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How to Make a Public Choice about the Value of a Statistical Life: The Case of Road Safety

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Abstract

Cost-benefit analysts involved in evaluating projects influencing the risk of death and injury have access to a wide group of studies that provide a large range of estimates of the value of a statistical life (VOSL). It is of course a difficult task to pick the right estimate. This paper discusses the potential avenues available to analysts looking for values of a statistical life and of injuries to be used in cost-benefit analyses of Quebec projects involving changes in road safety. Actually, the discussion is conducted in the context of Quebec, but most of it could easily apply to the rest of Canada. First, we discuss the relevance of looking for an original set of estimates involving a new study and the collection of new data. We present many arguments in favour of such a strategy. Second, if the time or the resources necessary to conduct a new study are not available, we offer an analytical framework that allows one to make a choice of estimates (or of a range of estimates) from existing studies. We conclude that a VOSL of 5 million dollars (CAN $, 2000) would be acceptable. Another contribution of this paper is to present, to our knowledge, the most up-to-date survey of studies on the value of a statistical life covering more than 85 papers.

Keywords: Value of a statistical life, estimate, transportation, road safety, cost–benefit analysis.

Résumé

Les spécialistes des analyses avantages–coûts impliqués dans l'évaluation des projets influençant le risque de mort et de blessure ont accès à un éventail important d'études donnant des estimations très dispersées de la valeur statistique d'une vie. Il est difficile de choisir la bonne estimation. La présente étude discute des différentes possibilités disponibles à ces spécialistes pour des projets de sécurité routière au Québec. Cette discussion est concentrée sur le Québec mais pourrait certainement s'appliquer au reste du Canada. Dans un premier temps, nous discutons de la pertinence de calculer des estimations au moyen d'une nouvelle étude avec des données originales correspondant au contexte de l'application. Nous présentons plusieurs arguments en faveur d'une telle stratégie. Dans une deuxième étape, si le temps et les ressources disponibles pour réaliser une nouvelle étude ne sont pas disponibles, nous proposons un cadre d'analyse permettant de faire un choix à partir des études existantes. Nous proposons qu'une valeur de la vie de 5 millions de dollars ($CAN, 2000) serait acceptable. Une autre contribution de l'article est de présenter la revue de la littérature la plus à jour sur le sujet, couvrant plus de 85 études.

Mots clés : Valeur statistique de la vie, estimation, transport, sécurité routière, analyse avantages–coûts.

Introduction

Many public projects for better road safety impose costs on society in exchange for reducing the risk of death and injuries. To determine whether a project is socially desirable, one has to compare the value of reducing risks to the costs of such reductions. Several methods have been proposed for generating estimates of the value of reducing risks of death and injuries, in particular the *human capital approach* and the *willingness-to-pay (WTP) approach.*

In the human capital approach, the value of a premature death for society is determined by the difference between what that person was expected to provide to society (his production or revenue) minus what that person was expected to consume. For many reasons, this approach is no longer popular. In particular, people with very low income would be attributed a very low value of life, which can be ethically debatable.

A willingness-to-pay (WTP) estimate values the change in well-being that would result from changing the risk of death; it is measured by how much wealth a person is willing to forgo to obtain that reduction in the risk of death. Similarly, a willingness-to-accept (WTA) estimate is measured by how much more wealth an individual would require to accept a given increase in the risk of death. Summing such a measure across individuals can provide an estimated value of a "statistical life" (VOSL). Rather than the value for any particular individual's life, the value of a statistical life represents what the whole group is willing to pay for reducing each member's risk by a small amount. For example, if each of 100 000 people is willing to pay $ 40 for a reduction in risk from three deaths per 100 000 people per year to one death per 100 000 people, the total WTP is $ 4 million, and the value per statistical life is $ 2 millions (with two lives saved).

There two main methods for obtaining the value which people are willing to pay: the *revealed preference method* based on market data (wage-risk studies and consumer-market studies) and the *contingent-valuation method* based on data gathered through questionnaires. We surveyed around 85 studies belonging to one of these categories or the other with a very wide range of estimates: 0,16 to 33 million dollars (CAN $, 2000).

Cost-benefit analysts involved in evaluating projects influencing the risk of death and injury have thus access to a wide group of studies that provide a large range of estimates of the VOSL. It is of course a difficult task to pick the right estimate. This paper discusses the potential avenues available to analysts looking for values of a statistical life and of injuries to be used in cost-benefit analyses of Quebec projects involving changes in road safety. Actually, the discussion is conducted in the context of Quebec, but most of it could easily apply to the rest of Canada. First, we discuss the relevance of looking for an original set of estimates involving a new study and the collection of new data. We present many arguments in favour of such a strategy. Second, if the time or the resources necessary to conduct a new study are not available, we offer an analytical framework that allows one to make a choice of estimates (or of a range of estimates) from existing studies. We conclude that a VOSL of 5 million dollars (CAN $, 2000) would be acceptable. Another contribution of this paper is to present, to our knowledge, the most up-to-date survey of studies on the value of a statistical life covering more than 85 papers.

The rest of the paper is organized as follows. Section 1 briefly presents the two main methods for obtaining the value which people are willing to pay for risk reduction: the *revealed preference method* and the *contingent-valuation method,* and briefly surveys existing studies that have used these methods. Section 2 discusses the relevance, for cost-benefit analysts of Quebec projects involving changes in road safety, of looking for an original set of VOSL estimates involving a new study. Section 3 proposes a choice of estimates emerging from existing studies.

1. Two methods for estimating willingness-to-pay

The revealed-preference method has been used extensively to deduce the value of a statistical life. The underlying assumption of this method is that individuals reveal their preferences by their market behaviour. The information is obtained by identifying situations in which individuals, either implicitly or explicitly, actually make a trade-off decision between wealth and physical risk.

The majority of the revealed-preference studies conducted to date have been of the wage-risk type. *Wage-risk studies* estimate the wage premium associated with greater risks of death on the job. This premium is deduced by regressing the wage on the risk of death. Regression analysis is used to account for the factors other than risk that may influence the wage. The premium indicates that there is a trade-off between wealth and physical risk, and may be used to compute the VOSL in the way described above. Following the same line of argument, when regressions include a variable reflecting the risk of injury, the studies can also provide a value for injuries. The wage-risk method relies on several assumptions. Among others, it assumes that workers have correct information concerning the physical risk associated with different jobs. Table A1 in the Appendix presents the results of 42 wage risk studies that were performed between 1974 and 2000. For each study, we present the authors, the year of publication, the country and the “best” estimate[1]. One should note that the early wage-risk studies used data from the Society of Actuaries, which, based on standard life-insurance tables, computes « excess » risk, over and above that faced by the general population, for each occupation. There is now a consensus about the fact that these data overestimate on-the-job risk and thus provide values of life that are biased downward (Viscusi, 1993). Other researchers have then used data from the BLS (Bureau of Labor Statistics) which are at the industry level. Again, this was criticized since two workers in the same industry may face very different risk (a secretary and a miner). Risk data at the occupation level are more appropriate and were used starting in the middle of the 80s.

Consumer-market studies, another category of revealed preference studies, examine the observable trade-offs people make between risk and wealth in their every day consumption decisions. For instance, Dardis (1980) uses data on the purchase price of smoke detectors and their effectiveness in reducing the probability of death and injury to estimate the value of statistical life. Atkinson and Halvorsen (1990), as well as Dreyfus and Viscusi (1995), provide estimates based on the price of different safety features on cars and the associated reduction in risk. Unlike wage-risk studies, consumer market studies have not been repeated many times by

1. For a more complete literature survey, see Dionne et al. (2002).

different authors, which limit their ability to provide credible estimates of the value of a statistical life. The major advantage of both the wage-risk and consumer-market studies is that they are based on actual behavior. Table A2 in the Appendix presents the results of 15 consumer-market studies that were performed between 1973 and 1995.

The second major method, *contingent-valuation*, poses a hypothetical market situation to survey respondents who are then asked about their WTP or WTA for a given variation in the risk level. A typical question would be: how much more would you be willing to pay for a means of transportation to a given destination that would reduce your risk of death from two in 100 000 to one in 100 000. The main advantage of this method is that it allows the researcher to tailor the questionnaire and sample to elicit precisely the information needed. It can also be applied to the general population, while wage-risk studies are restricted to workers. Furthermore, availability of individual responses allows the researcher to identify the determinants of the WTP. For instance, Jones-Lee et al. (1985) find that the WTP increases with the level of income and with the level of the initial risk faced by the individual. The major drawback of this method is that the individual's response is based on a hypothetical rather than an actual situation. An individual's response to a hypothetical situation and his or her actual behaviour in that situation may differ. Table A3 in the Appendix present the results of 29 studies based on contingent-valuation.

2. An original study

2.1 Model for calculating the statistical value of a human life

As we have seen, for almost forty years now, economists have been proposing that the willingness-to-pay concept be adopted to determine the statistical value of a human life needed to estimate the benefits of an investment project designed to reduce the number of deaths on a given territory (Drèze, 1962). So as to eliminate potential biases arising from emotions or other personal, regional or strategic considerations, the values of life used by the method are anonymous and are thus called 'statistical'.

Before discussing the reasons justifying an original study, it is useful to get back to the conceptual framework behind the value of a statistical life. For the moment, let us concentrate on the value of a human life within a given territory or the value of a death avoided within the same territory. Let us suppose that there are two possible states of nature for each individual over the period considered: to die from a traffic accident or not to die for that reason. The respective probabilities of these two states of nature are p and 1-p. This is the initial situation in terms of risk, meaning the situation prevailing before undertaking the project.

The total cost associated with the death of a person includes material or financial losses (including the loss of income) and the other losses linked to suffering, loss of quality of life, and the pain inflicted on friends and relatives or other individuals in the society. Let us call the foregoing welfare losses. Let us suppose, for the moment, that insurance will completely cover all material or financial losses (including employment income), but that there is no market for welfare losses. This would mean that society has already paid for the financial losses by bearing the corresponding insurance premiums. If, in a given place, the project reduces or eliminates the insured risk, reductions in premiums or corresponding claims will have to be taken into account when calculating the benefits.

We also assume the probability of death to be exogenous to the individual. In insurance terms, there is no significant residual moral hazard in the society considered. In more concrete terms, we suppose that the probability of death will depend on an inadequate road infrastructure. This implies that this infrastructure problem will generate a negative externality or a social cost for the individuals involved, unless society agrees to correct it. Of course, society will only intervene if the net social benefits of the correction surpass its costs. This explains the need to make a careful evaluation of the correction's potential effect on the probability of death and the benefits to be derived from the effect estimated. Let us suppose, for example, that, on average, one person will die every year on a stretch of bad road which is used regularly by 10,000 people. The probability of a fatal accident is 1/10,000. In many societies, the probability associated with the initial risk can be rather precisely evaluated. What is difficult to estimate is what effect a project might have on this probability. We shall see that inaccurate evaluations of these variations in probability may have a significant effect on values of life and on the benefits of projects. It is easy enough to say that repairing a stretch of road will reduce the number of deaths by two per year, but a great deal more difficult to prove it. Moreover, most governments do no follow up after carrying out their projects, which implies that no banks of real data exist on this subject.

In order to evaluate the value of life associated with welfare losses, the society must now ask itself the following question: How much are we willing to spend to reduce (or in certain cases to eliminate) the probability of death for individuals using dangerous roads? This is the value which will be used to estimate the portion of the project's benefits linked to loss of welfare. To be added to these benefits are those linked to the reduction of income losses and of the other costs associated with accidents (hospitalization, medical, material damages, etc.)

The welfare of an individual exposed to this accident risk may be represented by its expected utility function:

$$EU_i(w) = (1-p)U_l(w) + pU_d(w) \qquad i = d,l \tag{1}$$

The right side of (1) gives the weighted sum of the levels of well-being associated with each of the states of nature; w is the individual's wealth, U, is his welfare function in each of the states of nature 'i' (i=l for living, i=d for dead).

Note that the same level of wealth, w, is used in each state of nature, since we have assumed that insurance will cover losses in income and all other losses of a material or financial nature. The willingness-to-pay element used in evaluating the value of life boils down to asking how much we are willing to reduce w in order to lower p and keep the same level of welfare. In mathematical form, this question is a matter of calculating:

$$\frac{dw}{dp} = \frac{U_l(w) - U_d(w)}{(1-p)U_l'(w) + pU_d'(w)} > 0 \tag{2}$$

by taking the total differential of (1) where U'_i is the marginal utility of wealth in state i, dw/dp is the marginal amount of willingness to pay and the corresponding value of life is given by (dw/dp)/dp. Δp is often used in the denominator instead of dp in order to stress the fact that variations in probabilities are usually discrete rather than infinitesimal.

In more concrete terms, let us take the example of a society of 8 million citizens, 800 of whom die in road accidents each year. This implies that the probability of a traffic fatality in this society is 1/10,000, the same as in the preceding example. Let us now suppose that the objective pursued is to reduce the number of deaths to 640. The new probability of a traffic fatality is equal to 0.8/10,000 and the corresponding Δp is 1/50,000. Suppose that, questioned about their willingness to pay an annual amount to attain this objective, citizens cited a figure of $20. This means that, if there existed an insurance market for this portion of the benefits, these citizens would be willing to pay an average insurance premium of $20 for such welfare costs. However, as stated earlier, no market for such losses exists. The social value of a human life corresponding to the foregoing scenario would be $ 1 M: $20/(1/50,000). Now suppose that the average amount of the WTP rose to $100. The value of life would go up to $5 M. If each citizen gave $100, society would then have $800 M to finance the work required. And to this amount must be added the benefits derived from preventing injuries, loss of income, and material damages, in order to estimate how socially profitable it would be to reduce the number of deaths to 640.

More specifically, the insurance payments saved by preventing material damages and loss of income must be factored into the total benefits associated with the project. If such data are not available, the equivalence in claims actually made for material damages and compensations actually paid for loss of income can be used instead. In Quebec, for example, this would mean factoring in SAAQ[2] compensations (other than those for the value of life) as well as claims paid by private insurers for material damages. As we shall see below, the willingness to pay for a project is higher when there is no insurance coverage for such losses; thus, a portion of the higher amount will not be chalked up to the value of life but rather to the reduction of uninsured material and financial losses. As a rule, life insurance premiums should not be adjusted for road safety projects, for they are not defined in terms of road-accident risks.

Finally, the SAAQ pays up to $179,375 for inconveniences such as loss of quality of life, psychological suffering and pain. These amounts must also be taken into account when evaluating the value of a human life. In our discussion, they are included in the $5 M example. Thus, if this amount is used to evaluate the benefits of projects, the SAAQ compensations should be dropped so as to avoid double counting.

Now suppose that the citizens of another society with the same insurance and traffic-risk parameters decide they are willing to pay $150 instead of $100, thus implicitly implying that they value a human life at $7.5 M. This difference may be explained simply by something as unobservable or hard-to-observe as personal preferences, cultural or religious differences,

2. SAAQ : Société d'assurance automobile du Québec. It is the Quebec auto insurance board.

reactions to risk (often linked to age structure), etc. These are captured by the U utility index in (1). Are they important enough to justify an independent study in Quebec?

Different societies usually want different insurance plans. For example, Quebec's automobile insurance plan has several unique features. To be specific: it is a no-fault plan where all citizens are covered by public insurance against bodily injuries. As indicated above, there is even some compensation for the loss of well-being associated with suffering, but such compensation is not universal. Material damages, on the other hand, are covered by private insurers offering standard North American policies with a liability deductible. Such insurers have waived their right to take legal action and this makes the average claim considerably lower than in the United States.

Does this type of insurance plan prevent us from using the WTP data from other Canadian provinces or other countries to define the values of life linked to road accidents in Quebec? No: If these data truly isolate the WTP for losses of well-being and do not contain any values associated with partial insurance compensations. Otherwise, yes; for, unless clearly explained, the forms of insurance used in the analysis can affect WTP and values implicit to human lives. Let us go back to our example using the $5 M value of life.

Suppose that insurance covers, on average, 80% of salary losses and hospital/medical costs in the countries, provinces or regions from which we obtain our values for estimating a human life in Quebec. Suppose as well that all the other parameters are the same for accident rates, living standard, and preferences. There are at least two scenarios.

In the first scenario, we note that the questionnaires used or the econometric calculations performed take explicit account of the insurance coverages for individuals in the samples used and isolate a value of life which takes into account only welfare losses. In that case, there would be no need to adjust for differences in insurance plans. (It must however be noted that very few studies isolate such differences.)

In the second scenario, we note that these researchers or administrators have not taken into account the differences among individuals' insurance policies nor have they documented insurance coverages on the territory studied. This may imply that, in disclosing their WTP, individuals took into account their own partial insurance coverages and cited amounts higher than those associated with pure welfare losses. Since these insurance differences are not documented in most of the studies stated in the preceding section, this value may contain a bias due, in part, to differences in the insurance coverages of the individuals surveyed in the different studies but due, above all, to the fact that the average insurance coverages for the individuals studied were lower than those in Quebec.

The average personal wealth or w variable in (1) is another important factor which may affect the amounts of WTP. Wealthier societies are usually more willing to pay for this kind of benefit. To neutralize this effect, we should thus use values from societies with the same standard of living as that existing in Quebec. Otherwise, the values used would have to be adjusted. To give a specific example: Americans' standard of living has in recent years grown more rapidly than that of Canadians. So if American data are used, the amounts in their studies may possibly be too high to be applied directly.

We must also pay serious attention to the accident rates in the places from which our data come and the variations of these probabilities studied in WTP disclosures. As indicated in the theoretical model, dw/dp increases with p under the reasonable hypotheses related to the parameters of the model. This implies that societies whose accident rates are higher than those in Quebec will also have a higher WTP. Statistics show that the Canadian average for fatal accidents is lower than Quebec's but that the death toll in the United States (except for a few states) and France are higher than in Canada (see Table 1). It would thus be necessary to adjust the values obtained in these countries, provinces or States if we want to apply them in Quebec, although the right adjustment would not be straight forward.

Table 1
Motor vehicle accidents
Deaths/100,000

Geographic region	1994	1997
United States	16.3	15.8
California	14.3	10.5
Illinois	15.0	11.7
Massachusetts	8.0	7.2
New Jersey	9.8	9.3 (1998)
south Carolina	22.6	23.8
Canada	10.9	9.6
Quebec	11.3	10.4
France	13.8	14.1

Source: Dionne (2002).

To truly grasp the effect of these differences, let us consider an example calculating Americans' WTP in order to reduce the probability of wounds from rifle shots (Ludwig and Cook, 2001). The recently published human-life estimates corresponding to this reduction range from $5.4 M to $6.8 M (US $). It is quite unlikely that residents of Quebec would have an equally high WTP corresponding to this risk, since the probability of such events must be much lower in Quebec.

In several sections of this article, we stress the fact that very precise estimates of death-and-injury probabilities are essential in evaluating willingness to pay. We also stress the fact that very precise estimations of the variations in these probabilities are needed for evaluating the benefits of proposed projects. Indeed, variations in accident probabilities are used in the denominator when making the transition from willingness to pay to value of life. Values of life are very sensitive to these variations in accident probabilities. We used the (1/50,000) variation to obtain $5 M with the willingness to pay of $100. If we now use (0.5/50,000), the corresponding value of life will be $ 10 M! This example clearly shows the necessity of carefully documenting variations in the probabilities used in the studies from which values of life are imported.

In Quebec, we have access to very good data on road safety. It would thus be possible to use this precise information to make an accurate evaluation of Quebecers' willingness to pay for improvements in road safety. In our opinion, this argument based on statistical data is the one which best justifies an original study.

2.2 Reasons justifying an original study

In this section we shall sum up the arguments which could be advanced to justify undertaking a Quebec study to determine the value of life to be adopted when calculating the benefits of road safety projects.

The first argument is linked to the Quebec automobile insurance plan which several experts claim is the only one of its kind in the world (see on this subject the special issue of *Assurances*, October 1998). This is a universal no-fault plan. As discussed in the preceding section, it is not obvious that the average value obtained from the different studies selected takes any explicit account of coverages for loss of employment income linked to bodily harm from accidents, particularly coverages related to road safety projects. If a value emerging from existing studies is to be legitimately applied in Quebec, we must first check to see whether it contains insurance coverages provided by insurers in the territories selected. If this value takes into account willingness to pay for loss of employment income, the average compensations paid by the SAAQ will have to be subtracted when calculating the benefits of projects. Also to be subtracted are portions of SAAQ benefits paid for inconveniences such as loss of quality of life, psychological suffering, and pain. But these subtractions may not be enough, since the insurance plans in the territories where the various studies selected were conducted may have average insurance coverages very different from those in Quebec. For example, if the average insurance coverages are, on average, lower than those paid in Quebec for fatal accidents, a value emerging from existing studies accounting for these partial coverages will overestimate the willingness to pay as compared to individuals with a more generous insurance plan.

The second argument concerns Quebec medical and hospitalization insurance plans. Once again, it is difficult to document accurately whether or not the American studies selected take into account coverage of these costs by individual insurance policies. It is also very difficult to evaluate the amounts implicit in the willingness to pay derived from American studies, for U.S. insurance plans vary widely from one individual to the next. It would be easier to handle the question with data derived from other Canadian provinces, since the health insurance plan is applied universally across the Canadian territory. What needs careful documentation is how these universal medical and hospitalization plans were accounted for in their calculations or how data imported from other countries can be adjusted to take the Canadian health insurance plan into account.

The third argument is linked to evaluations of the injuries avoided. The international data on this subject are of very poor quality and they often do not correspond to the definitions used in Quebec for different types of injury.

The fourth argument is linked to the initial level of risk. As indicated in table 1, the rate of fatal accidents is much higher in the United States than in Canada and in Quebec. It is well documented that individuals' willingness to pay will increase as the risk of accident rises. Consequently, willingness to pay derived from American studies will overestimate the risk of fatalities in Quebec. To correct this value, it would be useful to know the fatal-accident rates for the populations studied.

Quebec data on different types of injuries by type of accident are very precise. This specifically means that we can, for example, calculate the average number of serious injuries for fatal accidents and for accidents with serious injuries. Rates of the different types of injuries are not the same from one type of accident to the next. As a rule, there are many more seriously injured victims in an accident causing serious injury than in a fatal accident. To assume that rates are the same can introduce a significant bias into the results. This fifth argument is more important in calculating willingness to pay by type of accident than by type of injury. Indeed, calculating willingness to pay by type of accident requires very detailed data on the weight of the different injuries by type of accident. We know of no studies in the literature which have examined these weights in detail.

Finally, it is also well accepted that the average wealth of the individuals in a society will have a positive effect on the willingness to pay. This finding implies that the WTP values imported must be adjusted. Variations in the probabilities considered in the different studies must also be taken into account. We have indeed seen that in the transition from WTP values to values of life the latter are very sensitive to the influence of values associated with variations in the probabilities chosen.

3. A value based on existing publications

3.1 Value of a statistical life

We consider a provincial government who must make decisions about projects affecting road safety, and who must make choices (for cost-benefit analysis purpose) on a value of a statistical life (or interval of values), and on values for serious and minor injuries drawn from existing publications. As concerns value of life, several choices present themselves: (1) value emerging from a meta-analysis; (2) value emerging from Canadian studies; (3) value emerging from studies based on transportation safety; (4) value emerging from the best studies, regardless of their source; (5) a combination of the foregoing approaches. Before recommending a specific choice, we shall examine each of these avenues. In the discussion, we suppose this government is the Quebec provincial one. However, the discussion can be applied to any government that has to make decisions in transportation and, more particularly, on road safety.

As well known in the literature (Viscusi, 1993), ideal choice will be based on the willingness to pay approach (WTP). This immediately eliminates any studies based on the human-capital approach or on any middle course using a weighted average of values emerging from the human-capital approach in conjunction with values derived from application of the willingness-to-pay approach. The weighted average is fundamentally arbitrary, since there is no objective criterion governing what weight is assigned from one type of study to the next.

- Value emerging from a meta-analysis

Two meta-analyses (or statistical analyses of the VOSL drawn from the literature) can allow us to suggest a value of life for Quebec: the study by Bowland and Beghin (1998) and the one by Miller (2000). Both these studies were expressly designed to adapt the findings of existing studies (mainly American and European ones) to other countries. However, we must point out that both these analyses have methodological shortcomings which limit their reliability. In particular, they put the same weight on each study, independently of their accuracy, which is not entirely rigorous. When the Bowland and Beghin findings are applied to the Quebec context, we obtain a value of life of about $1.9 million. Using the multiplier factor that Miller (2000) deduces for Canada (a value of life equal to an interval of 109 to 161 times the per capita GDP), we obtain a value of between $3.2 to $4.75 M with an average of $4M (CAN $, 2000).

- Value emerging from Canadian studies

If we wanted to suggest a useful value of life based on existing studies, another avenue would be to draw on studies conducted in Canada. As shown in the preceding section, the value of life seems to vary from one country to the next, especially because of income level but probably also because of the initial risk level or the population's age structure. Recourse to Canadian studies offers one advantage: the results obtained are not affected by fluctuations in the exchange rate. The table below presents the findings of eight Canadian studies. First of all, we note that these studies are "relatively recent," as they were all carried out after 1989. Two studies used contingent evaluation; five used the wage-risk approach, and one study (Lanoie et al., 1995) used both approaches. The average of the values obtained amounts to $6,852,000 (CAN $,2000) and their median to $5,590,000. If we exclude the Lanoie et al. study (which was not based on a representative sample), we then obtain an average and a median converging at $4,688,000 and $4,910,000 respectively.

Table 2
Studies on the statistical value of a human life in Canada

Authors	Year	Statistical value of a human life ($)	Method
Belhadji	1994	1,226,000	Contingent
Lanoie et al.	1995	22,000,000	Contingent and Labor market
Krupnick Crooper	2000	2,500,000	Contingent

Meng	1989	4,910,000	Labor market
Meng and Smith	1990	7,970,000	Labor market
Cousineau and Lacroix	1991	4,510,000	Labor market
Martinello and Meng	1992	5,590,000	Labor market
Vodden et al.	1994	6,110,000	Labor market
Average		6,852,000	
Median		5,590,000	
Average (without Lanoie et al.)		4,688,000	
Average (without Lanoie et al.)		4,910,000	

- Values emerging from studies based on road safety

Another way of using existing studies would be to focus on those based on road safety. A number of reasons favour this choice. First, most of the empirical studies we surveyed are based on the job market; they are useful in evaluating the benefits of improvements in occupational safety, but not necessarily those related to road safety. It may indeed be said that there is a "private market" for occupational safety, which is expressed in terms of the bonuses paid for more dangerous jobs. Individuals can therefore choose among job offers once they know the characteristics of the market ("quantity" of risk and "price"). In other words, individuals expose themselves somewhat voluntarily to risks, aware of the pros and cons being negotiated. Actually, most of the job-market studies conducted are based on blue collar jobs or on those in primary and secondary sectors which are intrinsically more risky. As for improvements in road safety, no such private market exists, because improvements at this level often fall in the public-good category—particularly those likely to come under government intervention mandate. In this type of situation, contingent studies are probably more suitable, since they make it easier to handle questions related to public goods. Besides, individuals involved in highway transportation probably have less latitude in their choices. Exposure to the risks inherent in this activity is a fact of life for almost everyone today, and it comes with little control over the behaviour of other drivers, weather conditions, etc. In sum, the parameters of decision are not the same.

As Ludwig and Cook (2001) point out, job-market studies could be useful in the field of road safety when dealing with individuals for whom a work-accident risk is mainly a traffic-accident risk (this applies to truckers, sales representatives, and other people who work on the road). But, to our knowledge no existing job-market study makes this kind of distinction.

Secondly and in the same vein, most individuals covered by studies based on the job market face higher risks at work than on the road. As we have seen, willingness to pay depends on the initial level of risk; we might thus expect the value of a statistical life to be greater in studies emerging from the job market than in those focusing on road safety—presupposing the exclusion of professional drivers for whom road accidents are, after all, the same as work accidents. This is in fact the conclusion reached by Lanoie et al. (1995) who used a single sample to investigate this question, and by Elvik (1995) who made a systematic comparison between a series of studies based on the job market and another series based on road safety.

The following table presents the values for a statistical life found in 28 studies on road safety. Of these 28 studies, ten are American, seven come from the United Kingdom, and four from Sweden. The other countries produced no more than two each, which is the case for Canada. As concerns the approach used: nine studies relied on consumer markets and the 19 others on contingent evaluations. In chronological terms, we note that nine of the studies were published before 1990 (exclusively) and that the 19 others were published afterward. As to the results, we find an average of $5.7 M (CAN $,2000), with a median of $4.3 M, indicating that the average was pushed up by a few studies obtaining extremely high results.

Table 3
Studies on the statistical value of a human life in the transportation sector (CAN $, 2000)

Authors	Year	Statistical value of a human life	Method	Country
Atkinson and Halvorsen	1990	5,985,000	Consumer	U.S.
Baker	1973	8,811,000	Consumer	U.S.
Beattie and al.	1998	10,725,000	Contingent	U.K.
Belhadji	1994	1,226,000	Contingent	Canada
Blomquist	1979	684,000	Consumer	U.S.
Blomquist and Miller	1992	4,655,00	Consumer	U.S.
Carlin and Sandy	1991	1,021,000	Consumer	U.K.
Cohen	1980	506,000	Contingent	U.K.
Corso and al.	2001	4,270,000	Contingent	France
Desaigues and Rabl	1995	1,300,000	Contingent	U.S.
Dreyfus and Viscusi	1995	5,369,000	Consumer	U.S.
Ghosh, Lees and Seal	1975	1,080,000	Consumer	U.K.
Johannesson et al.	1996	5,994,000	Contingent	Sweden
Jones-Lee	1976	26,560,000	Contingent	U.K.
Jones-Lee	1976	5,160,000	Consumer	U.K.
Jones-Lee et al.	1985	6,679,000	Contingent	U.K.
Kidholm	1995	1,255,000	Contingent	Denmark
Lanoie et al.	1995	3,099,000	Contingent	Canada
Maier et al.	1989	3,716,000	Contingent	Australia
McDaniels	1972	25,397,000	Contingent	U.S.
Melinek	1974	1,002,000	Contingent	U.K.
Miller et Guria	1991	1,835,000	Contingent	New Zealand
Persson and Cedervall	1991	15,671,000	Contingent	Sweden
Persson et al.	1995	4,858,000	Contingent	Sweden
Persson et al.	2001	3,224,000	Contingent	Sweden
Schwab Christe	1995	1,167,000	Contingent	Switzerland
Viscusi et al.	1991	4,758,000	Contingent	U.S.
Average		5,659,000		

Authors	Year	Statistical value of a human life	Method	Country
Median		4,270,000		

- Values emerging from the best studies regardless of origin

Another avenue would be to decide to settle for the values emerging from the most reliable studies no matter what their origin. This would ensure that only those figures obtained by means of a rigorous method would be used. A first way of choosing the best quality studies would be to select only those published in journals with peer-review committees, which presupposes peer evaluation of their analytical rigour. However, there are three reasons why this criterion may not be restrictive enough. First, a number of published articles seek to illustrate methodology rather than actually provide any reliable outcome emerging from a representative sample: Several articles published in the 70s would fall into this category, including the first analyses using contingent evaluation. Secondly, several studies from the 70s and the 80s, though based on representative samples, used data which were later proven to be of poor quality. This applies to wage-risk studies such as the first American ones based on data from the Actuarial Society or the Bureau of Labor Statistics (BLS). Thirdly, several studies relying on consumer markets seem questionable even though published in reputable academic journals. Some of these studies refer to a consumer product which is never again mentioned in any subsequent study, thus eliminating the opportunity to see whether it became the focus of a consensus of opinion. We here have in mind some studies on car seats for babies (Carlin and Sandy) or on cigarettes (Ippolito and Ippolito). Moreover, some studies used more or less arbitrary hypotheses to extract a value of life from negotiations between risk and a source of discomfort (travel time, Gosh et al., 1975; discomfort of seat belt, Blomquist, 1979).

In sum, to make our selection among high quality studies, we shall first choose those published in journals with a peer-review committee and then eliminate the following:

- Studies on the job market with non-representative samples or those having used data from the BLS or the Actuarial Society

- Contingent evaluations relying on non-representative samples

- Consumer-market studies based on questionable hypotheses or on studies of consumer goods featured in no other studies, thereby preventing the observation of any emerging consensus

Table 4
The "best" studies

Authors	Year	Statistical value of a human life (CAN $, 2000)	Countries
Job-market studies			
Marin and Psacharopailos	1982	4,438,300	U.K.
Folsom and Leigh	1984	15,376,000	U.S.
Folsom and Leigh	1984	16,326,000	U.S.
Smith	1984	1,110,000	U.S.
Dillingham	1985	7,157,000	U.S.
Weiss	1986	9,160,000	Europe
Herzog and Schottleman	1987	16,309,000	U.S.
Leigh	1987	16,485,000	U.S.
Garen	1988	21,399,000	U.S.
Moore and Viscusi (a)	1988	7,767,000	U.S.
Moore and Viscusi (b)	1988	11,571,000	U.S.
Meng	1989	4,910,000	Canada
Moore and Viscusi	1989	12,364,000	U.S.
Meng and Smith	1990	7,970,000	Canada
Cousineau and al.	1991	4,510,000	Canada
Gegax and al.	1991	3,115,000	Multiple.
Kneisner and Leeth	1991	12,047,000	Canada
Kneisner and Leeth	1991	5,231,000	Asia
Kneisner and Leeth	1991	951,000	U.S.
Martinello and Meng	1992	5,590,000	Canada
Siebert and Wei	1994	15,999,000	U.K.
Elliot and Sandy	1996	1,800,000	U.K.
Jin-Tan et al.	1997	655,000	Asia
Kim and Fishback	1999	1,007,500	South Korea
Arabsheibani and Marin	2000	17,663,700	U.K.
Consumer-market studies			
Atkinson and Halvorsen	1990	5,985,000	U.S.
Dreyfus and Viscusi	1995	5,369,000	U.S.
Contingent evaluations			
Corso et al.	2001	4,270,000	U.S.
Johannesson et al.	1996	5,994,000	Sweden
Jones-Lee et al.	1985	6,679,000	U.K.
Gerking et al.	1988	5,290,000	U.S.
Ludwig and Cook	2001	6,588,000	U.S.
Persson et al.	2001	3,224,000	Sweden
Viscusi et al.	1991	4,756,000	U.S.
Average		8,292,000	
Median		5,994,000	

In this table, we find 26 studies based on the job market, two studies based on consumer goods, and seven studies based on contingent evaluations, which totals 35 studies. We note that 17 of these studies are American, five are from the United Kingdom, and five from Canada. The large majority of these studies were produced after 1985 (31 out of 35) and after 1990 (22 out of 35). As to values, as mentioned above, we note first that the job-market studies usually generate higher values than those using other approaches. The average for the 35 studies amounts to $8,292 M and the median, to $5,994 M. Some studies with very high values (more than $15 M) thus weigh heavily in the average.

- A combination of the preceding approaches : values emerging from the best studies based on safety in the transportation sector

In the end, what seems most relevant is to choose the values emerging from the best studies based on transportation safety. Given the arguments developed above, these studies seem better suited to the context we are concerned with and they also highlight useful ways of clearly identifying the value of improvement in road safety. We shall thus choose from table 3 those studies which were published in journals with peer-review committees and which meet criteria (ii) and (iii) presented in the preceding subsection.

Table 5
The best studies in the transportation sector
(CAN $,2000)

Authors	Year	Statistical value of a human life	Method	Countries
Atkinson and Halvorsen	1990	5,985,000	Consumer	U.S.
Corso and al.	2001	4,270,000	Contingent	U.S.
Dreyfus and Viscusi	1995	5,369,000	Consumer	U.S.
Johannesson et al.	1996	5,994,000	Contingent	Sweden
Jones-Lee et al.	1985	6,679,000	Contingent	U.K.
Persson et al.	2001	3,224,000	Contingent	Sweden
Viscusi et al.	1991	4,758,000	Contingent	U.S.
Average		5,183,000		
Median		5,369,000		

There are seven studies in table 5.[3] Two of these studies draw on the consumer market and the others are contingent studies. Four of the studies are American in origin, two are from Sweden, and a last one comes from the United Kingdom, all countries with a standard of living similar to

3. Also note that, in Table 3, four studies were published in a volume edited by Schwab Christe and Soguel. Though this volume has been rather widely circulated in the milieu, we checked with the editors and learned that there was no formal arbitration procedure before the texts were published. We shall thus eliminate these studies.

that of Canada[4]. One of these studies dates back to 1985, the others were published in the 90s and in 2000. For the values observed, we obtain an average and a median converging at \$5.2 M (CAN \$,2000) and \$5.4M respectively. The values in fact range from \$3.2 to \$6.7 M.

- Synthesis

The following table presents a synthesis of the five avenues we have just explored. We note that the average values obtained from applying each of the approaches (except that of Bowland and Beghin) ranges between \$4 and \$8.3 M. This represents a rather close convergence when we think that the values obtained in existing studies vary, on the whole, between \$160,000 and \$33 M!

Given our foregoing arguments in favour of the best studies in the field of transportation, **we recommend that, in its cost-benefit analyses, the Canadian Federal and Provincial transportation authorities should value a statistical life at \$5 M (CAN \$,2000) and perform sensitivity analyses using values of \$3 to \$7 M.** We are all the more comfortable with this recommendation, when we note that the values obtained based solely on the Canadian studies also come to around \$5 M.

Table 6
Summary table of different avenues explored
(millions CAN \$,2000)

Average value of life	Value
Meta-analysis, Miller method	3.2 to 4.8
Meta-analysis, Bowland and Beghin method	1.9
Canadian studies	4.688
Studies in the field of transportation	5.659
Best studies, regardless of origin	8.292
Best studies in the field of transportation	5.183

3.2 Value of injuries

With regard to values for injuries, the available literature on the willingness to pay (WTP) to avoid injuries is much less vast and much less precise. Moreover, in Quebec, as the SAAQ and the MTQ (ministère des Transports du Québec) usually distinguish between serious injuries[5] and minor injuries, it would be good to supply values corresponding to this classification. Before

4. Strictly speaking, as discussed in the preceding section, if all these studies were American, we would like to make adjustments to account for the higher income and initial risk in the U.S. but, given that three out of seven studies are coming from countries which are more similar to Quebec, we do not feel an adjustment would make a large difference. Furthermore, such an adjustment would not be straight forward.

5. An injury is deemed serious or minor depending on whether or not it requires that the victim be hospitalized for more than a day (SAAQ, 2001).

recommending any such values, we need to take a good look at three possibilities: (1) use the values provided by Viscusi (1993), updating them to take into account studies published after that date; (2) use the values suggested by the large American transportation organizations; and (3) use an extrapolation based on the human-capital approach Bordeleau applies in his work for the SAAQ.

- Using the results presented by Viscusi (1993)

Viscusi (1993) reports results from studies which examined occupational risk premiums and deducted a WTP for avoiding premature death and a WTP for avoiding a serious injury. By serious injury, we here usually mean injuries causing the victim to miss at least one day of work. We reproduce Viscusi's table below, after having converted its values into CAN $,2000 and after having updated it with a review of all the job-market studies published after 1992.

Table 7
Estimations of the value of a serious injury
Job market (CAN $,2000)

Authors	Risk source	Estimation
Viscusi (1979)	BLS	46,585
Viscusi (1978)	BLS	77,365
Olson (1981)	BLS	34,915
Viscusi (1981)	BLS	73,458
Butler (1983)	*Southern Carolina Workers' Compensation Board*	1,160/day
Smith V.K. (1983)	BLS	44,003
Leigh and Folsom (1984)		132,725
Viscusi and O'Connor (1984)	Perceived risk	25,098
Viscusi and Moore (1987)	BLS	87,609
Biddle and Zarkin (1988)	BLS	201,170
Garen (1988)	BLS	33,423
Hersch and Viscusi (1990)	Perceived risk	89,893
Evans and Viscusi (1990)	Estimated risk	29,489
French and Kendall (1992)	*Federal Railroad Adm. US*	60,672
Kniesner and Leeth (1991)	BLS	75,177
Hersch and Picton (1995)		111,347
Meng (1989)	*Workers' Compensation Board in Canada*	14,666 (minor) 173, 438 (serious)
Cousineau et al. (1991)		18,511
Average		73,831
Median		73,458

The results from 19 studies appear in table 7. Except for two, all of these studies are American and draw on the job market. It is also interesting to note that these studies were all published in journals with peer-review committees. The values obtained range between $18,511 and $201,170 (CAN $,2000). The average and median converge at $73, 841 and $73,458 respectively.

- Employing amounts used by large American transportation organizations

In the United States, the different transportation organizations —the Federal Highway Administration (FHWA); the National Highway Traffic Safety Administration (NHTSA); and the U.S. Department of Transportation— all use two major studies as their basis for finding a value for injuries avoided. The two major studies in question are Miller et al. (1991), published by the Urban Institute, and the National Safety Council's study. These two studies call on the notion of willingness to pay. In the study by the Urban Institute, we find such things as a WTP for avoiding injuries based on an extrapolation combining the value of a statistical life and a ratio between the years of functional capacity lost by type of injury (serious, critical, etc.) and the years of functional capacity lost in a fatality:

> *To value the quality of life associated with nonfatal risk reduction, we multiplied the value of fatal risk reduction times the ratio of the years of functional capacity at risk in a fatality versus the injury of interest (Urban Institute, 1991, p. 74).*

In other words, if a fatal accident loses us, on average, twenty years of functional capacity and a serious accident loses us six years of functional capacity, the WTP to avoid this type of injury will be 6/20 x the value of a statistical life. The figures obtained are thus critically dependent on the value of life used. The authors of the study use reasoning similar to ours in determining what value of life of to select. They make a critical examination of existing studies and select a value emerging from the best studies of all origins: $2,2 M (US $/1998). Table 8 reports the principal results from both studies (Urban Institute and National Safety Council).

Table 8
Values for an injury
used by large American transportation organizations
(CAN $,2000)

Miller study (1991) (Urban Institute)
Costs per injury

Injury	Cost (CAN $,2000)
Minor	6,390
Moderate	55,600
Serious	208,500
Severe	681,100
Critical	2,752,200
Fatal	3,614,000
Average cost for an accident	109,675

National Safety Council study
Costs per accident

Accident		Cost (CAN $,2000)
K	Fatal injury	3,447,2000
A	Injury with permanent disability	190,430
B	Apparent injury w/o permanent disability	51,430
C	Possible injury (non apparent)	27,800
O	Material damages only	2,780

Source: *BOOZ Allen and Hamilton, 1999*
U.S. Department of Transportation, 1994

We note that the results are shown in terms of severity. The Urban Institute study distinguishes six types of severity: minor, moderate, serious, severe, critical, and fatal. This is a cost-per- injury approach. For its part, the National Safety Council makes use of the well-known KABCO acronym to distinguish mainly between injuries with or without permanent disability. This is a cost-per-event approach. As we shall see, the Urban Institute classification of injuries is closer to the one used in Quebec, which makes this organization's study more relevant to our purposes. This study also provides us with an average (weighted) value for an accident which, incidentally, is not so far from the one emerging from the studies reviewed by Viscusi.

- Employing an extrapolation based on Bordeleau's work for the SAAQ

Bordeleau (1996) uses the human-capital approach to examine the value of avoiding a death or injury. He obtains the following results:

Table 9
Results from Bordeleau's work (1996)
(CAN $, 2000)

Type of accident	Average cost
Fatalities	403,100
All victims (injured)	20,079
All victims (claimants)	78,249
Material damages	7,489

If our recommended value of human-life ($5 million obtained by the WTP) is compared to the value obtained by Bordeleau with his human-capital approach, we observe that the latter is 12 times smaller. Making the hypothesis that the injuries-avoided values obtained with the human-capital approach are also 12 times smaller than those obtained with the WTP, we get the following results:

- Average cost for all injured victims: $240,948
- Average cost for all victims/claimants: $938,988

A victim/claimant is one to whom the SAAQ had to pay compensation.

- Discussion and recommendations

There are three problems which reduce the relevance of the estimates collected by Viscusi (1993). First, all these studies concern the job market and not road transportation safety. We presented above the arguments which sway us towards the data emerging from road-safety studies. Secondly, several of these studies used BLS data and we have already seen that these data are less precise than those deriving from other sources. Thirdly, the definition used for a serious injury (causing at least one day's absence from work) does not correspond to the definition chosen by many transportation organizations such as the MTQ and the SAAQ.

With regard to the results obtained by extrapolating from values found in Bordeleau's work, there are two reasons why they are of little use. First, any extrapolation we make would be arbitrary. Nothing guarantees the proportionality of amounts obtained with WTP values for avoiding a fatality or an injury and amounts obtained with the human-capital approach. Secondly, a close reading of the Bordeleau study shows that "victims/claimants" cannot be converted into victims with serious or minor injuries, which reduces the relevance of his figures for what we propose to do here. Besides, we note that there is a very wide gap between the results obtained by selecting Bordeleau's work and the figures obtained by our other two approaches.

This being said, we recommend the following procedure for determining the value of injuries. We shall apply the ratios used by the Urban Institute (in terms of years of functional capacity lost from premature death or from various types of injuries), but we shall apply them to the value of life selected in the preceding section. In fact, as we have seen, it seems more rigourous to choose a value of life emerging from the best studies in transportation rather than from the best studies as a whole.

However, this leaves us facing another difficulty. The Urban institute uses five types of non-fatal injuries (minor, moderate, serious, severe, critical), whereas the MTQ and the SAAQ use only two: slight injuries and serious injuries with hospitalization. We must thus find a "rule of conversion." After having looked at the Urban Institute's definitions,[6] we propose using the following rule. Slight injuries will be equivalent to the weighted sum of minor and moderate injuries, while serious injuries will be equivalent to the weighted sum of serious, severe, and critical injuries. The Urban Institute study provides us with the proportions for each type of injury and these will serve as our weights.

In brief, using the Urban Institute's ratios, a \$5 M (CAN \$,2000) value of life, and our rule of conversion for injuries, we recommend the following values: \$16,780 for a slight injury and \$533,461 for a serious injury.[7]

Conclusion

Cost-benefit analysis is clearly a useful tool to guide policy makers. It is particularly challenging when projects or regulations to be analysed involve changes in the risk of death or of injury faced by individuals. This paper has discussed the potential avenues available to analysts looking for estimates for values of a statistical life (VOSL) and of injuries to be used in cost-benefit analyses of Quebec projects involving changes in road safety. Actually, the discussion was conducted in the context of Quebec, but most of it could easily apply to the rest of Canada. After a brief literature survey of the different methods that have been used to deduce a VOSL, we have discussed the relevance of looking for an original set of estimates involving a new study and the collection of new data. We have presented many arguments in favour of such a strategy. Second, in case the time or the resources necessary to conduct a new study are not available, we have offered an analytical framework that allows one to make a choice of estimates (or of a range of estimates) from existing studies. We concluded that a VOSL of 5 million dollars (CAN \$, 2000) would be acceptable. One should note that the use of this amount would represent a relatively important change for many Canadian Departments or Ministries conducting cost-benefit analyses in the area of road safety. For instance, Transport Canada is using 1,75 millions (CAN \$, 2000)[8].

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6. Urban Institute (1991), p. 10. For example, we find that a broken tooth is included under slight injuries, a broken leg is included under moderate injuries or a trauma causing coma lasting more than a day is considered a critical injury.

7. For example, we computed the amount for slight injuries as follows: minor injuries are worth \$8,840 ((\$6,390/\$3,614,000) x \$5,000,000). The amounts of \$6,390 and \$3,614,000 appear in Table 8. These minor injuries represent 88% of all the minor and moderate injuries. Moderate injuries are worth \$76,923 ((\$55,600/\$3,614,000) x \$5,000,000) and they represent 12% of the minor and moderate injuries. Based on these data, we obtain the following weighted sum: value of slight injuries = (0,88 x \$8,840) + (0.12 x \$76,293) = \$16,780.

8. For a more complete survey of the values used in different public organizations, see Dionne et al. (2002).

Table A1
Wage-risk studies

No	Authors	Year	Country	VOSL
1	Melinek	1974	U.K.	2 684 902 $
2	R.S. Smith	1974	U.S.	11 412 772 $
3	Thaler et Rosen	1976	U.S.	1 268 086 $
4	R.S. Smith	1976	U.S.	7 291 493 $
5	Viscusi(a)	1978	U.S.	6 498 939 $
6	Dillingham	1979	U.S.	2 534 698 $
7	Brown	1980	U.S.	2 377 661 $
8	Needleman	1980	U.S.	370 000 $
9	Olson	1981	U.S.	8 242 557 $
10	Viscusi	1981	U.S.	10 303 197 $
11	Marin and Psacharopoulos	1982	U.S.	4 438 300 $
12	Arnould and Nichols	1983	U.S.	1 426 596 $
13	Folsom and Leigh	1984	U.S.	15 375 540 $
14	Folsom and Leigh	1984	U.S.	16 326 604 $
15	Gilbert and Smith	1984	U.S.	1 109 575 $
16	Dilingham	1985	U.S.	7 156 795 $
17	Kim	1985	North Korea	1 296 000 $
18	Weiss et al.	1986	Europe	9 160 000 $
19	Herzog and Schottleman	1990	U.S.	16 308 684 $
20	Leigh	1987	U.S.	16 485 115 $
21	Hsueh and Wang	1987	Taiwan	2 251 000 $
22	Garen	1988	U.S.	21 398 947 $
23	Moore and Viscusi(a)	1988	U.S.	7 767 025 $
24	Moore and Viscusi(b)	1988	U.S.	11 571 282 $
25	Meng	1989	Canada	4 910 000 $
26	Moore and Viscusi	1989	U.S.	12 363 836 $
27	Meng and Smith	1990	Canada	7970 000 $
28	Moore and Viscusi(a)	1990	U.S.	25 678 736 $
29	Cousineau and al.	1991	Canada	4 510 000 $
30	Gegax, Gerking and Schulze	1991	Multiple	3 115 005 $
31	Knieser and Leeth 1	1991	Japon	12 046 815 $
32	Knieser and Leeth 2	1991	Asie	5 230 854 $

No	Authors	Year	Country	VOSL
33	Knieser and Leeth 3	1991	U.S.	951 064 $
34	Martinello and Meng	1991	Canada	5 590 000 $
35	Siebert and Wei	1994	U.K.	15 999 523 $
36	Vodden and al.	1994	Canada	6 110 000 $
37	Lanoie and al.	1995	Canada	23 450 000 $
38	Elliott and Sandy	1996	U.K.	1 800 000 $
39	Liu and Smith	1996	Taïwan	1 302 000 $
40	Jin-Tan and al.	1997	Asie	654 649 $
41	Kim and Fishback	1999	Corée du Sud	1 007 500 $
42	Arabsheibani and Marin	2000	U.K.	17 662 785 $

Table A2
Consumer Markets

No	Authors	Year	Country	VOSL
1	Baker	1973	U.S.	8 811 000 $
2	Melinek and al.	1973	U.K.	1 120 000 $
3	Ghosh, Lees and Seal	1975	U.K.	1 080 000 $
4	Jones–Lee	1976	U.K.	5 160 000 $
5	Blomquist	1979	U.S.	684 000 $
6	Dardis	1980	U.S.	951 064 $
7	Cohen	1980	U.S.	506 000 $
8	Portney	1981	U.S.	665 745 $
9	Ippolito and Ippolito	1984	U.S.	1 553 405 $
10	Garbacz	1989	U.S.	4 184 683 $
11	Atkinson and Halvorsen	1990	U.S.	5 985 000 $
12	Carlin and Sandy	1991	U.S.	1 021 000 $
13	Garbacz	1991	U.S.	5 817 343 $
14	Blomquist and Miller	1992	U.S.	4 655 000 $
15	Dreyfus and Viscusi	1995	U.S.	5 369 000 $

Table A3
Contingent Valuation

No	Authors	Year	Country	VOSL
1	Acton	1973	U.S.	158 511 $
2	Melinek	1974	U.K.	1 000 200 $
3	Jones–Lee	1976	U.K.	26 560 000 $
4	Mulligan	1977	U.S.	798 211 $
5	Frankel	1979	U.S.	33 000 000 $
6	Maclean	1979	U.K.	6 990 000 $
7	Jones–Lee and al.	1985	U.K.	6 679 000 $
8	Gerking, DeHaan and Schulze	1988	U.S.	5 389 364 $
9	Maier, Gerking and Weiss	1989	Austria	3 716 000 $
10	Jones–Lee	1992	U.K.	6 023 407 $
11	Miller and Guria	1991	Australia	1 835 000 $
12	Viscusi, Magat and Huber	1991	U.S.	4 758 000 $
13	Persson and Cedervall	1991	Sweden	15 671 000 $
14	McDaniels	1992	U.S.	25 397 000 $
15	Belhadji	1994	Québec	1 226 000 $
16	Soderquist	1994	Sweden	1 645 000 $
17	Schwab Christe	1995	Switzerland	1 167 000 $
18	Lanoie and al.	1995	Québec	3 099 000 $
19	Desaigues and Rabl	1995	France	1 300 000 $
20	Kidholm	1995	Denmark	1 255 000 $
21	Johannesson et al.	1996	Sweden	5 994 000 $
22	Beattie and al.	1998	U.K.	10 725 000 $
23	Guria and al.	1999	New Zealand	3 120 600 $
24	Carthy and al.	1999	U.K.	2 459 000 $
25	Krupnick and al.	2000	Ontario	2 500 000 $
26	Corso, Hammit and Graham	2001	U.S.	4 270 000 $
27	Persson and al.	1995	Sweden	4 858 000 $
28	Persson and al.	2001	Sweden	3 224 000 $
29	Cook and Ludwig	2001	U.S.	6 588 000 $

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