Age, Health, and the Willingness to Pay for Mortality Risk Reductions: A Contingent Valuation Survey of Ontario Residents

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RESOURCES FOR THE FUTURE

Resources for the Future
1616 P Street, NW
Washington, D.C. 20036
Telephone: 202–328–5000
Fax: 202–939–3460
Internet: http://www.rff.org

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Abstract

Much of the justification for environmental rulemaking rests on estimates of the benefits to society of reduced mortality rates. This research aims to fill gaps in the literature that estimates the value of a statistical life (VSL) by designing and implementing a contingent valuation study for persons 40 to 75 years of age, and eliciting WTP for reductions in current and future risks of death. Targeting this age range also allows us to examine the impact of age on WTP and, by asking respondents to complete a detailed health questionnaire, to examine the impact of health status on WTP.

This survey was self-administered by computer to 930 persons in Hamilton, Ontario, in 1999. The survey uses audio and visual aids to communicate baseline risks of death and risk changes and are tested for comprehension of probabilities before being asked WTP questions. We credit these efforts at risk communication with the fact that mean WTP of respondents faced with larger risk reductions exceeds mean WTP of respondents faced with smaller risk reductions; that is, our respondents pass the external scope test.

Our mean WTP estimates for a contemporaneous risk reduction imply a VSL ranging approximately from $1.2 to $3.8 million (1999 C$), depending on the size of the risk change valued, which is at or below estimates commonly used in environmental cost-benefit analyses by the Canadian and the U.S. governments. Interestingly, we find that age has no effect on WTP until roughly age 70 and above (the VSL is about $0.6 million for this age group) and that physical health status, with the possible exception of having cancer, has no effect. We also find that being mentally healthy raises WTP substantially. In addition, compared with estimates of WTP for contemporaneous risk reductions, mean WTP estimates for risk reductions of the same magnitude but beginning at age 70 are more than 50% smaller.

Key Words: mortality risk valuation, Canada, contingent valuation, age, health status

JEL Classification Numbers: I1, Q20, Q26

Contents

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1. Introduction and Overview

Much of the justification for environmental rulemaking rests on estimates of the benefits to society of reduced mortality rates. Reductions in risk of death are arguably the most important societal benefit underlying many of Health Canada's and U.S. Environmental Protection Agency's (U.S. EPA) legislative mandates, including the Safe Drinking Water Act, the Resource Conservation and Recovery Act, and the Clean Air Act in the United States and the Environmental Protection Act in Canada. For example, in two recent analyses of the benefits of U.S. air quality legislation, *The Benefits and Cost of the Clean Air Act, 1970 to 1990* (U.S. EPA 1997) and *The Benefits and Cost of the Clean Air Act, 1990 to 2010* (U.S. EPA 1999), more than 80% of monetized benefits were attributed to reductions in premature mortality. Similarly, a high proportion of monetized benefits in Canadian regulations, including Regulations Respecting the

* The authors are from Resources for the Future; the University of Maryland; the University of Maryland and the World Bank; the U.S. Environmental Protection Agency; McMaster University; McMaster University; and Resources for the Future, respectively.

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Sulphur Content in Diesel Fuel and Regulations Respecting the Sulphur Content in Gasoline, are attributable to reductions in premature mortality.

There are two sources of empirical estimates of individuals' willingness to pay (WTP) for mortality risk reductions: revealed preference studies, based on compensating wage data or consumer behavior, and stated preference studies, including those employing contingent valuation methods. Each approach to measuring WTP has its drawbacks. Revealed preference studies, whether based on labor market data or consumer behavior, make untested assumptions about individuals' risk perceptions; that is, that risk perceptions correspond to objectively measured risks. It is, furthermore, often difficult to separate objective risk measures from other attributes of the job or product examined. Stated preference studies are, in principle, capable of testing whether individuals correctly perceive mortality risks and changes in mortality risks. Many studies, however, fail to examine whether WTP for risk reductions varies with the size of the risk change—an essential method of testing whether individuals are processing risk information correctly. When such tests are performed, they often indicate that individuals do not react to risk changes of different sizes in the way theory predicts (Hammitt and Graham 1999).

From the perspective of valuing lives saved by environmental programs, both estimation techniques—as applied to date—share a common shortcoming. They focus on measuring the value that prime-aged adults place on reducing their risk of dying, whereas the majority of statistical lives saved by environmental programs, according to epidemiological studies, appear to be the lives of older people and people with chronically impaired health. It has been conjectured that older people should be willing to pay less for a reduction in their risk of dying than younger people because they have fewer expected life years remaining. Theory, however, cannot predict exactly how WTP varies with age, and, to our knowledge, few empirical studies have included subjects over the age of 65. Likewise, no studies have examined the impact of health status on WTP for mortality risk changes.

A second shortcoming of revealed preference studies and of most stated preference studies is that they value only immediate risk changes. When environmental programs reduce exposure to a carcinogen, the costs of reducing exposure are often incurred in the present, whereas cancer risks are reduced in the future, following a latency period. What is needed for policy affecting pollutants with latent effects is an estimate of how much people would pay now for a reduction in their risk of dying in the future.

This research aims to design and implement a contingent valuation study for persons 40 to 75 years of age to elicit WTP for reductions in current and future risks of death. Targeting this age range allows us to examine the impact of age on WTP and to provide an empirical answer to the above speculations. By asking respondents to complete a detailed health questionnaire (Standard Form 36, Ware et al. 1997), we can also examine the impact of health status on WTP. Our primary challenge in designing the survey was to make probability concepts sufficiently transparent so that the average WTP of respondents confronted with different-sized risk changes would be sensitive to the size of the risk change.

This paper reports the results of our survey, which was self-administered by computer to 930 persons in Hamilton, Ontario, in 1999. The survey uses audio and visual aids to communicate baseline risk of death and risk changes. Respondents are given experience with graphical representations of risks of death (depicted by colored squares on a rectangular grid) and are tested for comprehension of probabilities before being asked WTP questions. We credit these efforts at risk communication with the fact that mean WTP of respondents faced with larger risk reductions exceeds mean WTP of respondents faced with smaller risk reductions; that is, our respondents pass the external scope test.

Our mean WTP estimates for a contemporaneous risk reduction imply a value of a statistical life (VSL) of approximately $1.2 to $3.8 million (1999 C$), depending on the size of the risk change valued. These estimates are in the range of estimates from revealed preference studies of consumer behavior (Moore and Viscusi 1988, Kneiser and Leeth 1991, Cousineau et al. 1992) and in previous contingent valuation studies (Gerking et al. 1988, Jones-Lee et al. 1985, Miller and Guria 1991, Viscusi et al. 1991). Interestingly, we find that age has no effect on WTP until roughly age 70 and above and that physical health status, with one possible exception, has no effect. This exception is cancer, where we find that those with cancer are willing to pay substantially more for risk reductions (at an 8% significance level) than those without cancer but who in other respects have similar characteristics. We also find that mental health affects WTP, with more mentally healthy individuals willing to pay more for a given risk reduction. In addition, compared with estimates of WTP for contemporaneous risk reductions, mean WTP estimates for risk reductions of the same magnitude but beginning at age 70 are more than 50% smaller.

The remainder of the paper is organized as follows. In Section II, we discuss the nature and limitations of current estimates of VSL. In Section III, we describe our goals and how we structured the survey questionnaire to achieve them. Section IV presents our results, and Section V offers concluding remarks.

2. An Evaluation of Existing Value Estimates of Mortality Risks

A. The Nature of Mortality Risk Reductions from Environmental Programs

Life-saving benefits from environmental regulations have been quantified for conventional air pollutants, especially particulate matter, and for carcinogens. Epidemiological studies suggest that the majority of statistical lives saved by reducing air pollution apply to persons over the age of 65. We come to this conclusion for three reasons. First, epidemiological studies typically assume that the effect of a change in pollution concentrations is proportional to baseline mortality rates.[1] Because death rates are higher for older persons, this assumption implies that the benefits of reducing exposure to air pollution accrue primarily to older people. This point is made explicit in Table 1, based on Pope et al. (1995), which shows the age distribution of statistical lives saved as a result of reductions in particulate exposures achieved by the U.S. Clean Air Act. The table estimates that three-quarters of the statistical lives saved by the Clean Air Act in 1990 are persons 65 years of age and older.

The second reason why older people may benefit disproportionately from air quality regulations is that the impact of a given change in air pollution on mortality rates has, in some cases, been found to be larger for older persons than for younger persons (Schwartz 1991, 1993).[2] However, this finding is not consistent across all studies.

The third reason for focusing on older people (and people that suffer from chronic illnesses) is that some epidemiological studies (Schwartz 1991 and 1993, Pope et al. 1995) have linked air pollution to specific causes of death and have found larger effects of particulate matter

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[1] This assumption is implicit in time-series models in which deaths on day t are assumed to be an exponential function of air pollution on day t-s, weather, and other variables. It is also embodied in the prospective cohort study of Pope et al. (1995), which assumes that the impact of air pollution is proportional to the probability of dying at each age (given that one survives to that age). Formally, this latter assumption means that the hazard function for an individual of age *a* (i.e., the density of dying at age *a*, conditional on having survived until age *a*) is $h(a, x;\theta)\cdot f(P, z;\delta)$, where *h* is the baseline hazard, which depends on age and possibly individual characteristics x, and *f* scales up or down the baseline hazard, depending on pollution levels and other factors z. θ and δ are vectors of parameters.

[2] Formally, this amounts to specifying the hazard function for a person of age *a* to be $h(a, x:;\theta)\cdot f(a, P, z:\delta)$, where the factor by which the hazard function is scaled up or down with pollution is also age-specific.

Table 1. Distribution of Premature Fatalities Avoided by the U.S. Clean Air Act, 1990

Pollutant	Age Group	1990 U.S. Population*	Remaining Life Expectancy	Statistical Cases Avoided
PM2.5	Under 65	218	25	45,000
	65–74	18	14	43,000
	75–84	10	9	54,000
	>84	3	6	41,000

Note:* Population of United States (millions).
Source:U.S. EPA, *The Benefits and Costs of the Clean Air Act, 1970 to 1990, Report to Congress,* 1997.

concentrations on deaths due to chronic lung disease and heart disease (which tend to be more common among older people). These findings may indicate that individuals with preexisting conditions are more vulnerable to the effects of pollution. It remains to be seen whether such individuals have WTP values for risk reductions that differ systematically from those held by healthier individuals.

Reducing exposure to pollution may also reduce risk of cancer.[3] Although the toxicological studies used to quantify cancer risks provide only an estimate of lifetime cancer risk, rather than age-specific risk estimates, 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. Because cancer mortality rates are concentrated among individuals aged 65 years and over, the statistical lives saved by reducing exposure to carcinogens will be concentrated among people in the same age group.[4]

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[3] Cancer is the health endpoint most often quantified in connection with hazardous waste sites, pesticide regulations, and drinking water standards.

[4] In 1996, 71% of all cancer deaths in the United States were concentrated among residents aged 65 years and over (U.S. Census Bureau 1999).

The timing of risk reductions is also important, both in the case of cancer and in the case of exposure to the criteria air pollutants. If the cancer in question involves a latency period (a lag between exposure to the carcinogen and the manifestation of cancer), the correct valuation concept is what people will pay today for a reduction in their probability of dying at the end of the latency period. A lag between reduction in exposure and risk reduction may also occur in the case of particulate matter. In *The Benefits and Costs of the Clean Air Act, 1990 to 2010*, the U.S. EPA assumed that the full benefits of reducing exposure to particulate matter, as measured by Pope et al. (1995), would not occur for eight years.

B. Current Approaches to Valuing Mortality Risk Reductions

The preceding section suggests that most of the quantified mortality benefits from reducing air pollution exposures could accrue to persons over the age of 65 years and people with chronic respiratory or heart disease. What is therefore vital for policy purposes are estimates of what older people, many of whom may be in poor health, are willing to pay for reductions in their risk of dying, both in the near term and in the future. The dominant approach for valuing these reductions in death risks, however, is simply to transfer estimates from compensating wage studies, or contingent valuation studies that value risk reductions in the context of transport- or job-related accidents.

A key shortcoming of labor market studies is that they measure compensation received by prime-aged men for immediate reductions in risk of death. Attempts have been made to adjust estimates of the value of risk reductions from the labor market literature for age by converting the value of a statistical life from a labor market study (or other source) into a value per life-year saved.[5] The value of a life-year can then be multiplied by discounted remaining life expectancy to value the statistical lives of persons of different ages. This procedure is, however, ad hoc. It assumes that the value per life-year saved is independent of age, and it is sensitive to the rate

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[5] To illustrate this calculation, suppose that the value of a statistical life based on compensating wage differentials is $5 million, and that the average age of people receiving this compensation is 40. If remaining life expectancy at age 40 is 35 years and the interest rate is zero, then the value per life year saved is approximately $140,000. If, however, the interest rate is 5%, then discounted remaining life expectancy is only 16 years, and the value per life-year saved rises to approximately $300,000.

used to discount the value of future life-years, which is usually assumed by the researcher rather than estimated on the basis of actual behavior.[6]

Estimates of the value of a statistical life from labor market studies also share limitations common to most revealed preference studies. They are based on the assumption that workers correctly perceive objectively measured risks of death, without testing this idea. Also, estimates are sensitive to which other factors affecting wage rates are included in the hedonic wage equation. Leigh (1995), for example, has shown that estimates of compensating wage differentials are much larger if the researcher fails to control for inter-industry wage differentials.

Dissatisfaction with labor market studies has led to the use of stated preference methods to value changes in risk of death. In a contingent valuation study, persons of different ages can be asked to value a reduction in risk of death so that one can compare WTP for younger and older people, holding the size of the risk reduction the same. Before such approaches can be used, however, it must be demonstrated that valuation questions can be posed in a manner that is meaningful to respondents. One measure of the success of a contingent valuation survey is that, when different groups of respondents are asked to value risk changes of different magnitudes, WTP increases with the size of the risk change. An external scope test is passed when the mean WTP of respondents faced with the larger risk change is significantly greater than the mean WTP of the respondents faced with the smaller risk change.[7] In the context of valuing risk changes, however, a more stringent criterion can be applied. If respondents maximize expected utility or, more generally, if their utility function is linear in probabilities, WTP for small risk changes should increase in proportion to the size of the risk change.

As a recent literature review by Hammitt and Graham (1999) demonstrates, few contingent valuation studies of mortality risks pass either internal or external scope tests. In some cases (e.g., Jones-Lee et al. 1985, Smith and Desvousges 1987) WTP fails to increase at all with the size of the risk change. Only three contingent valuation studies designed to value mortality risks pass external scope tests. All of these studies were conducted in the context of traffic safety, and two involved extremely small samples ($N < 110$). None of these studies focused on valuing

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[6] Moore and Viscusi (1988) have used labor market data to infer the rate at which workers discount future utility of consumption; however, their models make very specific functional form assumptions to infer a discount rate from a single cross section of data.

[7] An internal scope test asks whether a respondent's WTP increases with the size of the risk reduction valued.

mortality risk reductions among older people, and none examined the impact of health status on WTP for risk reductions.

3. Valuing Mortality Risks Among Older Persons

A. Goals of the Survey

The goal of our survey is to estimate what older people would pay for a reduction in their risk of dying and to examine the impact of health status on WTP. We target a population ranging in age from 40 (the mean age of workers in compensating wage studies) to 75 years and collect extensive information on health status. We ask respondents to value annual risk reductions on the order of 10^{-4}. Risk changes valued in labor market studies are on the order of 1 in 10,000 per year. A risk change of this order of magnitude could also be delivered by an environmental program (e.g., air pollution control). For instance, the Pope et al. study (1995) predicts that a 10 $\mu g/m^3$ change in PM10 results in an average risk change of 2.4 in 10,000, whereas studies based on time series generally predict that the same change in pollution levels results in a .8 in 10,000 risk change.

For use in benefit–cost analyses, it is important that risk reductions be a private good; that is, that we estimate each respondent's WTP to reduce his or her own risk of dying. For this reason, we have chosen an abstract product (not covered by health insurance) as the mechanism by which risk reductions are delivered. In practice, most environmental programs reduce mortality risks for all persons in an exposed population: In other words, risk reductions are a public good. Johansson (1994) and Jones-Lee (1991) have shown, however, that when people exhibit pure altruism, maximization of net social benefits calls for equating the sum of individuals' marginal WTP to reduce risks to themselves to the marginal cost of the risk reductions.[8] Therefore, the appropriate measure of benefits is the sum of private WTP for reductions in risk.

[8] Whether counting benefits from altruistic behavior leads to double counting of benefits depends on the type of altruism being exhibited. If an individual is a pure altruist then he cares about his neighbor's preferences as well as his health and the altruistic benefits should not be counted in the benefit–cost analysis. That is, a pure altruist would realize that an increase in the scope of a program that raises the amount his neighbor would have to pay for the program would not increase his neighbor's utility. The rate at which the recipient is willing to substitute costs and benefits is already captured in his private WTP. If, however, the altruist exhibits paternalistic altruism, caring only for his neighbor's health and safety and not about his wealth, then it would be correct to include the altruist's WTP for the recipient's health/safety when determining the socially optimal level of health/safety (Jones-Lee 1991).

B. Avoiding Past Pitfalls

The failure of many contingent valuation studies to pass tests of internal and external validity may be traced to three types of problems:

1. Respondents may not understand the risk changes they are asked to value.
2. Respondents may not believe that the risk changes (or baseline risks) apply to themselves.
3. Respondents may lack experience in trading money for quantitative risk changes or lack the realization that they engage in this activity.

Our approach to dealing with each problem is described below.

Communication of Risk Changes. Our survey relies on a graph containing 1,000 squares to communicate probability of dying. White squares denote chances of surviving, red squares represent chances of dying. Reductions in the risk of dying are represented by changing red squares to blue.

Because we value annual risk changes on the order of 10^{-4}, the graph represents the chances of dying (surviving) over a 10-year period with risks on the order of 10^{-3}. The use of a 10-year period is motivated by two considerations. When respondents are told their baseline risk of dying over the next 12 months, they often believe that the risks do not apply to them. In focus groups, respondents more readily accepted baseline risks over longer periods. Secondly, the use of a 10-year period makes it possible to represent risks using 1,000 squares. In our questionnaire development, we found that respondents regarded grids with more squares (e.g., 10,000 or 100,000) confusing and tended to dismiss such small risk changes as insignificant.

Understanding of Risk Changes. Each respondent goes through the survey on a computer screen, at his own pace. We encourage respondents to think about changes in mortality risks by showing them side-by-side depictions of the risks with and without the product, and by asking them questions to test their understanding of how risks (and risk changes) are represented. If the respondent answers a question incorrectly, he or she is provided additional educational information and is asked an additional, similar question.

Harbaugh (1999) argues, however, that, even when people are nonpaternalistic altruists, it is appropriate to include some portion of their WTP into the calculation of the socially optimal amount of health/safety if it is cheaper to transfer the good to the recipient than it is to transfer cash. This situation is true for parental transfers to children.

Experience Trading Quantitative Risk Changes. Although most respondents engage in activities or purchase goods to reduce their risk of dying, they often fail to associate quantitative risk reductions with these activities. We acquaint respondents with the quantitative risk reductions associated with medical tests and products with which the respondent may be familiar (e.g., mammograms, colon cancer screening tests, and medicine to reduce blood pressure) prior to asking what he or she would pay for a product that will reduce risk of dying. In doing so, we keep the cost information provided to the respondent qualitative in nature (e.g., “expensive,” “moderate”, and “inexpensive”).

Communication of Payments. Tests in focus groups and one-on-one interviews suggested that payments for risk reductions should be made annually, over a 10-year period. We use graphs to convey the timing of the payments and the relationship between the timing of payments and risk reductions. This relationship is especially important when eliciting WTP today for a future risk reduction.

C. Survey Protocols

The survey instrument used in this project was developed over several years. The development effort included extensive one-on-one interviews in the United States, pretests in the United States and Japan, and several focus groups in Hamilton, Ontario, including one at a senior citizen recreation center, followed by another pretest.

Our survey was administered to 930 subjects in Hamilton, Ontario, in 1999. Thompson-Lightstone, a survey research firm headquartered in Toronto, administered the survey over a five-month period. Subjects were recruited by telephone through random-digit dialing and asked to go to a facility in downtown Hamilton to take the survey. Our target population consisted of persons between 40 and 75 years of age. One-third of the respondents was to be over age 60.

Clearly, because of our emphasis on recruiting respondents in the older age brackets, and because we asked people to go to a centralized facility, we cannot claim that our sample is representative of the population of Hamilton. However, our sample is still very similar to the population of Hamilton aged 40 to 75 years in many respects.

Table 2 provides descriptive statistics for our entire sample. The average age of respondents was 54 years old, with 31% of the sample above age 60 and 9% above age 70, which is consistent with our sampling plan. Although 80% of the sample completed high school, only 20% completed a university degree. (Average educational attainment was 10.3 years of schooling.) The average household income in our sample was approximately $58,000 (1999 C$), with median household income equal to $50,000 (1999 C$). The average individual in our sample is thus slightly wealthier and more educated than the average Hamilton resident, but is very similar to the average Ontario resident.[9]

Table 2. Characteristics of Respondents

Variable Name	Mean (standard deviation)		
	Wave 1 (N = 630)	Wave 2 (N = 300)	Total Sample (N = 930)
AGE IN YEARS	54.0 (10.2)	54.4 (10.4)	54.2 (10.3)
FEMALE	53%	56%	52%
YEARS OF EDUCATION	10.3 (3.11)	10.2 (3.25)	10.3 (3.11)
ANNUAL HOUSEHOLD INCOME (C$)	$58,896 ($35,596)	$57,446 ($33,103)	$58,425 ($35,487)
HAS SUPPLEMENTAL INSURANCE	32% percent	31.4%	32%
MENTAL HEALTH SCORE (1–100)	76.5 (16.8)	77.5 (15.6)	76.8 (16.4)
PHYSICAL FUNCTIONING SCORE (1–100)	81.1 (21.2)	82.2 (21.8)	81.4 (21.4)
BASELINE RISK OVER 10 YEARS (times 1,000)	122.6 (123.5)	122.5 (119.4)	122.6 (122.1)
HEART DISEASE	10.3%	8.3%	9.6%
HIGH BLOOD PRESSURE	19.4%	21.8%	20.2%
CANCER	4.1%	2%	3.4%
ASTHMA	11.3%	8.4%	10.3%
BRONCHITIS, EMPHYSEMA, OR CHRONIC COUGH	14.1%	13.7%	14%
SELF-ASSESSED YEARS BEFORE DEATH	26.0 (12.5)	26.2 (12.5)	26.1 (12.4)

Although Canada has universal health insurance, many people carry supplemental insurance. In our sample, 32% of respondents reported having additional insurance. Most

[9] This finding dispels our concern that the recruiting procedure enlisted only people with low values of time and low incomes.

respondents rated their health as very good to excellent, although 41% reported some chronic respiratory or heart disease. Only 4% had been hospitalized in the past five years.

The average index scores for physical and mental health taken from answers to the SF-36 questionnaire (84 and 77, respectively, out of 100) are also reported in Table 2. Although Canadian index scores for SF-36 are currently not available for comparison, the results suggest that our respondents are slightly below the U.S. national average for physical health, and slightly above it for mental health.

Still, our sample is very similar to the population of Hamilton aged 40 to 75 years with respect to the prevalence of chronic conditions. According to the National Population Health Survey, 8.9% of the Hamilton population suffered from heart disease in 1998 and 15.2% had high blood pressure. Similarly, 2.6% of the population had bronchitis or emphysema while 8.3% suffered from asthma. A total of 2% of the population aged 40 to 75 years reported having cancer (Stieb 2000).[10] These prevalence statistics are very similar to those reported for our sample.

Because of our need for travel to a centralized facility, response rates were low. Out of 17,841 residential phone contacts 8,260 were "cooperative," but 4,917 households proved ineligible for age reasons (there was no one in the household of ages 40 to 75 years). Among the 3,591 eligible households, 455 declined to participate because of mobility problems and 1,079 refused, stating that the incentive payment (C$35) was insufficient. 1,545 persons agreed to participate in the survey, but in fact only 930 of these (60%) kept their appointments. All persons who began the survey completed it, bringing our response rate to 26%.[11]

The survey was administered on a computer with a simplified keypad, which was color-coded and especially labelled for use with the survey (e.g., "Press the BLUE key to see the next screen."). Respondents moved through the survey at their own pace. Words on each screen appeared in large font and were read to the respondent by a voice-over.

[10] Prevalence statistics are also available from the Ontario Health Survey (OHS). Although in most cases, prevalence figures are similar to those provided in the National Population Health Survey, OHS reports a higher prevalence of bronchitis and emphysema (11.5 %) in Hamilton among the target age group for 1996.

[11] The response rate is calculated as the number of respondents successfully completing the study (930) divided by the number of eligible contacts (3,591).

D. Description of the Questionnaire

The questionnaire is divided into five parts. Part I introduces Resources for the Future, McMaster University, and Health Canada as sponsors of the survey and then elicits personal information, including health information about the respondent and his or her immediate family.

Part II introduces the subject to simple probability concepts through coin tosses and roulette wheels. The probabilities of dying and surviving over 10-year periods are then depicted using a 1,000-square grid. The respondent goes through simple exercises to become acquainted with our method of representing the probability of dying. The respondent is then shown two 25 by 40 grids: one for person 1, with 5 red squares (representing death), and one for person 2, with 10 red squares (see Figure 1). The respondent is asked to indicate which person faces the higher risk. If the respondent picks person 1, he or she is provided with additional information about probabilities and is asked again. The respondent is then asked which person he or she would rather be. Individuals responding “Person 2” (the person with the higher risk) are asked a followup question to verify this answer and are given the opportunity to change their answer if they wish. The baseline risk of death for a person of the respondent’s age and gender is then presented numerically and graphically.

Part III presents the leading causes of death for someone of the respondent’s age and gender. Common risk-mitigating behaviors are listed, together with the quantitative risk reductions they achieve and a qualitative estimate of the costs associated with them (“inexpensive,” “moderate,” and “expensive”). The purpose of this section is twofold. We wish, first, to acquaint the respondent with the magnitude of risk changes delivered by common risk-reducing actions and products (cancer screening tests, medication to reduce high blood pressure) and, second, to remind the respondent that such actions have a cost, whether out-of-pocket or not.

Part IV elicits WTP for risk reductions of a given magnitude, occurring at a specified time, using dichotomous choice methods. (Table 3 summarizes our survey design.) In one sub-sample (Wave 1), respondents are first asked if they are willing to pay for a product 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 (WTP5); that is, by 5 in 10,000 annually. In the second WTP question, risks are reduced by 1 in 1,000 (WTP1); that is, by 1 in 10,000 annually. In a second subsample (Wave 2),

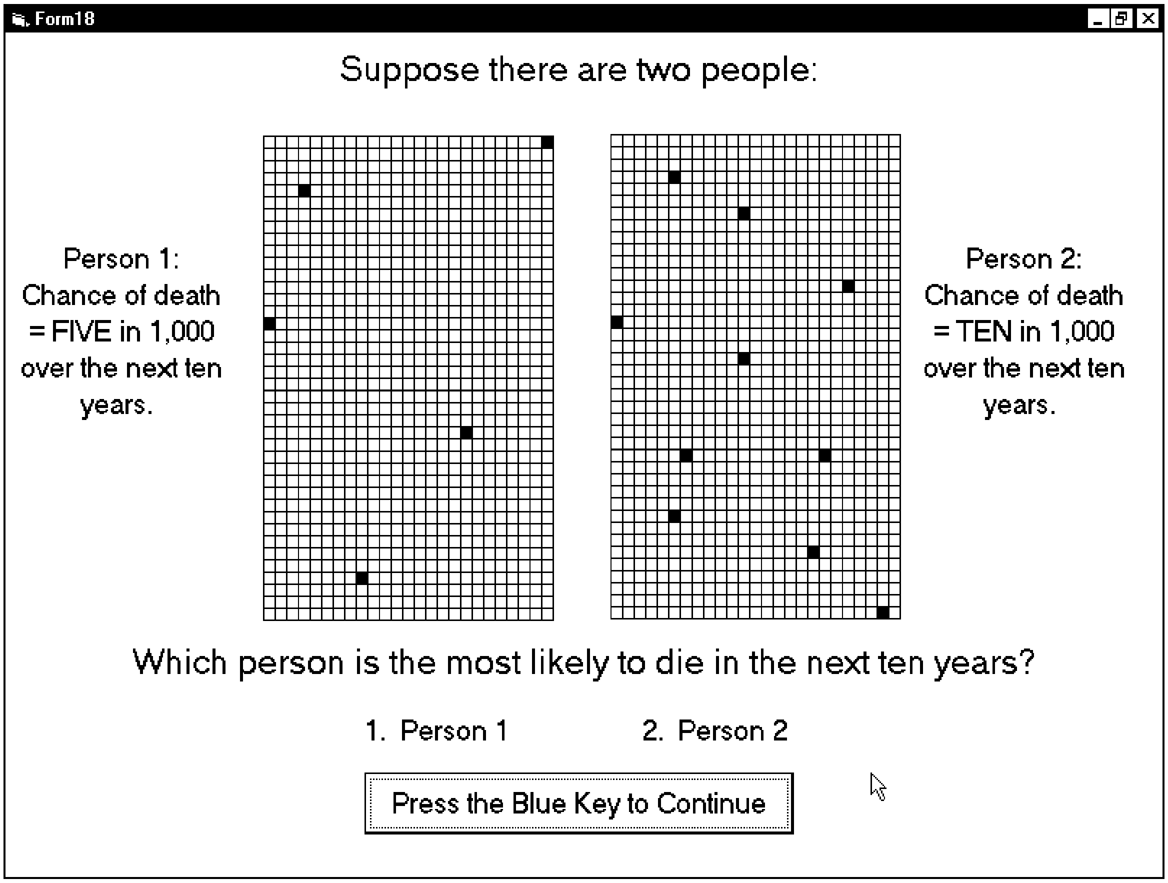

Figure 1. Use of Grids to Represent Probabilities in Mortality Risk Questionnaire

respondents are given the 1 in 1,000 risk change question first. Baseline risk is age- and gender-specific, and increases with age and for males. The baseline risks are shown as red squares on the 1,000-square grid. The red squares are first randomly scattered over the grid, and then grouped together. The risk reductions delivered by the products are shown by changing the appropriate number of squares from red to blue.

After the first two questions, respondents in both subsamples under age 60 years are asked their WTP over the next 10 years for a 5 in 1,000 risk reduction over 10 years beginning at age 70 years (WTP70). This question serves two purposes. First, it tests whether respondents are willing to pay anything today for a future risk reduction—what one would like to measure to value reduced exposure to a pollutant with a latency period. Second, it provides a test of internal consistency of responses because WTP today for a future risk change should be less than WTP today for an immediate risk change. This question is preceded by a question that asks the respondent to estimate his or her chances of surviving to age 70.

Table 3. Survey Design

Group of Respondents	Initial Risk Reduction Valued	Second Risk Reduction Valued	Future Risk Reduction Valued
Wave 1 (N = 630)	5 in 1,000	1 in 1,000	5 in 1,000
Wave 2 (N = 300)	1 in 1,000	5 in 1,000	5 in 1,000

Table 4 provides the bid structure used in the survey. Bids were selected to make sure that respondents would have the opportunity to provide answers that would imply VSL estimates that would not only exceed Health Canada's standard VSL of $5 million, but would also exceed U.S. EPA's central, default VSL estimate of $7.5 million (C$). All respondents were given followup dichotomous choice questions to obtain more information about WTP. All WTP dichotomous choice questions answered by "No–No" responses were followed by a question asking if the respondent is willing to pay anything at all and, if so, how much. With bids secured, respondents were then asked, on a 1 to 7 scale, their degree of certainty about their responses.

Table 4. Bid Structure in the Mortality Risk Survey (1999 C$)

Group of Respondents	Initial Payment Question	Followup Question (if "Yes")	Followup Question (if "No" or "Not Sure")
I	100	225	50
II	225	750	100
III	750	1100	225
IV	1100	1500	750

Part V asks an extensive series of debriefing questions, followed by some final sociodemographic questions (e.g., education and household income). The debriefing questions are used to identify respondents who had trouble comprehending the survey or did not accept the risk reduction being valued.

The computerized questionnaire is followed by a pencil-and-paper 36-question quality of life survey (Standard Form-36, abbreviated SF-36), which is used routinely in the medical community to gauge physical functionality and mental and emotional health states (Ware et al. 1997). The 36 health questions supplement those posed at the beginning of the interview and can be used to construct eight indices commonly used in the health literature. A brief description of each index and what it measures appears in Table 5.

Table 5. Definition of SF-36 Indices

Index Name	Label	Definition and Interpretation
Physical functioning	PF	Measures limitations in behavioral performance of everyday physical activities. Low score indicates limitations in performing all physical activities due to health. High score indicates that all types of physical activities are performed with no limitations due to health.
Role-physical	RP	Measures the extent of disability in everyday activities due to physical problems. Low score indicates problems with work or other daily activities resulting from physical health. High score indicates no problems with work or other daily activities as a result of physical health.
Bodily pain	BP	Measures the severity of bodily pain and resulting limitations in activities. Low score indicates very severe and extremely limiting pain. High score indicates no pain or limitations due to pain.
General health	GH	Bipolar scale measuring respondents' perceived general health. Low score indicates respondent evaluates personal health as poor and believes it is likely to get worse. High score indicates the respondent evaluates personal health as excellent. Midrange score indicates that no unfavorable evaluations of health were reported.
Vitality	VT	Bipolar scale measuring energy level and fatigue. Mid-range score indicates that the respondent does not report feeling tired or worn out. Score = 100 indicates that in addition, respondent feels full of pep and energy all of the time.
Social functioning	SF	Measures the impact of either physical or emotional problems on the quantity and quality of social activities. Low score indicates extreme and frequent interference with normal social activities due to physical or emotional problems. High score indicates respondent performs normal social activities without interference due to physical or emotional problems.
Role-emotional	RE	Measures the extent of disability in everyday activities due to emotional problems. Low score indicates problems with work or other daily activities resulting from emotional problems. High score indicates no problems with work or other daily activities as a result of emotional problems.
Mental health	MH	Bipolar scale measuring mental health status. Midrange score indicates respondent reports no symptoms of psychological distress. Score = 100 indicates respondent reports frequently feeling happy, calm, and peaceful.

Source: Ware et al. (1997).

4. Results

Before presenting respondents' WTP for risk reductions, we describe respondents' ability to deal with probability concepts. We also present evidence that most respondents appeared to find the "abstract" valuation scenario in the questionnaire reasonable. This presentation is followed by a summary of WTP responses and their implied VSLs. The section concludes with external scope test results and examines the impact of age and health status on WTP responses.

A. Risk Comprehension

The statistics in Table 6 refer to questions testing comprehension of risks, listed in order from the weakest to the most stringent tests. The probability test question asks respondents which person, 1 or 2, has the higher risk of death, when risks are represented by using darkened squares on a grid. The probability choice question asks respondents which one of these people they would rather be. Whereas 11.5% and 13% of the respondents chose the "wrong person" in these questions, only 2.6% of the sample failed both tests. About 1% of the sample preferred to be the person with the higher risk in both the test and the retest. In a question at the end of the survey, 7% of respondents assessed their understanding of chance as fair to poor.

Table 6. Descriptive Statistics: Risk Comprehension

Percent of respondents who…	**Wave 1 (N=630)**	**Wave 2 (N=300)**	**Total Sample (N=930)**
Chose wrong person in probability test	11	13	12
Chose wrong person in the probability choice	12	16	13
Chose wrong person in probability test and wrong person in the probability choice	2	3	3
Confirmed wrong person in probability choice	1	2	1
Selected 3 or less in self-assessed understanding of probability (1=does not understand at all; 5=has excellent understanding of probability)	7	7	7

B. Understanding/Acceptance of the Scenario

Table 7 reports statistics on the percentage of respondents who questioned assumptions made in the survey or said they did not understand the scenario presented to them. On debriefing, 20% of respondents did not think that the baseline risk of death given in the survey applied to them. Thirty-one percent of the sample did not believe our abstract product would work, but only 20% said this belief affected their WTP, with most (17%) saying they bid less because of it. Side effects were expected by 25% of the sample, an effect that may potentially lower WTP. Forty percent of the sample thought the product would provide benefits in addition to reducing mortality risk, and 20% of the sample stated that these other benefits increased their WTP.

Table 7. Descriptive Statistics: Scenario Acceptance

Percent respondents who…	**Wave 1 (N=630)**	**Wave 2 (N=300)**	**Total Sample (N=930)**
Did not believe the stated risks applied to them	19	22	20
Had doubts about the product's effectiveness	30	31	31
Had doubts about the product's effectiveness, and said doubts affected WTP	20	20	20
Thought product might have side effects	26	23	25
Thought about other benefits of the product	40	38	40
Said other benefits influenced WTP	21	19	20
Did not understand the payment scheme	12	15	13
Did not consider whether they could afford the payment	23	27	26

We believe that it is an empirical matter whether beliefs about product efficacy, side effects, or nonmortality benefits affect WTP. We therefore investigate the impact of these responses below by including them as regressors in an equation to explain WTP. [12] The answer to the last two questions in Table 7 are also used as regressors in explaining WTP.

[12] See Table 10 for more detail.

Regarding the payment for the life-extending product, 13% of the sample professed not to understand the payment scheme, whereas 26% of the sample said they did not think about affordability when they answered. As will become clear below, this response does not mean that subjects ignored their income constraints and reported excessively large WTP amounts. Instead, we found that this type of response is very common among people who are not willing to pay anything at all for a product. Because this dummy variable enters WTP regressions with a negative sign, we think that most people who so answered this debriefing question did not bother to consider income constraints because they had no intention of buying the product.

C. WTP Responses: Current Risk Reductions

When respondents are asked to value several "commodities" within an interview, WTP tends to be affected by the order in which the commodities are presented. Our survey is not exempt from this effect; hence we analyze WTP for only the first risk reductions presented in the questionnaire (see Table 3).[13] Therefore, for respondents in wave 1 and wave 2, we examine WTP for risk reductions equal to 5 in 1,000 and 1 in 1,000, respectively.

We depict the proportion of "yes" responses to the initial payment questions in Figure 2. The figure indicates that in both waves the proportion of "yes" responses falls for higher initial bids, and that the proportion of "yes" responses is higher at all bids for the 5 in 1,000 risk change than for the 1 in 1,000 risk change. This finding suggests that responses are consistent with economic theory, and that WTP is sensitive to the magnitude of the risk reduction.[14]

Figure 3 shows the percentage of respondents choosing each of the possible response options ("yes," "no," and "not sure") for the initial payment question, and the 5 in 1,000 risk reduction. Whereas the percentage of "yes" responses declines with the initial bid, the percentages of "no" and "not sure" responses rise with the initial bid amount.

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[13] Those respondents who received the 1 in 1,000 risk reduction first (wave 2) exhibit higher WTP than those respondents who received it as the second risk reduction in the questionnaire (wave 1). Because Tables 2, 6, and 7 show clearly that the two waves of respondents are very similar in terms of demographics, probability comprehension, and acceptance of the life-extending product, and thus represent similar populations, we conclude that the effect noted above is questionnaire-induced.

[14] The percentage of "yes" responses declines as the bid increases for the 1 in 1,000 risk reduction, except at the initial bid amount of C$1,100, where it is virtually the same as that for the initial bid amount of C$750 (19.67% vs. 19.32%, respectively).

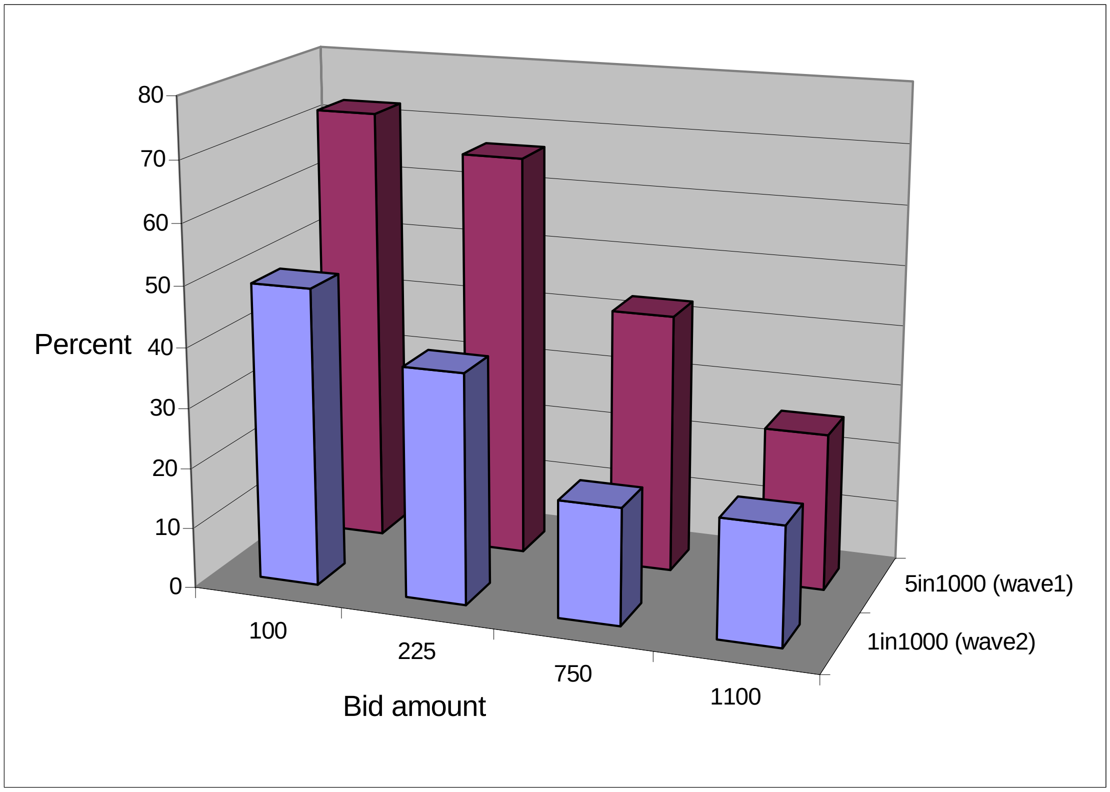

Figure 2. Percentage of "Yes" Responses to the Initial Payment Question

This finding prompted us to check whether it is reasonable to interpret the "not sure" responses as "no" responses for the purpose of statistically modeling WTP. We fit a multinomial logit model to predict the probability that the respondent chooses one of these three response categories as a function of respondent characteristics and a vector of coefficients that are specific to each response category.[15] We present two specifications of this model in the Appendix (Tables

[15] A multinomial logit model presumes that the respondent picks the response category associated with the highest utility level. Formally, $U_{ij} = \mathbf{x}_i \beta_j + \varepsilon_{ij}$, where *i* (*i* = 1, 2, …n) indexes the respondent, *j* (*j* = 1, 2, 3) indexes the response categories, *U* is the utility level, **x** is a vector of individual characteristics, β is a vector of coefficients, and ε is an i.i.d. error term that follows the type I extreme value distribution. It can be shown that the probability that response option *k* is chosen by the respondent is equal to $\exp(\mathbf{x}_i \beta_k) \Big/ \sum_{j=1}^{3} \exp(\mathbf{x}_i \beta_j)$.

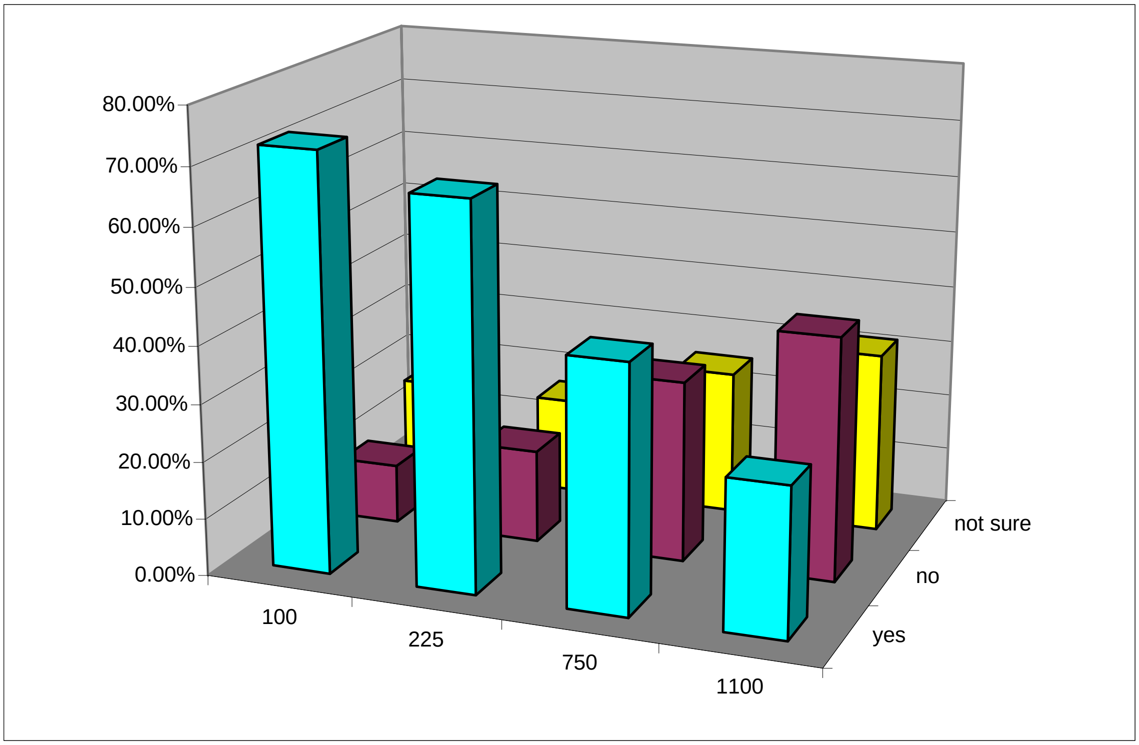

Figure 3. Responses to the Initial Payment Question: Wave 1, 5 in 1,000 Risk Reduction

A.1 and A.2) for the response to the initial payment question of the 5 in 1,000 risk reduction. The specification of Table A.1 focuses on individual characteristics of the respondents, whereas that of Table A.2 focuses on scenario acceptance and understanding of probabilities. In both tables, the likelihood of answering "no" or "not sure" increases with the bid, and a Wald test does not reject the null hypothesis that the coefficients of the bid variable are the same for both response categories. Carson et al. (1998) interpret this finding as indicating that "not sure" and "no" responses can be pooled together and treated as "no" in statistical models of WTP.

Respondents who said "no" to both initial and followup bids were asked whether they were willing to pay anything at all for the product delivering the risk reduction. The fraction of respondents refusing to pay for the product was 19.4% for the 5 in 1,000 risk reduction (wave 1) and 36.8% for the 1 in 1,000 risk reduction from wave 2. Although it is comforting that the percent of zeros is smaller for the larger risk reduction, these numbers are large but not very different from those seen in earlier CV studies about risk reductions.

To identify reasons for not paying anything at all, we estimated a probit model to explain zero WTP for the 5 in 1,000 risk reduction for wave 1. As Table A.3 indicates, there is no particular association between zero WTP and individual characteristics, with the exception of the mental health score from SF-36. People with lower mental health scores are more likely to hold zero WTP values for the risk reduction. People with zero WTP decline to pay anything at all for the product without even considering whether they can afford the payments.

D. WTP and VSL Estimates: Current Risk Reductions

With three rounds of payment questions, we can form three different sets of estimates for mean WTP. For all sets of estimates, we recode "not sure" responses as "no" responses.

The first set of estimates utilizes only the responses to the initial payment questions and is thus safe from undesirable response effects sometimes observed in the presence of followup questions (Herriges and Shogren 1996, Alberini et al. 1997). To keep our estimates of mean WTP distribution-free and conservative, we apply the lower-bound Turnbull estimation technique described in Carson et al. (1994).[16]

The second set of estimates combines the responses to the initial payment questions with the responses to the followup questions and forms so-called double-bounded intervals around each respondent's (unobserved) WTP amount. Here, we specify a distribution for the underlying WTP variable, where θ is a vector of parameters, and form the log likelihood function

(1) $$\log L = \sum_{i=1}^{n} \log[F(WTP_i^H;\theta) - F(WTP_i^L;\theta)]$$

[16] Our Turnbull estimator uses the responses to the first payment question in the different subsamples to compute the relative frequencies of various WTP intervals. Here, the five intervals created by the four initial bids are: (1) C$0 to C$100; (2) C$100 to C$225; (3) C$225 to C$750; (4) C$750 to $1,100; and (5) C$1,100 to infinity. The lower-bound nonparametric Turnbull mean is computed by assuming that the fraction of the sample estimated to be in each interval has a WTP value equal to the lower bound of the interval, and then obtaining the ordinary sample mean. To illustrate, consider the responses to the WTP question for the 5 in 1,000 risk reduction provided by respondents in wave 1. The percentage of respondents willing to pay C$100 was 72.56, those willing to pay C$225 were 66.87% of those asked, and the percentages willing to pay C$750 and C$1,100 were 42.96% and 25.95%, respectively. This is taken to imply that the densities (i.e., change in cumulative probability) associated with the intervals (0, 100), (100, 225), (225, 750), (750, 1,100) and (1,100, infinity) are (in order) 0.2744, 0.0569, 0.2391, 0.1701, and 0.2595. Denoting these densities as p_j, we compute our lower-bound mean WTP as $\sum_{j=1}^{5} B_j \cdot p_j$, where $\{B_j\}$={0, 100, 225, 750, 1,100}.

where WTP^H and WTP^L denote the upper and lower bounds around respondent *i*'s WTP amount. Once the parameters θ have been estimated using the method of maximum likelihood, mean (and median) WTP can be computed, exploiting the properties of the distribution of WTP. We choose to work with the Weibull distribution because of its flexible shape.[17] We note that further information available from the third round of questions (which reveal whether a respondent has zero WTP or holds a positive, but small, value for the risk reduction) is ignored with this estimation procedure. We regard the estimates of mean WTP from this procedure as "generous," because a person who answered "no" to the initial and followup questions, but later revealed an unwillingness to pay anything at all, is still interpreted as having WTP between 0 and the value offered in the followup question.

The third and final set of estimates utilizes the most complete information available about a respondent's WTP, explicitly allowing respondents to hold zero WTP values. Because zero WTP values are numerous, the appropriate statistical framework is an interval data/continuous data variant of the tobit model, also known as the "spike" model (Kriström 1997). We adapt the tobit/spike model to the present sample, which includes a mix of zero WTP, continuous observations, and interval data, working with the normal distribution for WTP. The contributions to the likelihood are:

$$\frac{1}{\sigma}\phi\left(\frac{WTP_i-\mu}{\sigma}\right) \tag{2}$$

for positive WTP observed on a continuous scale;

$$\Phi\left(\frac{0-\mu}{\sigma}\right) \tag{3}$$

for those respondents who are not willing to pay anything at all for the product; and

$$\Phi\left(\frac{WTP_i^H-\mu}{\sigma}\right)-\Phi\left(\frac{WTP_i^L-\mu}{\sigma}\right) \tag{4}$$

[17] In practice, we compared the fit of the Weibull distribution with that of a lognormal distribution and found that they were very close. The estimates of median WTP produced by these two distributions were very similar, but the estimates of mean WTP were rather different. We prefer to rely on the Weibull distribution when forming estimates of mean WTP, based on prior experience with the performance of this distribution when interval data are used (Alberini 1995).

for all other respondents.

Mean WTP is computed by integrating the survival function (i.e., one minus the cdf), which displays a spike at zero, with respect to the bid from zero to infinity (Kriström, 1997).

As shown in Table 8, mean WTP for a 5 in 1,000 risk reduction taking place over the next 10 years ranges from $361 to $726 (1999 C$) a year depending on the model used. Because it is based on the most complete information available, our preferred estimate is the one obtained by using the Kriström spike model, and is $601 (1999 C$) a year. The corresponding figures for the 1 in 1,000 risk reduction are $272 to $450, with our preferred estimate of mean WTP equal to $368 per year.

Wald tests show that—regardless of the estimation procedure used—mean WTP for the 5 in 1,000 risk reduction is statistically greater than mean WTP for the 1 in 1,000 risk reduction. In other words, our estimates pass the external scope test and prove sensitive to the size of the risk reduction.[18] It is also clear from Table 8 that WTP is not proportional to the size of the risk reduction: Mean WTP for the 5 in 1,000 risk reduction is much less than 5 times mean WTP for the 1 in 1,000 risk reduction.[19]

The WTP figures can be used to compute the corresponding VSL. We computed VSL by dividing annual WTP by the size of the annual risk reduction (5 in 10,000 or 1 in 10,000).[20] Because the hypothesis of proportionality is violated, VSL changes with the size of the risk reduction and is always greater when WTP for the 1 in 10,000 risk reduction is used in the calculation. The respective VSLs, also reported in Table 8, range from $722,000 (1999 C$) to $4.5 million (1999 C$), below or equal to the age-adjusted VSL used by Health Canada and well below the official $7.5 million (1999 C$) figure used by U.S. EPA.

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[18] The Wald statistics are 8.66 for the conservative estimates based on the responses to the initial question, 12.98 for the double-bounded estimates based on the Weibull distribution, and 33.64 for the estimates from the spike model.

[19] We formally tested the hypothesis of proportionality using Wald tests. The Wald tests for each of the three sets of estimates are equal to 65.99 for the conservative procedure, 26.37 for the Weibull double-bounded model, and 72.27 for the estimates of mean WTP based on the spike model. The null hypothesis of proportionality is thus soundly rejected for all models at the 1% significance level or better.

[20] The VSLs are calculated assuming that the risk change is evenly distributed over the 10-year period. Because the payment and the risk change are discounted over the same period using the same discount rate, the choice of discount rate in this scenario is irrelevant.

Table 8. Mean WTP for Current Risk Reductions and Implied Value of Statistical Life Entire Sample (N = 930), 1999 C$

Risk Reduction	"Conservative" WTP Estimates: Lower-Bound Turnbull (nonparametric)		"Generous" WTP Estimates: Weibull Double-Bounded Model		Most Information about WTP: Kriström's Spike Model (normal distribution)	
	Mean WTP	VSL	Mean WTP	VSL	Mean WTP	VSL
5 in 1,000 (wave 1)	361 (17.6)	722,000	726 (49.7)	1,452,000	601 (28.1)	1,202,000
1 in 1,000 (wave 2)	272 (24.4)	2,272,000	450 (58.4)	4,496,000	368 (28.6)	3,684,000

Notes: Standard errors in parentheses. VSL is computed using annual WTP, divided by the annual risk reduction (5 in 10,000 and 1 in 10,000). "Not sure" responses are interpreted as "no" answers.

It should be noted that all respondents are included in Table 8, regardless of their performance on our probability tests. In Table 9, mean WTP is computed after dropping respondents who failed to correctly identify the person with the higher risk of death from the graphs presented at the beginning of the survey and who insisted that they would rather be the person with the higher risk of death. This adjustment reduces the size of wave 1 from 630 to 611 respondents and wave 2 from 300 to 288 respondents.

Use of the cleaned sample has little effect on estimates of the VSL when our preferred model, the spike model, is used: The VSL remains $1.2 million (1999 C$) for the 5 in 10,000 annual risk change and $3.8 million for the 1 in 10,000 annual risk change. When the Turnbull or Weibull models are used, the VSL is, with one exception, larger with the cleaned sample. Other, more stringent data-cleaning criteria were also applied but, as shown in Table 10, they had very little effect on mean WTP estimates.

Table 9. Mean WTP for Current Risk Reductions and Implied Value of Statistical Life, Cleaned Sample*, 1999 C$

Risk Reduction	"Conservative" WTP Estimates: Lower-bound Turnbull (nonparametric)		"Generous" WTP Estimates: Weibull double-bounded model		Most information about WTP: Kriström's Spike Model (normal distribution)	
	Mean WTP	VSL	Mean WTP	VSL	Mean WTP	VSL
5 in 1,000 (wave 1) N = 611	470.92 (27.66)	941,840	725.53 (52.30)	1,450,000	597.65 (27.66)	1,196,000
1 in 1,000 (wave 2) N = 288	269.02 (24.96)	2,690,200	463.43 (60.15)	4,630,000	376.11 (28.67)	3,790,000

Notes: Standard errors in parentheses. VSL is computed using annual WTP, divided by the annual risk reduction (5 in 10,000 and 1 in 10,000). "Not sure" responses are interpreted as "no"answers.
* The data are subject to the base level of cleaning (Level A, see Table 10). In addition, respondents who gave the wrong response to the probability test and wished to be the person with the higher probability of death in the probability choice question (FLAG1 = 1) are excluded from this sample.

Table 10. Sensitivity of Mean WTP for Current Risk Reductions to the Data-Cleaning Criteria–Spike Model

Data-Cleaning Criteria	Mean WTP for the 5 in 1,000 Risk Reduction (s.e.) [Wave 1]	Mean WTP for the 1 in 1,000 Risk Reduction (s.e.) [Wave 2]
Level A = Minimum data cleaning	600.78 (25.88) n = 625	368.43 (29.89) n = 298
Level A + (Drop if flag1 = 1)	597.66 (25.75) n = 611	376.11 (29.51) n = 286
Level A + (Drop if flag4 = 1 and flag5 = 1)	597.44 (24.29) n = 615	373.21 (30.07) n = 288
Drop if flag1 = 1 or flag2 = 1 or flag3 = 1 or flag4 = 1 or flag6 = 1	593.05 (28.41) n = 524	386.16 (34.06) n = 247

Level A = drop respondents that answer the followup, open-ended question on WTP with an amount greater than the lowest bid previously received. For instance, a person who would not pay C$ 225 and would not pay $100 but, when probed in an open-ended fashion, would pay $300 is excluded from the sample.

Flag1 = 1 if respondent answers the first probability test incorrectly and shows preference for having the higher risk of death.

Flag2 = 1 if respondent answers the probability test incorrectly and initially shows preference for having the higher risk of death, but changes preference selection when asked to confirm.

Flag3 = 1 if respondent shows preference for having higher risk of death.

Flag4 = 1 if respondent answers both probability tests incorrectly.

Flag5 = 1 if respondent shows preference for higher risk of death even after followup.

Flag6 = 1 if respondent claims to not understand probability well.

To summarize, even with cleaned data, the estimates of WTP from our study show good sensitivity to the size of the risk reduction but do not exhibit proportionality with respect to the size of the risk reduction. The corresponding VSLs are generally lower than those used by the Health Canada and the U.S. EPA in benefit–cost analyses.

This finding remains true when the sample is partitioned into two groups consisting of those respondents who were sure of their WTP responses and of those respondents who did not feel confident, respectively, as shown in Table 11. We note, however, that degree of confidence acts in opposite ways in the two samples. Those in wave 1 who were more certain of their responses were WTP more that those who were less certain, but the opposite result was found for those in wave 2.

Table 11. Mean WTP by Certainty Level with Which Respondents Answered the Payment Questions (standard errors in parentheses, cleaned data*)

Risk Reduction	**Mean WTP**		
	All Respondents	**Respondents with High Confidence (Certainty = 6 or 7)**	**Respondents with Less Confidence (Certainty <6)**
5 in 1,000 (wave 1)	597.65 (27.66) n = 611	764.03 (62.55) n = 265	518.66 (28.43) n = 346
1 in 1,000 (wave 2)	376.11 (28.67) n = 288	361.51 (49.16) n = 137	397.17 (37.51) n = 151
Mean WTP for 5 in 1,000 Divided by Mean WTP for 1 in 1,000 Risk Reduction	1.59	2.11	1.30
Wald Test of Null Hypothesis of Proportionality**	16.93	59.82	77.21
Accept or Reject null?	Reject at all conventional levels	Reject at all conventional levels	Reject at all conventional levels

* The data are subject to the base level of cleaning (Level A, see Table 10). In addition, respondents who gave the wrong response to the probability test and wish to be the person with the higher probability of death in the probability choice question (FLAG1 = 1) are excluded from this sample.
** Under the null, the Wald statistic is distributed as a chi square with one degree of freedom.

E. Sensitivity of WTP to Age and Health Status: Current 5 in 1,000 Risk Reduction

If the avoided mortality benefits of reduced pollution are experienced primarily by older people and people in poor health, are their WTP amounts different from those held by younger and healthier individuals?

To answer this question, we estimated several models in which WTP is regressed on age and health status variables, while controlling for factors such as income and education, probability comprehension, and acceptance of the risk reduction delivery scenario. In Tables 12 and 13 we present results of the spike model, estimated using our preferred cleaning procedure (which excludes respondents with FLAG = 1) and wave 1 observations. The coefficients of the variables entered in the model should be interpreted as indicating the effect that a change in one variable has, all else unchanged, on unconditional median WTP.[21]

Table 12, which refers to the 5 in 1,000 risk reduction, shows the effect of age in three model specifications. In model 1, we impose a linear relationship between age and WTP, while in model 2 we specify a quadratic function. Simple age-group dummies are entered in model 3 to allow for greater flexibility in the relationship between age and WTP.

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[21] Mean WTP is a nonlinear function of the regression coefficients. For respondent *i*, mean WTP is $\Phi(\mathbf{x}_i\beta/\sigma)\cdot\left[\mathbf{x}_i\beta+\sigma\frac{\phi(\mathbf{x}_i\beta/\sigma)}{\Phi(\mathbf{x}_i\beta/\sigma)}\right]$, where ϕ and Φ are the standard normal pdf and cdf, respectively, **x** is the vector of regressors and β is the vector of regression coefficients.

Table 12. Internal Validity of WTP: 5 in 1,000 Risk Change, Wave 1, Spike model, Cleaned Data (N = 600)

Variable	Coefficient (t-statistic)		
	Model 1	Model 2	Model 3
Intercept	475.25 (.67)	–1060.79 (–1.08)	198.09 (.67)
Age	–2.52 (.84)	54.61 (1.53)	--
Age squared	--	–.51 (–1.61)	--
Ages 40 to 50	--	--	207.55** (2.04)
Ages 51 to 60	--	--	255.10** (2.38)
Ages 61 to 70	--	--	253.32** (2.29)
Male	–36.23 (–.60)	–31.94 (–.53)	–33.13 (–.55)
Bottom 25% of distribution of income in the sample (dummy)	–220.12** (–3.03)	–208.78** (–2.88)	–205.47** (–2.84)
Education (Years of Schooling)	–12.74 (–1.26)	–13.73 (–1.37)	–13.68 (–1.36)
Chronic Illness Dummy	2.35 (.04)	1.25 (.02)	6.60 (.11)
Mental health score	4.56** (2.54)	4.54** (2.54)	4.62** (2.59)
Does not believe risk figures	–61.68 (–.79)	–57.85 (–.75)	–61.85 (–.80)
Other benefits	241.51** (3.88)	237.61** (3.83)	235.38** (3.80)
Did not consider if he can afford payments	–386.79** (–5.46)	–394.86** (–5.57)	–398.65** (–5.63)
Did not understand timing of payments	108.91 (1.22)	100.30 (1.13)	102.38 (1.15)
Scale parameter	651.62** (22.44)	649.24** (22.43)	647.59** (22.90)
Log likelihood	–1308.09	–1306.80	–1305.18

Note: ** indicates significance at 5% level.
The data are subject to the base level of cleaning (Level A, see Table 10). In addition, respondents who gave the wrong response to the probability test and wished to be the person with the highest probability of death in the probability choice question (FLAG1 = 1) are excluded from this sample.

When our preferred data cleaning protocol is implemented, WTP does not change in either a linear or quadratic fashion with age. The results of specification 3 show that median WTP is similar across age groups up to about 70 years of age, but is lower for persons aged 70 years and older (C$198). One problem with this specification is that the estimated intercept, which captures respondents aged 70 years and older, is not significant, probably as a result of the low number of respondents in this age group.

In Table 13, we calculate mean WTP for each age group by separating the data by the age of the respondent, and fitting to each subsample a tobit/spike model that includes only the intercept. Table 13 shows that mean WTP is about C$583 among the younger respondents in our sample (ages 40 to 49). It is higher for respondents in the 50 to 59 year-old, and 60 to 69 year-old, groups, but virtually indistinguishable between these two age groups (about $657 for both). Finally, the oldest respondents (aged 70 and older) report mean WTP of about $417. A Wald test shows that this latter figure is different from those for the immediately preceding age groups as well as that from the 40 to 49 year-olds.[22]

When this estimation procedure is repeated using only two broad age categories (older and younger than 65 years), the tendency of older people to report lower WTP values remains; however, the difference in mean WTP across the two age groups is not significant. The appropriate Wald statistic is 2.89, failing to reject the null hypothesis at the 1% and 5% levels.

When the tobit/spike regression models of Table 12 are repeated for different data-cleaning criteria, the results are generally similar. The only difference we noticed is that, when a relatively stringent cleaning criterion is used (excluding respondents who admit poor understanding of the concept of probability and, as before, fail the probability test and choice questions), the coefficients of age and age squared become strongly significant, providing evidence of an inverted U-shaped function relating WTP with age. The peak WTP value is reached at age 57, but the curvature of the inverted-U curve is not very pronounced, confirming that the impact of age is modest.[23]

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[22] The Wald statistics are equal to 8.64, 8.97, and 6.44 respectively, and thus fall in the 1% rejection region for the chi square with one degree of freedom.

[23] In practice, we believe that the results from the specification that is quadratic in age should be interpreted with care because of the very high linear dependence between age and age square over the range of ages of our respondents.

Table 13. Mean WTP by Age. Predictions Based on Cleaned Data, Wave 1

Age Group	Predicted Mean WTP (1999 C$)	Standard error of prediction (1999 C$)
Ages 40–49 (N = 260)	582.82	35.63
Ages 50–59 (N = 165)	656.88	58.37
Ages 60–69 (N = 120)	657.83	60.87
Ages 70 and over (N = 66)	417.99	54.30
Less than 65 (N = 494)	617.19	30.22
65 and over (N = 117)	514.69	52.15

Of particular interest are the coefficients of variables measuring health status. The dummy for the presence of a chronic condition (any one of high blood pressure, chronic heart disease, asthma, cancer, or bronchitis, emphysema, or persistent cough) has a small, positive coefficient (6.60), but the associated t-statistic is very low (.11).

Rather than collapsing the presence of any such chronic illness into a single indicator, it is also possible to form separate dummies, one for each condition, and enter them in the regression (alone or in various combinations). The results of these specifications are presented in the Appendix, Table A-4. In short, we found that most of the individual chronic-condition dummies failed to produce statistically significant results.

There is some evidence that having cancer may raise WTP for higher probability of survival. The coefficient of the cancer dummy is significant at the 8% level, and both its magnitude and the significance level are robust to the inclusion of the mental health score and the use of age and age squared in lieu of age group dummies. The presence of cancer raises median WTP by C$258 to C$269 (depending on the specification), holding the values of the other regressors unchanged.

The representative person with cancer is older than the remainder of the sample (62.4 v. 53.7 years old), more likely to be a female, slightly less educated, and much *less* likely to question the risk figures presented to them in the questionnaire, but similar to respondents not affected by cancer in most other respects. Using the estimated coefficients from a "spike" model similar to that in Table 8, specification 3, and including the cancer dummy, we predict that a person with these characteristics *and* cancer would be willing to pay, on average, C$837.02 (standard error 156.87). A person with these characteristics but no cancer holds mean WTP values of C$568.33 (s.e. 66.86). The Wald statistic for the null hypothesis of no difference between these two mean WTP is 2.48 (P-value=0.11). The two mean WTP figures might exhibit a statistically stronger difference if we had more than 26 respondents who reported having cancer (4% of wave 1).

This result is potentially very interesting for policy purposes, since it has been suggested that persons with cancer might hold different values for mortality risk reduction than the rest of population, but it is unclear whether such values should be higher or lower. However, it is important to keep in mind that our survey respondents—even if they had cancer—were functional and mobile enough to go to a centralized facility to participate in the survey. Had they been bed-ridden and unable to travel, their WTP values may have been lower.

Similar results were obtained when we replaced the chronic illness variable with a measure of the physical health score from the SF-36 questionnaire, and when we included the chronic illness dummy and the physical health score in the regression (see Table A-5 in Appendix 4). By contrast, the variable measuring the SF-36 mental health score has a positive coefficient that is significant at the 1% level. The estimated coefficient implies that every additional point for the mental health score raises median WTP by almost C$4.50. As described previously in Table 4, the mental health score is bipolar and measures an individual's mental health function and well-being. A median score indicates the absence of psychological distress, whereas a score of 100 indicates that the respondent reports feeling peaceful, happy, and calm all of the time. It stands to reason that the happier the respondent feels about life, the more he or she should be willing to pay for an increase in the chance of survival. Another related variable, the SF-36 role-emotional score, which is strongly related to the mental health score, is marginally significant at the 5% level.

F. Other Determinants of WTP for the Current 5 in 1,000 Risk Reduction

As illustrated in Table 12, males tend to have lower WTP, but this effect is not statistically significant. Being in the lowest quartile of the income distribution significantly reduces median WTP by about C$205. Somewhat surprising is that people with higher educational attainment seem to hold lower values for the risk reductions, but this effect is insignificant.

Table 12 also includes dummy variables that measure respondent acceptance of the scenario. It is comforting that the WTP of people who did not believe baseline risks does not differ systematically from that of people who did. This result suggests that people accepted the questionnaire's request to make decisions and answer questions "as if" the risk figures applied to them, even though the respondent may have privately disagreed with them.

Those persons who thought of "other benefits" of the product (presumably, improved quality of life) have median WTP values for mortality benefits that exceed pure mortality benefits by C$235. Finally, confirming earlier results, we find that WTP is remarkably lower for people who did not even consider whether they could afford the product—having already ruled out that they would purchase it.

G. WTP for the Current 1 in 1,000 Risk Reduction

The regression results for the smaller risk reduction (1 in 1,000) using the same three model specifications are reported in Table 14 for wave 2 respondents. The most striking result is that, of our many regressors, only one—the dummy indicating whether respondents were considering whether they could afford the payment—is significant.

Table 14. Internal Validity of WTP: 1 in 1,000 Risk Change, Wave 2, Spike model, Cleaned Data (N = 286)

Variable	Coefficient (t-statistic)		
	Model 1	Model 2	Model 3
Intercept	–246.16 (–.67)	1012.95 (.66)	162.31 (.50)
Age	5.15 (1.06)	–42.08 (–.75)	--
Age squared	--	.42 (.84)	--
Ages 40 to 49	--	--	–170.38 (–.97)
Ages 50 to 59	--	--	–220.49 (–1.20)
Ages 60–69	--	--	–111.53 (–.62)
Male	–151.56 (–1.64)	–150.02 (–1.63)	–157.93 (–1.71)
Bottom 25% of distribution of income in the sample (dummy)	–36.71 (–.34)	–34.44 (–.32)	–32.85 (–.30)
Education (years of schooling)	11.62 (.78)	13.28 (.88)	13.50 (.89)
Chronic illness dummy	10.71 (.11)	7.25 (.07)	21.57 (.22)
Mental health score	2.27 (.79)	2.13 (.68)	2.24 (.78)
Does not believe risk figures	–90.02 (–.81)	–92.49 (–.83)	–88.34 (–.80)
Other benefits	133.27 (1.45)	142.89 (1.55)	139.67 (1.52)
Did not consider affordability of payments	–417.71** (–3.95)	–416.24** (–3.94)	–413.04** (–3.90)
Did not understand timing of payments	–79.46 (–.64)	–83.51 (–.68)	–87.73 (–.71)
Scale parameter	666.79** (14.43)	665.77** (14.43)	665.46** (14.43)
Log likelihood	–632.72	–632.37	–632.47

Note: ** indicates significance at 5% level.
The data are subject to the base level of cleaning (Level A, see Table 10). In addition, respondents who gave the wrong response to the probability test and wished to be the person with the highest probability of death in the probability choice question (FLAG1 = 1) are excluded from this sample.

Age appears to have the opposite effect on WTP when compared with the results for the 5 in 1,000 risk reduction reported previously, but its coefficient is not statistically significant in any of the three model specifications. Gender is significant or almost significant at the 10% level with males willing to pay amounts approximately C$150 lower than females. Education also appears to have the opposite effect on WTP compared with that reported for the larger risk reduction but, once again, the coefficient of this variable is not statistically significant. With the exception of the dummy that indicates whether the respondent failed to understand the timing of payments, all of the dummies constructed from the responses to the debriefing questions have coefficients of the same signs as those seen in regressions for the 5 in 1,000 risk reduction from wave 1. However, only the coefficient of the dummy indicating that the respondent did not consider whether he or she could afford the product is significant. Specifically, we find that WTP is, again, lower for people who did not consider whether they could afford the product.

There are two possible reasons why most of the regressors we examined are not statistically significant. The first possible reason is the relatively small sample size. Given the relatively large dispersion of WTP (see scale parameters in Table 14), a sample size of less than 300 individuals may be insufficient to obtain strong t-statistics. The second possible reason is that a 1 in 1,000 risk reduction might be too small a risk reduction for people to relate strongly their WTP to their socioeconomic circumstances.

To discriminate between these two possible reasons, we experimented with taking several random subsamples of 300 observations from the 611 data points of wave 1 (valuing the 5 in 1,000 risk reduction). In doing so, we asked the question: Had the sample size been smaller, and comparable with that of wave 2, would most of the regressors for the 5 in 1,000 risk reduction (wave 1) become insignificant? If so, the lack of significance of the coefficients of the 1 in 1,000 risk reduction might also be ascribed to insufficient sample size.

In practice, even with the reduced sample size, the coefficients of the regressors of WTP for the 5 in 1,000 risk reduction had signs and magnitudes similar to those for the full sample reported in Table 13, and those coefficients that were significant in Table 13 remained statistically significant at the conventional levels. This finding leads us to speculate that other reasons, perhaps the small magnitude of the risk reduction, lie behind the lack of significance of most coefficients in the equation for WTP for the 1 in 1,000 risk reduction.

H. WTP for Future Risk Reductions

Also of interest is whether individuals are willing to pay anything today for risk reductions that occur in the future. This issue is especially important in the context of latent risks such as those caused by exposure to carcinogens. Following the WTP questions on risk changes occurring over the next 10-year period, we asked respondents under the age of 60 a series of questions concerning a future risk change of 5 in 1,000 occurring between the ages of 70 and 80.

Mean WTP for this future risk reduction is reported in Tables 15 and 16 below, and the effects of the various explanatory variables on WTP are reported in Table 17. The results reported in these three tables rely on the assumption that the responses to the payment questions for the risk reduction beginning at age 70 are statistically independent of the previous questions on risk reductions occurring over the next 10 years. This assumption should not affect the point estimates of mean WTP but can be expected to affect the standard errors around those estimates (see Fahrmeir and Tutz 1994).

Table 15 reports the mean WTP estimates from the same three models that were applied to the current risk reductions. Estimates based on the entire sample and the cleaned sample are reported. Comparing these results with WTP estimates for a risk reduction of the same magnitude (5 in 1,000) occurring over the next 10 years, we find that respondents are willing to pay considerably less for future risk reductions as expected (see Table 16). WTP estimates for future risk reductions based on the spike model are approximately 60% lower than WTP for "current" risk reductions of the same magnitude.

Table 15. Mean WTP for the Risk Reduction of 5 in 1,000 Beginning at Age 70 Cleaned Data, Both waves (1999C$)

Data Used in Analyses	**"Conservative" WTP Estimates: Lower-Bound Turnbull (non-parametric)**	**"Generous" WTP: Weibull Double-Bounded model**	**Most Information About WTP: Kriström's Spike Model (normal distribution)**
Raw data *(n = 650)* Mean WTP (s.e.)	201.73 (13.80)	314.47 (31.45)	260.73 (18.49)
Cleaned data *(n=638)* Mean WTP (s.e.)	201.09 (13.71)	308.46 (31.69)	254.89 (16.23)

Table 16. Comparison of WTP for Risk Reductions of 5 in 1,000 Starting Now to Risk Reductions Starting at Age 70, Wave 1.* (1999 C$)

Risk Reduction	Mean WTP	Standard Error Around the Mean
5 in 1,000 effective now	606.77	32.20
5 in 1,000 effective at age 70	237.72	19.66
Is the difference significant at 5%?**	Yes Wald test = 5.80	
Is the internal scope test passed?	Yes	

Note: * Comparison limited to those respondents in wave 1 who received the question about future risk (i.e., those aged 40 to 60 years).
** Assumes that the responses to the payment questions for the two risk reductions are independent. The Wald test statistic is distributed under the null hypothesis as a chi square with one degree of freedom.

Table 17 reports the results of the tobit/spike model for the future risk reduction of 5 in 1,000. It is interesting to note that the time lapse between the payment and the actual risk reduction proxied by age is not statistically significant; however, the self-assessed probability of survival until age 70 is positively and significantly related to WTP. This result is comforting in that respondents are willing to pay more for the future risk reduction if they believe they will be alive to reap the benefits.

Income and education are not statistically significant. Nor do current mental status and physical health status have significant effects. Although the income and education coefficients are somewhat troubling, the results do suggest that respondents' perceptions regarding their future health can color WTP for future mortality risk reductions. Specifically, respondents who believe their health at age 75 will be worse than 10 years from now have lower WTP by approximately C$116. This result is barely significant at the 10% level, however. As before, those individuals thinking about other benefits had significantly higher WTP.

Table 17. Internal Validity of WTP: 5 in 1,000 Risk Reduction at Age 70, Spike Model, Both Waves, Cleaned Data

Variable	Coefficient	t-statistic
Intercept	–706.25**	–1.96
Chance of surviving to age 70	2.27**	2.32
Age	4.24	.38
Male	57.30	.81
Bottom 25% of distribution of income in the sample (dummy)	–86.84	–.98
Education (years of schooling)	.11	.01
Chronic illness dummy	107.91	1.41
Mental health score	1.46	0.68
Wave 1 dummy	–86.50	–1.19
Believes health at age 75 will be worse than at 10 years from today	–116.00**	–1.61
Does not believe risk figures	–31.30	–.35
Other benefits	437.98**	6.00
Did not consider affordability of payments	–363.58**	–4.19
Did not understand timing of payments	64.85	.66
Scale parameter	723.73**	17.62
Number of observations	626	
Log likelihood	–1070.89	

V. Conclusions and Implications for Policy

Traditional estimates of WTP for mortality risk reductions suffer from a number of methodological and empirical problems. Our survey is designed to address some of these problems and to provide credible estimates of such values broadly applicable to the context of mortality risk reductions associated with environmental policy.

We find that for 930 persons aged 40 to 75 years obtained from random-digit dialing techniques in Hamilton, Ontario, WTP for risk reductions varies significantly with the size of the reduction. Mean WTP for an annual reduction in risk of death of 5 in 10,000 is about 1.5 times WTP for an annual risk reduction of 1 in 10,000. WTP is, therefore, sensitive to the size of the risk reduction, but not strictly proportional to it.

The estimates of mean WTP from our preferred model translate into values of a statistical life of approximately $3.8 million (1999 C$) for a 1 in 10,000 annual risk reduction and $1.2 million (1999 C$) for a 5 in 10,000 annual risk reduction. These figures are 10% to 70% lower than Health Canada's age-adjusted VSL of $4.3 million (1999 C$) and one-half (or less) the size of the $7.5 million (1999 C$) figure used by U.S. EPA. That the VSL is lower than official estimates remains generally true even under the most generous interpretations of the WTP responses (i.e., the double-bounded Weibull model).

The questionnaire also contains a variety of questions and tasks to check for understanding of probability and acceptance of our scenarios. Whereas only a small fraction of the sample appears to fail the probability comprehension tests, up to a quarter of the sample express doubts about the abstract risk reduction scenario. Provided that we control for these individuals, regression models reveal that WTP is internally valid.

We find that WTP does not vary much by age. Persons 40 to 49 years old do have slightly lower WTP than persons 50 years of age and older; however, mean WTP (C$657 for the 5 in 1,000 risk change) remains approximately constant age until about age 70, decreasing by about one-third thereafter. This latter WTP ($417) is probably the most relevant one for use in valuing most of the lives "saved" from air pollution reductions.

Regardless of the measure of physical health status used (with one exception), WTP does not vary appreciably with physical health status either—an important result for environmental policy, because older people and people with chronic conditions often benefit from improvements in environmental quality. We do, however, find that individuals with cancer and those in better mental health have a larger WTP than those without cancer and those scoring lower on tests of their mental health, respectively.

This project has raised a number of issues, some of which we plan to address in two new studies pending in the United States, in northern Prince George's County, Maryland, to duplicate the Canadian protocols, and another using a Web TV-based, preselected national sample of 1,000 people. One issue is the lack of significant results for the 1 in 1,000 scenario. Although we provide some evidence that this result is not due to a small sample size, a larger sample would be desirable for a more definitive test. This issue may be addressed in the U.S. surveys by using a more balanced sample, or perhaps by choosing to assign the 1 in 1,000 risk reduction as the first commodity valued to more than half of the sample.

Second, to gain more insights on why WTP fails the proportionality test we may experiment with asking respondents to value yet another risk reduction. For instance, we may introduce a 10 in 1,000 risk reduction scenario in addition to the 5 in 1,000 scenario, which would require only that mean WTP for the former risk reduction be twice that of the latter. This change may be built into one of the U.S. surveys.

Third, we were not able to test whether WTP is sensitive to the timing of the risk reduction using an external scope test. In the questionnaire used for this project, the WTP question regarding a risk reduction occurring between ages 70 and 80 always followed questions on the WTP for contemporaneous risk reductions. In the future we would like to devise a survey that would permit us to ask this question first for a subsample of respondents so that we could test whether timing of the risk change significantly affects WTP.

Finally, our work with focus groups suggests that some individuals may find it easier to think about mortality risk reductions in terms of increases in life expectancy rather than as small reductions in mortality risks. In the future we would like to develop a survey to test whether WTP is sensitive to this major difference in risk framing.

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Appendix

Table A.1
Responses to the Initial Payment Question: Multinomial Logit Model

- Wave 1 (N = 614)
- 5/1,000 Risk Reduction
- Specification A

Variable	Not sure	No
Intercept	–.8177 (–1.20)	–1.6299 (–2.29*)
Initial bid	.0017** (6.20)	.0023** (8.40)
Income (thou.C$)	–.0012 (–.37)	.0027 (.84)
Male	–.1854 (–.85)	.5323** (2.46)
Education	.0382 (.99)	.0414 (1.10)
Has chronic illness	.0489 (.22)	–.0425 (–.19)
SF-36 mental health score	–.0025 (–.38)	–.0110§ (–1.69)
Reports understanding probability well	–1.0768 (–2.74)	–.4623 (–1.00)

t-statistics in parentheses; §: significant at 10%; *: significant at 5%; **: significant at 1%.

Table A.2
Responses to the Initial Payment Question: Multinomial Logit Model

- Wave 1 (N =614)
- 5/1,000 Risk Reduction
- Specification B

Variable	Not sure	No
Intercept	–.6444 (–1.03)	–1.1879§ (–1.77)
Initial bid	.0018** (6.39)	.0024** (8.62)
Failed probability test and probability preference	–1.2731 (–1.41)	–1.9404§ (–1.66)
Does not believe the risks apply to him or her	.1818 (.65)	.2233 (.78)
Did not consider whether (s)he could afford payment	1.0695** (4.22)	1.2415** (4.90)
Reports understanding probability well	–1.0756** (–2.68)	–.3782 (–.80)
Did not understand timing of payments	.2141 (.68)	–.2945 (–.85)
SF-36 mental health score	–.0057 (–.87)	–.0112§ (–1.75)

t-statistics in parentheses; §: significant at 10%; *: significant at 5%; **: significant at 1%.

Table A.3
Identifying Reasons for WTP equal to Zero: Probit Model

- Wave 1 (N = 614)
- Zero WTP for 5/1,000 Risk Reduction

Variable	Estimate	T-statistic
Intercept	–.9603	–.33
Baseline Risk:		
Male	–.0224	–0.17
Age	.0521	.47
Age Squared	–.0005	–.51
Individual Characteristics:		
Income (thou. C$)	–.0018	–.96
Has chronic illness	–.1144	–.80
SF-36 mental health score	–.0095**	–2.43
Understanding of Probability/Acceptance of Scenario		
Failed probability test and preference test	–.6173	–1.09
Did not believe risks apply to him or her	.1552	.95
Did not consider whether (s)he could afford payment	.7713**	5.35
Did not understand timing of payments	–.3337	–1.51

§: significant at 10%; *: significant at 5%; **: significant at 1%.

Table A.4
Coefficients and P-value of various chronic illness dummies in spike model for willingness to pay for the 5/1,000 risk reduction
(minimal data cleaning + respondents with FLAG1 = 1 excluded).

	Heart disease	High blood pressure	**Cancer**	Asthma	Bronchitis, emphysema, or chronic cough
Coefficient	16.3671	87.5335	**269.7156**	32.4220	–111.0011
P-value	.870	.2588	**.0867**	.7365	.1975

Other regressors included in the model: age group dummies, male, education, dummy for bottom 25% of the distribution of income, FLAG7, FLAG11, FLAG15, and FLAG16.

Table A.5
Coefficients and P-value of various SF-36 health scores in spike model for willingness to pay for the 5/1,000 risk reduction
(minimal data cleaning + respondents with FLAG1 = 1 excluded).

A. Results from specification that includes age group dummies, MALE, education, dummy for bottom 25% of the distribution of income, FLAG7, FLAG11, FLAG15, FLAG16, plus one of the SF-36 health scores.

	scorepf	scorerp	scorebp	scoregh	scorevt	scoresf	**scorere**	**scoremh**
Coefficient	–1.059	1.2083	–.603	1.2963	2.1237	2.0046	**1.7165**	**4.4513**
P-value	.491	.132	.621	.365	.1570	.1204	**.0495**	**.0122**

B. Results from specification that includes age group dummies, MALE, education, dummy for bottom 25% of the distribution of income, FLAG7, FLAG11, FLAG15, FLAG16, plus the CHRONIC dummy, plus one of the SF-36 health scores.

	scorepf	scorerp	scorebp	scoregh	scorevt	scoresf	**scorere**	**scoremh**
Coefficient	–1.304	1.1984	–.7004		2.1060	1.9859	**1.7017**	**4.4340**
P-value	.413	.145	.571		.172	.162	**.0524**	**.0132**