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Public Choice about the Value of a Statistical Life For Cost-Benefit Analyses: The Case of Road Safety

Georges Dionne* and Paul Lanoie**

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* Georges Dionne is Chairholder, Risk Management Chair, HEC Montréal and Associate Researcher, Centre for Research on Transportation, University of Montreal, georges.dionne@hec.ca.

** Paul Lanoie is director of the Bachelor in business administration program at HEC Montréal, paul.lanoie@hec.ca.

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Executive Summary

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 to be used in cost-benefit analyses of projects involving changes in road safety. 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 factors 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 ($ CND, 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. To illustrate our arguments, we refer to the situation prevailing in Quebec, but most of our discussion could easily apply to the rest of Canada, or to any other jurisdiction.

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

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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 million (with two lives saved).

There are 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 ($ CND, 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 to be used in cost-benefit analyses of projects involving changes in road safety. 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 factors 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 ($ CND, 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. To illustrate our arguments, we refer to the situation prevailing in Quebec, but most of our discussion could easily apply to the rest of Canada, or to any other jurisdiction.

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 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. The last section concludes.

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.

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

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 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

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 the 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.)

We assume that individuals have the same level of wealth, w, in each state of nature (live or dead), which means 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.

The marginal amount of willingness to pay can be written as $dw/dp > 0$ 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 (p) 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 (dw/dp). 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. For example, this would mean factoring insurers' compensations for loss of income (other than those for the value of life) as well as claims paid for material damages. It can be easily shown that 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. In general, life insurance premiums are not adjusted for road safety projects, for they are not defined in terms of road-accident risks.

Finally, insurers may pay 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 because we assumed there was no insurance coverage for such losses when individuals were asked to reveal their willingness to pay. Thus, if this amount is used to evaluate the benefits of projects, these insurers' 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, reactions to risk (often linked to age structure), etc. These are captured by the individuals' utility index. They may be important enough to justify an independent study in a given country.

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. Supplementary insurance is also available in the private market for higher income groups. 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; 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 a state or province. 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 different than those where we want to apply the results.

The average personal wealth or w variable 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. 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 many other countries. 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. We can show that dw/dp increases with p under the reasonable hypotheses related to the parameters of the standard model (Dionne et al., 2002). This implies that societies whose accident rates are higher will also have a higher WTP. Statistics show that the Canadian average for fatal accidents is lower than Quebec's but that the death rate 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 a given country, although the right adjustment would not be straight forward. For example, we would have to take into account of the average risk exposure by drivers (average kilometres driven or any other measure; see the recent study of Smith, 2003).

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, 1998). It is quite unlikely that residents of many countries would have an equally high WTP corresponding to this risk, since the probability of such events must be much lower. Moreover, as documented above, the standard of living is higher in the United States and this last factor may be of same significance as the average accident probability for this particular study.

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 many countries, policy makers 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 residents' 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 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 automobile insurance 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 a given country, 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 that are already covered (double counting), the average compensations paid by the insurers will have to be subtracted when calculating the benefits of projects. Also to be subtracted are portions of insurers' 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 where the values are going to be used. For example, if the average insurance coverages are, on average, lower than those paid 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 other 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. For example, it is 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. For application of these values in Canada, for example, one needs careful documentation is how the universal medical and hospitalization plans have to be accounted for VOSL 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 different countries 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, for example. 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 Canada. To correct this value, it would be useful to know the fatal-accident rates for the populations studied.

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 between countries 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. (See, however, Dionne et al., 2002.)

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

We consider a state or 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), drawn from existing publications. 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 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.

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 would be 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 ($ CND, 2000). 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 $4 M.

- 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 another 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. It is noteworthy that the wage-risk studies in Canada present fairly stable results contrary to what is observed elsewhere (e.g., U.K.). The average of the values obtained amounts to $6,852,000 ($ CND, 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
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
Belhadji	1994	1,226,000	Contingent
Vodden et al.	1994	6,110,000	Labor market
Lanoie et al.	1995	22,000,000	Contingent and Labor market
Krupnick Crooper	2000	2,500,000	Contingent
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 is 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 this is what is observed in Table 2 (Canadian Studies). Furthermore, Elvik (1995), who made a systematic comparison between a series of studies based on the job market and another series based on road safety, reaches the same conclusion.

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 $5.7 M ($ CND, 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 ($ CND, 2000)

Authors	Year	Statistical value of a human life	Method	Country
McDaniels	1972	25,397,000	Contingent	U.S.
Baker	1973	8,811,000	Consumer	U.S.
Melinek	1974	1,002,000	Contingent	U.K.
Ghosh, Lees and Seal	1975	1,080,000	Consumer	U.K.
Jones-Lee	1976	26,560,000	Contingent	U.K.
Jones-Lee	1976	5,160,000	Consumer	U.K.
Blomquist	1979	684,000	Consumer	U.S.
Cohen	1980	506,000	Contingent	U.K.
Jones-Lee et al.	1985	6,679,000	Contingent	U.K.
Maier et al.	1989	3,716,000	Contingent	Australia
Atkinson and Halvorsen	1990	5,985,000	Consumer	U.S.
Carlin and Sandy	1991	1,021,000	Consumer	U.K.
Miller and Guria	1991	1,835,000	Contingent	New Zealand
Persson and Cedervall	1991	15,671,000	Contingent	Sweden
Viscusi et al.	1991	4,758,000	Contingent	U.S.
Blomquist and Miller	1992	4,655,00	Consumer	U.S.
Belhadji	1994	1,226,000	Contingent	Canada
Desaigues and Rabl	1995	1,300,000	Contingent	U.S.
Dreyfus and Viscusi	1995	5,369,000	Consumer	U.S.
Kidholm	1995	1,255,000	Contingent	Denmark
Lanoie et al.	1995	3,099,000	Contingent	Canada
Persson et al.	1995	4,858,000	Contingent	Sweden
Schwab Christe	1995	1,167,000	Contingent	Switzerland
Johannesson et al.	1996	5,994,000	Contingent	Sweden
Beattie et al.	1998	10,725,000	Contingent	U.K.
Corso et al.	2001	4,270,000	Contingent	France
Persson et al.	2001	3,224,000	Contingent	Sweden
Average		5,659,000		
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 is. 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 those based on data from the Actuarial Society or the early ones (before 1982) based on data from 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 trade-off 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:

i) Studies on the job market with non-representative samples or those having used data from the Actuarial Society or from the BLS (before 1982);

ii) Contingent evaluations relying on non-representative samples;

iii) 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 ($ CND, 2000)	Countries
Job-market studies			
Marin and Psacharopoulos	1982	4,438,300	U.K.
Folsom and Leigh	1984	15,376,000	U.S.
Folsom and Leigh	1984	16,326,000	U.S.
Gilbert and 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.
Kniesner and Leeth	1991	12,047,000	Canada
Kniesner and Leeth	1991	5,231,000	Asia
Kniesner 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			
Jones-Lee et al.	1985	6,679,000	U.K.
Gerking et al.	1988	5,290,000	U.S.
Viscusi et al.	1991	4,756,000	U.S.
Johannesson et al.	1996	5,994,000	Sweden
Corso et al.	2001	4,270,000	U.S.
Ludwig and Cook	2001	6,588,000	U.S.
Persson et al.	2001	3,224,000	Sweden

Authors	Year	Statistical value of a human life ($ CND, 2000)	Countries
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
($ CND, 2000)

Authors	Year	Statistical value of a human life	Method	Countries
Jones-Lee et al.	1985	6,679,000	Contingent	U.K.
Atkinson and Halvorsen	1990	5,985,000	Consumer	U.S.
Viscusi et al.	1991	4,758,000	Contingent	U.S.

Dreyfus and Viscusi	1995	5,369,000	Consumer	U.S.
Johannesson et al.	1996	5,994,000	Contingent	Sweden
Corso and al.	2001	4,270,000	Contingent	U.S.
Persson et al.	2001	3,224,000	Contingent	Sweden
Average		5,183,000		
Median		5,369,000		

There are seven studies in table 5.[2] 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 that of Canada[3]. 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 $5.2 M ($ CND, 2000) and $5.4 M 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 $5 M ($ CND, 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.

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2. 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.
3. 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

Table 6
Summary table of different avenues explored
(million $ CND, 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

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) to be used in cost-benefit analyses of 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, or to any other jurisdiction. 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 ($ CND, 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 million ($ CND, 2000)[4].

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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.

4. 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.K.	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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