, while initial focus group and pilot testing in Japan initially helped build this survey.

We find that the VSLs implied by the answers to these survey questions are somewhat lower (103 to 344 million yen) than those in current use in developed countries and lower than those found in studies of the U.S. and Canadian populations. These values were subject to a variety of credibility tests, which they generally passed (such as the probability understanding tests), although relatively small sample sizes cloud some of the findings and the results for WTP for the 5 in 1,000 risk reductions far outperform the results for the 1 in 1,000 risk reductions. In addition, there were a relatively large set of respondents who questioned various aspects of the survey, as determined in debriefing questions. Dropping them had limited effect on WTP, except when dropping those respondents who considered ancillary benefits from taking the product or action to reduce their mortality risks. In this case mean WTP fell by 35%.

We further find that respondents age 70 and over have lower WTP than those in other age groups (from 40 to 69), although this effect is not always significant. The more robust age result is that WTP generally increases with age throughout the ages in our sample. Although those in poor health are likely to be more at risk from environmental insults, our story on valuation is mixed, with the WTP of those with cancer lower than that of healthy respondents (for the same risk reduction) while the WTP of those with heart disease is greater. Sample sizes are small for these groups, however. As in the Canada survey, those with poorer mental health are willing to pay less than those with better mental health.

Turning to the WTP for future risk changes, the results are less complicated and more consistent. The VSLs for future risk changes are lower than those for contemporaneous risk reductions, as was hypothesized because of positive time preference and the chance that one may not be alive to capture the benefits of a future risk reduction. In explaining the variation in future WTP across our sample of 40-60 year olds, we found evidence for these effects, where one’s self-assessed probability of living to 70, the degree of latency, and one’s expectation of their health in the future were all related to WTP.

Because we estimated the WTP today for an equivalent risk reduction in the present and in the future, we can compute implied rates of time preference. We find implicit discount rates of 5.8 –8.0%, which is relatively larger than the discount rate regularly used in environment policy analyses.

This first-of-its-kind survey in Japan provides information directly useful for estimating the benefits of environmental and other policies that lower mortality risks to the general population and sub-groups with a variety of specific traits. Because of its novelty, additional studies will be needed to validate these results. A larger sample size would be very useful as would be the investigation of individual WTP for health improvements in the family or community, as opposed to an individual's WTP for their own health improvements.

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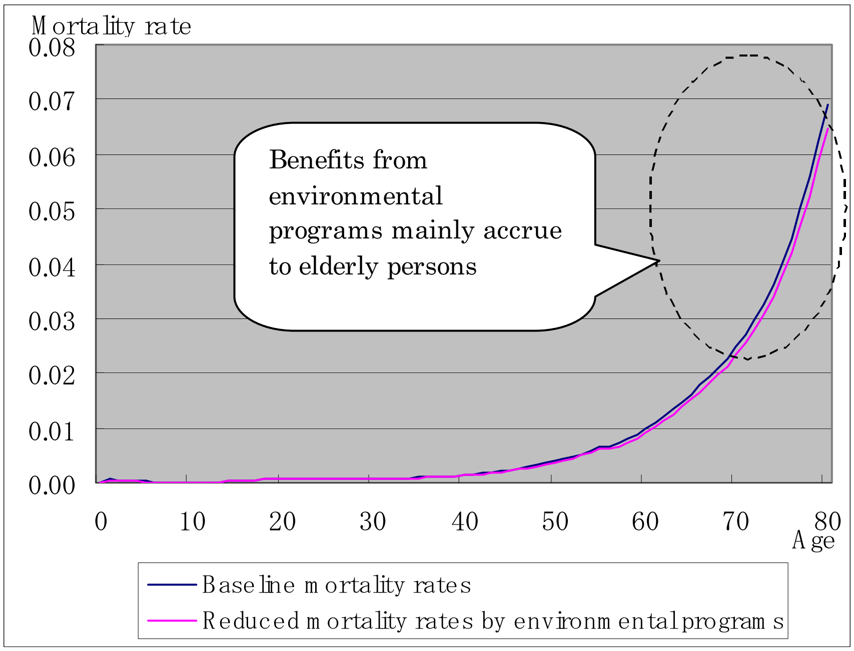


Note: Baseline mortality rates are based on Japanese Census data, and reduced mortality rates are calculated assuming a 10 microgram/m3 reduction in small particulate matter (PM2.5).

Figure 1. Example of Baseline Mortality Rates and Reduced Mortality Rates by Environmental Programs

Table 1. Order of Questions

Group of Respondents	Current Risk Reduction		Future Risk Reduction Valued
	Initial Risk Reduction Valued	Second Risk Reduction Valued	
Wave 1 (N = 368)	5 in 1,000	1 in 1,000	5 in 1,000
Wave 2 (N = 309)	1 in 1,000	5 in 1,000	5 in 1,000

Table 2. Bid Structure (Yen)

Version	Initial Payment Question	Follow-up Question (if "Yes")	Follow-up Question (if "No")
I	2,500	7,000	700
II	5,000	15,000	2,500
III	10,000	25,000	5,000
IV	20,000	40,000	10,000
V	40,000	100,000	20,000

Table 3. Individual Characteristics of Respondents

Variable	Wave 1 (N = 368)	Wave 2 (N = 309)	Total Sample (N = 667)
Average Age (years)	56	56	56
Age distribution (%)			
40–49	23	25	24
50–59	43	39	41
60–69	24	29	26
70 and older	11	7	9
Female (%) [national average: 51.1]	49	50	50
Average education (years)	12	12	12
Average annual household income (000 yen) [national average: 6,494]	6,401	6,386	6,394

Table 4. Health Status of Respondents

Variable	Wave 1 (N = 368)	Wave 2 (N = 309)	Total Sample (N = 677)
Heart disease (%)	6	4	5
High blood pressure (%)	18	17	17
Cancer (%)	2	1	2
Lung (%)	5	5	5
Asthma (%)	2	3	2
Bronchitis, emphysema, or chronic cough (%)	4	4	4
Chronic, any of the above (%)	27	23	25
Good health (%) (self-assessed as excellent or very good, compared with others of the same age)	34	37	35
Self-assessed years before death	28	29	29
General health score from SF-36	65	65	65
Mental health score (1–100)	81	81	81
Physical functioning score (1–100)	91	91	91
Role-emotional score (1–100)	86	91	88
Has supplemental insurance (%)	75	68	72
Baseline risk of dying over the next 10 years (per 1,000)	89	86	88

Table 5. Acceptance of the Product and Scenario

Variable	Wave 1 (N = 368)	Wave 2 (N = 309)	Total Sample (N = 677)
Did not believe risk of dying applied to them	43%	45%	44%
- Thought own risks were higher	34%	29%	32%
- Thought own risks were lower	66%	71%	68%
Had doubts about effectiveness of product	41%	36%	39%
Thought about side effects	32%	31%	31%
Considered other benefits	51%	51%	51%
Did not consider whether he could afford payments	29%	30%	29%
Did not understand timing of payments	16%	15%	16%

Table 6. Descriptive Statistics for Sample Cleaning Procedure

		Wave 1 (N = 368)	Wave 2 (N = 309)
Chose wrong person in probability test		4	1
Chose wrong person in probability choice (preferred to live in the city with a higher mortality risk)		15	18
Answered the open-ended follow-up WTP question with an amount greater than the previous bid	Initial Risk Reduction Valued	0	2
	Second Risk Reduction Valued	4	0
	Future Risk Reduction Valued	3	3
Answered "Don't know" three times	Initial Risk Reduction Valued	33	41
	Second Risk Reduction Valued	39	37
	Future Risk Reduction Valued	26	29

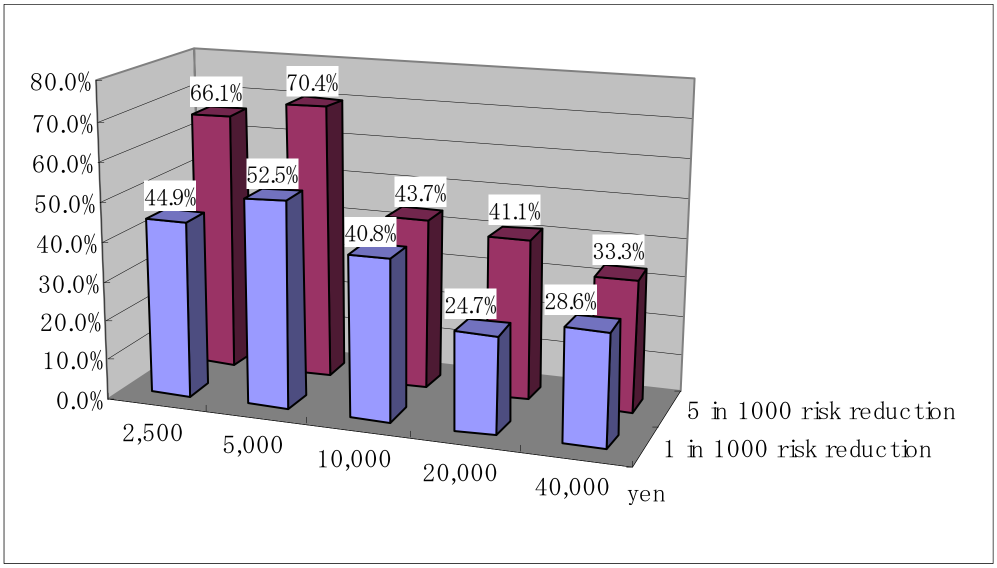


Figure 2. Percentage of "Yes" Responses to the Initial Payment Questions

Table 7. WTP for a Current Mortality Risk Reduction and VSL (Cleaned Sample, Based on Weibull Distribution)

	Order of Question	Commodity (Timing of Risk Reduction)	n	Log Likelihood	Type of Central Value	WTP (yen)	Std. Error (Yen)	Implied VSL* (Yen) (000,000)	Implied VSL* (US$) (000)
Wave 1	1	5 in 1,000 (current)	318	-407.543	median	16,105	2,259	32	206
					mean	51,522	11,637	103	661
	2	1 in 1,000 (current)	309	-389.724	median	5,005	841	50	321
					mean	23,556	5,125	236	1,510
Wave 2	1	1 in 1,000 (current)	248	-318.114	median	7,595	1,307	76	487
					mean	34,408	9,045	344	2,206
	2	5 in 1,000 (current)	253	-321.564	median	8,652	1,614	17	111
					mean	50,039	15,929	100	642

* 156yen = US$1 in 2000 purchasing power parity. Source: OECD *Main Economic Indicators*

Note: To compute standard errors around mean WTP and median WTP, we drew samples of 1,000 observations from multivariate normal distribution centered on the estimated Weibull parameters with variance-covariance matrix of the covariates. VSL is computed using annual WTP, divided by the annual risk reduction (5 in 10,000 and 1 in 10,000). “Don’t know ” responses are interpreted as “no.”

Table 8. External Scope Test

Are WTP figures for the risk reductions of different sizes……….

	Median WTP	*Mean WTP*
Are WTP figures for risk reductions of different sizes significantly different?	Yes	No
Scope Test: Wald Statistic	10.63	1.348
Are WTP figures for risk reductions of different sizes proportional to the size of the risk reduction?	- (the ratio is 2.1)	- (the ratio is 1.5)
Proportionality Test: Wald Statistic	10.00	-
Is the distribution of WTP significantly different?	Yes	
Scope Test: the Likelihood Ratio	12.374(p=0.002)	

Table 9. Influence of Rejection of the Product or Scenario on WTP for 5-in-1000 Current Risk Reduction (Wave 1, Cleaned Sample, Based on Weibull distribution. Respondents who fall into each category are dropped in estimating WTP)

Variable	WTP (yen)		N remaining
	Mean	Median	
Basic Sample	51,522	16,105	318
Did not believe risk of dying applied to them			
- Thought own risks were higher	53,264	17,778	276
- Thought own risks were lower	62,509	17,859	229
Had doubts about effectiveness of product	59,200	17,305	183
Thought about side effects	68,603	16,998	217
Considered other benefits	33,582	7,557	150
Thought about side effects or considered other benefits	44,148	7,664	120
Did not consider whether he could afford payments	50,261	24,827	192
Did not understand timing of payments	54,008	25,523	235

Table 10. WTP for a Current Mortality Risk Reduction in Different Age Groups (Cleaned Sample, Based on Weibull Distribution)

	Age Group	n	Log likelihood	Type of Central Value	WTP (yen)	Standard Error (yen)	Wald statistic on the difference between age groups	Likelihood ratio test on the difference between two age groups
Wave 1 5-in-1,000 Risk Reduction	40–49	75	-91.08	median	16,303	5,089	0.05	0.49
				mean	57,118	38,042	0.07	
							(age 40–49 vs. 50–59)	
	50–59	136	-170.52	median	17,659	3,571	0.01	0.56
				mean	45,933	15,417	0.12	
							(age 50–59 vs. 60–69)	
	60–69	76	-103.63	median	17,172	5,270	1.88	1.93
				mean	61,219	41,639	0.17	
							(age 60–69 vs. 70+)	
	70+	31	-40.56	median	8,018	4,092		
				mean	35,195	46,583		
Wave 2 1-in-1,000 risk Reduction	40–49	66	-90.44	median	7,411	2,346	0.14	1.77
				mean	25,338	10,931	0.64	
							(age 40–49 vs. 50–59)	
	50–59	93	-118.48	median	8,802	2,913	0.21	0.73
				mean	54,394	34,550	0.34	
							(age 50–59 vs. 60–69)	
	60–69	76	-92.91	median	7,072	2,422	0.27	0.82
				mean	31,891	17,402	0.08	-
							(age 60–69 vs. 70+)	
	70+	13	-14.72	median	4,709	3,869		
				mean	13,532	61,482		

Table 11. WTP for a Current Mortality Risk Reduction in Different Age Groups (Cleaned Sample, Based on Weibull Distribution)

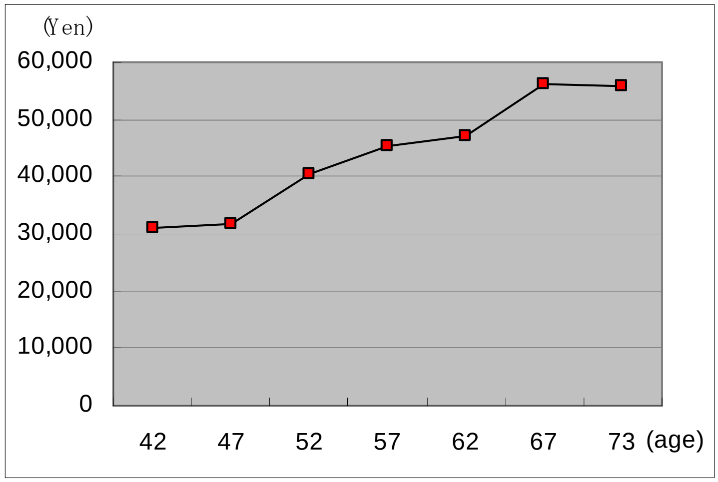
	Age Group	n	Log Likelihood	Type of Central Value	WTP (Yen)	Standard Error (yen)	Wald statistic on the difference between two age groups	Likelihood ratio test on the difference between two age groups
Wave 1 5-in-1,000 risk Reduction	Below 60	211	-261.85	median mean	17,234 49,514	2,825 13,030	0.50 0.03	1.08
	60 and Over	107	-145.15	median mean	13,914 54,893	3,733 28,036		
	Below 65	253	-323.20	median mean	16,179 52,409	2,473 13,790	0.00 0.02	0.03
	65 and Over	65	-84.33	median mean	15,793 48,099	4,906 30,791		
	Below 70	287	-365.62	median mean	17,246 52,625	2,432 12,399	3.76* 0.13	2.73
	70 and Over	31	-40.56	median mean	8,018 35,195	4,092 46,583		
Wave 2 1-in-1,000 risk Reduction	Below 60	159	-209.81	median mean	8,214 37,481	1,782 13,192	0.34 0.24	0.52
	60 and Over	89	-108.04	median mean	6,606 28,406	2,099 12,928		
	Below 65	199	-258.17	median mean	8,135 37,178	1,580 10,855	0.68 0.43	0.94
	65 and Over	49	-59.47	median mean	5,823 23,328	2,305 18,008		
	Below 70	235	-302.82	median mean	7,829 35,831	1,472 9,908	0.57 0.13	1.15
	70 and Over	13	-14.72	median mean	4,708 13,532	3,868 61,481		

Note: * indicates significance at the 5% level.

Table 12. Construct Validity of WTP for 5-in-1,000 Current Risk Reduction, Wave 1 (Cleaned Sample, Based on Weibull Distribution)

Variable	Specification A		Specification B		Specification C		Specification C'		Specification D	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Intercept	10.40**	0.00	6.67**	0.00	4.02§	0.07	3.70	0.13	3.78§	0.09
Ages 50 to 59	-	-	-	-	-	-	-	-	-	-
Ages 60 to 69	-	-	-	-	-	-	-	-	-	-
Ages 70 and over	-0.68§	0.09	-0.09	0.85	-	-	-	-	-	-
Age	-	-	-	-	0.03§	0.08	0.04*	0.03	0.04*	0.03
Mental Health Score	-	-	-0.01§	0.09	-0.01§	0.08	0.00	0.60	-0.01	0.53
Physical Functioning Score	-	-	-	-	-	-	-	-	-	-
Respiratory disease dummy	-	-	-	-	-	-	-	-	-	-
Cancer dummy	-	-	-2.07*	0.04	-2.45*	0.03	-0.68	0.71	-0.35	0.85
Heart disease dummy	-	-	1.05§	0.09	0.96§	0.10	0.49	0.30	0.34	0.53
High blood pressure dummy	-	-	0.57	0.16	0.35	0.43	0.30	0.51	0.20	0.66
Years of schooling	-	-	0.15*	0.03	0.20**	0.01	0.15*	0.03	0.18**	0.01
Gender dummy (male)	-	-	-	-	-	-	-	-	-	-
LN (income)	-	-	0.48*	0.05	0.53*	0.03	0.51*	0.05	0.41§	0.09
Family chronic disease history	-	-	-0.26	0.40	-0.26	0.40	-0.41	0.18	-0.35	0.25
Family cancer history	-	-	-	-	-	-	-	-	-	-
ER visit in last five years or hospitalization in last year	-	-	-	-	-	-	-	-	-	-
Did not believe risk of dying applied to them	-	-	-	-	-	-	-	-	0.02	0.94
Had doubts about effectiveness of product	-	-	-	-	-	-	-	-	-0.45	0.12
Thought about side effects	-	-	-	-	-	-	-	-	-0.65*	0.02
Considered other benefits	-	-	-	-	-	-	-	-	0.88**	0.00
Did not consider whether he could afford payments	-	-	-	-	-	-	-	-	-0.51§	0.07
Did not understand timing of payments	-	-	-	-	-	-				
Scale parameter	1.78**	0.00	1.69**	0.00	1.69**	0.00	1.35**	0.00	1.27**	0.00
Log Likelihood	-406.333		-350.362		-348.847		-251.179		-241.77	
Number	318		288		288		215		215	

Note: § indicates significance at the 10% level; * indicates significance at the 5% level; ** indicates significance at the 1% level. The variables shown in the left column but excluded in the above specifications were included in other specifications. However, we found the estimated coefficients of the variables were not significant. Respondents who "did not understand timing of payments" are dropped in Specification C' and D



Note: Age 42 represents age 40–44, age 47 represents age 45–49, age 52 represents age 50–54, age 57 represents age 55–59, age 62 represents age 60–64, age 67 represents age 65–69, and age 72 represents age 70 and over. WTP is estimated by regression analysis of specification: *log WTPi=0.0392 *age+1.3092*LN(income)*, N=304, Log likelihood = -384.734. Both coefficients are significant at the 1% level. Mean income and mean age of each age group is used for the estimation.

Figure 3. Estimates of WTP for 5-in-1000 Current Risk Reduction of Age Groups Based on Regression Analysis (Wave 1)

Table 13. WTP for a Future Mortality Risk Reduction and Comparable WTP for a Current Mortality Risk Reduction

(Cleaned Sample, Based on Weibull Distribution)

	Order of Question	Commodity (Timing of Risk Reduction)	n	Log Likelihood	Type of Central Value	WTP (Yen)	Standard Error (Yen)	Implied VSL*	
								(Yen) (000,000)	(US$) (000)
FUTURE RISK REDUCTION (40–60 yr olds)									
Wave 1	3	5 in 1,000 (future)	213	-263.93	Median Mean	5,597 33,579	1,223 11,452	11 67	72 430
Wave 2	3	5 in 1,000 (future)	160	-206.08	Median Mean	6,656 43,480	1,750 18,404	13 87	85 557
Wave 1+2 (pooled)	3	5 in 1,000 (future)	373	-470.26	Median Mean	6,017 37,594	1,018 9,486	12 75	77 482
CURRENT RISK REDUCTION (40–60 yr olds)									
Wave 1 (age 40-60)	1	5 in 1,000 (current)	223	-279.74	Median Mean	16,628 47,661	2,658 12,731	33 95	213 611
Wave 2 (age 40-60)	2	5 in 1,000 (current)	172	-223.72	Median Mean	10,251 60,066	2,348 26,032	21 120	131 770
Wave 1+2 (age 40-60) (pooled)	1 or 2	5 in 1,000 (current)	395	-506.35	Median Mean	13,797 53,573	1,813 11,948	28 107	177 687

* 156 yen = US$1 in 2000 purchasing power parity. Source: OECD *Main Economic Indicators*

Note: VSL is computed using annual WTP, divided by the annual risk reduction (5 in 10,000 and 1 in 10,000). “Don’t know” responses are interpreted as “no.”

Table 14. Internal Validity of WTP for 5-in-1000 Future Risk Reduction, Wave 1 and Wave 2 (Cleaned and Combined Sample, Based on Weibull distribution)

Variable	Specification A		Specification B		Specification C		Specification D	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Intercept	11.09**	0.00	16.77**	0.00	7.78**	0.00	13.50**	0.00
Interval to age 70	-0.08**	0.00	-0.07**	0.00	-0.10**	0.00	-0.08**	0.00
Mental Health Score	-	-	-0.01	0.40			-0.01	0.56
Physical Functioning Score	-	-	-0.01	0.52				
Respiratory disease dummy	-	-	-	-	-0.51	0.40		
Heart disease dummy	-	-	-	-	0.66	0.29	0.13	0.85
High blood pressure dummy	-	-	-	-	-0.50	0.30	-0.22	0.67
Years of schooling	-	-	-	-	0.06	0.41	0.02	0.81
Gender dummy (male)	-	-	-	-	0.06	0.84		
LN (income)	-	-	-	-	0.52§	0.07	0.23	0.47
Family chronic disease history	-	-	-	-	-0.66*	0.04	-0.50	0.11
Family cancer history	-	-	-	-	0.13	0.67		
ER visit in last five years or hospitalization in last year	-	-	-	-	-0.29	0.90		
Expected health status at age 75	-	-	-0.59**	0.00			-0.63**	0.00
Thought how likely (%) to live till age 70	-	-	-0.03**	0.00			-0.02**	0.01
Did not believe risk of dying applied to them	-	-	-	-			-0.43	0.16
Had doubts about effectiveness of product	-	-	-	-			-0.93**	0.00
Thought about side effects	-	-	-	-			-0.55	0.08
Considered other benefits	-	-	-	-			0.81**	0.01
Did not consider whether he could afford payments	-	-	-	-			-0.91**	0.00
Wave1 Dummy	-0.21	0.46	-0.05	0.87	-0.22	0.44	0.09	0.77
Scale parameter	2.27**	0.00	2.05**	0.00	2.14**	0.00	1.64**	0.00
Log Likelihood	-464.65		-433.027		-439.192		-300.833	
Number	372		357		359		267	

Note: § indicates significance at the 10% level; * indicates significance at the 5% level; ** indicates significance at the 1% level. A stable coefficient of Cancer dummy cannot be estimated due to too few observations of cancer in Specification C and Specification D, but its standard error suggests the coefficient is not significant. Respondents who “did not understand timing of payments” are dropped in Specification D

Table 15. Implied Discount Rate Based on WTP (Cleaned Sample, Based on Weibull Distribution)

	Implicit Discount Rate	Standard Error of the Estimate
Wave 1	0.0800 (=8%)	0.0105
Wave 2	0.0580 (=5.8%)	0.0110
Wave 1+2 (pooled)	0.0700 (=7%)	0.0077

Note: The average age of respondents in the total sample who stated WTP for risk reduction (5 in 1,000) starting at age 70 was 51.2; thus the average internval to age 70 is 18.8 years.