Using value of statistical life for the ex ante evaluation of transport policy options: a discussion based on ethical theory

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Abstract This paper aims to discuss a number of questions that are highly important for the ex ante evaluation of the safety impacts of transport policy options, from the perspective of ethical theory: (1) Is it morally OK to express prevention on acceptance of fatalities or risks in monetary terms? (2) How useful is the concept of the value of a statistical life (VOSL) for ex ante evaluations of transport policy options? (3) What are the pros and cons of pricing protection of lives or prevention of risks in ex ante evaluations? (4) Which methods are available for expressing (protection of) human lives in monetary terms, and what are the main related methodological discussions? (5) Are all safety-related costs generally included in ex ante evaluations of the safety impacts of transport policy options, and if not: what is the relevance of excluded costs categories from an ethical perspective? (6) How important is the distribution of safety effects from an ethical perspective? The answer to the first question highly depends on the ethical theory that is used. With respect to question 2 we think that the VOSL is a useful concept, but that its application is not straightforward, for several reasons. Thirdly we think that probably pricing safety improves the quality of decision making, but to the best of our knowledge there is no research to underpin this expectation. The answer to question 4 is that several methods exist to estimate the value of a statistical life (VOSL), willingness-to-pay (WTP) methods being the most common category of methods. However, several methodological issues arise that make estimates of VOSL less straightforward. With respect to question 5 we conclude that behaviour-related avoidance costs are often overlooked and that these costs are relevant from an ethical perspective because the freedom to move and the freedom to participate in activities are challenged. Finally the answer to question 6 is that from an ethical perspective, in terms of the evaluation of policy measures, it might matter which groups of the population are the victims of the transport system, or are at risk.

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Egalitarian theories as well as sufficientarianism are useful theories to discuss distribution effects. Different theories conclude differently.

Introduction

Transport policy making largely relates to accessibility, the environment and safety. Nowadays almost all countries have safety related policies. Common ingredients of such policies include speed limits that vary by road category, regulations for drinking (maximum alcohol content in the blood) and the obligation to wear helmets on motorized two wheelers and seatbelts in larger vehicles, and design criteria (as often expressed in manuals) for road and rail infrastructure. In most countries it is very common to evaluate candidate policy options on an ex ante basis. Cost–Benefit Analysis (CBA) is nowadays the standard method of evaluating infrastructure plans in most countries (Hayashi and Morisugi 2000). Basically a CBA is an overview of all the pros (benefits) and cons (costs) of a project. These costs and benefits are as much as possible quantified and expressed in monetary terms. Benefits are in general based on consumer preferences. Consequently the monetary valuation of changes in safety levels are based on the Willingness To Pay (WTP) of consumers for lower risk levels. Costs and benefits occur in different years within the time horizon of the CBA. To deal with this, they are presented as so called net present values, implying that taking into account interest and inflation it is better to have 1 euro or dollar nowadays than in, for example 2030. The discount rate is used to express this valuation. Final results are often presented in summarizing indicators. The main indicators that are presented are the difference between costs and benefits, the return on investment, and the benefit–cost ratio. Almost every handbook on transport economics pays attention to CBA in transport (see, for example, Button 2010).

For specific safety policies Cost-Effectiveness Analysis (CEA), comparing the (changes in) safety effects per monetary unit, is often applied. CBA requires valuing (changes in) safety effects in monetary terms. CEA does not, but the decision making at least has an element of valuing protection of human lives or changes in risk, because 'expensive' policies are often not implemented.

Much of the academic literature generally discusses pricing from a methodological perspective, assuming that pricing risk changes is OK, though there certainly is debate on this issue, for over three decades—see for example Kelman (1981). To the best of our knowledge a comprehensive discussion on pricing safety and risk from an ethical perspective in the context of CBA is missing. This paper aims to fill this gap. We first discuss various systems of ethical perspectives, because the answers to many questions on pricing protection of human lives or risks depend on the ethical-theoretical point of departure.

The paper focuses on road traffic only.

More specifically this paper discusses the following questions:

1. Is it morally OK to express (prevention on acceptance of) fatalities or risks in monetary terms?
2. How useful is the concept of the Value Of a Statistical Life (VOSL) for ex ante evaluations of transport policy options?
3. What are the pros and cons of pricing protection of lives or prevention of risks in ex ante evaluations?

4. Which methods are available for expressing (protection of) human lives in monetary terms, and what are the main related methodological discussions?
5. Are all safety-related costs generally included in ex ante evaluations of the safety impacts of transport policy options, and if not: what is the relevance of excluded costs categories from an ethical perspective?
6. How important is the distribution of safety effects from an ethical perspective?

We discuss these questions from the perspective of transport safety. The discussion might also be relevant for other areas of application, such as risks in industry—see, for example, Evans (2009) who reflects on this topic. In addition we discuss the ethical aspects of one category of accident avoidance costs, those related to changes in behaviour, a cost category that is often missing in ex ante evaluations of transport policy options.

Where appropriate, we introduce ethical theories in the discussion of these six questions.

The following sections from "Is pricing risk changes acceptable?" to "The distribution of safety effects: an ethical discussion" discuss questions 1–6, respectively. "Conclusions" section summarizes our findings. We explain the concept of the VOSL and its competitors in "The usefulness of the VOSL for the ex ante evaluation of safety effects" section, because the related discussion is strongly interwoven with question 2.

Is pricing risk changes acceptable?

Within the community of persons involved in ex ante evaluations of transport plans and policies the subject of pricing human lives is one of the most controversial. We have been involved in many discussions about this subject. Some think intuitively that it is immoral to price human beings, others highly support doing this. We will not give a clear and indisputable answer to the question in the heading of this section: there is no clear answer. The answer depends on the ethical theory one uses as a basis (see below). The two most extreme positions probably follow from the Kantian perspective, an influential perspective in a category of ethical theories called 'deontology' and the utilitarian perspective, an influential perspective in a category of ethical theories called 'consequentialism'. We will firstly discuss these two perspectives, followed by more perspectives.

Deontology—the Kantian perspective

Deontology is a category of ethical theories regarding which choices are morally required, forbidden, or permitted. In other words, deontology falls within the domain of moral theories that 'guide and assess our choices of what we ought to do' (Stanford Encyclopedia of Philosophy). Deontologists hold that at least some fundamental moral principles, rules or ideas are to be followed, regardless of the outcomes. Contractualism is an example of a deontological theory which states that 'morality is based on contract or agreement' (Stanford Encyclopedia of Philosophy). The contracts or agreements should be based on mutual respect. The most well-known deontologist is Immanuel Kant. In this paper we firstly discuss the Kantian perspective because of its 'extreme' position. Kant developed the so called principle of the Categorical Imperative. We cite Audi's (2007) formulation because it is much simpler than the original formulation by Kant: '*Act in such a way that you always treat humanity, whether in your own person or in the person of any other, never simply as a means, but always at the same time as an end*'. This applies to oneself as well

as to others. Everyone matters and matters equally. Although a Kantian perspective does not directly relate to risks, we argue such a perspective could lead to quite extreme the conclusion that pricing risks is immoral. People should not be considered only as a means to something else. It would then follow, for example, that shorter travel times cannot compensate for a reduction in safety: travel time savings should not come at the cost of additional risks for others. From a Kantian perspective safety of people could be prioritized over travel times of others. Even the suggestion that such a trade-off can be made, implying that a price can be given to a human life or even risks, would be considered as immoral. This suggestion can, but does not necessarily have to, be derived from a Kantian perspective. This extreme position would, for example, lead to the conclusions that speeds of road traffic on most roads in the build-up environment should be very low, e.g., 15 km/h, to reduce risks to pedestrians and cyclists to almost zero. To our opinion this position raises serious practical concerns.

When considering transport projects and policies, a potential problem with the Kantian perspective is that the ex ante evaluation of transport projects and policies relates to *statistical* lives, there are no clearly defined people who will lose their lives. We consider probabilities, not specific individuals (see below).

The utilitarian perspective

Utilitarianism is an influential theory within the wider family of Consequentialism, or more specifically Act Consequentialism. Consequentialism 'is the view that normative properties depend only on consequences' (Stanford Encyclopedia of Philosophy). Utilitarianism, can be defined as follows. It 'is the claim that an act is morally right if and only if that act maximizes the good, that is, if and only if the total amount of good for all minus the total amount of bad for all is greater than this net amount for any incompatible act available to the agent on that occasion' (Stanford Encyclopedia of Philosophy). Consequentialism is a category of theories, and more or less the opposite of deontology. Benefits and costs should be summed over all parties. Utilitarianism was developed by Jeremy Bentham and John Stuart Mill. Mill developed the master principle: *Choose that act from among your options which is best from the twin points of view of increasing human happiness and reducing human suffering.*

This perspective holds that people may not necessarily price their own life or the life of others, but they do value risks. For example, a person buying a new car considers the safety level (at least the perceived level of passive safety, the crash worthiness of a car, as expressed in the Euro NCAP ratings) but also many other characteristics of a car, such as price, size, performance, and emotional values. And people know that driving 120 km/h is less safe than driving 100 km/h, but they trade-off travel time and maybe the fun of driving, and safety (and fuel costs). So maximizing any form of utility should include safety. And this can be done, based on the preferences of humans as consumers or—more generally—persons making choices.

Some have even claimed that striving for maximum safety levels is unethical. An example is provided by the discussion on the Swedish vision Zero (for road traffic). One of the architects behind the vision, Claes Tingvall, stated that the requirements of the vision were so strong that "*Whenever someone is killed or seriously injured, necessary steps must be taken to avoid a similar event*" (Tingvall and Haworth 2000; cited in Elvebakk and Steiro 2009). This position is claimed to be naïve, overly ambitious, and even unethical (Fahlquist 2006). Elvik (1999; cited in Fahlquist 2006) asserts that the aim to eliminate road traffic deaths would demand such substantial resources that other areas where

people's lives are also at risk would suffer. Allsop (2005: 16) also warns for being too ambitious and concludes: '"How far to zero?"…a long way from where we are now, but not all the way!'

Deontology—the doctrine of double effect

In addition to the two most extreme positions with respect to pricing changes in safety levels, we now discuss some 'in between positions'. We first discuss the Deontological principle of the 'doctrine of double effect', according to which there is a moral difference between causing harm or evil as an unintended side-effect of an intended action or policy, and intending the harm of evil directly, either as an end or as a means to an end. From this perspective it would at least make a difference if a fatality resulted from immorally risky driving behaviour by someone who deliberately endangers the life of others, or from 'normal' driving behaviour. People who drive riskily do not intend to harm others (or themselves) but they accept endangering others. Examples include drink driving and speeding. In general, a follower of deontological principles would be reluctant to price accident risks, although the introduction of the distinction between intended and unintended effects according to the 'doctrine of double effect' might lead to a refinement of this position. This refinement could be relevant if the position is linked to policy, because the two kinds of effects may well differ in their preventability by policy interventions. One could argue, however, that from the perspective of consequentialism no difference should be made between a fatality resulting from immoral driving behaviour and a fatality resulting from a 'normal' accident.

Contractarianism

The idea of contractarianism (and contractualism—a theory we will not discuss here) is that '*whether an action is right or wrong depends on whether it accords with or violates principles that would be the object of an agreement, contract, or choice made under certain conditions by members of the moral community*' (Darwall 2003, p. 21). 'The moral theory of contractarianism claims that moral norms derive their normative force from the idea of contract or mutual agreement' (Stanford Encyclopedia of Philosophy). From a contractarianism perspective a person could be asked questions about which agreements she would like to make with others. Applied to the question of risks, agreements could, for example, include maximum speeds that trade-off travel times (and maybe also the fun of driving at certain speeds) and risk levels. From this perspective pricing is not really needed for moral reasons, but it is desirable from the perspective of ex ante evaluations because it could improve or facilitate the process of making agreements. There is a clear link between this approach and the well-known Coase (1960) theorem, which says that when property rights are well defined and there are no impediments to bargaining—implying zero transaction costs—an agreement between the members of the community will lead to an efficient outcome, irrespective how the property rights have been distributed initially.

Strict application of this principle to many future options for transport policies is problematic, however. A more in-depth analysis of the Coase theorem shows that a good number of additional factors may lead to distorted negotiation outcomes, including strategic misrepresentation of the information on potential benefits and losses for members of the community (Hahnel and Sheeran 2009). Contractarianism could lead to a strong, probably undesirable, tendency towards the status quo because some people might not be willing to sign a contract that makes them worse off, even if large gains for others would

result. For example, if speeds on motorways are reduced, those who like driving fast (despite the risks) would not sign an agreement. If maximum speeds were increased, those who prefer lower risks would not sign up. There is a close link between Coasian negotiations and the well-known Hicks (1939) and Kaldor (1939) principle in social cost benefit analysis. This principle says that a project has net positive welfare effects when the benefits are large enough that the winners could in principle compensate the losers. This implies compensation that remains hypothetical in nature. In theory, such a compensation would indeed make everybody better off, but implementation in reality will easily lead to a wide range of problems involving high transaction costs and asymmetric information. The similarity between the two concepts is that both are based on welfare economics, and both deal with compensations. The difference is that Coasian negotiation is voluntary, whereas the Hicks Kaldor principle is based on state coercion.

To summarize, there is no clear answer to the question of whether pricing human lives is OK. One could wonder: why discuss the question at all? Our answer would be that we should respect the positions of people who support both sides of the argument.

The usefulness of the VOSL for the ex ante evaluation of safety effects

Based on ethical theory, or because of other motivations, several people have recognized that moral objections against pricing human lives can be raised. In medicine and medical ethics traditionally many persons have objected to doing so (Elvik 2002). In economics and in the transport and safety community this is done much more often, despite the critics. An often used 'solution' to (potential) moral critics is to not price lives directly, but to use what is called a 'statistical life'. The result is the indicator 'Value of a Statistical Life' (VOSL, also abbreviated in literature as VSL). In this section we discuss the usefulness of the VOSL for the ex ante evaluation of safety effects. The discussion is not predominantly an ethical discussion, but setting its value is—this issue is discussed in "Which methods are available for expressing (protection of) human lives in monetary terms, and what are the main related methodological discussions?" section.

The VOSL is an 'anonymous indicator' that is used to place a monetary value upon a change in the estimated number of fatalities in traffic over a certain period of time under given circumstances. In fact a value is put on risk, and this risk is multiplied by traffic or travel volumes. Proponents argue that people may not be able to say how much their life is worth, but they are able to say how much they are prepared to pay for lower risks. And if we know the WTP for lower risks, we have an indication of the VOSL. Examples of choices that people make that give an indication of the WTP could be the safety features in cars (such as additional airbags) or preferences with respect to driving speed (and related travel times).

This implies that the term VOSL is actually somewhat misleading. Its essence is that it represents the valuation of people exposed to travel risks in terms of an amount of Dollars (or other currency) per unit of risk reduction. Consider the case of a group of travellers who are prepared to pay 200 dollars per year to drive in a safer car so that the risk of a fatal accident is reduced by 1/10,000 per year. This is equivalent to saying that 10,000 travellers would be prepared to pay 2 million dollar and that this would reduce the risk for these 10,000 travellers by 1/10,000 each. The expected number of lives saved would then be equal to 1. A convenient way to represent the willingness to pay for this group is to say that its collective value of a statistical life is equal to 2 million dollar. Hence the use of the VOSL concept is nothing more than a handy way to represent consumer's preferences for

risk reductions. When the use of the term gives the impression that human lives are valued this is a regrettable misunderstanding that could easily be avoided by abolishing the concept. To avoid misunderstanding one could consider the use of another term. The term Value of Preventing a Fatality (VPF) is already used in the literature and would be less misleading. Cameron (2010) in her paper titled 'Euthanizing the Value of a Statistical Life' definitely rejects the concept of the VOSL and proposes the Willingness to Swap (WTS) in full: the 'WTS other goods and services for a microrisk reduction in a specified type of risk.' Because the VOSL is by far the most frequently used term, we will use it in our paper, despite the criticism.

Consider for example the case that a safety enhancing investment is proposed for the roads used by these drivers to make it safer such that it would lead to an identical reduction in risks of 1/10,000 per year. Then what is done in CBA is simply to adopt the willingness to pay in the private domain to make cars marginally safer and apply the same figure in the context of a public decision to make roads marginally safer. Hence, a CBA of safety enhancing measures can be carried out in terms of willingness to pay for marginal risk reductions. The standardisation to the willingness to pay per 1 statistical life saved is, strictly speaking, superfluous. The essence of the economic approach is not 'pricing human lives', but pricing human risks'.

However, applying the concept is not completely straightforward, a first reason being that the concept of the VOSL (and certainly how it is used in practice) assumes no relationship between the VOSL and risk levels. However, the level of risk can have an impact on the VOSL, because it has an impact on choices and WTP. Generally speaking: the higher the risk, the higher the monetary value people put to a constant unit of output (Morton 1991; Hammitt 2007). For example, people might be willing to accept a risk of 1/10,000 for 200 dollar (resulting in a VOSL of 2 m dollar), but only very few people will accept a risk of 50 % for 1 m dollar. Therefore the risk level can cause variations in the outcomes of choices, leading to other VOSLs. In other words: the patterns of choice, and thus also the VOSLs, are *risk level dependent*. Due to the increase in VOSL with increasing risk levels (the VOSL could approach infinity for risks nearing the value of 1) it can even be argued that the VOSL is not the same as the value of an unidentifiable person's life (Hammitt 2007).

Secondly, if the VOSL is based on people's choices, it assumes a 'correct' perception of the risks. The usefulness of VOSL could be questioned if it is based on a misperception of the risks by people. For example, from research it is known that people are not very able to deal with very small risks, and to translate a small risk reduction into a monetary benefit (Kahneman and Tversky 2000; Kahneman et al. 1982, 1999; Kahneman and Knetsch 1992; De Blaeij 2003). VOSL based on WTP for lower risks may be primarily useful if risk levels in a particular ex ante evaluation matches those of the cases of the stated or revealed preference research. In "What are the pros and cons of pricing protection of lives or prevention of risks in case of ex ante evaluations?" section we further discuss the problem of discrepancies between objective and subjective safety levels.

Thirdly the VOSL generally includes a valuation of the statistical lives of the people involved, but not their descendants, though there could be a good point in doing so (see Broome 2005; the explanation is quite complicated and is beyond the scope of this paper). This point refers to the conventional way of doing WTP research in this area—questions do not explicitly relate to descendants that could be born in the future but are not because, for example, the woman who would have been their mother has been killed. A well designed research could nevertheless include related questions.

Fourth, if one argues that each person is equally important and thus the VOSL (at least within one country) should not depend on income levels, an inconsistency can occur between the VOSL and the Marginal Value of Travel Time Savings (MVTTS). This is because the MVTTS is income dependent: the MVTTS for higher income groups is higher than for low income groups. As a result high income groups score better in a CBA than lower income groups (e.g., Mackie et al. 2003). As a reaction, the so-called "equity value of time" was introduced in virtually all cost–benefit analyses carried out in the U.S. and abroad. The equity value of time is based on an average income level (Morisugi and Hayashi 2000; cited in Martens 2006). This topic is particularly relevant for CBA of infrastructure projects because travel time savings often are the dominant benefit category. Note that our discussion relates to evaluations, not to forecasting behaviour. In the latter case person dependent VOTs and risk acceptance levels should be used.

It is interesting to observe that a similar notion of equity weighting has been proposed and applied to VOSL in the context of climate change (Schipper 2004). Here the issue of differences in income levels leading to differences in VOSL between rich and poor countries is pertinent—for example, the WTP for risk reductions in a poor African country will definitely be much lower than in a Scandinavian country, but applying these differences to the ex ante evaluations of climate change policies will meet moral opposition. Without such equity weighting there may well be a strong bias against poor countries when it comes to taking measures to address global environmental problems. Within countries the income differences between various socio-economic groups would also lead to differences in VOSL. The common practice of using VOSL in a CBA of safety projects within countries would be that no distinctions are made between various socio-economic groups, but that an average value for the whole population is applied. This is indeed very similar to the above comments about the equity value of time.

What are the pros and cons of pricing protection of lives or prevention of risks in case of ex ante evaluations?

The consideration that pricing protection of human lives or even risks is unethical is an extremely powerful argument, probably strong enough to overrule all other arguments for those who accept it. One could even take the position that raising this section's question is not acceptable as it seems to suggest that the pros and cons can be compared, or traded-off.

On the other hand, there may be good reasons to value human lives. One reason is that people trade-off safety levels and other impacts of their choices anyway, so using a monetary value for the changes in risks (and, multiplied with volume indicators, resulting in the number of fatalities) based on peoples preferences contributes to a balanced way of including peoples preferences in ex ante evaluations.

A second, and related, reason could be that if a CBA is carried out anyway, outcomes of interest that are not expressed in monetary terms probably have less impact on decision making. Many researchers and policy makers have the impression that decision makers, certainly in the case of a CBA, primarily look at financial indicators such as benefits minus costs, the benefit–cost ratio, or the return on investment. If safety is not included, its impact on decision making could be less compared to including safety in monetary terms. On the other hand, if safety levels hardly differed between choice options, e.g., alternatives for new roads, expressing them in monetary terms will hardly influence indicators, as just mentioned. In that case, a + or − to compare choice options may have more impact. But is 'more impact' necessarily 'better'? We would not like to rule out the possibility that in

addition to underinvestment in traffic safety there may also be overinvestment, which would imply that less resources are available for other welfare enhancing activities. Hills and Jones-Lee (1983, p. 355) reflect on the risks of inconsistency and allocative efficiency: 'if inconsistency and allocative inefficiency are to be avoided, then explicit monetary costs of accidents and values of accident prevention are required'. An equal amount of discussion can also be found in the literature on intergenerational justice: risk reductions come at a cost. The price of risk reductions to zero can easily be too high (Davidson 2009), as in the case of vision zero as explained in "Is pricing risk changes acceptable?" section.

In our opinion it is important, if ex ante evaluations are used as input for decision making, that the research is of the highest quality. A practical rule of thumb could be that the quality of this research is higher if as a result of it the decision makers make the choice they would have made (1) if they had all the potential choice options available, (2) if they were fully informed and (3) if they were able to evaluate different choice options. Giving more information on the value of risk improves the information base of decisions and hence would increase the quality of decision making according to the above rule of thumb. We can therefore carefully conclude that expressing safety in monetary terms more often increases the usefulness of research for decision making than that it decreases. A possible exception may be that information overload may undermine the quality of decision making. However, when cost benefit information is presented in a proper way with different options in terms of details on certain cost and benefit items, this is probably not a real problem. Another exception might occur when the additional information provided—although being correct as such—is misleadingly presented and thus not well understood by the user. This is indeed a point of interest, implying that the information provided must minimise the risk of misinterpretation.

Which methods are available for expressing (protection of) human lives in monetary terms, and what are the main related methodological discussions?

An overview of methods

The current state-of-the-art in valuing changes in safety levels is that both material and non-material costs should be included (De Blaeij et al. 2003). Material costs include damage to vehicles and in some cases also infrastructure, loss of production of people, and costs of medical treatment. Non-material costs include loss of the quality of lives of the victims and the people who care about them (family, friends, others).

Several methods are available to express protection of human lives in monetary terms. A first distinction can be made between consumer-based and other methods. In the CBA community the impression is that consumer-based preferences are generally to be preferred: Who else is better able to value the importance for consumers than the consumers themselves? We will discuss related methods below. Nevertheless it is good to realize that other methods also exist. Such methods are labelled as 'costs per life saved methods' (De Blaeij 2003). Such methods mainly look at choices of policy makers in the past: One can look at the implicit VOSL that results from policy measures taken in the past. This could be done within or outside the transport system. Examples in the transport system could be safety regulations to reduce the risks of car or rail accidents, examples outside the transport system could be regulations for safety standards in industry.

In the category of consumer-based methods, a distinction can be made between willingness to pay (WTP) and willingness to accept (WTA) methods. WTP relates to the

willingness to pay for any improvement, such as a reduction in risk levels. WTA relates to the willingness to accept any losses, such as an increase in risk levels, e.g., due to other car drivers driving faster. For several reasons WTP values are of more use than WTA values. One of the reasons is that WTA values that follow from questionnaires could be biased because of strategic behaviour of respondents. In addition, WTA can more easily be non-realistic: people might (implicitly or explicitly) suggest that they have a much higher WTA for measures that will yield risk reductions than they are really prepared to pay for given the choice (see, for example Hanemann 1991; Perman et al. 2003). WTP methods include Revealed Choice and Revealed Preference (RC/RP), and Stated Choice and Stated Preference (SC/SP) methods. For reasons of simplicity below we will refer to SP and RP methods. RP methods focus on what people in the real world have shown themselves to be willing to pay for decreased risk. One can for example look at the WTP for airbags that were optional in new cars. A complication is that choice options often vary not only with respect to safety levels, but also with respect to other characteristics. A bigger car generally is not only safer, but also more comfortable. The toll roads in France are not only safer than the *Routes Nationales*, but also result in shorter travel times and maybe a lower appreciation of scenery. SP research asks people what they would be willing to pay for a decrease in risk, e.g., for additional airbags in their next car. RP methods have the advantage that it is real choices that are available, not choices in less reliable hypothetic situations. On the other hand, for RP methods it is important to realize that people may have had the wrong perceptions of the (changes in) risks when they made their choices, which could have influenced their choices. SP research has the advantage that the researcher can present the (changes in) risk levels. Another advantage of SP is data availability: RP data are often not available. In SP research people can be asked about many hypothetical situations, even if they do not exist (yet). For a discussion on SP and RP methods in the area of safety see De Blaeij (2003) and De Blaeij et al. (2003). VOSLs as found in meta-analyses that review many studies are in the order of magnitude of 3–6 million US dollars, in 1995–2000 prices (e.g., Dionne and Lanoie 2004; De Blaeij et al. 2003).

A discussion of methods

Below we will discuss these methods using ethical theory. An important issue in the valuation of safety is the question: Does each fatality have an equal value or not? If one answers this question with 'yes' the conclusion would be that it is as bad if a 90 year old blind and deaf person dies 2 weeks earlier than he or she would otherwise have done due to high concentrations of ozone, as when a 15 year old school child gets killed in a road accident. Only a few people would agree. If the answer is negative, the question is: which method to use? There are at least two options: the WTP as discussed above, and the concept of QALYs (Quality Adjusted Life Years). We first discuss this concept, followed by a discussion on the inconsistencies between QALY and the WTP-based VOSL.

The concept of QALY is introduced to express the combination of quality and quantity of lost life years. The concept is widely applied in health care decision making (Loomes and McKenzie 1989). The QALY concept firstly has the advantage that the quantity and quality of lost life years do count. A second advantage is that it can also be used to include injuries causing permanent negative health impacts: even if the quantity of life years of an injured person remains the same, the loss of quality can be expressed. A major point of discussion is that it is disputable whether very young persons should be compared with others. To quote Morton (1991: 112): '*For very few people would think that, for example,*

one should sacrifice more for the safety of a newborn baby than for that of a fifteen-year-old child'.

We now continue the discussion comparing QALYs and the WTP. It is important to realize that an inconsistency can occur between WTP and the concept of QALYs. A good overview of the discussion on WTP versus QALYs can be found in Hammitt (2002). He states that although both methods are based on individual preferences, the underlying assumptions differ. The different bases yield systematically different conclusions about the relative value of reducing health and mortality risks to individuals that differ in age, health conditions, income, and other factors. The choice of which method to use depends on judgments about what constraints should be placed on individual preferences and what factors should be considered in aggregating preferences across people. Estimates of QALYs are likely to be less variable across people and studies than estimates of WTP because the QALY framework imposes greater constraints. To quote Hammitt (2002: 998): 'QALYs impose substantial and somewhat unrealistic constraints on the form of individual preferences and combine preferences across people on a relatively egalitarian basis. In contrast, WTP imposes few constraints on individual preferences and gives relatively greater weight to more affluent sectors of society'.

The inconsistency between QALYS and WTP firstly relates to the relationships between age and both concepts. Researchers have explored the relationship between the WTP for a statistical life and age. For example, Shepard and Zeckhauser (1984) found that VOSL peaks near age 40 and is less than half as large at ages 20 and 65. The increasing VOSL between the age of 20 and 40 contradicts the QALY concept. An explanation may be that between the age of 20 and 40 income increases. But probably even a person having an increased WTP between the age of 20 and 40 might prefer to get killed in a road accident at the age of 40 rather than at the age of 20. So the inconsistency is notable. De Blaeij (2003) found another example of such an inconsistency between the QALY approach and the VOSL approach, stating that the VOSL peaks between 50 and 65, and hence only starts to decline beyond 65 years. In De Blaeij's analysis a correction was applied for income levels, hence the age pattern was not distorted by age–income interrelationships.

The inconsistency between QALYs and WTP next relates to travel mode. For the concept of QALYs it does not matter how people are killed in a road accident, but for WTP it may matter. This is illustrated by Johansson-Stenman and Martinsson (2008) who did research on people's general *ethical preferences* and the value of life. They combine age and mode; Table 1 presents their results. The values are 'relative value of life' figures (a 70 year old driver = 1). These relative values are simply the ratios between probit coefficients of their model. The Social Marginal Rate of Substitution (SMRS) figures thus express how many 70-year-old drivers would have to be saved to be equivalent to saving one individual of a certain age and type of road user for each of the six samples. For example, the value of 4.646 in the first row should be interpreted as respondents being indifferent between saving 4.646 70-year-old car drivers and saving one 10-year-old pedestrian.

Table 1 not only shows the strongly decreasing 'ethical preference value' of a life with age (giving support for the concept of QALYs over WTP), in addition, it shows that pedestrian fatalities are valued higher than an equivalent driver.

A third potential inconsistency between QALYs and WPT arises with respect to children. Children hardly have any money, so their WTP for reduced risks will be very low. One can seriously debate if even doing research into the WTP of children for risks is morally acceptable. One could argue that what then matters is the WTP of their parents (Leung and Guria 2006). But suppose a 10 year old child lost her parents. Would that mean

Table 1 Ethical preferences: comparisons of fatality categories

	SMRS
10-year-old pedestrian	4.646
30-year-old pedestrian	3.030
30-year-old driver	2.489
50-year-old pedestrian	2.394
50-year-old driver	2.159
70-year-old pedestrian	1.428
70-year-old driver (base case)	1

Source Johansson-Stenman and Martinsson (2008)

that the WTP for risk reduction of that child is hardly more than zero? Would it make the life of the orphan child of less value than the life of her friend that still has both parents? And if the parents still live, the WTP for reduced risks of children may very well depend on income as well as on the number of children they have. Would this really matter? To discuss this question we introduce a specific category of ethical theories, called egalitarian theories. Several authors have stated that it is questionable whether all ex ante evaluations should focus on maximizing an indicator (such as—in CBAs—utility often expressed as benefits minus costs, the benefit–cost ratio, or return on investment) at all, and if so: which indicator. Influential philosophers supporting egalitarian theories like Rawls and Sen do not suggest optimizing an indicator, and have proposed alternatives for the indicator(s) to be considered, such as 'primary social goods', capabilities, or the welfare or well-being of the least advantaged. See for, for example, Rawls (1971) and Sen (2009). According to Rawls (1971, 1982), primary social goods include

- Basic liberties, including freedom of association, and so on
- Freedom of movement and choice of occupation
- Powers and prerogatives of offices and positions of responsibility
- Income and wealth
- The social bases of self-respect

Rawls discussed the use of the optimization of primary social goods as an alternative for optimizing welfare. Sen (2009) disagrees with Rawls. He argues that it is not welfare or the provision of a certain kind of 'primary goods' that should be equalized, but what he calls 'capabilities', which lies between goods and welfare. For the question raised above we think probably egalitarian theories like those of Rawls and Sen are of more use than utility-based WTP studies to judge the ethical aspects of valuing children's lives.

The fourth inconsistency between QALYs and WTP results from the distinction between risky behaviour and people in general. Again this distinction is not relevant for the QALY concept, but it may be for WPT. In literature a distinction is made between people who utilise substances that are bad for their health, such as smokers and users of illicit drugs, versus people in general. Researchers have found several differences (Johansson-Stenman and Martinsson 2008). People think that persons responsible for their own bad health should be given lower priority (e.g., Anand and Wailoo 2000 and Cookson and Dolan 2000). Accordingly it could be that the public's opinion on WTP for risk reductions is lower in case of people with risky behaviour, compared to the wider public.

The fifth inconsistency between both concepts follows from a distinction between involuntary risks versus voluntary risk. This distinction is not relevant for QALYs, but it is for people's ethical preferences and related WTP. People think involuntary risks are to be valued higher (e.g., Slovic et al. 1985; Mandeloff and Kaplan 1989).

Sixth, people think that risks that are difficult to avoid should be valued higher than those that are not (e.g., Subramanian and Cropper 2000), a distinction that is not relevant from a QALY perspective.

Note that several of the differences in ethical preferences do not match the utilitarian perspective taken in a CBA; from a utilitarian perspective it would not matter whether, for example, a person gets killed in an accident that was easily avoidable or not. But CBA would favour spending on effective measures to prevent avoidable accidents over spending on vain attempts to prevent unavoidable ones.

It has to be added that the above discussion on the valuation of life risks of different categories of people is somewhat theoretical if it is compared with real world applications of the VOSL in the cost benefit analysis of transport policies. Real world applications tend to avoid the use of differentiation values for different types of people at risk and just apply an average value. There are probably two reasons for this. First the overall quality of estimates of VOSL is probably not strong enough to allow specific values for various subgroups. Second, the researchers responsible for the cost benefit calculations may fear debates about 'unethical' assumptions on which the calculations are based. They prefer therefore to stay on the safe side by using just the average VOSL. A similar reason would be that researchers doing CBA would anticipate that the application of strongly differentiated VOSL levels might lead to conclusions that decision-makers might find difficult to swallow, like a low priority for traffic safety themes that would in particular benefit very old people. Thus, by using an average value for the VOSL analysts responsible for CBA make sure that the potential gap between market-oriented economics based policy support on the one hand, and the domain of policy convictions and equity concerns on the other hand can be kept to a manageable size.

A second subject for methodological discussion is discounting future safety effects. Discounting reduces the value attributed to long-term benefits. Applying usual discount rates to protection of human lives would reflect a preference for preventing a person's death now over preventing the death of an equivalent person in the future. This makes perfect sense in the context of cost benefit analysis. Consider, for example, the case that an investment has safety benefits now compared with an equally expensive investment that has identical safety benefits in the future. Then it makes sense to prefer the investment with immediate effect over the one with delayed effect. Along similar lines, not discounting the benefits of investments in terms of lower probabilities of death (or higher QALYs), while at the same time discounting the costs of such measures leads to the implausible result that postponing this investment is always to be preferred (e.g., Keeler and Cretin 1983; Hammitt 2002). The reason is that postponement would lead to lower costs given the discounting, whereas the benefits would remain unaffected. Thus, the case for discounting VOSL or QALYs is stronger than one might think. Johanneson et al. (1994) indicate that a limited change in definition—and measurement—of QALYs would suffice to allow discounting within this concept.

In cases where discounting is justified, the next question is: which discount rate should be used? In the case of cost–effectiveness calculations the same discount rate as for costs would lead to consistency within the method. If consumers' preferences were the point of departure, an important question is how people discount the future utility of their lives. Ng (1992) suggests that individuals may discount their future utility at a rate lower than the rate of return to financial assets, whereas Shepard and Zeckhauser (1984) assume these rates to be equal (Hammitt 2002). A generic way to address differences in discounting rates would be to use the same discount factor for all cost and benefit items, but to allow different paths in the valuation of various cost and benefit components. For example, if the income elasticity of health and VOSL were higher than 1, it makes sense to give these a higher weight in future periods, depending of course on the assumed increase in income per capita.

A third subject of methodological discussion is related to the fact that objective safety and perceived safety do not always match. Traffic situations can be unsafe but people do not always perceive that to be so. Alternatively, objective numbers show that risk levels are low, but people might feel unsafe. Research has shown that the correlation between objective and subjective safety is often poor, not only in the area of road safety (Vlakveld et al. 2008), but also elsewhere in society (Nilsen et al. 2004). Does this matter? From a CBA (utilitarian) perspective the answer could be that it matters if people are willing to pay (WTP) for an increase in perceived safety *even if the objective safety does not change by an equal amount*. This subject can be seriously debated. People might be prepared to pay for increased safety, but only if objective safety increases. If they initially thought that a traffic situation would become safer, but they find out—or are informed—later that it does not, one can seriously doubt the WTP for increased perceived safety. In fact, one can doubt if perceived safety will increase at all if people know the real safety levels. A comparison can be made with medicine. People might buy drugs because they think they work. But if they were convinced they did not have any effect, the WTP would probably be zero.

A fourth subject for methodological discussion is the interaction between risk influencing factors. In the case of road safety, risk levels result from (at least) driving speed, the use or otherwise of protective devices of cars (active and passive safety levels), infrastructure characteristics, and the quality of the health care system. In addition, some of these determinants interact, and this interaction has an impact on the final risk levels. For example, if cars become safer, drivers may drive faster. But the combined impact on risk levels may be infrastructure dependent. Understanding such interactions is primarily a challenge for researchers. But an important ethical question is whether changes in determinants and their interactions should firstly have design consequences, and secondly consequences for evaluating designed options. Should, for example, safer cars lead to higher maximum speeds at motorways? Calculations based on the 'optimal' design of speed on motorways from a utilitarian perspective would argue so. On the other hand higher speeds can lead to changes in the distribution of risks. For example, low income people may have smaller, less safe cars, and drive at lower speeds compared to high income people with big, new, safer cars. Would that matter? Egalitarian theories would argue that it does, consequentialism would probably conclude that it does not.

Finally, a methodological discussion is the transferability of results over time and space. To start with the transferability over space: it can be highly ethically problematic to transfer the outcomes of one country to another country. For example, the VOSL based on WTP in the USA will not be of value for evaluating the lives of people in Bangladesh, and vice versa. For a discussion of the impact of the world region under consideration on the ethics of fatalities see Lorenzo et al. (2010). In addition, the transferability of VOSLs over time deserves attention. If people get richer their WTP for risk reductions is likely to increase. But are the lives of rich people of more value than those of poor people? In other words, is the WTP the best method for valuing a statistical life? On the other hand, an ageing population would—ceteris paribus—lead to a decrease in the VOSL if it was based on the concept of QALYs.

Avoidance costs and ethical considerations

This section discusses question 5 as addressed above. We firstly introduce the concept of avoidance costs, followed by a discussion of a specific category of avoidance costs that is generally missing in the societal ex ante evaluation of policy options.

Avoidance costs are costs made to improve safety, and can be split into several categories:

- Infrastructure related costs
- Vehicle related costs
- Costs related to the health system
- Costs related to changes in human behaviour

The first three categories are usually included in CBA and will not be discussed here. The fourth category of avoidance costs are the costs of changes in human behaviour due to (perceived) changes in safety. People can adapt their behaviour because they perceive safety levels to be low. For example older persons may prefer to stay at home because they think travelling is too risky. Or they may travel by taxi because they perceive cycling to be too risky. Or a person may prefer to cycle but travels by car because of a perceived low safety level of cycling. In addition, parents may not allow their children to travel to school independently because of a certain (perceived) risk, and therefore bring their children to school themselves. Or they may want them to use the school bus instead of cycling to school. Such adaptations come at a cost. A person that prefers to travel but stays at home because of a low perceived safety level is worse off compared to a (perceived) safer situation that does not stop her from travelling. Parents that bring children to school may value the loss of time negatively, and maybe also the necessary adaptation in their own activity patterns. The school bus and car are also more expensive than cycling. In addition, if adaptations result in a decrease in the use of slow modes, there are losses related to health. For example, the health benefits of cycling are substantial. In a Norwegian study on costs and benefits of cycling infrastructure in cities these benefits count for more than half (55–75 %) of all benefits of cycling (Saelensminde 2004).

Avoidance costs, even behaviour related avoidance costs, can be estimated, at least theoretically. The idea is that safety related costs play a role in mode choice or route choice models and may also affect the number of trips made and the destination of trips. An example of safety as a road attribute in a route choice model is given in De Blaeij (2003). However, the usual way of dealing with accident risks is to incorporate them into mode-specific constants and route-specific constants, which means that safety aspects remain implicit, though they can in principle be made explicit by more detailed analysis. The fourth category is particularly relevant from an ethical perspective because the 'freedom of movement' can be at stake—see below.

Of course avoidance costs are relevant for ex ante evaluations anyway. From an ethical perspective we would argue that if people adapt their travel behaviour, and in some cases even their activity behaviour (as in the example of the older person that stays at home because of a low perceived safety level) the value of the freedom is at stake, a value that is considered as very relevant in ethics. Freedom relates to the freedom to move, as well as the freedom to participate in activities. The indicators that are generally chosen to evaluate transport policy options do not include such changes in behaviour and certainly not the 'freedom to move' impacts. This subject is linked to the theme of transport and social exclusion (see for example Church et al. 2000; Preston and Raje 2007), but traffic safety usually only plays a modest role in this literature. Safety and safety perceptions may nevertheless be more important here than is often thought. Just think of the share in the population that owns a driver's licence but nevertheless does not drive cars because of a fear of accidents.

So at least theoretically avoidance costs are relevant for ex ante evaluations. But are they in practice? We think in many cases the *changes* in perceived risks due to candidate

policy options are very low, and consequently the impact of ignoring avoidance costs may be small. But in some cases they could matter, examples being changes in maximum speeds on distinguished road classes, or the planning of schools and related routes between homes of school children and schools. In addition they are relevant when an estimation of the total costs of safety needs to be made.

The distribution of safety effects: an ethical discussion

It is very possible that the pros and cons of policy options related to safety in the transport system are not equally distributed across the population. This distribution is relevant from an ethical perspective. Trade-offs may exist between car users and others (e.g., children, the elderly that do not drive). Such trade-offs exist in both directions. It is the non-car user who benefits from restrictions with respect to car use at the cost of car users. If priority is given to car users, the latter benefit, at the cost of the non-car users. If and how distribution related impacts should be evaluated depends on the ethical perspective. CBA and a related utilitarian perspective would allow for a straightforward calculation of utilities, either simply summarised in the value of a single indicator or accompanied by an estimated distribution of benefits and disbenefits over various categories of affected (groups of) people. However, egalitarian theories would specifically address distribution effects. A focus on, for example, the 20 % of people who are 'worse off' in the transport system would probably result in a shift to policies that favour the safety of the non-car user. Distribution effects also matter from the perspective of sufficientarianism, which holds the view that what primarily matters is that everybody is well-enough off, i.e., has well-being above a certain given threshold which is considered 'sufficient'. For 'weak sufficientarianism' the improvement of well-being matters if people's well-being is below a threshold. The lower the level of well-being, the higher the moral value of benefiting a person. For strong sufficientarianism, absolute priority should be given to the improvement of well-being of those whose level of well-being is below the threshold. And the lower their welfare, the more important it is to improve their well-being (Meyer and Roser 2009; see also Wolf 2009). The perspective of strong sufficientarianism could even imply that absolute priority should be given to improving safety if safety levels are below the minimum level. A problem then exists that a sufficientarianism approach relates to persons, not to (segments of) infrastructure or vehicles, whereas safety policies often do not focus on individuals, although traffic education, driving lessons, and obligations like wearing helmets and not drinking are exceptions. Safety policies often try to make infrastructure or transport modes safer. In such cases benefits are distributed in a rather diffuse manner which makes it difficult to link them to specific individuals, so that overall safety levels at the individual level cannot be estimated. The sufficientarianism approach implies 'personalising' safety, and therefore bringing this approach into practice is not at all straightforward, and needs to create stronger links between people and safety relevant policy options. To conclude, in ex ante evaluations of the safety impacts of policy options, the indicator chosen can easily lead to overlooking such ethically relevant impacts on distribution, but need not do so.

Conclusions

Pricing or not pricing the protection of unidentifiable human lives in the case of ex ante evaluations is a controversial subject that raises several questions. Below we repeat the questions and summarize the answers.

1. Is it morally OK to express (prevention on acceptance of) fatalities or risks in monetary terms?

Summarizing the most important conclusions of this paper, the answer to this question highly depends on the ethical theory that is used. As a result we think both a positive as well as a negative answer should be respected. A Kantian perspective could lead to the conclusion that pricing fatalities or even risks is wrong, whereas according to a utilitarian perspective it is acceptable, indeed desirable. An intermediate position could follow from the deontological principle of the 'doctrine of double effect', from which one could argue that a fatality resulting from immoral driving behaviour should not be priced, contrary to a fatality as a result of 'normal' accidents. From the perspective of contractarianism pricing is not really needed, but it is an option because it could improve or facilitate the process of making agreements.

2. How useful is the concept of the value of a statistical life (VOSL) for ex ante evaluations of transport policy options?

We think that the VOSL is a useful concept, but that its application is not straightforward, firstly because the concept of the VOSL (and certainly how it is used in practice) assumes no relationship between the VOSL and risk levels. Secondly, misperceptions of risk can easily occur, leading to 'wrong' WTP-values. Thirdly the VOSL generally includes the valuation of the statistical lives of the people involved, but not their descendants, at least not following common practice of doing research in this area. Fourth, an inconsistency can occur between the use of an income independent VOSL and income dependent values of time.

3. What are the pros and cons of pricing protection of lives or prevention of risks in ex ante evaluations?

Probably pricing safety improves the quality of decision making, but to the best of our knowledge there is no research to underpin this expectation.

4. Which methods are available for expressing (protection of) human lives in monetary terms, and what are the main related methodological discussions?

Several methods exist to estimate the VOSL, willingness-to-pay (WTP) methods being the most common category of methods. However, several methodological issues arise that make estimates of VOSLs less straightforward. Firstly, the WTP can differ from ethical preference values. Secondly, it is hardly debatable whether discounting should be applied to protecting human lives when it is standard practice to apply discounting to other welfare effects, but definitely the choice of the level of the discount rate is an important theme. Thirdly, objective safety and perceived safety do not always match, as a result of which the use of WTP values for risk changes may be problematic. Fourth, interactions between risk influencing raise several ethical questions. Fifth, the transferability of VOSL over time and space is problematic. Finally, a problem might occur because results based on WTP methods could conflict with the concept of Quality Adjusted Life Years (QALY). So any method that is used should be used with care and with awareness of its limitations.

5. Are all safety-related costs generally included in ex ante evaluations of the safety impacts of transport policy options, and if not: what is the relevance of the excluded costs from an ethical perspective?

Behaviour-related avoidance costs are often overlooked and these costs are relevant from an ethical perspective because the freedom to move and the freedom to participate in activities are challenged.

6.   How important is the distribution of safety effects from an ethical perspective?

From an ethical perspective, in terms of the evaluation of policy measures, it might matter which groups of the population are the victims of the transport system, or are at risk. Egalitarian theories as well as sufficientarianism are useful theories to discuss distribution effects. Different theories conclude differently. In ex ante evaluations not much attention is paid to the question of who loses out (victims) in an accident, whereas it could really matter from an ethical and evaluative perspective, and more attention could be paid to it without undue difficulty. With respect to distribution effects it is important to realize that increased safety levels often come at a (monetary or non-monetary) price. Trading-off therefore is inevitable.

We realize that answering these questions does not give undisputed guidelines for CBA practice—such guidelines cannot be given because a lot of debate is possible. We personally think that it is not a good idea to reject CBA as the preferred method to ex ante evaluate candidate transport policy options because of the issues raised in this paper. And we believe that including safety effects in CBA might improve the quality of a CBA. But we think the question if current practices of doing this is OK, cannot be answered positively. Consequently we propose more research and development of methods is carried out in search of a mature way to include safety in CBAs. It is beyond the aims of this paper to further discuss such research and methods.

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