

The Optimisation of Consumer Safety

A report on behalf of

**Department of Trade and Industry
Consumer Safety Unit**

Contract No. CSU 4773/96/1

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October 1997

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Acknowledgements

The authors have benefited over the years from many debates and discussions with academics and risk managers operating in this contentious field. We cannot name them all here, but in respect of this report we would wish to acknowledge in particular the advice and information provided over the years by the following - Mr Adrian Sayce of the CAA, Mr Neil Davies of the HSE, the late Dr Andrew Fleishman and Dr Michael Hogg of British Petroleum, Dr John Robb and colleagues at NRPB, Dr Jane Ince of MAFF, Mr Warren Prunella of the US CPSC, safety managers, old and new, at Railtrac plc., and Mr Malcolm Barrow of the DTI CSU.

This project was funded by the Department of Trade and Industry Consumer Safety Unit under Contract No. CSU 4773/96/1.

The views expressed in this report are the responsibility of the authors and do not necessarily reflect those of the parties mentioned above.

RECOMMENDATIONS

Recommendation 1: On the basis of the arguments in this report, that the DTI Consumer Safety Unit consider adopting a review-based VOSL (value of a statistical life) as a *guide* to consumer safety decision making.

Recommendation 2: That any chosen VOSL be stated as a range rather than a point value in recognition of inherent uncertainty in this measure.

Recommendation 3: That direct and indirect costs of injuries be added to human costs where appropriate.

Recommendation 4: That the VOSL for consumer safety purposes lie in the broad range of £1 million to £10 million, but with a narrower range of £2 million to £4 million being applied for most routine purposes.

Recommendation 5: That contextual and other factors which might affect risk decisions be incorporated into the decision process via expert judgement and accumulated experience in preference to the use of a system of fixed weighting factors.

Recommendation 6: That the DTI CSU continue to monitor progress on the valuation of consumer injuries, including direct and indirect costs and human costs.

Chapter 1: INTRODUCTION

1.1 Background and Context

The Consumer Safety Unit (CSU) of the UK Department of Trade and Industry (DTI) commissioned this study to investigate the valuation of human life in the context of standards for consumer safety. The CSU has statutory responsibility for the safety of consumer products in the UK and for specific product safety regulations made under the Consumer protection Act (1987), Gun Barrel Proof Acts (1868, 1950, 1978), product liability, the General Product Safety Regulations (1994) and home safety in general. As noted in a recent report (HM Treasury, 1996), UK safety regulation is increasingly determined by the European Union. However, UK regulators retain responsibility for setting domestic standards, and for interpreting the provisions of, and contributing to the development of, international standards. The CSU therefore continues to face the complex task of determining the appropriate level of safety that should be provided for consumers.

The rationale for the project is that resources for risk interventions are both finite and subject to Compliance Cost Assessment, and thus decisions must be made by agencies responsible for safety, such as the CSU, on the extent to which such resources should be allocated to achieve an appropriate level of protection for the consumer. In evaluating the appropriateness of various preventative measures, it is also necessary to identify the optimum balance between restrictions on consumer choice arising from risk controls and reductions in consumer exposure to risk. While zero risk is usually an unachievable and, at times, undesirable goal, CSU has adopted the rationale that risks to consumers should be reduced and controlled at a level which is *as low as reasonably possible*.

We take this notion to be broadly equivalent to that of 'reasonable practicability,' which is the cornerstone of risk management decision making in the UK. This principle implies that risk management decisions should be balanced decisions which, *inter alia*, weigh the costs associated with the introduction of safety measures against the value of the associated benefits in the form of increased safety. The CSU openly acknowledges that in almost all of its policy work, it is necessary at some stage to form a view on how much financial cost should be incurred to improve consumer safety by a given amount.

Such comparisons require the quantification, in common terms, of both the costs and benefits associated with risk controls. It is widely recommended that valuation of costs and benefits should be in monetary units. For instance, the Treasury Guide '*Economic Appraisal in Central Government: A Technical Guide for Government Departments*' (1991) states that:

'Appraisal in Central Government is concerned with the best use of the nation's resources, and the economic analysis of major decisions should, in principle, be wholly in terms of economic costs and benefits' (HM Treasury, 1991 p. 10).

However, in practice, there will always be some costs or benefits for which no market price exists. In particular, the benefits of safety interventions, though providing a reduction in the number of deaths and injuries, have no direct market value. As a result, various methodologies have been developed by economists for deriving values of safety.

In accordance with the principles of that branch of economics known as social welfare economics, the value of safety should ideally reflect individuals' preferences and the strengths of those preferences. Over recent years a view has developed amongst welfare economists that the so-named 'willingness-to-pay' (WTP) techniques, said to be based on individual preferences for safety, constitute the appropriate methodology for determining the valuation of safety benefits. However, while most of those professions involved in risk management decision making readily accept the need for incorporation of economic factors into risk decisions, the degree of acceptance afforded to WTP techniques themselves is highly variable, even among economists. Thus, regulatory agencies should be aware of not just the results emerging from the application of these techniques and the discussions over the minutia of the different methodologies, but also on the broader issues raised by the many other professions legitimately engaged in the process of risk management decision making. These would include consumer safety experts, sociologists, lawyers, ethicists, and economists of different persuasions. As noted in a recent paper to the European Society for Risk Analysis, experts tend to be expert within

specific well-defined domains and to have their own culture when it comes to matters like risk decisions (Ball and Golob, 1997), whereas complex issues like consumer safety are arguably best served from a more broadly-grounded, multidisciplinary perspective.

Suffice it to say at this stage that these are issues which will be returned to later. For now it is perhaps helpful to acknowledge that estimates of WTP for reduced risk have been inferred from a variety of sources including the retrospective analysis of past regulatory decisions; from the study of consumer behaviour, usually in relation to the purchase of safety devices such as smoke detectors or even organic foodstuffs; and from examination of wage-risk trade-offs made by workers in dangerous jobs. Alternatively, values have been derived by asking individuals more-or-less direct questions about their stated preferences for safety using what have come to be known as expressed preference methods. Whatever the approach, estimates of willingness-to-pay for a given reduction in risk, when averaged across a given population, form the basis for the 'value of a statistical life' (VOSL), often referred to for convenience as the 'value of life'.¹

As a historical note, in 1990 the DTI CSU commissioned CERM to review the various approaches for deriving a VOSL with specific regard to the nature of home and leisure accidents (Soby and Ball, 1991). This report recommended, on the basis of extant knowledge, that the VOSL was a potentially useful tool for policy makers and that the WTP approach appeared at that time the most appropriate method for deriving theoretically sound and defensible values for use in policy formulation. The broad purpose of the current project is to update and extend this earlier work and to examine the approaches now being adopted by other agencies responsible for safety in the UK and internationally.

1.2 Report Objectives

The primary objective of this study is to inform the CSU of current thinking on the valuation of human life for safety decision purposes from a multi-disciplinary perspective in order to ensure that CSU's work in developing and applying effective policies and interventions to protect consumers is as well founded as possible, and in accord with the best available evidence.

One specific objective is to identify the extent to which society, implicitly or explicitly, already accepts the concept of safety valuation and, where it is accepted, the magnitude of any 'benchmark' monetary 'values of life' which might be used as a basis for assessing consumer safety interventions. Thus, the various approaches to the valuation of safety are discussed, and a review is made of theoretically-derived valuations of safety and those finding practical application within other agencies. We also examine values of safety used by other agencies and, bearing in mind that CSU's primary responsibility is product-related safety, whether any of these existing values are or are not directly transferable to the consumer sector. We also look at the implications of a decision by CSU to generate its own value of safety. For instance, should any such initiative be based on a new consumer-oriented WTP survey, or on an alternative approach?

Other, subsidiary, objectives include the examination of the evidence for and against the use of differential values of life in policy formulation. For example, should the VOSL vary with the age of the population at risk? Should the nature of the risk i.e. whether it is involuntary, potentially catastrophic, unforeseen and unfamiliar, dreaded or unknown, or the risk level, matter in establishing a VOSL? Should lives saved now count more than lives saved in the future?

1.3 Report Structure

Chapter 2 summarises the various theoretical approaches to safety valuation, prior to embarking upon a more detailed discussion of the present issues surrounding the use of revealed and expressed preference techniques for safety valuation from a multi-disciplinary perspective. This Chapter also contains the results of a new review, specifically for this project, of value of life estimates from the literature.

¹ This terminology itself promulgates the misconception that such approaches actually attempt to place a value on the life of a human being, which many would argue is ethically unacceptable as human life is infinitely valuable. In reality, it should be remembered that what is actually being valued is not an identified individual, but a 'statistical life', based on small changes in the risk of death or injury across a population. In this report therefore, the term 'value of a statistical life' (VOSL) is used.

Chapter 3 examines the arguments for and against the use of different values of life in different contexts.

Chapter 4 describes approaches to safety valuation and policy formulation adopted by a number of leading UK and international agencies operating in the public and private sectors.

Chapter 5 tackles outstanding questions and formulates proposals for the CSU on the valuation of consumer safety.

As an aid to readers, each of Chapters 2 to 5 begins with a summary of the main points in that Chapter.

Chapter 6 makes recommendations on the VOSL which might be applied in consumer safety decisions and how it incorporates necessary flexibility.

Finally, an extended list of documents, some with abstracts, is provided for referral in Chapter 7.

Chapter 2: VALUING SAFETY

Summary of Key Points

- Most professions and most sectors involved in decisions about safety and risk in the UK readily accept the need for economic factors to be taken into account in these decisions;
- There is fairly widespread acceptance in the UK of the validity of incorporating direct and indirect costs into decisions involving human safety. The third cost element, 'human costs,' has gained increasing though not universal perceived legitimacy in the UK in recent years, and to a lesser extent in most other European countries;
- Early approaches to the elicitation of the human costs of safety, such as life insurance premia and court decisions, have been replaced by WTP approaches. Human Capital methods have also lost favour, but still provide useful information on foregone earnings which is helpful to decision makers in some circumstances. However, there are questions about how these indirect costs should be calculated and some authors suggest a friction cost method which is a more accurate measure of societal costs and incidentally generates significantly lower numbers than the conventional accounting method;
- WTP approaches come in several varieties, broadly classified as revealed and expressed preference methods. The former include retrospective analyses of regulatory decisions, wage differential studies, and consumer behaviour studies. All are found to have a few advantages but also their fair share of limitations, and much effort has been invested in developing the apparently more flexible expressed preference approach;
- Although expressed preference CV surveys are seen in some quarters as theoretically-sound according to the principles of welfare economics, and therefore the only way, this view is by no means universal. Many authors, drawn from economics and other professions alike, have identified serious and unresolved problems with CV, and some doubt that solutions can ever be found. The most problematical issue may lie in the position that human beings are human beings and neither act nor think like classical utility maximisers, and perhaps do not wish to. The question is rightly posed, however, as to whether CV, with all its attendant problems exposed, is nonetheless 'the only game in town;'
- Other indirect valuation methods are described. These avoid certain moral difficulties associated with direct valuation by examining risk-risk and not risk-cost trade-offs. Ultimately, these methods fall back on a VOSL, however, and are still subject to many of the difficulties assigned to CV itself;
- There is an ongoing debate over the merits of VOSL versus QALYs and VOLYs. VOSLs tend to appeal to purists whereas QALYs and VOLYs, when accepted, are easier to use in some decision making situations;
- Our *ad hoc* review of 88 published VOSL studies finds a range of about two orders of magnitude in VOSL valuations, with no discernible difference in valuation between methods or sectors. Most data points lie in the range of £0.5 million to £10 million (January 1997 value). Most published CV results have, however, already undergone some data manipulation and this no doubt will have reduced the variance.

(WTP - willingness-to-pay; CV - contingent valuation; VOSL - value of a statistical life; QALY - quality-adjusted life-year; VOLY - value of a life-year)

2.1 The Cost of Fatal and Non-fatal Injury

Three distinct cost elements are generally recognised to be associated with fatal and non-fatal injury and ill-health. These are as follows:

- *Direct costs* - constituting the medical care and other expenses associated with injury or illness which may include, for example, the cost of emergency services (police and ambulance), the acute and long term medical treatment costs which arise as a result of injury (or illness), or property damage;
- *Indirect costs* - broadly defined as the costs of production losses associated with injury, which may include the lost output of employed persons, lost non-market production, and future or potential losses of production; and
- '*Human costs*' - being the more subjective or intangible costs arising from the loss of both the quantity of life (life expectancy) and quality of life (in terms of pain, grief and suffering or incapacity) associated with an injury or illness.

The first cost component, direct costs, is in principle relatively straightforward to estimate, although the availability and reliability of data may pose a problem (see, for example, Davies and Teasdale, 1994).

There is, however, a more serious debate over the appropriate approach for the estimation of indirect costs, and two alternative approaches, the 'human capital' approach and the 'friction costs' method, have been proposed. The traditional human capital (HK) approach which is based on lost earnings has been criticised for ignoring the fact that in production processes, everyone can be replaced (e.g. short-term absenteeism usually results in no more than work being taken over by other employees, or postponed, rather than lost; likewise longer term absenteeism may result in work being taken over by the unemployed, or by reallocation of other employees). To address this, the 'friction costs' method has been devised, based on the premise that a worker who is the victim of premature death or disability will be replaced by another worker after a 'friction period'. Production losses are thus confined to this friction period, the length of which is clearly dependent on the situation in the labour market. It will come as no surprise that this method produces significantly lower cost estimates than HK, as the 'friction period' is generally much smaller than the period arising from premature death or disability up to the retirement age, or the mean age of death. Details of the methodology are provided in van Beeck *et al.* (1997).

Although these methodological problems and data constraints cause problems in estimating direct and indirect costs, the estimation of the third of the cost components belongs in another realm altogether, as it has to deal with the more subjective and intangible welfare losses associated with injury. This Chapter therefore focuses primarily on the estimation of these 'human costs,' although reference to the other cost components is occasionally included. Another important reason for concentrating on human costs is that in most circumstances these are the major contributor to the VOSL. A number of methodologies have been used to estimate the human costs associated with injury and we start with a brief review.

2.2 Approaches to Safety Valuation

As noted, over the years a variety of approaches have been tried as a means of estimating the 'intrinsic' value or 'human costs' associated with reductions in the risk of death or injury.

Life insurance cover was at one time examined as a basis for determining the VOSL, based on the presumption that the appropriate amount to spend on safety could be determined from the amount of life insurance coverage that people purchased. It was soon realised, however, that this approach has serious deficiencies and it has largely fallen out of favour. For example, life insurance is purchased to protect one's heirs from financial hardship and thus has no clear connection with the value that an individual would place on reducing personal health risks.

Similarly, court awards have also been proposed at one time as a means of identifying society's views regarding the value of life and injury. Once again, however, there are arguments which indicate that court

awards are inappropriate for this purpose. For example, these are meant to compensate surviving family members in cases of fatality and are not meant as compensation for the loss of one's own life. Some court awards may also include a premium, possibly intended as a deterrent, which is hard to disentangle from that part of the award intended to provide compensation. Furthermore, court awards are *ex post* payments for injury or death, while safety investment decisions require *ex ante* valuations of safety. These are not necessarily the same.

Thus, until the mid-1970s, the Human Capital (HK) method was the predominant approach to safety valuation. This method calculates the loss of expected future earnings of an individual involved in an accident with fatal or non-fatal consequences. The calculation is based on the average age of the individuals at risk, the probability of occurrence of the accident, the social discount rate, and either gross earnings or earnings net of consumption. Sometimes a nominal amount to account for 'pain, grief and suffering' associated with death has been added in.

Unsurprisingly, the HK approach has been widely criticised as being cold-blooded, valuing life as it does solely in terms of economic output. In the case of children, or the elderly, or other groups who are not wage earners (such as house-persons, the disabled, carers and so on), the HK method would suggest little, if any, investment in safety measures to protect such groups. This is generally considered to be both morally repugnant and intuitively unacceptable and the HK method has largely fallen out of favour as a sole means of valuing safety. However, while it is recognised to be inadequate as a methodology for estimating the value that individuals would place on their own safety, the HK method still has value in that it provides a measure of the indirect economic costs (lost productivity) associated with both fatal and non-fatal illness or injury which, from a societal perspective, clearly merit consideration.

In recent years a view has come to prominence that the willingness-to-pay methodology is the theoretically appropriate measure for the estimation of the VOSL. The WTP approach stems from the premise, originating in social welfare economics, that individuals' preferences and the strengths of those preferences should form the basis of public sector safety investment decision making. The approach assumes that when people indicate the amounts they are willing to pay to reduce the probability of death, they incorporate a value for 'aversion to suffering' and the 'joy of living'. Arguably, policies founded on the basis of public preferences would be more acceptable to the public, not to mention more democratic.

The WTP approach therefore identifies the monetary trade-offs which individuals are prepared to make for a reduction in the risk of death.¹ The method is conducted by averaging individual marginal rates of substitution of wealth for survival probability in order to obtain an estimate of the VOSL. As noted in Chapter 1, several methodologies have been developed to derive WTP-based VOSLs. Estimates of WTP have been inferred from the examination of past regulatory decisions, from the study of consumer purchasing behaviour, and from the wage-risk trade-offs made by workers. These are known collectively as 'revealed preference' methods and are based on the real choices that regulators and consumers or wage earners have made regarding trade-offs between wealth and safety. WTP values can also be derived from the direct elicitation, usually by the use of questionnaires, of individuals' stated preferences for safety in hypothetical markets. These are known as 'expressed preference' methods.

The various WTP approaches themselves are discussed more fully in Soby and Ball (1991). Below the emphasis is on more recent developments which have implications for the applicability of these techniques.

¹ Or, alternatively, the amount that people are willing to accept (WTA) for an increase in their level of risk.

2.2.1 Revealed Preference Approaches

a) Regulatory Revealed Preference When a decision is made by a regulatory agency to undertake a safety investment, this of itself implies a value of life. A number of studies have examined the range of VOSLs implied by past decisions and found, not surprisingly, a large range in the values that emerge in terms of cost per life, or life-year saved (see, for example, Fernandes-Russell et al. (1986) or Ives et al. (1993)). A major criticism of this approach to eliciting safety values is that it is difficult to disentangle many of the factors which underpin these past spending decisions. Political considerations, or social sensitivities and public values of the day, may well have influenced the amount that was spent in any given decision. It may therefore be inappropriate to attempt to 'bootstrap' current decisions to past decisions, where many of the determining factors which influenced that earlier decision are unknown or unclear. There are some arguments in favour of the 'bootstrapping' approach, however. For instance, these are decisions which, in some cases at least, have been tried and tested to a degree by exposure to the processes of democratic society.

b) Wage Differential Studies Wage differential studies work by examining the trade-offs that some workers make when accepting a risky job for a wage premium (Viscusi, 1993). Since there are many confounding factors (age, work experience, union membership, workplace conditions etc.) which also affect earnings, statistical techniques such as regression analysis are normally used to control for these factors. It has to be acknowledged, however, that strident criticisms of this method remain, in part as workers do not have total freedom to choose their jobs, and those that choose risky jobs may be atypical of the working population. Indeed, it is not hard to think of jobs which are simultaneously dangerous *and* badly-paid. This approach also assumes 'perfect information' i.e. that workers are aware of the risks that they are taking, which may not be the case, and that workers behave like 'powerful computers,' able to manipulate a vast database of information pertaining to earnings and safety (Dorman, 1996). It is also true that this approach provides VOSLs based on a restricted sample of the population drawn mainly from working class employees. These values may not be representative of values that the rest of society holds.

c) Consumer Behaviour Studies Other revealed preference studies have attempted to infer a VOSL by observation of consumer purchasing behaviour in the market. One example is the purchase of smoke detectors for use in the home, from which, knowing the purchase price and the change in the probability of dying or being injured in a household fire associated with smoke detector use, a VOSL can be calculated. Again, shortcomings of these approaches are noted. For example, it is unknown whether the individual purchased the device to protect him or herself alone, or whether the individual had any idea of the change in risk which the device signified.

Thus, the primary problem with the above revealed preference methodologies is that one cannot be sure exactly what individuals are considering in the decisions they make when apparently trading off safety and wealth. Also, data on these kinds of market choices are available in only a limited set of contexts e.g. worker safety, or safety device purchase.

2.2.2 Expressed Preference Approaches

The expressed preference approach on the other hand, seeks to get around this by postulating a hypothetical market, and then asking people explicitly how much they would be willing to pay for a given risk reduction in specific scenarios. As will be seen, although this subterfuge overcomes one set of limitations, the method continues to be overshadowed by severe and fundamental limitations of its own.

The predominant expressed preference approach is known as the contingent valuation (CV) method. This is the name given to a group of survey-based methods which may be used to value, inter alia, environmental or safety goods in the absence of data on market or surrogate-market prices, and which rely upon direct questioning concerning individual WTP (or required compensation) for improvements which are contingent upon the existence of hypothetical markets for such goods. It asks people directly, through the use of a

questionnaire, how much they would be willing to pay for risk reduction in specified circumstances. Individuals are typically provided with information on the nature and level of a risk, the type of intervention proposed, the method of payment (e.g. tax, one-off payment etc.) and so on, thus creating a hypothetical market. These surveys can also instruct individuals to ignore certain factors, such as risks to friends and family, or the direct costs (such as medical costs or lost earnings) associated with an accident. Contingent valuation methods can also be used in an experimental setting, as applied in the experimental auction technique. This approach places respondents in a simulated real-world situation in which they have to trade off money and health risk. Preferences are revealed through 'bids' made in the simulated market (see Hayes *et al.*, 1994; Shin *et al.*, 1995 for detailed descriptions of the method).

In principle these expressed preference approaches are much more flexible than revealed preference approaches, as the hypothetical scenario presented can be tailored exactly to the situation in which the decision maker is interested. In theory, at least, CV studies can therefore be designed to value any good. A random sample of the population can be used as respondents, so values can be representative of the general population rather than certain specific groups. Questionnaire studies also enable data on the respondents socio-economic characteristics to be gathered, so that some tests of the validity of WTP estimates can be made e.g. stated willingness to pay in relation to actual ability to pay. Also, test-retest techniques can be used to investigate aspects of the reliability of WTP responses (Kidholm, 1996).

Of course, to achieve statistical validity a representative sample of the general population is necessary, which makes this method both time consuming and expensive to undertake. Further, despite the many advantages described above, CV approaches have, in recent years, attracted increasing criticism with regard to the validity and reliability of the numbers being produced. A full review of the ongoing debate about the CV method would be a lengthy undertaking and beyond the scope of this report, so what is presented here is a summary of the main points. The interested reader should refer to more comprehensive texts such as those of Mitchell and Carson (1989), Hausman (1993), Diamond and Hausman (1994), Dorman (1996), Swaney (1996) and others for a fuller discussion and critique of the CV method. In summary, then:

- *People may not have clear pre-formed preferences for non-market goods and survey responses may therefore not be an accurate measure of true economic preferences.*

A fundamental assumption of the CV method is that people have pre-determined preferences for non-market goods and that these preferences can be elicited in a meaningful way. However, research shows that peoples preferences for safety are often highly imprecisely held. In defence of CV, Dubourg (1995) argues that so long as individuals are reasonably confident about the range within which their exact WTP might lie, then the values would remain usable in decision analysis. However, survey data has shown that individuals' preferences for safety are extremely vague and that the 'confidence intervals' around estimates of WTP are wide and unstable. Such variation in individuals' responses to CV questions can become magnified into large differences in the resulting VOSL (Covey *et al.*, 1995) and the significant imprecision often found in CV responses calls into question the general reliability and usefulness of the method for valuing risk changes.

- *People may 'construct' their preferences using the information provided.*

Experience with CV surveys has shown that responses are sensitive to small changes in study design and to the elicitation methods used to derive WTP estimates (Dubourg, 1995; Jones-Lee *et al.*, 1995). As above, this sensitivity has led some authors to argue that, contrary to economic theory, people often may not have either pre-determined beliefs or pre-existing preferences for unfamiliar market goods such as safety. Furthermore, any beliefs that are held are unlikely to be readily expressible in either quantitative or monetary terms. Thus, individuals attempting to place a monetary value on safety may do so arbitrarily (Gregory *et al.*, 1993; Lin, 1994) or may use the information presented in the CV survey to effectively 'construct' their preferences (Gregory *et al.*, 1993). If respondents use the information provided in the CV scenario to 'construct' preferences, then such surveys are failing to fulfil their intended purpose.

- *The contingent valuation task may be too complex.*

CV studies often require individuals to make complex judgements about human values while at the same time posing questions about changes in small probabilities regarding unfamiliar risks. It should come as no surprise that many respondents may find this very taxing, resulting in inconsistent answers to CV questions. Individuals, irrespective of intelligence, have been noted to have problems in processing small probabilities alone. Neither is it always clear what considerations respondents are including in their WTP responses. Some studies indicate that respondents are often unable to consider, say, the individual human costs alone, even when asked to ignore other factors, and may include other items in their valuation.

- *A variety of biases may occur in the survey methodology.*

For example, *strategic bias* may occur when people do not answer CV questions truthfully. People may overstate their WTP with the intention of getting a policy implemented, or understate WTP for fear that they may really have to pay if the policy is implemented. Respondents may also fail to treat the trade-offs made in a *hypothetical* market in the same way (or with the same degree of seriousness) that they would treat real-life trade-offs. Furthermore, the design and construction of the survey itself, in terms of the *starting point* of WTP bids, the choice of *payment vehicle* (tax or premium on purchase prices etc.) or the type, amount and order of *information* presented to respondents have been shown to influence the answers that respondents give to CV questions.

- *Insensitivity to the good being valued and 'embedding' effects.*

An 'embedding' effect may occur when the good to be valued is part of a more inclusive good. People may therefore not distinguish between a subset of the good and the whole good when providing valuations e.g. when respondents are found to be willing to pay the same premium to save one lake as to save all the lakes in a given region, or to preserve one area of wilderness as against several areas of wilderness (see, for example, Kahneman and Knetsch, 1992; Diamond and Hausman, 1994). In the context of environmental valuation, this insensitivity to the scope of the good being valued may indicate that respondents are expressing support for a 'good cause' which does not change much with changes in the nature of the commodity. Responses may therefore be based on 'moral satisfaction' or a 'warm glow effect' rather than providing a true indication of individuals' economic preferences. Such insensitivity to theoretically important information has also been clearly identified in the context of safety, where respondents have often been found to be insensitive to factors such as the magnitude of the reduction in risk (Smith and Desvousges, 1987; Jones-Lee *et al.*, 1995) and the severity of different injury states (Jones-Lee *et al.*, 1995).

Clearly, peoples preferences are not always 'rational' in the narrow sense of conforming with expected utility theory. The elicitation of individuals preferences suffers from a number of problems including framing effects, preference reversals, embedding effects, and other biases resulting from heuristics or simplified 'rules of thumb' which respondents may use to simplify complex tasks of judgement (Tversky and Kahneman, 1986).

- *Different elicitation techniques appear to generate different values.*

Theoretically, of course, differences in elicitation procedures should not affect the value of life. However, studies comparing revealed preference and expressed preference approaches applied to the same sample of people have produced different values (Ford *et al.*, 1995; Lanoie *et al.*, 1995). Studies have also found significant differences in expressed preference values derived using different elicitation procedures (Viscusi, Magat and Huber, 1989; Buzby *et al.*, 1993). For example, Jones-Lee *et al.* (1995) report significant differences in the values derived for the same set of non-fatal injury states using two different techniques - contingent valuation and standard gamble. According to economic theory, the two approaches should give the same result (Kidholm, 1996).

- *A disparity exists between Willingness to Pay (WTP) and Willingness to Accept (WTA).*

Theoretically, measures of willingness to pay for a reduction in risk and willingness to accept compensation for a corresponding increase in risk should be similar in magnitude. However, empirical estimates show

systematic and substantial disparities between estimates of WTP and WTA in a number of studies (see Fisher, McClelland and Schulze, 1989). As a result, whether information in CV surveys is presented as a loss or as a foregone gain appears to alter subjects' perceptions and their stated preferences over alternatives (Kahneman and Tversky, 1979; Viscusi, Magat and Huber, 1987; McDaniel, 1992).

It should be acknowledged that some of the problems noted above may be attributable to problems of study design. If so, then the reliability and validity of CV responses largely depends upon how rigorously the individual CV study is designed and carried out and how the results are interpreted. Soguel (1995) argues that the contingent valuation method 'is perfectible,' through simplifying the procedure, providing better descriptions of the phenomena being valued, and so on. Others, however, are far less sanguine. MIT economists Diamond and Hausman (1994) have concluded that CV surveys do not measure the preferences they intend to measure and, further, that changes in survey design offer little prospect of an alternative conclusion. Dorman (1996), another economist writing in the context of workplace safety, queries how much credence should be placed in responses to purely hypothetical questions when respondents can simply throw out numbers with no apparent consequences for themselves, nor does he believe that creative survey design can dispose of all the troublesome features now associated with CV. And Lichtenstein *et al.* (1990) have proffered the advice that experimental (survey) results, naively applied to complex social issues, may result in poor social decisions. Camerer and Kunreuther (1989), also recognise that CV results are labile and unreliable because people may not know or be able to articulate their true preferences. They also say, however, that the CV approach, despite its weaknesses, is *the only game in town*. That, of course, poses a fundamental question with which this report will grapple in later Chapters.

2.2.3 Indirect Valuation Methods

The continuing unresolved weaknesses of both the revealed and expressed preference approaches have led researchers down another avenue, which is to examine indirect methods for valuing safety. These methods attempt to avoid the difficulties and also the 'moral sensitivities' associated with the derivation of direct monetary values for safety, by examining the trade-offs of one risk against another risk.

These trade-offs can be made both within contexts (for example, trading off the risks of various injury or illness states of different severity) or across contexts (for example, trading off the risk of death from different types of hazards e.g. air pollution deaths v. road traffic fatalities v. food related deaths). Various relative scaling methods, such as visual analogue scales, paired comparisons, standard gambles or time trade-off techniques, the pros and cons of which are described in previous work for CSU (Soby and Ball, 1991), can be used to derive a scale of the relative utility associated with one health state compared to another. The catch is that these non-monetary relative valuations have then to be transformed into monetary estimates by 'anchoring' the utility values to a baseline state (usually death) for which a monetary VOSL has been derived. A number of variations on this theme have appeared in the literature in recent years and a few are described here by way of illustration.

Viscusi (1995), for example, used automobile fatalities as a common metric for valuing health risk outcomes representing the potential consequences of air pollution. The automobile fatality metric was selected because the health outcomes were familiar to respondents and the ensuing deaths are usually immediate (so that there is no need to deal with time lags before the adverse consequence occurs, which would require the added complication of rates of discounting). Respondents were asked to consider moving home to one of two new areas identical to their current area apart from a lower risk of chronic bronchitis and automobile fatality rates. Using an interactive computer program, respondents were presented with a series of pair-wise comparisons which were manipulated until indifference was achieved. Using this approach, values for health outcomes such as chronic bronchitis, and curable and non-curable lymph cancer were derived on a scale from zero (death in an automobile accident) to unity (good health).

In his study the author then applied a VOSL of US\$5 million, itself derived from a review of wage-risk studies in the literature, to assign monetary values to the various non-fatal health outcomes. For example, chronic bronchitis was assigned a value of 0.32 on the utility scale. Multiplying this figure by the \$5 million estimate for VOSL indicated that the value of having chronic bronchitis and remaining alive would

be \$1.6 million, compared to the value of being alive and in good health of \$5 million, and the value of being dead of \$0.

An exploratory study by Covey *et al.* (1995) for MAFF used matching or ‘equivalence questions’ to establish values for various types of food-related fatalities. This approach aimed to provide estimates of individual respondents’ monetary valuations for the prevention of food related deaths relative to their values for the prevention of deaths by other causes, such as road accidents. Respondents were told that Government had funding for one or the other (but not both) of two safety improvements, where one would prevent an estimated 100 deaths from food poisoning from consumption of eggs in the next ten years, while the other would prevent an estimated 100 deaths from single-vehicle and two-vehicle road accidents in the same period. The numbers were then varied until indifference between the two programmes was achieved. Similar exercises were repeated trading off ‘egg deaths’ against the prevention of deaths from food-related heart disease and pesticide-related cancer deaths.

The study found that respondents would, on average, prefer to place a lower value on prevention of an egg poisoning death compared to a road traffic fatality, a heart-disease death or a pesticide-related cancer, and the authors concluded that a refinement of this kind of technique might prove to be a useful guide for food policy makers. Covey *et al.* (1995) also used standard gamble methods to establish relative values for non-fatal food poisoning states against a food-poisoning death. The establishment of monetary values for these non-fatal conditions thus required a base-line VOSL in the context of egg safety. Based on the results of the ‘equivalence questions’ described above a value of £650,000 was suggested for illustrative purposes to assign values to the ratios derived.

Jones-Lee and Loomes (1994) also undertook an indirect ‘relative valuation’ approach based on focus group meetings, which was piloted and run between 1992 and 1994. The approach involved estimation of a *scale premium* for large, multiple fatality accidents on the London Underground relative to single-fatality Underground accidents, and a *context premium* for single-fatality Underground accidents relative to single-fatality road accidents. The resulting premia were then applied to the Department of Transport VOSL to arrive at an appropriate value for Underground safety projects.

Other studies have utilised existing ‘relative utility loss indices,’ published in the health economics literature, to derive relative values for various health states. This approach has been applied to the valuation of non-fatal road traffic injury states in both the UK (Ives *et al.*, 1993), and the US (Miller *et al.*, 1990), and to the valuation of food-related illness in the UK (Henson and Turner, 1995) and the US (Mauskopf and French, 1991). The primary difficulty with this approach relates to the compatibility of the health state indices with the injury/illness states to be valued. For example, many of the indices available have been designed for clinical use, or consider health states of specified duration (i.e. one year in a given condition). The methodology is discussed in more detail in Ball and Soby (1995).

It should also be noted that while the kinds of indirect approach discussed above may overcome some of the difficulties of direct monetary valuation, respondents in some such exercises have still been noted to have considerable difficulties in dealing with the rating tasks due to the complex and unfamiliar nature of the trade-offs involved (Covey *et al.*, 1995).

In summary, these indirect ‘relative valuation’ studies vary in two main respects:

- the method used to establish the relative utility of the health states (e.g. pair-wise comparisons, standard gamble, published utility loss indices); and
- the choice of ‘anchor’ value to provide monetary valuations for the utility scores (e.g. road traffic VOSL, review-based VOSL, or specific CV VOSL).

2.2.4 Non-fatal Injury Valuation

As with the derivation of values for fatalities, the valuation of non-fatal injury (NFI) has, in the past, been conducted primarily on a human capital basis, incorporating an assessment of the financial costs of injury, but on occasion with an added component for the ‘pain, grief and suffering’ that may be associated with a

given injury state. However, over time there have been proposals that the valuation of non-fatal injuries (abbreviated as value of injury - VOI) should be conducted on the same basis as the valuation of statistical lives - that is, on the basis of willingness-to-pay and by contingent valuation.

While this approach appears good from a theoretical perspective, the practicability of undertaking direct CV studies of NFIs is open to question. The sheer diversity of different injury states with which agencies like the CSU must deal means that the number of direct contingent valuation studies needed would be exorbitantly time consuming, and potentially complex, and confusing for respondents and policy makers alike. A variety of significant theoretical and methodological problems have indeed been described in the use of direct CV for the valuation of non-fatal road traffic injuries (Ball *et al.*, 1991; Kidholm, 1995).

As a consequence, relative scaling approaches have been examined in several studies in an attempt to circumvent the problems of using direct CV. With this approach each injury state is described and assigned a utility score on a scale from zero to one (where zero represents death and one full health). As discussed, a variety of different methods can be used to assign values although there is an abundance of published 'utility loss' scales already available in the medical literature which provide estimates for many injury and illness states.

Armed with these utility loss estimates, two approaches can be taken. For scales which explicitly consider and incorporate the duration of the health state in assigning the original score, the utility loss score for a health state can simply be multiplied by the 'anchor' VOSL for a fatality. Alternatively, where the duration of the injury or illness is not explicitly accounted for in the original utility loss score the utility loss associated with each health state can be weighted by the time in that condition on the assumption (open to challenge) that utility is proportional to time in a state.

Measures which explicitly incorporate consideration of both the quality and quantity of life have been variously termed Lost Years of Functioning (LYF), Healthy Year Equivalent's (HYEs) and Quality Adjusted Life Years (QALYs), of which the QALY measure is most widely used (see also section 4.2.6). The QALY measure is also based on peoples preferences, as quality of life scales and the resulting utility scores are drawn up on the basis of peoples' preferences about alternative health states. QALYs are primarily used for cost effectiveness analysis in cost per QALY-saved comparisons by the National Health Service. However, QALYs can be used in cost-benefit analysis, although this requires that a monetary value is assigned to a QALY. A monetary value for a given injury state can be derived by multiplying the number of QALYs gained by the value of a life year (VOLY), which can be derived from the VOSL, perhaps incorporating an appropriate discount rate.

To provide a brief example, this kind of approach has been used for estimating the value of morbidity and mortality from food-borne illness (Mauskopf and French, 1991). First, the duration of health impairment and reduction in life expectancy associated with different severities of food-borne illness were estimated. Second, information on the health states was converted into scores on two generic health state indices, the Rosser Index and, as a check, the Quality of Well-Being Index. The resultant scores were then used to estimate the loss of QALYs associated with fatal and non-fatal cases of the diseases. It was assumed that exposure occurred at 30 years of age with a remaining life expectancy of 46 years, and that individuals were in full health prior to exposure.

The monetary value of an individual QALY was estimated using a VOSL of \$5 million (the value of avoiding premature death at age 40 years, based on a wage-risk study by Moore and Viscusi, 1989). Assuming that the average remaining life expectancy at age 40 is 36 years and that these are spent in full health, this represents a monetary value of \$138,000 per QALY, undiscounted, or \$222,000, discounted at 3%. Multiplying the number of QALYs lost due to each disease by the value per QALY thus yields a monetary estimate of the welfare lost due to that disease.

There is, however, a continuing and unresolved debate over the relative merits of QALYs (or VOLYs) versus VOSLs, a choice which can have a significant impact upon the monetary values derived for different

health states and circumstances. VOSLs are, in a sense, more straightforward because they do not *inter alia* confront the tricky problem of discounting, and subscribers to the theory of welfare economics would also see them as more theoretically-sound. On the other hand, QALYs and VOLYs have attributes which make them more useful for those engaged in practical decision making.

2.3 A Review of VOSL Estimates in the Literature

2.3.1 Regulatory Revealed Preference

One of the first projects carried out by CERM was a review of past regulatory decisions on safety from which implied values of a life were deduced (Fernandes-Russell *et al.*, 1986). This study found mean and median implied VOSLs of £10 million and £140,000 (1986 prices) respectively, but with a range extending over six orders of magnitude from £10² to £10⁸ per life saved. Other studies have also examined implicit values of life derived from examination of past regulatory investment decisions. In a comparison of 57 lifesaving programmes in the US, Graham and Vaupel (1981) found striking differences between both agencies and programmes in terms of the cost per life saved, and even greater disparities in the cost per life year saved.

A more recent review by Tengs *et al.* (1995) examined the cost-effectiveness ratios implied by 587 safety interventions in the US. This study also found a substantial range, from programmes that actually saved more resources than they cost, to programmes which apparently cost more than \$10 billion per year of life saved. From this study the median intervention cost was, however, an arguably not unreasonable \$42,000 per life year saved. The review further found a (statistically) significant variation in cost-effectiveness between different categories of risk. For example, the median medical intervention cost was \$19,000 per life year (n=310), the median fatal injury reduction cost \$48,000/life year (n=133) and the median toxin control intervention cost \$2,800,000/life year. The study also revealed substantial differences in the median cost-effectiveness of interventions in different federal agencies as follows: Federal Aviation Administration \$23,000/life year (n=4); Consumer Product Safety Commission (CPSC) \$68,000/life year (n=11); National Highway Traffic Safety Administration \$78,000/life year (n=31); Occupational Safety and Health Administration \$88,000/life year (n=16), and the Environmental Protection Agency \$7.6 million/life year (n=89).

2.3.2 Individual Revealed Preference and Expressed Preference Studies

While institutional decisions of the type considered in the preceding section are likely to be influenced if not overshadowed by socio-political factors, business factors, and the like, there is some prospect that decisions at the level of the individual may be less burdened by such considerations, and hence show greater consistency and be more attuned to the pure valuation of safety. As described in section 2.2, however, the difficulties of revealed and expressed preference studies even at the level of the individual are hardly the less daunting, and, as will be seen later, most institutions which use VOSLs or VOLYs derived from studies of individual preferences have made use of some sort of consensus value rather than relying upon a single result derived from an *ad hoc* survey. This is the situation with regard to the UK Department of Transport (Dalvi, 1988), and the US CPSC, both of whom are leaders in their respective fields in the application of safety valuation in decision making. The UK National Radiological Protection Board (NRPB) also uses a consensus-based value of life for valuing radiological health detriments (Robb, 1990; Ball and Goats, 1996), derived in part from a CERM review of individual revealed and expressed preference studies (Ives *et al.*, 1993).

For this reason we have carried out a further review of a large number of published VOSLs. In all, we made use of 88 VOSL studies which provided 156 VOSLs. These studies are listed in Table 2.1. All monetary values in this Table have been updated to £ Sterling (January 1997) from data in '*International Financial Statistics, April 1997,*' and the '*International Financial Statistics Yearbook, 1996.*' Values were first updated to January 1997 in the original currency using the *consumer price index* for the relevant country, prior to conversion to £ Sterling using the January 1997 exchange rate.

Most of the studies reported VOSLs based on the mean of individual responses, although some used the median individual response. These have been kept separate in Table 2.1. In a few of the studies more than one VOSL was given and in these cases all figures were included in the review.

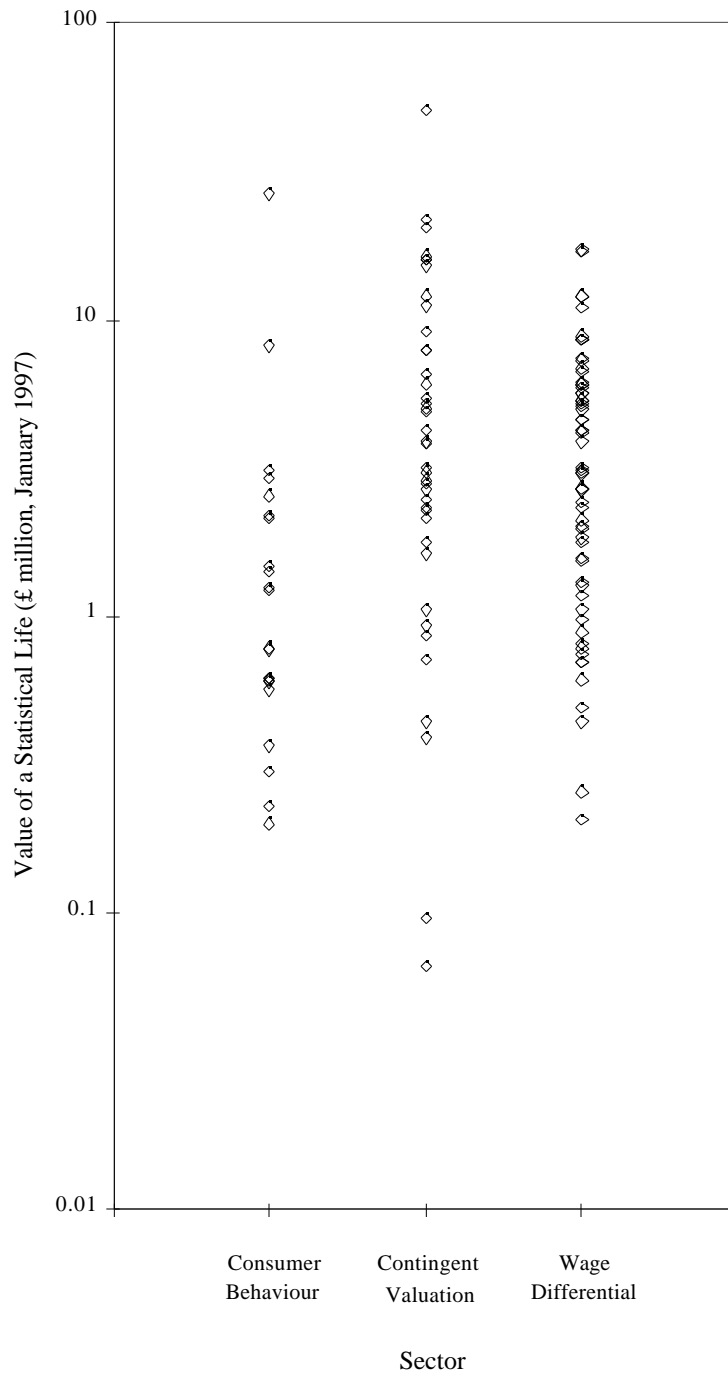
Table 2.2, which summarises these data, shows that overall there is a range of about two orders of magnitude in the mean VOSLs emerging from these studies. The range is from about £51 million to £66,000. The equivalent figures for medians are £27 million to £142,000. For the (124) mean-based VOSLs, the mean value over all studies was £4.9 million (SD £6.4 million), and the median £2.8 million. For the (32) median-based VOSLs the mean was £3.4 million (SD £4.7 million), and the median £2.2 million. It might also be recalled that in many of these studies some sort of data sifting will already have been undertaken. For example, it is fairly common practice for very low (especially zero) and very high valuations emerging from CV surveys to be eliminated prior to computation of the aggregate WTP, so the spread referred to above is less than that which would be encountered in the field. The fact that means are higher than medians is attributable to a skew towards high values in the survey responses, but the extent to which this skew is an artefact of survey technique and data handling is unclear.

Figure 2.1 and Table 2.2 also show the range of VOSLs found as a function of the different elicitation methods available: Compensating Wage Differential; Consumer Behaviour; and Contingent Valuation. These ranges, admittedly on a logarithmic scale, overlap substantially, and if the three means for these distributions are compared, there is no significant difference between them.

Figure 2.2 and Table 2.2 provide a further breakdown of the CV-derived valuations according to sector: transport (road and aviation); health (mainly food issues plus one study concerning coronary heart disease); occupational safety; and domestic fire risk. As with Figure 2.1, it can be seen that there is considerable overlap of data sets and it cannot be said that there is any significant difference between their means.

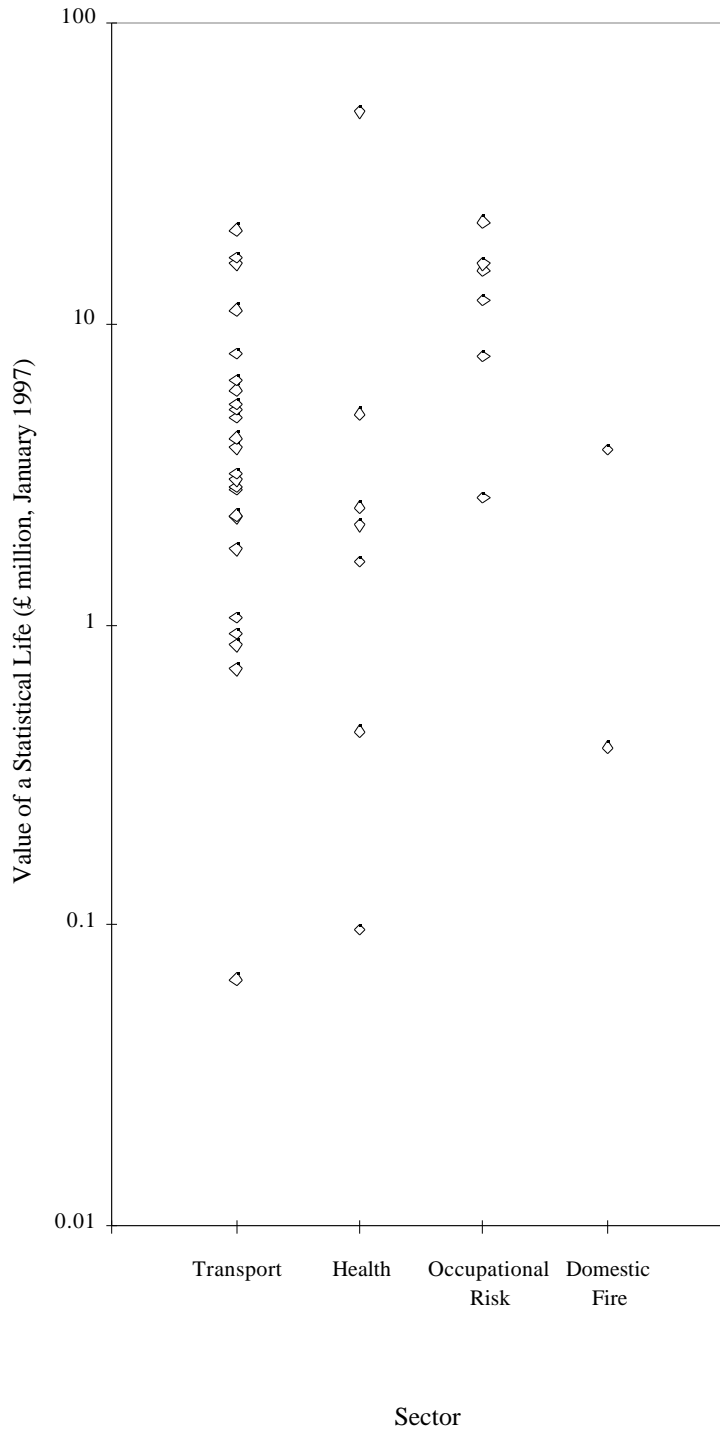
These results suggest that if there are differences in consumers' valuations of safety between sectors, then these are smaller than the inherent uncertainties associated with the contingent valuation method.

Figure 2.1: The Range of Values of a Statistical Life Using Different Techniques



All values shown are from the studies reviewed in Section 2.3.2 and giving VOSLs based on means of responses, updated to £ million (January 1997).

Figure 2.2: The Range of Values of a Statistical Life Across Sectors based on Contingent Valuation Studies



All values are from the Contingent Valuation studies reviewed in Section 2.3.2 and using VOSLs based on the means of responses, updated to £ million (January 1997).

Table 2.1: A Review of Value of Statistical Life Studies from the Literature

Authors	Year	Country	Context	Study Type	Mean VOSL	Median VOSL
Acton	1973	U.S.A.	Health (heart attack)	CV	97 k	
Anon.	1989	U.K.	Occupational risk (purchase safety clothing)	CV	11.9 m	
			Occupational risk (purchase safety equipment)	CV	7.8 m	
			Occupational risk (safer factory)	CV	21.7 m	
			Occupational risk (salary reduction)	CV	15.0 m	
Arnould & Nichols	1983	U.S.A.	Labour market	WD	695 k	
			Labour market	WD	775 k	
Atkinson & Halvorsen	1990		Transport (road)	CB	2.9 m	
Bailey	1980	U.S.A.	Labour market	WD	966 k	
Blomquist	1979	U.S.A.	Transport (road)	CB	772 k	
			Transport (road)	CB	2.5 m	
Blomquist & Miller	1990	U.S.A.	Labour Market	WD	1.5 m	
Brown	1980	U.S.A.	Labour market	WD	2.1 m	
Butler	1983	U.S.A.	Labour market	WD	807 k	
Cousineau, Lacroix, & Girard	1988	Canada	Labour market	WD	883 k	
			Labour market	WD	2.6 m	
Covey, Jones-Lee, Loomes, & Robinson	1995	U.K.	Health (food)	CV	50.6 m	0 - 26.7m
Dardis	1980	U.S.A.	Domestic (fire)	CB	362 k	
			Domestic (fire)	CB	565 k	
Desaigues & Rabl	1995	France	Transport (road)	CV	707 k	214 k
			Transport (road)	CV	3.8 m	1.1 m
			Transport (road)	CV	16.4 m	5.4 m
Dickens	1984	U.S.A.	Labour market	WD	2.0 m	
			Labour market	WD	2.3 m	

All values in £ U.K., January 1997; m = millions k = thousands

Study types: CV = Contingent Valuation WD = Wage Differential CB = Consumer Behaviour

Table 2.1: A Review of Value of Statistical Life Studies from the Literature
(continued)

Authors	Year	Country	Context	Study Type	Mean VOSL	Median VOSL
Dillingham	1979	U.S.A.	Labour market	WD	490 k	
			Labour market	WD	1.6 m	
Dillingham	1985	U.S.A.	Labour market	WD	1.765	
			Labour market	WD	4.9 m	
Dorsey	1983	U.S.A.	Labour market	WD	2.7 m	
Dorsey & Walzer	1983	U.S.A.	Labour market	WD	6.8 m	
Dreyfus & Viscusi	1995	U.S.A.	Transport (road)	CB	2.1 m	
			Transport (road)	CB	3.1 m	
Frankel	1979	U.S.A.	Transport (aviation)	CV	66 k	
			Transport (aviation)	CV	15.8 m	4.0 m
			Transport (aviation)	CV	20.3 m	5.1 m
Garbacz	1989	U.S.A.	Domestic (fire)	CB	1.5 m	
Garbacz	1991	U.S.A.	Domestic (fire)	CB	1.2 m	
			Domestic (fire)	CB	2.2 m	
Garen	1988	U.S.A.	Labour market	WD	4.2 m	
Gegax, Gerking, & Schulze	1985	U.S.A.	Health	CV	2.4 m	
Gegax, Gerking, & Schulze	1991	U.S.A.	Labour market	WD	1.2 m	
Gerking, deHaan, & Schulze	1988	U.S.A.	Occupational risk	CV	2.7 m	
Ghosh, Lees, & Seal	1975	U.K.	Transport (road)	CB	612 k	
Hammit	1990	U.S.A.	Health (pesticides)	CV		550 k
			Health (pesticides)	CV		4.8 m
Hammitt	1993	U.S.A.	Health (pesticides)	CB		3.6 m
Henson & Turner	1994	U.K.	Health (salmonella)	CV	5.0 m	3.5 m
Herzog & Schlottmann	1987	U.S.A.	Labour market	WD	6.7 m	

All values in £ U.K., January 1997; m = millions k = thousands

Study types: CV = Contingent Valuation WD = Wage Differential CB = Consumer Behaviour

Table 2.1: A Review of Value of Statistical Life Studies from the Literature
(continued)

Authors	Year	Country	Context	Study Type	Mean VOSL	Median VOSL
Ippolito & Ippolito	1984	U.S.A.	Health (smoking)	CB	297 k	
			Health (smoking)	CB	596 k	
Jondrow, Bowes, & Levy	1983	U.S.A.	Transport (road)	CB	623 k	
Jones-Lee	1976	U.K.	Transport (aviation)	CV	10.8 m	9.2 m
Jones-Lee	1977	U.K.	Transport (road)	CB	8.1 m	
Jones-Lee	1989	U.K.	Transport (road)	CV	2.8 m	
Jones-Lee, Hammerton, & Abbott	1983	U.K.	Transport (road)	CV		878 k
			Transport (road)	CV		2.2 m
Jones-Lee, Hammerton, & Phillips	1985	U.K.	Transport (road)	CV	2.9 m	1.4 m
Jones-Lee, Loomes, & Philips	1995	U.K.	Transport (road)	CV	4.9 m	2.9 m
Jones-Lee, Loomes, O'Reilly, & Philips	1993	U.K.	Transport (road)	CV		2.2 m
			Transport (road)	CV		3.0 m
Kidholm	1995	Denmark	Transport (road)	CV	8.0 m	2.2 m
Kidholm	1996	Denmark	Transport (road)	CV		1.8 m
Kniesner & Leeth	1991	U.S.A.	Labour market	WD	440 k	
		Australia	Labour market	WD	2.4 m	
		Japan	Labour market	WD	5.6 m	
Landefeld	1979	U.S.A.	Health	CV	2.1 m	
Landefeld & Seskin	1982	U.S.A.	Health (carcinogens)	CB	778 k	
Lanoie, Pedro, & Latour	1995	Canada	Labour market	WD	16.7 m	
			Occupational risk	CV	15.7 m	
			Transport (road)	CV	1.0 m	
Leigh	1987	U.S.A.	Labour market	WD	4.6 m	
			Labour market	WD	8.6 m	

All values in £ U.K., January 1997; m = millions k = thousands

Study types: CV = Contingent Valuation WD = Wage Differential CB = Consumer Behaviour

Table 2.1: A Review of Value of Statistical Life Studies from the Literature
(continued)

Authors	Year	Country	Context	Study Type	Mean VOSL	Median VOSL
Leigh & Folsom	1984	U.S.A.	Labour market	WD	5.6 m	
			Labour market	WD	7.4 m	
Low & McPheters	1983	U.S.A.	Labour market	WD	750 k	
Maclean	1979	U.K.	Domestic (fire)	CV	3.8 k	
Maier, Gerking, & Weiss	1989	Austria	Transport (road)	CV	3.0 m	
Marin & Psacharopoulos	1982	U.K.	Labour market	WD	2.7 m	
			Labour market	WD	3.1 m	
Martinello & Meng	1992	U.S.A.	Labour market	WD	4.6 m	4.5 m
McDaniels	1992	U.S.A.	Transport (road)	CV	5.4 m	
Melinek	1974	U.K.	Labour market	WD	612 k	
			Unknown	CB	200 k	
			Unknown	CB	618 k	
Melinek, Woolley, & Baldwin	1973	U.K.	Domestic (fire)	CV	391 k	142 k
Meng	1989	Canada	Labour market	WD	3.1 m	3.1 m
Meng & Smith	1990	Canada	Labour market	WD	5.1 m	6.1 m
Miller & Guria	1991	N. Z.	Transport (road)	CV	857 k	
Moore & Viscusi	1988a	U.S.A.	Labour market	WD	1.8 m	
			Labour market	WD	5.4 m	
Moore & Viscusi	1988b	U.S.A.	Labour market	WD	5.4 m	
Moore & Viscusi	1990a	U.S.A.	Labour market	WD	11.9 m	
Moore & Viscusi	1990b	U.S.A.	Labour market	WD	11.9 m	
Needleman	1980	U.K.	Labour market	WD	207 k	
Olson	1981	U.S.A.	Labour market	WD	8.8 m	
Persson	1992	Sweden	Transport (road)	CV	929 k	2.0 m

All values in £ U.K., January 1997; m = millions k = thousands

Study types: CV = Contingent Valuation WD = Wage Differential CB = Consumer Behaviour

Table 2.1: A Review of Value of Statistical Life Studies from the Literature
(continued)

Authors	Year	Country	Context	Study Type	Mean VOSL	Median VOSL
Persson & Cedervall	1991	Sweden	Transport (road)	CV	2.3 m	857 k
Persson, Lugner Norinder, & Scensson	1995	Sweden	Transport (road)	CV	3.2 m	1.2 m
Philips, Russell, & Jones-Lee	1989	U.K.	Transport (road)	CV	2.3 m	
			Transport (road)	CV	4.2m	
Portney	1981	U.S.A.	Health (air pollution)	CB	229 k	
Schwab-Christe	1995	Switzerland	Transport (road)	CV	11.0 m	5.1 m
Schwab-Christe & Soguel	1996	Switzerland	Transport (road)	CV	1.8 m	737 k
Smith	1974	U.S.A.	Labour market	CV	9.1 m	
			Labour market	WD	17.1 m	
Smith	1976	U.S.A.	Labour market	WD	4.2 m	
Smith	1979	U.S.A.	Labour market	WD	257 k	
			Labour market	WD	3.9 m	
Smith	1983	U.S.A.	Labour market	WD	2.0 m	
			Labour market	WD	6.0 m	
Smith & Gilbert	1984	U.S.A.	Labour market	WD	5.1 m	
			Labour market	WD	6.1 m	
Thaler & Rosen	1976	U.S.A.	Labour market	WD	698 k	
van Ravenswaay & Hoehn	1991a	U.S.A.	Health (pesticides)	CB	1.4 m	
			Health (pesticides)	CB	26.4 m	
van Ravenswaay & Hoehn	1991b	U.S.A.	Health (pesticides)	CV	440 k	
			Health (pesticides)	CV	1.6 m	
Veljanovski	1978	U.S.A.	Labour market	WD	6.1 m	
			Labour market	WD	8.5 m	

All values in £ U.K., January 1997; m = millions k = thousands

Study types: CV = Contingent Valuation WD = Wage Differential CB = Consumer Behaviour

Table 2.1: A Review of Value of Statistical Life Studies from the Literature
(continued)

Authors	Year	Country	Context	Study Type	Mean VOSL	Median VOSL
Viscusi	1978/9	U.S.A.	Labour market	WD	3.0 m	
Viscusi	1980	U.S.A.	Labour market	WD	3.0 m	
			Labour market	WD	8.5 m	
Viscusi	1981	U.S.A.	Labour market	WD	4.1 m	
			Labour market	WD	7.3 m	
Viscusi	1995	U.S.A.	Transport (road)	CV	5.2 m	1.4 m
Viscusi	1990	U.S.A.	Transport (road)	CV		734 k
			Transport (road)	CV		1.7 m
			Transport (road)	CV	6.0 m	
Viscusi & Moore	1987	U.S.A.	Labour market	WD	1.1 m	
			Labour market	WD	1.3 m	
Viscusi & Moore	1989	U.S.A.	Labour market	WD	1.3 m	
			Labour market	WD	5.8 m	
Viscusi, Magat, & Huber	1991	U.S.A.	Transport (road)	CV	6.5 m	1.8 m
Winston & Mannering	1984	U.S.A.	Transport (road)	CB	1.2 m	

All values in £ U.K., January 1997; m = millions k = thousands

Study types: CV = Contingent Valuation WD = Wage Differential CB = Consumer Behaviour

Table 2.2 A Summary of VOSL Estimates in the Literature

Study Type	VOSLs given as Means							VOSLs given as Medians						
	n	max. value	min. value	orders of mag.	mean	S.D.	median	n	max. value	min. value	orders of mag.	mean	S.D.	median
All Studies	124	51m	66k	3	4.9m	6.4m	2.8m	32	27m	142k	2	3.4m	4.7m	2.2m
Wage Differential	61	17m	210k	2	4.2m	3.7m	3.1m	3	6.1m	3.1m	< 1	-	-	-
Consumer Behaviour	22	26m	200k	2	2.7m	5.6m	1.0m	1	-	-	-	-	-	-
Contingent Valuation	41	51m	66k	3	7.1m	9.0m	3.8m	28	27m	142k	2	3.3m	5.0m	1.9m
CV: Transport	25	20m	66k	2-3	5.6m	5.4m	3.8m	23	9.2m	210k	1-2	2.5m	2.1m	1.8m
CV: Health	7	51m	97k	2-3	8.9m	19m	2.1m	4	27m	550k	1-2	-	-	-
CV: Occupational Risk	6	22m	2.7m	< 1	13m	6.6m	14m	0	-	-	-	-	-	-
CV: Domestic Fire	2	3.8m	390k	1	-	-	-	1	-	-	-	-	-	-

All figures in £ January 1997 m = millions k = thousands

Chapter 3: EXPLAINING VARIATION IN THE VALUE OF LIFE

Summary of Key Points

- It is proposed that the substantial across-studies variance in VOSLs which has been observed could be attributable to either fundamental difficulties in survey designs, or to a failure of consumers to behave like rational utility maximisers, or to a genuine influence of contextual factors;
- Evidence is rather sparse, but what there is suggests to the authors of this report that while contextual factors undoubtedly influence consumers preferences, that these influences are fairly modest when averaged over populations and do not account for the majority of the observed variance in VOSLs. This is thought more likely to be attributable to the vagaries of survey designs and the fact that the notion of VOSL is no more than a fuzzy concept for consumers;
- There is modest evidence that, in the final analysis, an underlying motivation of consumers is a tendency to want to maximise the number of lives saved rather than to apply substantial weightings based on qualitative factors. Consumers also appear to prefer resource allocations which present the prospect of tangible rather than speculative gains;
- Evidence, again limited, on consumer preferences regarding scale of consequence effects on preferences also points to risk neutrality and a general desire for safety measures leading to tangible results which, by-and-large, maximise life saving potential;
- It is suggested that the question of whether it is more important to invest in lives saved or life-years saved is complex. In some health service allocative decisions QALYs and hence life years may well be the most appropriate vehicle, but this is not necessarily so from the perspective of consumer safety. Fundamental shifts in attitudes to, for example, old age will mean that public preferences may change and agencies whose remit includes protection of the elderly at home, such as the CSU, may wish to accommodate these changes;
- Contextual factors are also less than straightforward. Even apparently simple notions of voluntarily versus involuntarily-accepted risks, often singled out as categories warranting less or more safety expenditure, may be over-shadowed by broader issues. Sports, for example, are both risky and voluntary but consumers are now actively encouraged by Health Education Authorities to participate because of recognised longer term health benefits, so signalling a shift in responsibilities;
- Finally, it is observed that consumer preferences are influenced by both the immediate context of a hazard, and by the broader context. The common absence of information on broader contextual issues in CV studies may be one contributory factor to the volatility of responses.

3.1 Introduction

The data in Chapter 2 reveal a substantial across-studies variance in estimates of VOSL, whether obtained by revealed or expressed preference techniques. There are three, at least, contrasting explanations as to why this should be so.

One is that the differences in the VOSLs found in the literature are attributable to inconsistencies and differences in survey design, methodological approach, data analysis, or survey population in the various studies. Viscusi (1993) thus notes that estimates of VOSL based on wage-risk trade-offs vary considerably depending on the nature of the population exposed to the risk, the individuals' income level and other such factors. Kidholm (1996) notes that differences may arise in VOSL estimates between countries as the income level in different countries varies and the general perception of safety might also be different. Furthermore, variations should be expected since the reduction of injury risk in various studies also differs. Hauer (1994) adds socio-economic characteristics, such as age, income, gender, race, education and so on, to the list of items which would also be expected to influence expressed WTP. Usher (1985) remarks that it should be expected that estimates of the VOSL would vary widely, for they refer to different groups of people, different situations and times, and reflect different hypotheses of the investigators. However, Usher also comments as follows:

“Measurement error is likely to be substantial for so elusive an object as the value of life, but there may be more involved” (p. 178).

A second explanation is that people neither behave nor think like ‘rational utility maximisers,’ as economic theory would like. As observed in section 2.2.2, there is growing evidence that people do not have clearly determined or pre-formed ‘rational’ preferences for safety and this is creating concern over the usefulness of such surveys as a tool for informing policy. This is particularly so when, as is normally the case, risk constitutes only one facet of a far more complex array of factors with which individuals have to contend in coping with most risk issues. Thus, the elicitation of individuals’ ‘true’ preferences by the kind of survey techniques commonly employed is fraught with difficulty, if not even beyond the bounds of reasonable expectation. One is left to conclude that variations in the VOSL can also be expected to arise from the spurious nature of many of the preferences elicited from respondents during many of the surveys which have been conducted. Covello, as long ago as 1983, put it quite bluntly:

- people typically respond to survey questions with the first thing that comes to mind and then become committed to that answer;
- people typically provide an answer to any question posed even though they may have no opinion, do not understand the question, or hold inconsistent beliefs;
- survey responses are influenced by the order of questions, whether the question is open or closed, supplementary information, interviewer prompting, and how the question is posed.

And, to be fair on the public, even for the most thoughtful and knowledgeable respondents, beliefs about many of the issues covered by these surveys may well be vague, ill-formed or even non-existent at the point of questioning (Lichtenstein *et al.*, 1990).

A third explanation also warrants consideration. This is that the VOSL, should it be a valid concept, may actually be different in different contexts. Some authors have argued that conventional WTP studies have often omitted crucial information on the risk characteristics (other than the size of the risk reduction and the initial risk level) which may influence the value that people are willing to pay for risk reduction. In the past, rather little attention has been afforded to the effect that such ‘contextual’ factors might have on WTP. In recent years, however, research combining both psychological and economic approaches has been undertaken which appears to indicate that peoples’ WTP may vary according to a number of social and psychological factors. It is thus worth considering whether the variation in VOSL estimates is either a reflection of our limited capacity to measure a single ‘true’ value out there in the market, or a reflection of the fact that there is no such thing as a single ‘true’ value in the minds of respondents due to a lack of sharply-delineated preferences, or whether the variation in the estimates actually reflects a real variation in preferences for risk reduction according to the context and characteristics of the risk considered.

In the following section we first examine underlying arguments for and against the use of different VOSLs in different contexts, prior to considering research on some of the factors which might influence individuals expressed WTP for safety.

3.2 Some Arguments for and against using Different VOSLs

The establishment of different VOSLs by the policy maker involves addressing fundamental value-based judgements about *what is valued* in our society and about the *relative value* of different factors. The commonly-voiced argument for valuing different types of deaths differently is that the characteristics of the individual, the situation in which the hazard is encountered, and the characteristics of the risk itself may vary and these should be reflected in policy. For example, the *average age of the victims* may be a factor, as some interventions will prevent the deaths of children or teenagers, while others may prevent the deaths of adults or the elderly. If it were believed that public policy should be concerned with the number of *life years* added, rather than simply the number of deaths prevented, then the age of victims becomes an issue and different programs should be valued differently.

The *immediacy of death* may also be an important factor. Some hazards may lead to prompt fatalities, while for other hazards, like exposure to low concentrations of toxic chemicals, the effects of exposure may be long delayed, or death may follow only after many years of continued exposure. Whether deaths prevented now should be valued more than deaths prevented in the future is a contentious issue, reflected in the never-quite-laid-to-rest debate over discounting and in part in the continuing discussion over VOSLs versus VOLYs and QALYs.

The *characteristics of the risk* may also be a significant consideration for policy makers. For example, some risks, like skiing, are accepted voluntarily if not willingly by skiers, and we might choose to provide greater protection for people who are subject to involuntary risks which they are unable to control through their own actions, rather than those who deliberately engage in risky activities. Like most things this issue is, however, less straightforward than it might first appear. For instance, people may not realise that a risk exists or may have inaccurate perceptions regarding the true magnitude of that risk. Further, sports activities, though in some cases bearing a surprisingly high level of risk, are now actively encouraged by governments and health educators because they promote exercise and substantially reduce risks of coronary heart disease and many other life threatening conditions in later years (Ball, 1997). Again, some risks which are generally perceived to be voluntary (such as driving a car) are often necessary for everyday life. Thus, determining the degree to which a risk is 'voluntary' can in itself be challenging. Some safety interventions may also be worthwhile from a societal perspective, for instance, in terms of reducing demands on the NHS.

Whether a premium should be added for 'catastrophic' or multiple fatality risks is a further important issue for some regulators. Is the loss of fifty lives in one accident more important than the loss of fifty lives in separate accidents? Many of those who specialise in the risks of major industrial hazards believe that a premium should be associated with the prevention of multiple-fatality events. But it could be argued that such events are no more worthy of public resources than, say, the fifty or so teenagers who die each year from solvent exposure, less dramatic and less public though these deaths may be.

The argument against using different VOSLs is essentially an egalitarian argument that all lives are equal. If this rationale is accepted, the value of preventing the death of an elderly person should be equal to that of preventing the death of a young person. Similarly, the value of preventing a death now should be equal to the value of preventing a death in the future. It could also be argued on this basis that differences in the characteristics of the risk should not be used as a basis for differing VOSLs, as if more money is spent to prevent some types of deaths than others, then the number of deaths avoided is not maximised (Zeckhauser and Viscusi, 1990).

3.3 Some Empirical Evidence Regarding Differential VOSLs

It is generally accepted that WTP responses should be expected to vary with the income of the respondent, the initial risk level, and magnitude of the proposed risk reduction. However, evidence indicates that peoples preferences for safety vary according to a number of other factors, some of which are not easily accounted for in utility theory. Such factors may result in different values of life for different risks. These factors come in different forms and may be referred to as 'contextual', 'scale', 'age' and 'temporal.'

3.3.1 Contextual Effects

Psychometric research, in particular by Slovic and colleagues in the US (for example, Slovic, 1987), has identified a suite of factors which are often influential in determining a persons willingness to tolerate a risky activity, for example, whether it is:

- observable or unobservable
- known or unknown to those exposed
- immediate in effect or delayed
- a novel risk or a familiar risk
- known or unknown to science
- controllable or uncontrollable
- dreaded or not dreaded
- giving rise to fatal or non-fatal consequences
- equitable or inequitable in terms of the distribution of risks and benefits
- posing risks to future generations
- voluntary or involuntary
- posing a personal threat or a threat to society
- has visible or invisible benefits
- occurs as a result of human failure or arises from natural causes
- is managed by a trusted and respected party

These kinds of factors may thus in theory be expected to have influence on people's WTP for reductions in the risk of death or injury. However, from the general review data described in Chapter 2 it is not possible to isolate factors of this kind. It is therefore necessary to look at studies which directly examine both the nature and the magnitude of the differences in peoples WTP to prevent different types of deaths. Only limited empirical evidence is, in fact, available which addresses this issue of contextual effects on estimates of WTP and the VOSL.

A 1989 study by Mendeloff and Kaplan aimed to assess peoples judgements about the relative values placed on preventing different types of deaths. The study did not aim to assess absolute values for safety (i.e. VOSLs) in order to keep the valuation task simple. Four groups of subjects (two sets of students at US universities, a clerical/administrative staff group and a group of retirees in continuing education) were used to provide the valuations. Participants were asked to play the role of policy maker and assume that ten deaths could be prevented in any of eight different programmes presented, but that resources were limited and only some of the programmes could be carried out. The programmes differed in terms of the risk context, the age of those at risk, and whether the deaths prevented would be now or in the future.

Participants were asked first to rank each programme from lowest to highest priority and were then asked to give a rating of 10 to the lowest ranked programme and rate the others in relation to this. Differences between the top and bottom rated programmes were found to be similar in all four samples, ranging from 5 to 6 fold. However, when the data were aggregated across individuals, the difference in the relative ratings of the various programmes was found to shrink to between two and three fold. The results from this study are interesting as they indicate that while fairly large differences in individual preferences for different lifesaving programmes occur, that when aggregated these differences may partially 'balance out' leaving a more modest overall difference in preference between programmes. These data stem, of course, from a single and rather small study, but there are findings from other quarters which are supportive.

Horowitz (1994), in a study of preferences for pesticide regulation, found that consumers had a distinct and consistent predilection for regulation of pesticide residues compared with automobile exhaust control when both options were posited as costing the same and saving the same number of lives. However, in cases where the options were described as saving different numbers of lives the contextual effect was greatly diminished and the strongest preference by far was for that programme which saved the most lives.

Preliminary research by Savage (1991) has confirmed that certain hazards, such as nuclear facilities, engender both a heightened psychological fear and an apparent high WTP to reduce risk. However, for more everyday risks, this study failed to find a systematic relationship between psychological fear of hazards and stated or revealed VOSL. Again, this study was based on a small, and possibly unrepresentative, sample. A later study by the same author (Savage, 1993) examined further the extent to which psychometric factors influenced peoples apparent WTP to reduce risk. Based on Chicago (n = 1027) the study examined four hazards: aviation accidents, fires in the home, automobile accidents and stomach cancer. Data on the risk characteristics 'dread' and 'unknown,' and an indication of personal exposure to risk, was obtained on a standard 7-point psychometric scale. Respondents were asked to allocate \$100 between the four hazards to reduce the risks posed, thus providing estimates of WTP. For one hazard, stomach cancer, high dread and high WTP were demonstrated. For other hazards, WTP was found to increase with dread, but declined with decreasing knowledge of the hazard. While this appears counter-intuitive at first, Savage argues that when people think a hazard is unknown, unpredictable, and poorly understood by science, then they may prefer money to be spent on research into hazards where there is a greater chance that preventive measures may be discovered.

Research by McDaniels *et al.* (1992) examined the relationship between various measures of perceived risk and stated WTP for risk reduction using a combined contingent valuation and risk perception survey. WTP questions were posed for ten hazards which were divided into two groups: five 'well-defined' or familiar risks (automobiles, commercial aviation, power tools, liquefied natural gas/liquefied petroleum (LNG/LPG), and a workplace chemical (vinyl chloride)) and five 'less well defined' risks characterised by greater uncertainty in exposure and effects (chlorinated water, hazardous waste, nuclear energy, sulphur air pollution and electromagnetic fields).

For the well-defined hazards, valuation questions were asked in terms of each household's WTP to reduce the annual deaths from the particular hazard by a given number, and where the deaths to be avoided

amounted to a 20% reduction in estimated annual fatalities. For the less well-defined hazards, questions were cast in terms of the household's WTP for a 20% reduction in the potential for death from each of these risks. Following the WTP questions, subjects were asked to rate each of the ten hazards on standard risk perception scales. The characteristics of perceived risk included voluntariness, severity, knowledge, control, dread, personal exposure and overall risk.

The study was conducted on a sample (n=55) of adults in Pennsylvania. Data were analysed in two ways. The first approach pooled all data for the 210 risks into one large regression, while the second split the sample into the categories of 'well-defined' and 'less well-defined' and treated the two as separate regressions. The pooled analysis suggested that socio-economic characteristics, perceived risk characteristics, and perceived exposure levels all influenced expressed WTP values for safety across a range of hazards. The split analysis showed a sharp contrast between the influences on values of safety for the two types of hazards. For well defined and familiar hazards, WTP was most influenced by the perceived level of personal exposure, whereas for less well-defined risks, WTP was most influenced by the characteristics of dread and severity.

Jones-Lee and Loomes (1994) examined individuals' preferences for safety on the London Underground using safety on the roads as a comparator. The authors concluded that a 'clear and sizeable' premium for underground travel safety (actually about 50%) emerged from this study, and that this was entirely attributable to considerations of control, voluntariness and responsibility, and not at all to scale.

Gregory *et al.* (1994) examined the trade-offs that people were willing to make between cost or injuries and qualitative aspects of risk. For example, one scenario, referred to as 'bike brakes,' described a new kind of brake that would work better in the rain. The trade-off was then between the cost of the new brakes and the reduction in injuries. In the 'injuries' version, the respondents were told the new brakes would add \$50 to the price of a bike and were asked to name the smallest reduction in injuries they would insist on before buying the new brakes. In the 'dollars' version the respondents were told that the bike brakes would lead to a 50% reduction in injuries and were asked to state the largest cost increase they would be willing to pay to buy a bike with the new brakes. For some versions, qualitative risk information was added which noted that the compound used on the new brakes was new, and poorly understood by science, although a few scientists were concerned that unspecified adverse effects on air quality could arise. The authors then tested how much the addition of the qualitative risk information altered the trade-offs between costs and injuries. Overall, the addition of qualitative risk information made the brakes less desirable. The median subject in the injuries/no perceived risk information group asked for a 50% reduction in injuries; this increased to 75% for those provided with additional risk information. In the dollars version, median WTP decreased from \$20 to \$5 with the addition of perceived risk information.

Conclusions, more or less tentative, which can be drawn from these and similar studies are that while context certainly does appear to have implications for expressed WTP, that these effects may be relatively modest (factors of two or three or so) when averaged over populations, and certainly when compared with the substantial variance in WTP estimates described in Chapter 2. Indeed, there are hints here and elsewhere (for example, Floyd and Ball, 1997) that there is an underlying public preference for the maxim of saving as many lives as possible when the chips are down. This suggests that the substantial variance in WTP may owe more to either our inability to measure WTP or to the fact that the VOSL is, at best, no more than a fuzzy concept, than to contextual factors.

Another point of note is that public preferences are shown to be influenced by both the immediate context of a hazard and by wider contextual issues. This could be important because most CV studies, while providing information on context, do so only in a narrow sense. For some respondents this would be tantamount to being asked to answer questions in a vacuum, and may be a partial explanation of why so many people find it difficult to provide meaningful answers to CV questions.

3.3.2 'Scale' Effects

The potential for large-scale technological hazards to generate 'catastrophic' consequences in terms of capability to cause multiple fatalities in a single event is widely recognised as one of the dimensions of perceived risk. It might therefore follow that people would be willing to pay more to reduce those risks with potentially catastrophic consequences. Despite the prevalence of this perception of public concerns in regulatory and political circles, however, that research which has been done finds relatively little evidence

of public support for a scale premium as such. Indeed, what evidence there is tends to support risk neutrality i.e. no additional premium for low frequency high consequence hazards over more conventional hazards (Floyd and Ball, 1997).

A case in point is the work of Slovic *et al.* (1984) who conducted an experimental test of attitudes to catastrophe avoidance. They found that the preference of most subjects was for minimising the number of lives lost overall, rather than for reducing the risk of catastrophic accidents in particular.

Jones-Lee and Loomes (1994) also found, as mentioned above and contrary to their expectation, that there was no evidence at all of a positive premium for London Underground safety compared to road safety which could be attributed to scale of consequences. Discussions with respondents did reveal a preference amongst some for a scale premium on the basis of aversion to the ambiguity and uncertainty of potential large-scale accidents. However, other respondents appeared to doubt whether expenditure aimed at attenuating risks of large-scale and unpredictable accidents would actually be effective in preventing the unique combinations of circumstances that often led to such accidents. In contrast, it was felt that spending on single-fatality, predictable accidents would be more likely to yield a tangible return. This scepticism served to cancel out the risk aversion expressed by those few.

These few results, if anything, tend to add further support to the notion of a generally pragmatic public who are in the final analysis swayed more by the thought of tangible lives saved than by weighting factors based on qualitative dimensions.

3.3.3 Age Preferences

Most risk interventions affect different ages to different degrees. For example, programmes to reduce deaths or injuries from slips, trips and falls in the home would save relatively fewer life-years than programmes to reduce neo-natal deaths, or programmes to reduce automobile accidents.

As described in Chapter 2, if it were considered important to take into account the age of victims when making allocative decisions to safety programmes, one approach to incorporating such considerations into policy would be to base analyses on the years of life lost, which implicitly values individuals in proportion to their life expectancies. Usually, a life-year is assigned a constant value over time. As a result, children would automatically be valued higher than adults because of their greater life expectancy, who would in turn be valued higher than pensioners.

However, this approach will not reflect society's preferences in all circumstances, although it probably would in some. For example, it could be deemed especially important to protect the lives of those involved in raising young children. But at a more fundamental level the views of western society towards old age itself are also undergoing fairly radical change (Houghton, 1997). This is partly because of the shift towards a multi-racial society including ethnic groups who have always placed a greater value on the elderly members of the community. It is also because, rather than seeing post-work, post-child raising years as short and comparatively devoid of meaning, there is an emerging concept of an extended 'Third Age' during which people are able to realise lifelong personal ambitions and rightfully enjoy the fruits of earlier years of labour. So, while age of victims may well be a factor for consideration in some circumstances such as health care, it is not one for which some all-embracing, simple algorithm can readily be prescribed.

3.3.4 Temporal Effects

Where benefits and costs are spread out over a number of years, it is common practice in policy analysis to apply a discount rate to expected consequences which occur in the future. Calculation of the present value of all future benefits and costs and subtraction of costs from benefits produces the present value of net benefits (PVNB). In principle this is straightforward, but in practice this is mainly true where the 'time stream' of costs and benefits extends over only a few years. Swaney (1994) argues that in other circumstances, when consequences are spread over many years, where the time distribution of costs and benefits is asymmetrical (e.g. where benefits occur over 10 years while costs are delayed for 100 years), when there is some probability, even if remote, that distant costs will be catastrophic, or when interests aside from those of today's resource owners and consumers will be affected, discounting is highly suspect.

A similar debate has also been apparent in Britain, for while on the one hand it is recognised that discount rates can be applied to future material goods, the same may not hold true for items such as environmental goods and the health and welfare of future populations (see also section 4.2.6).

Chapter 4: EXISTING APPROACHES TO SAFETY VALUATION

Summary of Key Points

- Recognition of cost-benefit analysis as a decision aid in relation to human safety is fairly widespread by key decision making agencies in Britain and has a substantial history in some, such as the NRPB, DoT and DoH. The concept of ‘reasonable practicability’ in British health and safety law is consistent with the consideration of cost-benefit trade-offs;
- Institutions responsible for safety in other countries also consider costs of safety measures but seldom in such a formalised way as in the UK;
- Limitations in the usefulness of cost-benefit are noted by most agencies. Such situations apply where risks and risk reductions are highly uncertain, as in food safety but also elsewhere, and where questions of discounting arise. It is also noted that cost-benefit can be an expensive activity to undertake in its own right, and its detailed application is unlikely to be justified except in circumstances where the stakes are high, or a decision is finely balanced. A pragmatic approach is adopted by some agencies such as BP and the CAA who in a sense use cost-benefit and VOSL as a tool for sifting plausible from implausible safety options;
- The most-widely acknowledged VOSL in the UK is that developed by the DoT. This, in fact, is a ‘consensus’ value, the human cost element of which was set at £0.5m (1987 prices) which represented the lower end of a credible range of theoretically-derived options including the national survey by Jones-Lee *et al.*. The value incorporates political considerations specific to road transport and the government of the day, and this should at the very least be borne in mind by agencies contemplating the application of this same value to other situations;
- The NRPB also makes use of a ‘consensus’ VOSL of £1.6m based on a literature review of existing values and suggestions taken from a report of the Royal Society. NRPB has chosen to anchor this VOSL to a fatal risk level of 10^{-4} per annum from which the dependence of VOSL on risk is estimated;
- Some agencies, such as Railtrack, have adapted the DoT VOSL for their own purposes, in some cases adding a layer of refinement specific to the type of hazards in their sector. Other agencies, such as the US CPSC, prefer to use a single VOSL and introduce factors specific to individual decisions at the final stage of policy formulation;
- The US CPSC, particularly important in the context of consumer safety, uses a VOSL of US\$5m based on a review of published literature;
- Several agencies, for instance the HSE and NRPB, are sensitive to contextual and scale factors which may influence VOSL. NRPB is comparatively unusual in having developed a rather sophisticated set of explicit safety valuations (based on costs per man Sv) which are determined by both risk level (analogous to the concept of gross disproportion) and years of life saved. There is some novelty in the risk level factor which is taken from a notional ‘fuzzy curve’;
- There is continuing debate over the preferred method of calculating the human costs of non-fatal injuries and health states, particularly over the relative merits of QALY- or VOLY- type approaches, said to entail fresh uncertainties, and the use of direct valuations of those states, which encounter other types of problem.

4.1 Introduction

This Chapter describes approaches adopted by other agencies with regard to the role of cost-benefit analysis and the valuation of life and injury in the formulation of safety policy. Section 4.2 commences by examining the position of various UK agencies in the public and private sectors with responsibility for safety. Section 4.3 examines the approaches taken by various international consumer safety agencies including notably the US Consumer Product Safety Commission (CPSC) which is highly regarded for its work on consumer safety. Both the general approach to policy formulation and specific issues pertaining to the valuation of life and injury are discussed where appropriate.

4.2 UK Agencies

In the UK, general guidance regarding the economic appraisal of expenditure decisions is provided by HM Treasury (1991) in the guide ‘*Economic Appraisal in Central Government.*’ The document outlines broad,

flexible guidelines for the systematic appraisal of expenditure decisions in UK government departments. The basic elements of an appraisal system are described as follows:

- define the objectives of the policy;
- consider the options for meeting the objectives;
- identify, quantify and where possible, value the costs, benefits and uncertainties of each option;
- put those costs and benefits which can be valued in money terms on a comparable basis;
- weigh up the uncertainties;
- assess the balance between options;
- present the results.

The balancing of costs and benefits is clearly a central component of the appraisal process. However, the Treasury guide explicitly recognises that there will often be significant uncertainties attached to estimates of cost or benefits, or to both, and that there are also likely to be significant elements which cannot be valued in money terms and may not even be easily quantifiable. These factors may include environmental issues, questions of equity and social justice, public values and social acceptability of issues, and the political implications of proposed policy measures.

A more recent Treasury report, *'The setting of safety standards,'* (HM Treasury, 1996) also states that the objective of all regulation should be a considered balance of costs and benefits (sometimes taking into account important ethical constraints on the distribution of costs and benefits). The process of weighing the costs and benefits of various control options is thus seen as the basis for the development of balanced safety regulations in the UK.

4.2.1 Department of Transport

The Department of Transport (DoT) has responsibility for policy on airports, railways, major ports, road traffic law and the Highway Code, licensing of lorry and bus operators and the registration of bus services in Great Britain (but not Northern Ireland). In the DoT, cost-benefit analysis incorporating explicit valuations of the risks of death and injury is routinely used as a major determinant of spending priorities (HM Treasury, 1996). The DoT has, in particular, been in the forefront of UK research into valuation methods for both fatal and non-fatal injuries. For instance, in weighing decisions about new trunk road schemes, a decision-aiding tool known as COBA is utilised in which attributes including the value of time savings and the value of accident reduction are monetised.

Prior to 1988, the DoT method of valuing fatal casualties was based on human capital costs together with a notional estimate for the value of pain, grief and suffering associated with a fatality. From 1988, however, the value of a fatality has been based on WTP methodologies and a value of £500,000 (1987 prices) for a road traffic fatality was introduced as the WTP component of the cost of a road traffic fatality. This VOSL was based in part, but not entirely, on a major WTP CV study of public preferences regarding road safety (Jones-Lee *et al.*, 1985). This, in many ways pioneering research, actually concluded that the probable range of true values for a fatal road traffic casualty lay between £0.8 million and £2 million. However, the 'consensus' value sought and finally adopted by the Department was to some degree a political decision which also took account of results from other WTP studies in the literature, and of the then government's political commitment to the speed of movement of traffic (Dalvi, 1988). The £0.5 million value was thus chosen for:

“.....reasons specific to that time, from the lower end of what was considered the then credible range, and has been updated since then only in proportion to GDP” (HM Treasury, 1996, p. 19).

From a risk management perspective the incorporation of specific domainal or political considerations at the decision stage is, without question, entirely reasonable. However, this modification to the VOSL also signifies that the DoT's value in use does not strictly possess the strong theoretical foundation (i.e. direct basis in expressed public preferences for road safety) with which it is sometimes associated, and that, because of the incorporation of traffic-related political factors of the day, some caution would be warranted in considering the direct transfer of the same value to other applications. Bearing these caveats in mind, the current value of a fatal road traffic casualty as used by the DoT is £812,010 (June 1995 prices), having been updated in line with GDP and also including direct and indirect cost elements.

Another stage in the DoT's programme has been to bring the methodology for valuing non-fatal injuries into line with that for fatalities by using a similar WTP-based approach. Two research methodologies were pursued, one based on national sample survey of WTP for reduction in the risk (Jones-Lee *et al.*, 1993), the other based on a relative utility loss approach (Ives *et al.*, 1993; Soby *et al.*, 1993). Based on the results of the research programme, the Department selected a value for a 'weighted basket' of serious non-fatal injuries, inclusive of direct and indirect economic costs (O'Reilly *et al.*, 1994), the current value of which for a 'serious' casualty is £92,570 (June 1995 prices), with the cost of a 'slight' casualty set at £7,170 (June 1995 prices).

A breakdown of the current (1996 prices) values for the total costs, including direct and indirect elements, of fatal and non-fatal incidents is to be found in Table 4.1, which shows average costs *per casualty* (personal communication, K. Mantle, DoT, 1997).

4.2.2 British Rail

British Rail (BR) have used cost-benefit analysis to ensure that available resources are directed to where they will bring the best return for investment. In terms of safety decisions, the return is in the form of lives saved and injuries prevented. The recent investigation into Automatic Train Protection (ATP) provided one example of the BR approach to safety valuation (British Railways Board, 1994). ATP is a system which supervises the train driver and ensures that brakes are applied in response to signal warnings. The adoption of ATP would thus prevent trains going past red signals ('signals passed at danger' or SPADS) and ATP was recommended for adoption on a network-wide basis by the Hidden Inquiry in 1989.

A cost benefit analysis of ATP by BR showed that the cost per life saved associated with the introduction of ATP was in the region of approximately £14m to £15m. Various sensitivity tests were applied to the calculations. Even assuming that ATP would prevent a major accident involving 50 deaths in addition to those deaths from smaller-scale accidents predicted from historic trends, the cost per life saved implied by the introduction of ATP was still found to be in the region of £10m.

BR comment that there is a broad consensus that society's current WTP for safety equates to its putting a value of around £1m to £2m on a statistical life. For railway investment, however, the figure that is generally used is £2m. This has been set higher than the road safety value for several reasons including the lack of control that rail passengers have over their travel risks compared with, say, car drivers. Also, from a business perspective, a further modest premium is considered appropriate as the impact on public opinion of an accident involving multiple deaths is thought likely to be greater than a series of lesser accidents on the roads in which the same number of people overall are killed.

As a result, BR concluded that it may be appropriate to consider a higher VOSL for ATP-preventable accidents which are foreseeable, potentially serious, and which pilot schemes have shown can be avoided. However, even with a higher VOSL of £3m to £4m, there is still a considerable gap between costs and benefits for the widespread adoption and retrofitting of ATP. As a result of this analysis, BR concluded that there are alternative, and lower cost, technologies that could be used to reduce or mitigate the effects of SPADS in the near future. It is also recognised that if the prices of rail travel were pushed up as a result of safety investments, passengers may be diverted onto the roads, where risks are higher.

4.2.3 Railtrack

As with other employers, there is a legal obligation on Railtrack (under the Health and Safety at Work Act 1974 etc.) to ensure that, so far as reasonably practicable, the safety of employees and the public is ensured. In the determination of what is 'reasonably practicable,' Railtrack may also apply cost-benefit analysis. Railtrack's Railway Safety Case (RSC), which was accepted by HSE in March 1994, specifies explicitly that the VPF (value of preventing a fatality, analogous to VOSL) should be the same as the value adopted by the DoT for road safety purposes. However, the RSC was revised in October 1995, as the DoT estimate recognised only one VOSL, while Railtrack identified a need for different values in special circumstances.

The VPF's subsequently authorised by Railtrack are described in their Code of Practice, '*Applying Values of Safety*' (Railtrack, 1995a). In this Code, a higher VPF of £2.3m applies where there is potential for multi-fatality accidents or where the victim has little or no control over the risk (e.g. train accidents and fires). An intermediate VPF of £1.4m applies to employees exposed to high levels of risk (e.g. trackside

staff), to passengers where the passengers' risk is not subject to their control, to risks to the public imposed as a result of railway operation, or to any other group which is particularly vulnerable. A basic VPF of £0.8m applies to other passenger accidents where the passenger's behaviour has contributed to the accident (e.g. slips, falls, alcohol, other drugs, or reckless behaviour), other staff accidents (e.g. office workers), and pedestrians or level crossing users. A lower VPF of £0.4m applies to trespassers and those who are engaged in illegal acts, except where the victim is a child or has diminished responsibility.

The Code of Practice '*Setting a Value on Preventing a Fatality*' (Railtrack, 1995b) states that the determination of a VPF should be suitable to the circumstance, the people involved, and the type of accident. Where the results of appropriate WTP studies are available, these should be used to determine the VPF. If such direct values are not obtainable, then VPFs should be set with reference to the authorised values outlined above. A VPF Assessment Form is used, which considers a number of factors which contribute to individual and social aversion. These factors, including voluntariness, dread, familiarity, delayed effects and so on, are rated on a scale from 'high' to 'low.'

Other costs associated with accidents, such as business costs, may be added to estimates of the VPF in the overall cost assessment.

4.2.4 London Underground Limited

London Underground Limited (LUL) is the state-owned operator of London's underground railway system. Empirical evidence of WTP for underground safety, based on a relative valuation methodology, has been described in Chapter 2 and stems from research by Jones-Lee and Loomes (1994). It appears that LUL are moving towards a position in which values of at least £2 million will be employed in safety project appraisal.

4.2.5 The Civil Aviation Authority

Within the Civil Aviation Authority, the Safety Regulation Group (SRG) is responsible for safety evaluation of proposed risk interventions. The CAA uses cost-benefit analysis at times along with other decision-aiding techniques, but acknowledges certain practical limitations, for instance that it can be expensive and time consuming to undertake and requires substantial resources, a point also recognised by the HSE. The data required to conduct an adequate assessment of safety benefits are also often insufficient. Therefore, CBA is generally only conducted when decisions are important or finely balanced (pers. comm. Adrian Sayce, Head of Safety Analysis, CAA, 1997).

When cost-benefit analysis is used by the CAA in the appraisal of aviation safety programmes it is customary not to use an explicit VOSL. Instead, an implicit VOSL is computed by analysis of the proposed measure, which can then be compared with commonly-used values in other sectors, either in the UK or the USA. Clearly, this kind of approach avoids the problem of establishing an explicit VOSL for use in policy appraisal, still a contentious issue in some sectors, for example, safety on the high seas. It is also recognised that many decisions to adopt new risk controls are prompted by political pressures or social sensitivities with the resulting strategy being more in line with the precautionary principle than with CBA. The CAA must also collaborate with other aviation authorities through the Joint Aviation Authorities, and in such cases a harmonisation of approaches may be required. The US Federal Aviation Administration, for example, uses a VOSL of \$2.4 million.

4.2.6 Department of Health

The guide to '*Policy Appraisal and Health*' (Department of Health, 1995) states that all policies, programmes and project options in the public sector should be systematically appraised and provides specific advice, although not mandatory, on the appraisal of health impacts. The guide specifies that consideration of health effects in policy appraisal requires the following stages:

- identification of any health impacts;
- assessment of their magnitude;
- valuation of impacts in monetary terms where this is helpful;
- identification of the main sources of uncertainty in the analysis; and
- clear presentation of the results for decision makers.

It is recognised that there is often a choice of methodology, and that different approaches for quantifying health effects may be appropriate in different circumstances, and beyond this that there remains a need for subjective judgement. The guide identifies the following possible approaches:

- *Number of lives lost* - measuring lives lost will be appropriate where the primary effect is mortality and/or where the individuals affected represent a random sample of the population or where no information is known on their specific characteristics;
- *Number of years of life lost* - it is conventionally assumed that a year of life is of equal value to all, but other valuations are possible. This approach requires that the average age of those affected by the policy, and the age to which they would be likely to live in the absence of the policy, are known. Only applicable to cases where the prime outcome is death and does not address issues of quality of life;
- *The severity and duration of any distress, discomfort or disability.*

In order to incorporate the quality of life into the estimation of health impact, the Quality Adjusted Life Year (QALY) measure has been developed. The QALY allows both life years and quality of life to be expressed in a single measure by weighting life-years (saved or lost) by the quality of life experienced in those years. Years of good health are thus more desirable than years of poor health. The quality of life measure is estimated using health status indices (for a review, see Kind, 1988). These range from simple indices limited to, say, consideration of pain and disability, to more sophisticated multi-dimensional measures. All the dimensions considered are then combined to form a weight which is applied for the duration of the illness (or until death). This approach enables consideration of health impacts where life expectancy is not reduced by an illness, but the quality of life is.

The guide recognises that the use of QALYs is contentious, that the measures are still under development, and can be misused,¹ but argues that there is currently no better way to compare the health effects of different policy proposals that change both the quantity and quality of life. Also, for some conditions such as mental health, no appropriate rating scale exists.

The guide also states that equity and distributional issues should be considered, and impacts on specific individuals or groups (by geographical area, gender or ethnicity, for example) should be examined. Adopting valuations on the basis of the number of life-years saved, or QALYs, is also acknowledged as open to the charge of 'ageism' as it implies that if two people are suffering from the same condition, better value is generally obtained by treating the younger, rather than the older.

The guide also notes that the appropriate rate of discounting for health benefits has been the subject of considerable debate. Monetary values occurring in the future are discounted to reflect the pure rate of time preference and the diminishing marginal utility of income (combined with the assumption that real incomes rise over time). These factors do not apply when health benefits remain in physical units (e.g. lives, life-years or QALYs). It is therefore not appropriate to discount health benefits (when quantified in physical units) at the same rate as monetary values. The only reason to discount health is the existence of pure time preference and it is suggested that this is around 1.5% to 2% in real terms, although it is recommended that sensitivity analysis should be conducted around this rate. Where health effects have been valued in monetary terms, these should be discounted at a rate of 6% in real terms along with other monetary values.

The guide recognises that valuation of health benefits in monetary terms is difficult and controversial, although it is common, where possible, to express the overall costs and benefits of a policy initiative in monetary terms. Other resource costs must be accounted for too, including, for example, GP costs, the costs of drugs and medical appliances, ambulance trips and so on. The cost of ill-health on other sectors (social services, social security and insurance costs) should also be accounted for. The valuation in monetary terms of changes in quality and quantity of life are more controversial. The guide recognises that

¹ For example, QALY values may be based on responses of people who have inadequate knowledge and experience of the health states they are being asked to evaluate, and losses of quality of life depend on whether the individual was in full health prior to the illness. The quality of life associated with a health condition may depend on the expected duration of the health state and QALY valuations between individuals may differ due to age, education, risk aversion or time preference.

the WTP approach is the preferred basis for the valuation of life and cites the DoT value for a road traffic fatality. The guide recognises that the DoT value is specific to road traffic accidents and that it may not be appropriate to use it in other circumstances, although it does provide a 'rough and ready' estimate for the value of life.

However, in order to value both quantity and quality of life, it is necessary to value a QALY. Several possibilities are recognised:

- direct surveys along the lines of the DoT's research into non-fatal road accident injury valuation. In principle it is possible to undertake surveys to value any health impact, although surveys are expensive and time consuming and the results not always helpful. Direct surveys may be theoretically preferable, as the individual WTP for health care will indicate the value derived from all aspect of health care, not just the improvement in health status. For example, people may realise other benefits from medical treatment (information, dignity, or autonomy) or from having medical treatment available (option value);
- an alternative approach is to value a QALY by linking it to a selected VOSL. Indeed, the VOSL could be viewed as the present value of QALYs expected to be enjoyed over the lifetime of an individual, which allows the value of a QALY to be derived from the VOSL, given the appropriate discount rate, the remaining life expectancy, and the QALY profile over those years. The value of health benefits associated with some policy could thus be calculated by combining the estimated change in QALYs associated with the policy and the estimated cost per QALY. Before this approach can be undertaken it is necessary to establish a reasonable level of agreement on the QALY value of various health conditions, the monetary VOSL, and the number of QALYs in a statistical life. The guide states that a reasonable approach to take in policy appraisal would be to use the DoT figures and undertake sensitivity analysis using other values of life;
- a further alternative is to cost the loss of time that illness causes (e.g. the loss of work or leisure time for minor and short-term illnesses).

4.2.7 Ministry of Agriculture, Fisheries and Food

Policy appraisal in MAFF follows the general guidelines set out in the Treasury 'Green Book' (HM Treasury, 1991) and the Department of the Environment publication 'Policy Appraisal and the Environment.'

The application of VOSL estimates to food-related risks presents singular difficulties. For some food-borne illnesses, such as food poisoning, the current risk and the potential impact of risk controls in reducing that risk level may be determined with some degree of reliability, but for many other food-related risks the difficulty of linking illness or death in a causative relationship with food is highly complex due to significant uncertainties in the toxicity and exposure data for various food contaminants. As a result, estimating the impact of proposed risk control efforts in terms of reductions in morbidity or mortality is often problematic. For example, although there is evident public concern about pesticide residues in foods, the scientific evidence regarding the relationship between residue levels and adverse effects on human health is highly uncertain. Thus, if a programme were devised to reduce chemical residues in foodstuffs, it would be difficult to determine the health benefits with any degree of certainty. Hence the usefulness of cost-benefit in such cases is limited and the concept of VOSL largely redundant.

Nonetheless, in order to try to make progress MAFF has recently commissioned two studies which examine consumer WTP to avoid food-borne illness (Henson and Turner, 1994; Covey *et al.*, 1995). Henson and Turner (1994) adopted two approaches to the valuation of food-borne salmonella; an indirect relative utility loss approach, and a direct contingent valuation approach. Covey *et al.* (1995) used standard gamble and direct contingent valuation methods for the valuation of death or ill-health arising from food-borne salmonella. As described earlier, they also examined the relative valuation given to different types of food-borne deaths, including a comparison of food poisoning death against a road traffic death, a pesticide-related cancer death, and a heart disease fatality.

In the absence of reliable information on probabilities, the issue is generally how much it would cost to introduce a new policy, in which case a judgement has to be made as to whether it is worth pursuing. The

VOSL concept can have a role to play in this process. For example, if a policy option costs £10 million to implement, this is equivalent to some 12 lives saved (on the basis of a VOSL of £0.83 million) and it provides a further means of gauging whether it is likely to be worth pursuing (pers. comm., J. Ince, 1997).

4.2.8 Health and Safety Executive

Since 1982 all new proposals for regulations on health and safety at work have been subject to some form of assessment of costs and benefits (Davies, 1993). The HSE has traditionally used human capital approaches for the valuation of life in CBA by estimating the value of a worker's future stream of output and then adding an arbitrary sum for 'pain, grief and suffering.' The result was a value of around £250,000 in 1989 prices (Davies, 1989) which, at best, was seen as providing a minimum value for the VOSL. However, a study was undertaken by HSE in 1989, in collaboration with the NRPB, of the feasibility of establishing values for WTP for workplace risk reduction (HSE, 1989). In the event, this study indicated that when faced with questions concerning WTP to reduce risks associated with occupational hazards by plausible small amounts, respondents gave volatile answers which were largely determined by the format of the question or other 'irrelevant' factors. The project was consequently abandoned.

Davies, economic adviser to the HSE, argues that the appropriate VOSL will vary with the size and nature of the risk involved (Davies, 1994). However, fatal workplace accidents may be sufficiently similar to fatal road accidents for the same VOSL to be applied, on the basis that:

- their risk is the same order of magnitude;
- in both cases there is the perception that the individual can control the risk;
- there is a similar degree of voluntariness in the acceptance of the risk by those affected;
- the activity presenting the risk brings benefits in both cases to those directly affected by the risk;
- both are situations of singular rather than multiple casualties in most cases and there is no additional 'societal risk' dimension;
- a broadly similar level of trauma, pain and suffering is involved.

On the other hand, it is acknowledged that some risks subject to HSE control are considered to be of a very different nature such that they might warrant a higher VOSL to reflect 'public aversion' to the risk. It is suggested that these could include:

- risks to the public rather than workers arising from work activities (involuntary, little direct benefit, vulnerable groups e.g. children);
- catastrophic risks with multiple casualties;
- cancer risks because of greater pain and trauma.

In a recent report on the costs of workplace accidents the DoT VOSL has been used by the HSE as a measure of the 'value of the cost to injured workers and their families of fatal injuries and premature death from work-related injuries' (Davies and Teasdale, 1994). Values for non-fatal occupational injuries and illness have also been derived using relative utility loss indices linked to the DoT VOSL (Table 4.2). Estimates of the property damage incurred by industry, the loss of potential output arising from reduction in the labour force, costs of medical treatment, and administration costs (incurred by firms, companies and the Department of Social Security), were added to the 'human cost' estimates, in order to derive estimates of the total cost of work-related injury and ill-health to society.

In assessing the reasonable practicability of industrial risk control options the DoT VOSL may also be used as a *minimum* value in any cost-benefit analysis. In higher risk situations the notion of gross disproportion comes into play, effectively increasing the VOSL by a factor of up to about ten times.

4.2.9 National Radiological Protection Board

The National Radiological Protection Board (NRPB) is concerned with radiation protection of the public and employees and has a substantial history in the use of cost-benefit analysis for this purpose, and in the monetary valuation of radiation doses which are measured in man Sieverts.² Monetary values of man

² The amount of ionising radiation energy that is absorbed per gram of tissue is called the absorbed dose and is measured in Grays. However, some radiation e.g. alpha radiation, is more damaging. It is

Sieverts can fairly readily be linked to VOSLs because the dose response relationship for radiation-induced cancer and other health detriments has been clearly defined.

NRPB has traditionally derived a value of the man Sievert (man Sv) by use of the human capital approach. A base-line value of £3000 per man Sv³ was established in the 1980s on the basis of the predicted health detriment (including pecuniary costs of lost output, health care costs and other matters associated with stochastic effects in irradiated populations) (NRPB, 1986). This base-line cost of unit collective dose was further multiplied by an additional factor related to the individual dose distributions encountered in specific circumstances, which is intended to reflect individual risk aversion towards increasing levels of individual dose. The Board recognises that this factor, taken from the ‘fuzzy’ graph shown as Figure 4.1, is based on judgement with the ‘fuzziness’ being intended to reflect the inherent uncertainties in these judgements. This notion, equivalent to a higher valuation of health at higher dose (risk) levels, is akin to the concept of gross disproportion referred to in the Health and Safety at Work Act.

As discussed above (section 4.2.8), moves towards the adoption of WTP as a basis for the valuation of radiation detriments were commenced when the NRPB commissioned a joint CV study with HSE in 1989. As noted, this study yielded disappointing and unreliable results. However, based on a review estimate of the VOSL of £1.6 million (Ives *et al.*, 1993) and consideration of values discussed by the Royal Society (1992), the NRPB derived a range of estimates for the value of a life-year (VOLY)⁴ of between £30,000 and £60,000 (future life years not discounted), the purpose of the range being to reflect inherent uncertainty in the valuations.

Using data on radiation-induced health detriment risks, in conjunction with weighting factors to take account of the severity of the various health detriments, an average weighted years of life lost (YOLL) per unit collective dose was calculated by the NRPB for the population of England and Wales. The value of YOLL was found to be about 1.0 year per Sv. Thus, at the implied value for a life year, and at the presumed risk level of the WTP studies reviewed, the value of the man Sv was estimated to be in the region £30,000 to £60,000.

In order to calculate a base-line value from the above, it was assumed that the WTP studies on which the VOLY had been based were carried out on a populations facing an average level of risk of, probably, around 1 to 3 x 10⁻⁴ per annum. In radiation terms this would be equivalent to a dose of a few mSv which, referring to Figure 4.1, implies a risk aversion multiplier of around 5 to 7. Thus, the base-line value corresponding to the low levels of individual dose at which the aversion multiplier would be unity is in the range of £5,000 to £12,000 per man Sv (with an additional scaling factor of 1.2 to 1.3 in recognition of changes in the retail price index between 1990 and the mid ‘90s). In light of the above considerations, the Board finally adopted a value of £10,000 for a man Sv as representative for the present decade.

These values are adapted by the NRPB for specific dose levels, or risks, to which different groups may be exposed, and the consequence in terms of life years lost. The results are shown in Table 4.3.

4.2.10 British Petroleum

BP has adopted a baseline value of US\$1 million per statistical fatality. The rationale underlying the selection of this value is that it is ‘broadly in accord with most WTP estimates, as reflected within the economics literature and, in particular, the ‘consensus’ UK DoT valuation updated to 1990 prices’ (Fleishman and Hogh, 1991; Hogh, 1993). However, it is recognised that there may be legitimate grounds for increasing the ‘baseline’ valuation of life in the case of statistical fatalities from major hazards. An increase of perhaps up to an order of magnitude higher is proposed, which is seen as providing limited allowance for risk aversion, and a sufficiently broad range of values to be applied to employees, contractors and the public alike on a world-wide basis.

customary therefore to weight the dose by its potential to do damage, and this weighted dose is measured in Sieverts (Sv). If a group of people is exposed, the total or ‘collective’ dose is reported in man-Sieverts (man Sv).

³ This value is based on UK prices 1985-1989. The use of a single value rounded for several years indicates that the valuation is not precise.

⁴ Value of Life Year (VOLY) = VOSL/ assumed remaining life expectancy

The values may be used to determine the cost-effectiveness of proposed safety measures by calculating the ratio of the cost of a risk reduction option to the statistical fatalities averted. Comparison of this ratio with the proposed VOSL thus gives a measure of whether the proposed measure is:

- clearly worthwhile (i.e. implied cost-effectiveness < \$1m per life saved);
- no strong indication of whether the measure is worthwhile or not (i.e. implied cost-effectiveness is between \$1m and \$10m per life saved);
- clearly not worthwhile (i.e. implied cost-effectiveness > \$10m per life saved).

Financial losses arising from major accidents (such as direct repair costs or business interruption costs) can also be included by calculating:

$$\frac{(\text{cost of risk reduction option}) - (\text{attendant reduction in expected economic losses})}{\text{statistical fatalities averted}}$$

BP recognises that other factors besides cost-effectiveness are important in the optimisation of safety decisions. For example, consideration of public, worker or government relations may result in a legitimate decision to spend in excess of \$10m to save a statistical life. Fleishman and Hogg, however, note that such decisions should not be presented as decisions on the basis of *safety* alone, and that where non-safety factors are considered in the decision process these should be explicitly identified.

4.3 Approaches Used by Other Consumer Safety Agencies

4.3.1 U.S. Consumer Product Safety Commission

In the US, Executive Order 12,291 under the Reagan Administration required that all federal agencies, including the Consumer Product Safety Commission (CPSC) should consider the benefits and the costs of their regulations and/or actions prior to implementing them (Camerer and Kunreuther, 1989). Within the CPSC, the Directorate for Economic Analysis conducts the economic, environmental and regulatory analyses used to assess the potential impacts of proposed CPSC regulations.

Published guidance for regulatory appraisal is very general, although the balancing of costs and benefits appears as a central theme. The CPSC is required by statute to consider the costs and benefits of most rule-making actions and as a matter of policy, considers the costs and benefits of many other undertakings (pers. comm. W. Prunella, CPSC, 1995).

For example, the *Procedure for Consumer Product Safety Rules*, set out under the US Consumer Product Safety Act, requires that regulatory analysis of a proposed consumer product safety rule should contain the following information:

- a description of the potential benefits and potential costs of the rule, including costs and benefits that cannot be quantified in monetary terms, and the identification of those likely to receive the benefits and bear the costs;
- a description of any alternatives to the proposed rule that were considered, together with a summary description of the potential benefits and costs and explanation of why the alternatives were not chosen;
- a summary of any significant issues raised by comments during the public comment period.

The CPSC '*Policy on Establishing Priorities for Commission Action*' identifies eight criteria which are applied in determining and revising priorities for action:

- frequency and severity of injuries
- causality of injuries
- chronic illness and future injuries
- cost and benefit of CPSC actions
- unforeseen nature of the risk
- vulnerability of the population
- probability of exposure to hazard

- additional criteria

The document states that the CPSC cannot commit itself to priorities solely on the basis of preliminary benefit-cost comparison that will be available at this stage of priority setting and recognises that in the comparison of costs and benefits there will frequently be analytical uncertainties and modifying factors (such as the unforeseen nature of the risk or vulnerable populations) which must be accounted for.

In regulatory analyses fatalities averted may, or may not, be quantified in monetary units, depending on the particular assessment. While CPSC commissioners do not endorse any measure of the value of life, CPSC staff do use a VOSL for analytical purposes. When valuation is needed an estimate which is broadly consistent with WTP research results is applied. In a 1993 analysis of cigarette lighters, a value of US\$2 million was applied. As of 1995, a statistical value of US\$5 million has been applied for each fatality. This figure is consistent with VOSL estimates in the published literature (see Viscusi, 1993), which generally fall into the US\$3 million to US\$7 million range (Pers. Comm. Prunella, CPSC, 1997).

The \$5 million figure applies for all fatalities, without distinguishing by factors such as age, type of hazard, or level of risk. However, there is an awareness that approaches based on 'life years lost' are likely to result in differential estimates for fatalities according to age, and it is envisaged that this approach may be employed as part of sensitivity analysis in future undertakings.

It therefore appears that factors such as the nature of the population at risk (children, the elderly etc.), the characteristics of the risk, and other such factors are not incorporated into the VOSL itself, but are introduced into the overall wider framework of policy evaluation. In this way a standard benchmark VOSL is applied in economic analysis and the other important factors considered in the wider process of policy formulation.

Non-fatal injury costs are calculated using the US Injury Cost Model (ICM) which incorporates eleven cost components including medical costs, foregone earnings, transportation costs, visitors' foregone earnings, visitor' transportation costs, health insurance administration costs, product liability insurance administration costs, litigation costs, disability costs, re-treatment costs, and pain and suffering costs.

4.3.2 Canadian Product Safety Bureau

The Canadian Product Safety Bureau within Health Canada is the body responsible for formulating national consumer product safety policy. Although there is no formal procedure established for the evaluation of risk control options, the following seven factors are considered in the formulation of consumer safety policy (pers. comm., Ireland, 1997):

- probability of exposure to hazards
- severity of hazards
- vulnerability of population
- public perception
- industry co-operation
- cost effectiveness
- government policies

Currently, all Health Canada regulations are required to undergo a cost-benefit analysis. The Government of Canada *'Benefit-Cost Analysis Guide for Regulatory Programs'* recognises that placing dollar values on lives is both difficult and controversial. The guide cautions that:

“Pretending that we know the cost of a life to the nearest dollar is obviously wrong, but so is arguing that it doesn't matter how much it costs to save a life” p. 79.

It is acknowledged that a number of federal departments use explicit figures for the VOSL, although it is openly recognised that no analytical approach can (or should) eliminate the need for judgement. The guide also addresses the issue of differential values of life with age:

“For example, should the focus be on lives saved or years of life saved? Is saving the life of someone aged 70 the same thing as saving the life of an infant? Probably not. Presumably, the focus should be on the estimated number of years of life saved”.

The issue of when those lives are saved is also addressed:

“Finally, consider whether it matters when lives are saved. If you were working in a factory, which safety program would you prefer: one that would save 20 lives this year, or one that would save one life per year for 20 years? The former is surely preferable, since 19 people will live longer. The implication is that your estimates of lives saved should be discounted. At the very least, you should present a table that summarises when lives will be saved” p. 81.

4.3.3 Danish National Consumer Agency

The National Consumer Agency of Denmark (Forbrugerstyrelsen) is responsible for the safety of toys and child products, and a number of other products come within the Agency’s sphere. Other authorities, such as the National Food Agency and the Danish Environmental Protection Agency, have special competence in matters of safety concerning products which come within their sphere of authority.

Overall, there is no formalised safety policy in Denmark which applies to all parts of the consumer arena, although basic principles of product safety subsist. Legal standards constitute the basis for risk evaluations (e.g. safety requirements of toys, as specified in 88/387/EEC). Risk evaluations conducted by the National Consumer Agency are based on a number of criteria:

- the potential damage associated with the product
- the likely frequency of accidents
- the utility value of the product
- the possibilities of improving the product
- the costs of changing the product
- the consequences for the market associated with intervention.

The agency does not make decisions on the basis of cost-benefit analysis or economic evaluation. However, economic evaluation does form a part of the overall process involved in determining what legal requirements are to be laid down. A pragmatic weighting of safety and economic considerations also forms part of the development of regulatory standards (pers. comm. J. Busse, Forbrugerstyrelsen, 1997).

4.3.4 The Netherlands Ministry of Health, Welfare and Sport

The view is that in principle, cost-benefit analysis should always be part of the phase of the decision process where preventative measures are selected (pers. comm., Thien, Ministerle van Volksgezondheid, Welzijn en Sport, 1997). It is also recognised that in practice this is not always so easy, as there is often a lack of knowledge about the costs of accidents on the one hand and about the effectiveness and efficacy of preventative measures on the other hand. In the Netherlands, efforts are being made to improve the methodology for estimating the costs of different types of accidents. Several methodologies have also been developed to estimate the loss of productivity as a consequence of illness and death. Research has generally focused on the ‘indirect’ costs associated with accidents, rather than on the human costs.

Table 4.1: Average Cost per Road Traffic Casualty by Severity (DoT, 1997):

	<i>Lost Output</i>	<i>Pain etc.</i>	<i>Medical etc.</i>	<i>£ (1996 prices)</i>
Fatal	294,772	552,252	553	847,577
Serious	12,431	76,654	7,535	96,621
Slight	1,314	5,612	558	7,485
Average	6,154	21,617	1,527	29,298

Table 4.2: Monetary values for human costs associated with work-related illness or injury (1990 prices) (Davies and Teasdale, 1994):

Detriment	£
Minor injury (involving up to 3 days' absence)	540
Non-serious reportable injury (involving over 3 days' absence)	1,000
Serious injury (involving absence of 3 months)	6,800
Permanent incapacity following injury	120,000
Fatal injury	550,000
Minor case of ill health (involving up to 7 days' absence)	50
Other cases of ill health (not permanently incapacitating)	1,000
Permanently incapacitating ill health	111,000

Table 4.3: Valuation of radiation dose equivalents (NRPB, 1993):

Exposed Group	£ per man Sievert
Geriatric Medical Patients in Diagnosis	10,000
General Public	20,000
General Medical Patients in Diagnosis	50,000
Occupationally Exposed	50,000
Paediatric Medical patients in Diagnosis	100,000

Figure 4.1 The NRPB multiplication factor or 'fuzzy curve'

Source: NRPB (1993)

Chapter 5: DISCUSSION

Summary of Key Points

- Four approaches which might be used for establishing a consumer-related VOSL are considered. These are transferral of a value from elsewhere; a new contingent valuation survey; a relative valuation survey; and the adoption of a review-based VOSL. It is concluded that a review-based approach offers the best prospect for the DTI CSU. Such an approach is quite commonly used by other institutions including, notably, the US CPSC and the UK NRPB;
- In view of the high level of uncertainty associated with the VOSL it is suggested that a range of plausible values be adopted rather than a point value;
- In view of the uncertainty associated with VOSLs and the complexity of consumer safety issues, it is also suggested that qualitative factors such as voluntary-involuntariness and the age of victims be accounted for in decisions by using expert judgement, rather than by attempting to incorporate weighting factors into the decision process.

5.1 Some Outstanding Questions

This report has reviewed approaches to safety investment decision making and the valuation of safety itself. From this there can be no doubt that many public and private sector UK agencies with responsibility for safety, and leading agencies abroad such as the US CPSC, make use of cost-benefit analysis and the associated concept of safety valuation. This, however, is done from a variety of perspectives.

The motivation for some in the field appears to be to establish safety policy on a theoretically-sound footing based in social welfare theory. Others appear less convinced by, or perhaps less interested in, the theoretical arguments and tend to view cost-benefit and contingent valuation from a perspective owing more to pragmatism than allegiance to any philosophical position. This appears to apply particularly to those with an evident need to get on with the job of resource allocative decision making, and with an eye to the socio-legal requirement of reducing risk 'so far as is reasonably practicable.' There are also differences in the perceived status of cost-benefit analysis. Everyone acknowledges that cost-benefit is a decision-aiding tool which is ultimately subject to modification in the light of social factors, but the degree to which this moderation is necessary is in dispute. Some suggest that social factors can be incorporated into the cost-benefit calculations, whereas others are less sanguine or prefer to keep them separate.

Despite the differences, it may at least be concluded that cost-benefit and safety valuation have gained a reasonably high level of acceptance in Britain and some other countries, both by experts and to some degree more widely through their public exposure via, for example, events such as the 1994 Railtrack conference on ATP, and publications ranging from those of the Royal Society to broadsheets.

With this in mind, there should be no undue sensitivity attached to the use of similar techniques in consumer safety. However, decisions still need to be made about the means of arriving at a valuation of safety, the use or otherwise of different values in different circumstances, and the role of VOSL in decision making. These matters are considered below.

5.2 Establishing a 'Benchmark' VOSL for Consumer Safety

Based on the evidence reviewed in the preceding chapters, several approaches exist by which the DTI CSU might derive a baseline or 'benchmark' VOSL for use in home and leisure safety decision making. These include the adoption of:

- a value derived for some other sector;
- an estimate derived from a direct consumer-related contingent valuation survey;
- an estimate derived from an indirect 'relative valuation' study;

- a review-based ‘consensus’ value for a VOSL.

5.2.1 To Transfer a Value from Elsewhere?

The evidence from the new review of CV studies, described briefly in Section 2.3, and elsewhere in this report, provides no clear indication of significant and consistent differences in public preferences for consumer safety valuation compared with other sectors considered in this study. Differences which have been recorded are relatively small compared with the inherent uncertainty of these measures. This suggests, *prima facie*, that it is reasonable to transfer values between sectors. However, as described in Chapter 4, agencies may subsequently modify safety valuations according to local factors. A clear case in point is the DoT VOSL.

As discussed in section 4.2.1, the VOSL that was finally selected by the DoT was a ‘consensus’ value originating from consideration of the results of the road transport WTP study and a review of other WTP-based VOSL estimates derived from the literature, together with political considerations of the day specific to road transport (Dalvi, 1988). Importantly, the figure chosen was at the lower end of what was determined, at that time, to be the ‘feasible range’ for the VOSL, and has only increased with inflation since. While these considerations were legitimate considerations in the context of road safety, they do not necessarily apply elsewhere.

It is also worth noting that the DoT VOSL is associated with an individual risk level of about 10^{-4} per annum of being killed. This is a rather high risk level compared with most faced on a regular basis by consumers, and creates some difficulties if one accepts the concept of gross disproportion, or the kind of logic portrayed by the NRPB’s fuzzy curve (Figure 4.1), which indicates that higher valuations should apply at higher risk levels (Ball, 1996). Thus, the fact that the consensus value is at the bottom end of the range sits uncomfortably alongside the actual risk level faced by road users and the notion of gross disproportion.

It could be that a major upward shift in the DoT’s valuation is necessary if the desired goal of cross-departmental consistency is to be achieved, since other agencies appear to be sensitive to the fact that the DoT’s value may be adrift of current thinking and are using higher VOSLs. On the other hand, there is nothing to say that a department should not adjust its own VOSL upwards or downwards in the final analysis to reflect wider issues uncaptured by the VOSL concept. Errors arise only if others are unaware of that and mistakenly take the valuation at face value and apply it to their own, different, circumstances.

For this reason we would caution against the uncritical adoption by the CSU of VOSLs from other sectors. CSU will have its own priorities which may well differ from those applying elsewhere. This is not to say that an awareness of VOSLs in use elsewhere is not useful.

5.2.2 A Consumer-oriented CV Survey?

The second option would be to finance a CV survey to derive a VOSL representative of home and leisure risks. As described in Chapter 2, however, the application of CV to human safety has encountered a number of significant and possibly insoluble problems. Perhaps most troublesome of these is the simple observation that people do not appear to have clear pre-formed preferences for the value of safety.

This option should not, however, be dismissed too lightly, on the grounds that social welfare theory is sometimes argued to provide the only sound basis for decisions of this kind and that this implies a definite need to elicit consumer preferences. There is indeed an element at least of justification in such a claim, for consumer preferences should clearly be taken into account in the making of consumer safety decisions. However, the notion of the theoretical soundness of the CV approach rests on a number of assumptions. These include whether the underlying theoretical basis itself is robust; whether the elicitation process is sound in that it actually elicits consumer preferences; and whether the conclusions drawn are valid. The second and third of these assumptions have already been considered in Chapter 2 and problems have been noted. There are in addition further questions regarding the first assumption which carries the presumption that societal goals can be constructed from individual preferences.

For instance Swaney (1997), and others besides, identify social preferences that in some cases should count more than individual preferences. These include preferences that an individual might hold as a result of membership of a community. As Swaney puts it, “The message seems to be, “The preferences of

individuals pursuing their own self-interest in the marketplace are not the only preferences that count.”” Further, “The broad array of legal constraints imposed on markets suggests that societies are generally unwilling to allow people and nature to be “valued” by unregulated (“self-regulating”) markets. Societies choose to insulate certain values (and valuables) from the “discipline of the market,” in effect “trumping” the market’s process for measuring and assigning value.” Thus, society may choose to impose child labour laws, a minimum wage, and restrictions on handguns, all of which conflict with the concept of individual choice.

The irony is that while WTP CV studies on the face of it hold out the appealing and laudable prospect of bringing about an appropriate allocation of resources which is based fairly and squarely on consumer preferences, they could actually lead to an inadvertent subversion of that process. This could happen in a number of ways, for instance, if preference questions were framed in such a way that they missed the real issues with which consumers were concerned, or if they mishandled those issues. It is well known that CV surveys frequently encounter apparently illogical responses, for instance zero or very high bids, or plain refusals to participate. Some of this behaviour reflects the fact that survey questions are coping poorly with the issue in hand. Considerations of this kind have led commentators to propose that surveys are not a good basis for defining preferences on complex issues.

From a practical perspective it is also inescapable that nationally-representative CV surveys can be both expensive and time consuming to undertake. Given also the large number of WTP surveys already conducted, CV-based and otherwise, and reported in the literature, one more study by the CSU is unlikely to add much to that store of information. It would generate just one more number among many.

5.2.3 A Relative Valuation Survey?

The third option, indirect or relative valuation of consumer safety, has some attractions as it is likely to be less demanding of resources and avoids a few of the tricky issues associated with direct valuation. A variety of relative scaling methods, such as paired comparisons or standard gambles, have been tried in other sectors with this goal in mind. This has met with varying degrees of success, however, since many of the problems encountered with direct valuation also emerge here. Further, with this approach, an existing VOSL is still required to be used as a reference state in order to establish monetary values. The DoT’s VOSL has in some cases been used as an anchor value for this purpose, as described in Chapter 3, but for the reasons given above (section 5.2.1) we are uneasy about this option.

5.2.4 A Review-based Consensus Value?

The fourth alternative, the adoption of a review-based estimate of the VOSL, provides a relatively straightforward, comparatively simple, and certainly inexpensive way for the DTI CSU to arrive at a ‘benchmark’ VOSL for use in decision making. Deplorable as this suggestion may be from the purist academic perspective, making no pretence as it does at any claim, however valid, of ‘theoretical rigour,’ it has certain positive attributes including, we would argue, the greatest plausibility.

It is also, on reflection, the choice of many agencies responsible for safety. These would certainly include both the US CPSC and the NRPB who are prominent in the field of consumer safety and safety valuation. It might even be argued that the DoT also comes into this regime, having opted in the final analysis for a consensus, rather than the CV-derived value which it sponsored. BR, Railtrack, the CAA and BP likewise, all pay heed to the wider range of valuations emerging from various sources, rather than linking in to any single, business-related value.

So what other attraction could this approach offer? As we see it, one of the major difficulties associated with the human costs of injuries is that they are highly uncertain, not just because of the difficulties of eliciting values, hard though this is, but also because the values themselves are only vaguely-held by consumers. We would not wish, particularly, to dispute with Camerer and Kunreuther (1989) that CV, despite its deficiencies, is the only game in town. But we would say, from the perspective of the societal decision maker charged with investing significant public or private resources, that when faced with such a level of uncertainty the wisest approach is to adopt as broad a foundation as possible for decisions, drawing on as big a knowledge base as possible. We suggest that in this case, this would imply the need for awareness of the broad range of results emerging from valuation research as a whole, such as provided here in section 2.3 and in other reviews (e.g. Tengs *et al.*, 1995) and including both revealed and expressed

preference results, together with an awareness of values currently being used by other institutions and which, through their public exposure, will have incorporated at least a measure of societal scrutiny, and which also permits, if desired, some move towards inter-agency consistency in safety investment decision making.¹

5.3 VOSLs and Uncertainty

All measurements are subject to uncertainties. These result in part from the nature of the process of measurement. Other measurements contain additional uncertainty because the object of measurement is itself imprecise. Even in the world of physics, physicists soon learn that entities such as electrons have wave-like properties and that their position can never be measured with accuracy, however good the instrument. We maintain that similar considerations apply to the valuation of safety. Both the measurement tools and processes introduce very considerable uncertainty, only to be compounded by the natural imprecision of the entity itself. To seek precision with quantities of this kind is consequently mistaken. Members of the Royal Society Study Group (1992) have warned transgressors in general as follows:

“.....The lack of mathematical culture is revealed nowhere so conspicuously as in meaningless precision in numerical computations.”

The implication for VOSL, with its particularly gross uncertainties, is that the best which can *realistically* be achieved is to define a range within which it might lie. This may be seen as inconvenient in some situations, but it can, and has been, accommodated already by many of the agencies involved, in one way or another. BP, for example, explicitly acknowledges the spread of VOSLs, as does the NRPB. This is also in part attributable to their awareness of the limits to which precision is reasonably required in risk decisions which, in any case, must also incorporate further, often considerable, uncertainties associated with the process of quantitative risk assessment (QRA).

Many consumer product safety interventions are also subject to significant uncertainties in risk assessment, which may be attributable, for instance, to risk compensatory behaviour by consumers. Evaluation of the effectiveness of consumer safety interventions, which could refine knowledge in this area, continues to be relatively rare (Soby et al., 1993). Therefore, the same situation by-and-large applies in consumer safety as elsewhere in terms of precision and uncertainty.

Although there are strong grounds for defining the VOSL as a range rather than a point estimate, there may still be some circumstances where a point estimate would be acceptable. This might be appropriate where accounts of the costs of injuries are being prepared for comparative purposes. However, the point estimate chosen for the purpose of the calculation would need to be clearly identified, and it is to be hoped that this would be recognised as a choice based more on convenience, political or actuarial, rather than scientific fact.

5.4 A Different VOSL for Different Contexts?

As discussed in Chapter 3, the adoption of a ‘universal’ review figure, either as a point estimate or a range, for VOSL seemingly ignores the possibility that the VOSL may vary according to context or other factors. One should therefore consider whether a single VOSL approach is sufficient for policy formulation, or whether multiple VOSLs are in fact required to reflect differences in the nature and characteristics of the risks of interest in different risk control programmes. Thus, in the case of the CSU, should different VOSLs apply to the appraisal of say, products associated with ‘voluntary’ leisure activities such as skiing or horse riding, compared to ‘involuntary’ risks such as accidents in the home? Likewise, children and the elderly are particularly at risk from home and leisure accidents. Should the age of the population at risk be reflected in the VOSL?

As discussed in Chapter 3, there is evidence that consumers’ WTP *is* affected by circumstances, in particular, by characteristics of the risk, referred to as ‘contextual’ effects. However, the evidence regarding how preferences differ and the magnitude of the potential differences is inconclusive, although the

¹ Consistency does not mean that everyone applies the same VOSL, since specific departmental priorities not reflected in the mode of derivation may have an overarching impact on the choice. However, one might expect some greater degree of conformity than has historically existed in the absence of this logic.

variability between contexts, when averaged over consumers, appears from our perspective to be fairly modest. Jones-Lee and Loomes (1994), for instance, report a premium for underground rail travel safety of 50% compared with roads, described there as ‘clear and sizeable,’ but which is actually quite small compared with our impression of the inherent uncertainties of VOSLs and the QRA process itself, whether it is applied to the safety of engineered structures or to consumer issues.

The review of approaches in Chapter 4 shows that some policy makers have openly and explicitly adopted differential VOSLs to reflect contextual differences in the characteristics of the risk. For example, Railtrack has set different values for different categories of risk based on consideration of the risk characteristics and the nature of the population at risk (voluntariness, catastrophic potential, control, and so on). In contrast, other agencies, such as the US CPSC, while openly recognising that these factors should be considered in policy decisions, prefer to account for them elsewhere in the decision process. The two approaches can be summarised as either:

- set differential values. This requires that many qualitative factors are accounted for and reflected within the VOSL estimate itself; or
- set a general VOSL and account for the other qualitative factors in the broader decision process.

The establishment of differential VOSLs effectively means incorporating qualitative issues such as equity, voluntariness, impacts on future generations, catastrophic potential and so on into numerical estimates of the VOSL. It is therefore necessary to consider whether the VOSL methodology is capable of accommodating these kinds of qualitative concerns in numerical form.

Alternatively, the policy maker may decide against the use of differential values as a means of reflecting contextual differences in risk. Rather than finding some way to establish and justify differential VOSLs, it may be considered preferable to concentrate on the development of a strong overall policy framework, where cost-benefit analysis and the VOSL are recognised as just one element in that framework, and where qualitative issues are not subsumed into the VOSL or cost-benefit calculation. The report of the HM Treasury (1996) working group appears to support this position when it concludes:

“In this and other fields it is unsatisfactory for public (or other) prejudices to be smuggled into policy through apparently technical decision formulae, by means of, for example, numerical factors imposed subjectively by technical experts to reflect supposed ethical or societal concerns.”

- a position which reflects our own. It is also our opinion that the range and complexity of the many qualitative concerns relevant to consumer policy may in any case be more adeptly and comprehensively accounted for in the wider process of decision making. As remarked earlier, the supposedly simple task of classifying risks as either voluntary or involuntary may be less than straightforward. Even in the apparently simple case of activities like sports, these are now promoted by Health Education Authorities because of health benefits which accrue mainly in later years, despite the fact that risks of short-term injury can be very high (Ball, 1997). It could therefore be argued that a moral responsibility exists to protect sports participants which should be undiminished by notions of voluntariness. Similarly, the concept of that period of life post-work and post-child raising is changing (Houghton, 1997) in a way which might signify that a higher value should be placed on this age than more straightforward accounting techniques might at first suggest.

Overshadowing all the discussion on differential VOSLs, however, is the matter of uncertainty. If VOSLs are associated with significant imprecision, then attempts to elicit differential values which are theoretically-sound may be unrealistic. Of late it has been acknowledged that this indeed may be the case. The HM Treasury (1996) report says that work on WTP for risk reductions “will always be imprecise - looking for values within say plus or minus 50 per cent.” We, ourselves, might suggest a higher figure for the uncertainty, but the principle remains the same. Elsewhere Jones-Lee (1993 p. 917) has suggested that the best one can hope for in this area is a broad indication of the order of magnitude of the value concerned, rather than a precise point estimate, a sentiment with which we would entirely agree.

5.5 The VOSL and Policy Formulation

Despite the lack of precision in VOSLs and cost-benefit calculations we continue to see these as important inputs into social policy formulation. Imprecision, after all, also features in many other inputs to policy making such as risk assessment, but this is not seriously questioned as a constructive tool, *providing the uncertainty is recognised*.

However, the extent of the uncertainty surrounding VOSL and QRA estimates should indeed preclude their use as absolute decision rules, instead recommending them as guidance. In many situations this would not present a drawback. For example, many proposed risk control measures will fall very clearly on to one side of the benefit-costs analysis or the other and will be little affected by the uncertainty of the VOSL within the feasible range (Evans, 1994). And in cases where the proposed VOSL appears to have a big impact on the benefit-cost outcome, sensitivity analysis to examine the impact of changes in the VOSL can be used (May, 1982).

In an earlier work Fischhoff *et al.* (1981) identify three distinct approaches to decision making, namely, formal analysis, professional judgement and bootstrapping. In formal analysis, techniques such as cost-benefit analysis, decision analysis and so on, essentially form the basis of decisions. The proposal here is simply that all three methods should be retained in the making of consumer safety decisions, rather than relying upon one. In other words, *professional judgement and accumulated experience should continue to play a key role in safety decisions*. This might mean, for example, that a decision maker would over-ride a VOSL-based decision if he/she felt certain other social factors had priority.

Finally, the evidence examined suggests to us that it is probably undesirable to adopt a single standard approach across the board to safety decisions. Different institutions face different risks, with widely differing characteristics, and approaches to issues such as valuing life and health must be tailored to reflect these differences. Decision makers are faced with a suite of approaches among which they must choose the appropriate approach. In some cases there appears to be no universally 'right' or 'wrong' approach to these issues and much remains up to the judgement of the decision maker. However, a more consistent approach to the valuation of life and injury, based on a common general rationale, but which is flexible and responsive to individual circumstances across institutions would help to improve consistency in the policy process and result in more systematic and defensible safety regulation. The development of guides such as the Department of Health's 'Policy Appraisal and Health' provides practical advice for health practitioners, and also provides a clear statement of how these issues are handled in the health sector. Setting out the decision making framework explicitly in this way enables clear comparisons of approaches in different sectors.

Chapter 6: CONCLUDING REMARKS

6.1 Choosing a VOSL

In the preceding Chapter it was proposed that in view of the inherent uncertainty in VOSL and the difficulties of measuring this parameter, that the most realistic and plausible approach for the CSU would be to define VOSL as a range rather than a point value. In selecting what this range might be we first draw attention to the data gathered in this report (section 2.3), which shows most valuations of the human cost component of fatal injuries to lie in a range from £0.5 million to £10 million (1997 £). We also note that the US Consumer Product Safety Commission currently uses a value of \$5 million based on a review by Viscusi (1993) which found a range of 'reasonable' estimates of VOSL from \$3 million to \$7 million, and that a review by Marin (Royal Society, 1992) led him to conclude that VOSLs of from £2 million to £3 million represented sensible minimum values. We also note the kinds of numbers being used for VOSL by other institutions, some of which are also review-based (e.g. NRPB) or apply a range of VOSLs (e.g. BP) and the commentary in Chapter 3.

From this we propose that so far as human costs are concerned a broad range, from £0.5 million to £10 million, which encompasses all the other 'reasonable' estimates should serve as a starting point for consumer safety decision making. To this it would be necessary for some applications to add direct and indirect costs which, in view of the uncertainty in the human cost element, would serve only to affect the bottom end of the proposed range yielding an adjusted range of £1 million to £10 million for the VOSL.

6.2 Contextual and Other Factors

We see three major advantages in defining the VOSL as a range, of which the first is realism and plausibility.

Second is the fact that the upper bound of £10 million is arguably stringent enough to dispose of most would-be rogue safety investment decisions.

Third is the fact that it still provides the decision maker with a fair degree of flexibility in dealing with contextual factors which will inevitably arise in many risk decisions. Thus, although for most decision purposes the DTI CSU may choose to work on the basis of a VOSL close to the centre of this range (say, £2 million to £4 million), higher or lower values could be applied in particular circumstances.

Factors which might contribute to the application of higher or lower VOSLs include the nature of the hazard, the vulnerability of the persons affected, and the usefulness of the product or activity involved. A further factor which could be relevant in some situations is the associated risk level. Higher risk activities might warrant a higher VOSL than lower risk activities. This would be in accord with the principle of gross disproportion. The NRPB has proposed one means of tackling this based upon its 'fuzzy' curve (Figure 4.1). Beyond these factors is the wider socio-political picture which may also warrant consideration in some risk decisions, but which is particularly hard to pin down in contingent valuation studies. Here again, the advantage of defining VOSL as a range is seen, since it affords the decision maker reasonable scope to incorporate these types of influence on the basis of expert judgement.

6.3 Who Bears the Costs?

Finally, it should be kept in mind that different risk decisions will impact on different sectors of society in different ways. Decisions on consumer safety will at various times affect either consumers, or manufacturers, or society at large e.g. through costs borne by the health service for treating injuries. The three cost elements discussed in this report, direct and indirect and human costs will not have the same relevance for all these bodies. For instance manufacturers may be more concerned with compliance costs, while society is likely to be more concerned with direct costs and human costs. One implication is that although direct and indirect costs have not figured greatly in this report, they are still important from some perspectives. It is pointed out that the European Consumer Safety Association (ECOSA) has a working group which is currently considering these costs on a pan-European basis.

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- Abstract: CBA techniques and the VSOL approach are attracting increasing interest, particularly in some more developed industrial nations, as aids to decision-makers. For those who use these techniques the currently preferred method for measuring the human (pain and suffering) element of VSOL is contingent valuation (expressed preference willingness to pay). It is recognised that this should be augmented by other costs such as lost earnings and medical/police/ambulance costs in arriving at a VOSL. Contingent valuation results are susceptible to many methodological problems, and margins of uncertainty are correspondingly large. Nonetheless, for those countries which engage in this type of activity, VOSLs are found normally to lie in the range US\$2M (+ or - 50%), indicating a degree of international consensus amongst current practitioners. The fact that there is uncertainty in VOSL is perhaps not overly important given that there are likely to be even greater uncertainties associated with the assessment of the risk reduction benefits of risk control options. The IMO, should it decide to make use of VOSL data as a means of evaluating CURRs for individual RCOs, would appear to have several options for arriving at a VOSL for its purposes. These include a contingent valuation survey relating to the marine environment, or a bootstrapping arrangement whereby IMO adopts a value in line with or somehow related to those in use in comparable sectors elsewhere. Given the uncertainties associated with all techniques it may be deemed prudent to rely upon none, but rather to make use of a suite of methodologies each of which will have its own strength and weaknesses, and then to arrive at an informed consensus value. In any event the final decision on which VSOL, or a range of VOSLs, to adopt as comparators, will likely be based in part at least on political needs, as was the case with the UK DoT. Indeed, political factors are likely to play an even larger role in the IMOs decision process since such a diversity of Member States are involved, many of whom will be unfamiliar with the approach and will have legitimate questions to ask.
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Abstract: Risk assessment and risk management techniques are being developed in many fields as an aid to safety investment decision making. Already these techniques are having impacts upon aspects of consumer safety which overlap with other sectors where safety is important and where these methods are being applied. Recent examples where this has happened range from public transportation to the safety of children's playgrounds. This paper reports on progress in risk management in some of these sectors. Key elements include the notion of 'acceptable' and 'tolerable' risk, the optimisation of safety according to principles known as ALARP (as low as reasonably practicable) or ALARA (as low as reasonably achievable), and the use of quantitative methods such as cost-benefit analysis as an aid to decision making. Attention is drawn to a number of factors which consumer safety practitioners may wish to consider should it be decided to follow the trend towards a risk-based approach to the management of consumer safety.

Ball, D.J. & Golob, L. (1997) *Risk ranking*. Proceedings of the European Society for Risk Analysis, 10th anniversary conference, Stockholm, pp606 - 614.

Abstract: The term 'risk ranking' is frequently encountered in the risk world but close examination reveals it to mean different things to different users. Ultimately, risk ranking, however defined, is about identifying goals and setting priorities. Subtle differences in goals and purposes can make big differences in the type of ranking methodology which is appropriate and great care is therefore warranted in the early stages of any ranking process. Practitioners should also be conversant with the limitations of selected methodologies and these limitations should be clearly conveyed to stakeholders. For instance, the definition of study boundaries, the choice of decision criteria, and even the application of selected statistical significance tests, may all influence the outcome of a risk ranking exercise.

Ball, D.J., Kemp, R., Turner, R.K., & Roberts, L.E.J. (1991) *Approaches to the valuation of non-fatal road traffic accident casualties*. Centre for Environmental and Risk Management report no. 8, University of East Anglia.

Ball, D.J. & Soby, B. (1995) *Valuing consumer safety*. International Journal for Consumer Safety, 2 (3), 117 - 131.

Abstract: The assignment of monetary values to human safety has long been regarded as a sensitive issue. Although difficulties remain, considerable progress has in fact been made towards achieving a more robust and socially-defensible methodology than ever before. The consequence is that these approaches are being more widely used by decision makers, in fields ranging from occupational to transport safety, as an aid in assessing the appropriateness of resource allocations which impinge directly or indirectly on human safety. Valuation of safety benefits can guide resource allocation both within sectors, and between sectors. With reference to consumer safety, it is suggested that injury valuation, if pursued, would in due course assist decision makers in achieving the goal of adequate and efficient allocation of resources within a socially acceptable framework. Further, valuation could best be achieved, in the authors' view, by application of the relative utility loss methodology linked to a willingness-to-pay derived value of life appropriate to the consumer sector. For maximum benefit, such valuations would need to be linkable with data gathered by the European Home and Leisure Accident Surveillance System (EHLASS). This would require the incorporation of an injury severity descriptor. One possibility may be to develop a modified version of the Abbreviated Injury Scale which discriminates effectively between the types of injuries encountered in home and leisure accidents.

Beattie, J., Chilton, S., Covey, J., Hopkins, L., Jones-Lee, M., Loomes, G., Pidgeon, N., Robinson, A., & Spencer, A. (1996) *Valuing health and safety controls: a literature review*. Health and Safety Executive.

Berger, M.C. (1987) *Valuing changes in health risks: a comparison of alternative measures*. Southern Economic Journal, 53 (4), 967 - 984.

Blomquist, G. (1979) *Value of life saving: implications of consumption activity*. Journal of Political Economy, 96, 675 - 700.

Blomquist, G. & Miller, T.R. (1990) *Values of life and time implied by the use of protection equipment*. The Urban Institute Working Paper 2525-06.

Blumenschein, K. & Johannesson, M. (1996) *Economic evaluation in health-care - a brief history and future directions*. Pharmacoeconomics, 10 (2), 114 - 122.

Abstract: Over the last decade there has been tremendous interest in economic evaluations of healthcare programmes, especially in the pharmaceutical field. Economic evaluations started about 30 years ago as rather crude analyses, in which the value of improved health was measured in terms of increased labour production. Now, more refined methods are available to measure health changes in terms of quality-adjusted life-years gained or willingness to pay. It is important to continue this development, and major fields for future work include the incorporation of quality-of-life measurements into economic evaluations and the linking of cost effectiveness and cost-benefit analyses into a unified framework of economic evaluation. How to incorporate distributional issues is another important area. Finally, it seems crucial to further explore the link between economic evaluation and decision making, since the purpose of economic evaluations is to affect decision making.

Boulding, W. & Purohit, D. (1996) *The price of safety*. Journal of Consumer Research, 23 (1), 12 - 25.

Abstract: This article presents a simple economic model to assess consumers' valuation of safety features. In particular, we model the benefit from safety as the reduction in the probability of death, and the associated economic value of this reduction. We then apply this theoretical model to investigate market valuation of antilock brakes and airbags via the specification and estimation of a hedonic price equation. Results indicate that consumers behave in a manner consistent with the economic model we develop.

Brent, R.J. (1991) *A new approach to valuing life*. Journal of Public Economics, 44, 165 - 171.

Abstract: Because the issue of how to put a monetary value on a life will always be controversial, this paper presents an alternative approach that can in certain circumstances avoid the use of monetary values. The alternative approach uses time as the numeraire. This numeraire can handle both the ex ante and ex post approaches to valuing a life. After showing how a simple two-period consumer choice problem can be translated into terms of time, the paper considers an application that involves reformulating the data used to evaluate the 55 mph speed limit decision in the US.

British Railways Board (1994) *Automatic Train Protection*. British Railways Board, London.

Broome, J. (1996) *The value of life and the value of population*. Journal of Population Economics, 9 (1), 3 - 18.

Abstract: This paper first distinguishes structured and unstructured approaches to valuing life. The unstructured approach bases its valuations on people's raw preferences, whereas the structured approach imposes a theoretical framework about the structure of value. The paper recommends the structured approach. This opens the way to considering the value of adding people to the population. The paper examines a common intuition that adding people is not in itself valuable, and explains the difficulties this intuition encounters.

Brown, C. (1980) *Equalizing differences in the labor market*. Quarterly Journal of Economics, 94, 113 - 134.

Brown, R.A. & Green, C.H. (1981) *Threats to health or safety: perceived risk and willingness to pay*. Social Science and Medicine, 15 (C), 67 - 75.

Abstract: This paper outlines the problems involved in determining how people perceive risks to human life, safety, or health. Central to the paper is the argument that one cannot arbitrarily assume that some convenient, probability measure actually has any relevance to the bases upon which people decide that one activity is riskier than another. The empirical results presented indicate that respondents made a series of distinctions between hazards, assessing the risks of each type upon different bases, suggesting that people do not appeal to evaluate risks to health and safety in the abstract. Indeed the principal problem of eliciting individuals' preferences in the context of risk is that people are unlikely to know what their preferences are before they confront a choice. In consequence it is proposed that any elicitation method must be so designed that respondents are first enabled to discover their preferences before stating them.

Busse, J. (1997) *Notes concerning consumer safety policy in Denmark*. pers. comm., 15 April, National Consumer Agency of Denmark.

Butler, R.J. (1983) Wage and injury rate responses to shifting levels of workers' compensation. In J.D. Worrall (ed.): *Safety and the work force*. Ithaca, N.Y.: ILR Press.

Buzby, J.C., Skees, J.R., & Ready, R. (1993) *Using contingent valuation to measure consumer's willingness to pay for food safety: results from a survey on pesticide risks*. Presented at NE-165 Valuing Food Safety and Nutrition Workshop, Alexandria.

Camerer, C.F. & Kunreuther, H. (1989) *Decision processes for low probability events: policy implications*. Journal of Policy Analysis and Management, 8(4), 565 - 592.

Civil Aviation Authority (1997) *Helicopter health monitoring: a cost benefit analysis* CAA paper 97002, January, Civil Aviation Authority, London..

Cohen, B.L. (1980) *Society's valuation of life saving in radiation protection and other contexts*. Health Physics, 38 (Jan), 33 - 51.

Abstract: Various situations are described in which societal action may be interpreted as a dollar value placed on averting a human fatality, and numerical values are derived in each case. Situations included are a variety of medical screening and medical care programs, and of automobile and highway safety measures, food for overseas relief, air pollution control, fire prevention, industrial safety, and several radiation-related activities including standards for radium in drinking water, radwaste systems in nuclear plants, and defense and civilian high-level waste management. Values varying from a few thousand dollars to hundreds of millions of dollars per fatality averted are obtained. An attempt to derive data of this type from polling is described. The problem of discounting when money is spent now to save lives far in the future (as with nuclear waste) is discussed. It is concluded that nearly all of the vast variation in the results is unjustified and represents a need for educating the public, especially in the area of radiation protection.

Cousineau, J., Lacroix, R., & Girard, A. (1988) *Occupational hazard and wage compensating differentials*. University of Montreal Working Paper, University of Montreal, Canada.

Covello, V.T. (1983) *The perception of technological risks: a literature review*. Technological Forecasting and Social Change, 23, 285 - 297.

Covey, J., Jones-Lee, M.W., Loomes, G., & Robinson, A. (1995) *Chapter 5: Exploratory study of WTP for food safety*, Report submitted to MAFF under contract no. 1A021, Centre for Environmental and Risk Management, University of East Anglia.

Cropper, M.L., Aydede, S.K., & Portney, P.R. (1992) *Rates of time preference for saving lives*. American Economic Review, 82, 469 - 472.

Abstract: An important characteristic of many environmental programs is that their benefits extend far into the future. The primary purpose of cleanups at hazardous waste disposal sites, for example, is often to prevent the contamination of groundwater that could pose risks to future residents at these sites. Such cleanups typically involve considerable capital and other costs, which are incurred at the front end of the project, and yield a stream of health benefits, often in the form of cancer cases avoided, that may not be recognised for many years. This would not pose unusual problems for program evaluation if everyone were comfortable with the assignment of dollar values to these reductions in future (see Cropper and Portney, 1990). However, regulatory agencies are sometimes reluctant to make such monetary valuations, preferring instead to evaluate programs on a cost-per-life-saved (CPLS) basis (Office of management and Budget, 1991). This raises an interesting question; should lives saved in the future be discounted for the purpose of calculating CPLS, or should they be counted the same as those saved tomorrow? To shed light on this, over the last year we have asked members of the public hypothetical questions that enable us to infer the rate at which they implicitly discount future lives saved (Horowitz & Carson, 1990, asked similar questions of students). In the remainder of this paper we summarise the results of this research, details of which can be found elsewhere (Cropper et al, 1991, 1992).

Cropper, M.L., Aydede, S.K., & Portney, P.R. (1994) *Preferences for life saving programs - how the public discounts time and age*. Journal of Risk and Uncertainty, 8 (3), 243 - 265.

Abstract: In surveys of 3,000 households, we have found that people attach less importance to saving lives in the future than to saving lives today, and less importance to saving older persons than to saving younger persons. For the median respondent, saving six people in 25 years is equivalent to saving one person today, while for a horizon of 100 years, 45 persons must be saved for every person saved today. The age of those saved also matters; however, respondents do not weight lives saved by number of life-years remaining: For the median respondent, saving one 20-year-old is equivalent to saving seven 60-year olds.

Cullis, J.G. & Jones, P.R. (1996) *What a difference a day makes - concern about a new approach to valuing a life*. Journal of Public Economics, 61 (3), 455 - 457.

Abstract: If individuals are interested in life per se (or perceive longevity as a goal worth attaining), there is reason to doubt that Brent (Journal of Public Economics, 1991, 22, 165-171) has provided a robust solution to the valuation of life in cost-benefit analysis.

- Dalvi, M.Q. (1988) *The value of life and safety: a search for a consensus estimate*. HMSO, London.
- Danish Ministry of Business & Industry (1994) Danish Product Safety Act: Act no. 364, 90-334-24, 18 May, Danish Ministry of Business & Industry.
- Dardis, R. (1980) *The value of life: new evidence from the market place*. American Economic Review, 70 (5), 1077 - 1082.
- Davies, N.V. (1989) *Cost-benefit analysis in safety policy making* Chemistry & Industry, 17 April, 251 - 256.
- Davies, N.V. (1993) *Health & Safety Executive (HSE) experiences in assessing the cost effectiveness of safety regulations*. Presentation given at the Ministry of Agriculture, Fisheries, and Food, London.
- Davies, N.V. & Teasdale, P. (1994) *The costs to the British economy of work accidents and work-related ill health*. Health & Safety Executive/HMSO, London..
- Department of Health (1995) *Policy appraisal and health: the health of the nation*. Department of Health, London.
- Department of Transport (1995) *Mawhinney endorses HSC view on future of Automatic Train Protection*. 30 March, Department of Transport Press Release.
- Department of Transport (1996) *1995 valuation of road accidents and casualties* Highways Economics Note no. 1, August.
- Desaigues, B. & Rabl, A. (1995) Reference values for human life: an econometric analysis of a contingent valuation study in France. In N.G. Schwab-Christie & N.C. Soguel (eds.): *Contingent valuation, transport safety and the value of life*. Kluwer, Boston.
- Diamond, P.A. & Hausman, J.A. (1994) *Contingent Valuation: is some number better than no number?* Journal of Economic Perspectives, 8(4), 45 - 64.
- Abstract: . . . we think that the evidence supports the conclusion that to date, contingent valuation surveys do not measure the preferences they attempt to measure. Moreover, we present reasons for thinking that changes in survey methods are not likely to change this conclusion. Viewed alternatively as opinion polls on possible government actions, we think that these surveys do not have much information to contribute to informed policy-making. Thus, we conclude that reliance on contingent valuation surveys in either damage assessment or in government decision making is basically misguided.
- Dickens, W.T. (1984) *Differences between risk premiums in union and nonunion wages and the case for occupational safety regulation*. American Economic Review, 74(2).
- Dillingham, A.E. (1979) *The injury risk structure of occupations and wages*. Unpublished PhD thesis, Cornell University, N.Y.
- Dillingham, A.E. (1985) *The influence of risk variable definition of value on life estimates*. Economic Inquiry, 24, 277 - 94.
- Dolan, P., Gudex, C., Kind, P., & Williams, A. (1996) *Valuing health states - a comparison of methods*. Journal of Health Economics, 15(2), 209 - 231.
- Abstract: In eliciting health state valuations, two widely used methods are the standard gamble (SG) and the time trade-off (TTO). Both methods make assumptions about individual preferences that are too restrictive to allow them to act as perfect proxies for utility. Therefore, a choice between them might instead be made on empirical grounds. This paper reports on a study which compared a "props" (using specially-designed boards) and a "no props" (using self-completion booklets) variant of each method. The results suggested that both no props variants might be susceptible to framing effects and that TTO props outperformed SG props.
- Dorman, P. (1996) *Markets and mortality: economics, dangerous work, and the value of human life*. Cambridge University Press.

Dorsey, S. (1983) Employment hazards and fringe benefits: further tests for compensating differentials. In J.D. Worrall (ed.): *Safety in the workforce*. Ithaca, N.Y.: ILR Press.

Dorsey, S. & Walzer, N. (1983) *Workers' compensation, job hazards, and wages*. Industrial and Labor Relations Review, 36(4), 643 - 654.

Dreyfus, M.K. & Viscusi, W.K. (1995) *Rates of time preference and consumer valuations of automobile safety and fuel efficiency*. Journal of Law and Economics, 38(1), 79 - 105.

Abstract: This article estimates hedonic price models for automobiles using a data set on almost 3,000 households from the U.S. Department of Energy Residential Transportation Energy Consumption Survey. The standard hedonic models are generalized to recognize the role of discounting of fuel efficiency and safety, yielding an estimated rate of time preference ranging from 11 to 17 percent. This range includes the prevailing rate of interest for car loans in 1988 and is consequently consistent with market rates. Purchasers exhibit an implicit value of life ranging from \$2.6 to \$3.7 million, which is within the range found in the labor market as well as other market contexts. The model also estimates a significant price effect for auto injury risks and fuel efficiency.

Dubourg, W.R. (1995) Are preferences for safety too imprecise for contingent valuation? In: N.G. Schwab-Christie & N.C. Soguel (eds.): *Contingent valuation, transport safety, and the value of life*. Kluwer, Boston.

Elvik, R. (1995) *The validity of using health status indexes in measuring the consequences of traffic injury for public health*. Social Science and Medicine, 40(10), 1385 - 1398.

Eom, Y.S. (1994) *Pesticide residue risk and food safety valuation - a random utility approach*. American Journal of Agricultural Economics, 76(4), 760 - 771.

Abstract: A new approach is developed for integrating consumers' risk perceptions with stated purchase behavior when consumption decisions must be made with incomplete information. The application involves health risks from exposure to pesticide residues on fresh produce. Unlike traditional food demand analysis, the present approach treats produce choices as discrete outcomes, resulting in a random utility model. Empirical results from a pilot survey suggest a clear linkage between perceptions and behavior in response to new risk information. Consumers' stated preferences for safer produce were primarily influenced by price differences and perceived risks, not by the technical risk information provided alone. However, the linkage between behavior and valuation was less clear cut. The risk/price tradeoffs entailed by contingent discrete choices indicate high price premia for small risk reductions and little variation in price premium across alternative risk reductions.

Evans, A.W. (1994) *Evaluating public transport and road safety measures*. Accident Analysis and Prevention, 26(4), 411 - 428.

Evans, A.W. & Verlander, N.Q. (1996) *Estimating the consequences of accidents: the case of Automatic Train Protection*. Accident Analysis and Prevention, 28.

Abstract: This paper considers estimates of the number of fatalities per year on rail lines operated by British Railways that could be expected to be saved by the installation of automatic train protection, based on historical data. The authors' preferred estimate is 3.66 fatalities per year, with an estimated 95% confidence interval of 1.44 - 5.89. It is possible to find orthodox probability distributions that fit the distribution of numbers of fatalities well. FN-graphs are not a suitable means of fitting such distributions

Evans, W.N. & Viscusi, W.K. (1991) *Estimation of state-dependent utility functions using survey data*. Review of Economic Statistics, 73(1), 94 - 104.

Fernandes-Russell, D., Bentham, G., Haynes, R., Kemp, R., & Roberts, L. (1988) *The economic valuation of statistical life (Research Report no. 5)*. Environmental Risk Assessment Unit, University of East Anglia, Norwich.

Fischhoff, B. (1981) *Can any statements about human behavior be empirically validated?* Behavioral and Brain Sciences, 4(3), 336 - 337.

Fischhoff, B. (1996) What do psychologists want? In N. Schwartz, W. Pommerehne, & R. Kopp (eds.): *Determining the value of nonmarketed goods (eds.)* Kluwer, Boston.

Fisher, A., McClelland, G.H., & Schulze, W.D. (1989) *Measures of willingness-to-pay versus willingness-to-accept: evidence, explanations, and potential reconciliation*. In: G.L.Peterson, B.L. Driver, & R.Gregory (eds.); *Amentity resource valuation: integrating economics with other disciplines*. Venture Publishing, State College, PA..

Fleishman, A.B. & Hogh, M.S. (1991) *The development of risk acceptability criteria for worldwide application: an international energy company view*. SRA-Europe 3rd Conference (Risk analysis: underlying rationales), Paris p79 - 87.

Floyd, P. & Ball, D.J. (1997) *Societal risks*. Report to Health & Safety Executive, in preparation.

Ford, J.L., Pattanaik, P.K., & Wei, X.D. (1995) *On measuring the value of life*. Economics Letters, 49(3), 223 - 230.

Abstract: This paper demonstrates a discrepancy between the value of human life calculated on the basis of the willingness to pay of individuals and the value of human life calculated on the basis of the compensating wage differential approach.

Frankel, M. (1979) *Hazard opportunity and the valuation of life*. Mimeo, University of Illinois at Urbana-Champaign.

Gafni, A. & Birch, S. (1993) *Searching for a common currency - critical-appraisal of the scientific basis underlying european harmonization of the measurement of health related quality of life (EuroQol(C))*. Health Policy, 23(3), 219 - 228.

Abstract: The EuroQol has recently been proposed as a measure of health-related quality of life based on individuals' valuations of health states. The derived values would be used in assessing cost-effectiveness and establishing priorities across a wide range of health care activities. In this paper we identify some of the limitations of the EuroQol in its role as a particular method for deriving the more generic QALYs. More specifically we explore the implications of using the EuroQol as a measure of individuals' and communities' valuation of health outcomes. We show that the EuroQol suffers from several major limitations and thus cannot be relied upon to provide a valid measure to be used in economic appraisals or studies concerned with establishing priorities as proposed by its proponents. An alternative approach is identified and discussed.

Garbacz, C. (1989) *Smoke detector effectiveness and the value of saving a life*. Economics Letters, 31, 281 - 286.

Garbacz, C. (1991) *More evidence on smoke detector effectiveness and the value of saving a life*. Population Research and Policy Review, 10(3), 273 - 287.

Abstract: Economic models of the fire fatality rate give estimates of smoke detector effectiveness. These estimates are much smaller than those generally accepted. Reasonable interpretation of these estimates, combined with the cost of a smoke detector and the risk of a fire death, places the smoke detector-based value of life saving in a range of \$1.41 to \$2.487 million 1986 dollars. The more generally accepted results of other studies of the value of life saving fall in a range of \$1.6 to \$8.5 million 1986 dollars. Smoke detector market data, along with effectiveness estimates from economic models, may provide a unique opportunity to estimate the value of life saving.

Garen, J. (1988) *Compensating wage differentials and the endogeneity of job riskiness*. Review of Economics and Statistics, 70, 9 - 16.

Gegax, D., Gerking, S., & Schulze, W. (1991) *Perceived risk and the marginal value of safety*. Review of Economics and Statistics, 73, 589 - 596.

Abstract: Two contributions are made toward understanding variation in marginal value of safety estimates from labour market studies. First, marginal safety values are obtained from direct measurements of workers' perceived job-related accidental death rates. Second, wage-risk relationships are explored for several categories of workers using the hedonic price method. Statistically, significant relationships found for unionised, blue collar and blue collar-unionised workers imply safety values of 1.50, 1.18, and 2.10 million dollars respectively. Further results in this paper suggest that alternative methods are needed to measure marginal safety values for workers in other categories.

Gerking, S., deHaan, M.H., & Schulze, W. (1988) *The marginal value of job safety: a contingent valuation study*. Journal of Risk and Uncertainty, 1(2), 185 - 199.

Ghosh, D., Lees, D., & Seal, W. (1975) *Optimal motorway speed and some valuations of time and life*. Manchester School of Economic and Social Studies, 43, 134 - 143.

Glendon, A.I. & McKenna, E.F. (1995) *Human safety and risk management*. Chapman & Hall, London.

Graham, J.D. & Vaupel, J.W. (1981) *Value of a life: what difference does it make?* Risk Analysis, 1(1), 89 - 95.

Green, C.H. & Brown, R.A. (1978) *Counting lives*. Journal of Occupational Accidents, 2, 55 - 70.

Gregory, R., Brown, T.C., & Knetsch, J.L. (1996) *Valuing risks to the environment*. Annals of the American Academy of Political and Social Science, 545, 54 - 63.

Abstract: Increasing awareness of exposure to environmental risks has focused attention on measures that would give greater assurance that such risks are effectively managed and that the adverse consequences of risky activities are mitigated. Implementing such actions is made more difficult by the uncertainties of environmental changes, their often delayed impacts, the great importance attached to extremely small risks, and the lack of clear measures of the values of environmental losses. Findings from recent behavioral studies of people's time preferences, valuations of losses relative to gains, and risk perceptions are providing information that should lead to more effective risk management strategies.

Gregory, R. & Lichtenstein, S. (1994) *A hint of risk: tradeoffs between quantitative and qualitative risk factors*. Risk Analysis, 14(2), 199 - 206.

Abstract: Risk perception research plays an active role in discussions of risk management alternatives. However, little guidance is provided regarding how public concerns should be weighted against other sources of cost and benefits. This paper reports the results of two experiments that measure tradeoffs among cost (in \$US), a quantitative risk measure (number of deaths or injuries), and several qualitative characteristics associated with perceived risk. Most subjects were willing to make the requested trade. However, the perceived risk information led others to reject the proposed technology.

Gregory, R., Lichtenstein, S., & Slovic, P. (1993) *Valuing environmental resources: a constructive approach*. Journal of Risk and Uncertainty, 7, 177 - 197.

H.M. Treasury (1991) *Economic appraisal in Central Government: a technical guide for governmental departments*. HMSO, London.

H.M. Treasury (1996) *The setting of safety standards*. H.M. Treasury, London.

HSE (1989) *Pilot survey into willingness-to-pay for risk reduction*. Health & Safety Executive.

Hadfield, G., Howse, R., & Trebilcock, M.J. (1996) *Rethinking consumer protection policy*. University of Toronto, Canada.

Hammond, P.B. & Coppock, R. (eds.) (1990) *Valuing health risks, costs, and benefits for environmental decision making*. National Research Council/National Academy Press, Washington D.C..

Harris, J. (1995) *Double jeopardy and the veil of ignorance - a reply*. Journal of Medical Ethics, 21(3), 151 - 157.

Abstract: This paper discusses the attempt in this issue of the journal by Peter Singer, John McKie, Helga Kuhse and Jeff Richardson, to defend QALYs against the argument from double jeopardy which I first outlined in 1987. In showing how the QALY and other similar measures which combine life expectancy and quality a life and use these to justify particular allocations of health care resource, remain vulnerable to the charge of double jeopardy I am able to clarify some of the central issues concerning the value of life. In particular, the idea that the value of a life varies with its life expectancy and with its quality, understood in terms of its richness, variety, success etc, is subjected to special examination. It is shown how defenders of QALYs are committed to the view that so far from all lives being of equal value, all lives are necessarily of subtly different value. The paper then analyses the use to which the notorious 'veil of ignorance' has been put both by Singer et al and by others and shows how this device of John Rawls's cannot do the work so often assigned to it. The paper then considers the issue of hypothetical consent and the role that it can play in justifying disposing of the lives of people who have not in fact consented to their lives being disposed of

in particular ways. Finally, the paper makes some points about the comprehensive nature of the data collection and storage which would be required by QALY advocates and points out the independent problems attaching to licensing such comprehensive collection and use of personal data.

Hauer, E. (1994) *Can one estimate the value of life or is it better to be dead than stuck in traffic?* Transportation Research Part A - Policy and Practice., 28(2), 109 - 118.

Abstract: In an analysis of whether to replace STOP signs by YIELD signs, the value of a life lost was pegged at \$1,500,000 and the value of time at \$6.71/hour. These numbers imply that when the sum of traffic delays accumulated by many drivers is equal in duration to the average lifetime lost in a fatal crash (37.3 years), the cost of such delay is higher than the cost of an average lost life. Most find this to be disturbing. If so, why is it that estimates of the value of time and life allegedly based on people's preferences are at odds with what most prefer? A search for the root of this problem leads to Schelling's distinction between the value of death to those who die and the value of the probability of dying to those who live. He thinks that while it is not possible to put a value on one's own death, it is possible to put a value on changes in the probability of one's own death. I think that this distinction does not solve the problem. If it is impossible to have preferences for consequences that would have to be experienced posthumously, it cannot help to make the event of death still more remote by a dimly perceived probability. People may be willing to express preferences and econometricians may be eager to interpret them. But, inasmuch as these preferences are vacuous, they have no interpretation and attempts to do so may lead to the noted inconsistency. Consistent use of a wildly incorrect value of life in cost-benefit analyses involving risk leads to consistently incorrect conclusions. Instead of using a questionable value of life in dispassionate-looking computations, it may be better to give legitimacy to public decisions more directly by a mechanism akin to a ballot or a jury.

Hausman, J.A. (ed.) (1993) *Contingent valuation: a critical assessment. (Contributions to Economic Analysis, vol. 220)*. Elsevier Science.

Hayes, D.J., Shogren, J.F., Shin, S.Y., & Kliebenstein, J.B. (1994) *Valuing food safety in experimental auction markets*. Journal Paper no. J-14937 Iowa Agriculture and Home Economics Experiment Station, Ames, IA..

Henson, S. (1995) *Consumer valuations of improvements in food safety*. *Appetite*, 24(2), 190.

Abstract: There is considerable evidence that consumers have become increasingly concerned about the risks associated with food products, although these concerns have been shown to be both quantitatively and qualitatively different from those of food scientists and nutritionists. In line with these concerns, there is evidence from food markets that consumers are prepared to pay more for food products perceived to be safer. This paper presents the results of a postal survey of a random sample of 2,500 primary food purchasers in the UK. Through expressed willingness to pay for food products offering higher/lower risks of food poisoning, the value of improvements in the safety of specific food products is estimated. The results indicate that the majority of consumers are prepared to pay positive amounts for improvements in food safety, although their actual valuation is influenced by socio-economic variables such as age, sex, income and children, attitudes to food and safety, and the food product itself.

Henson, S. (1996) *Consumer willingness to pay for reductions in the risk of food poisoning in the UK*. *Journal of Agricultural Economics*, 47(3), 403 - 420.

Abstract: The paper employs contingent valuation to estimate "willingness to pay" for reductions in the risk of food poisoning. The analysis accounts for the range of adverse health effects resulting from non-fatal cases of food poisoning as well as the risk of loss of life. A number of hypotheses regarding the value consumers attach to improvements in food safety are explored based on the results from a contingent valuation survey. Regression analysis is used to assess the factors influencing expressed "willingness to pay" for safer food, including demographic factors, personal experience of food poisoning and beliefs and attitudes about food-borne risk.

Henson, S. & Turner, P. (1994) *The costs associated with food-borne Salmonella*. Centre for Agricultural Strategy, University of Reading.

Herzog, H.W. & Schlottmann, A.M. (1987) *Valuing risk in the workplace: market price, willingness to pay, and the optimal provision of safety*. University of Tennessee Working Paper, University of Tennessee.

Heyde, J.M. (1995) *Is contingent valuation worth the trouble?* *University of Chicago Law Review*, 62(1), 331 - 362.

Hogarth, R.M. (1990) *Insights in decision-making*. University of Chicago Press.

Horowitz, J. (1994) *Preferences for pesticide regulation*. American Journal of Economics, 76, 396 - 406.

Houghton, J. (1997) *Are you planning to retire?* Norwich Union/Centre for Environmental and Risk Management, University of East Anglia.

Hyland, M.E. (1997) *Quality of life measures as providers of information on value for money of health interventions - comparison and recommendations for practice*. Pharmacoeconomics, 11(1), 19 - 31.

Abstract: Three different approaches to measuring quality of life have been developed. Global scales (e.g. time trade-off, visual analogue), multi-attribute utility Scales and multidimensional scales (which may be generic or disease-specific). Each of these approaches to measurement provides different kinds of information about quality of life and each can be used to provide information to healthcare purchasers concerning the relative value-for-money of health interventions. The value-for-money of health interventions, in terms of quality of life, can be demonstrated in 2 ways: a formuladriven approach based on cost-utility analysis, which uses scales generating the unit of a quality-adjusted life-year (i.e. global and multi-attribute utility); and a non-formuladriven approach, which uses scales generating multidimensional profiles of quality of life (i.e. multi-attribute utility and multidimensional). Analysis shows that no single approach is sufficient, and that healthcare purchasers should use a variety of types of information in their decision-making, including both cost utility and informal approaches. Healthcare resource allocation is inevitably a value-dependent activity.

Ippolito, P.M. & Ippolito, R.A. (1984) *Measuring the value of life saving from consumer reactions to new information*. Journal of Public Economics, 25, 53 - 81.

Ireland, D. (1997) *Notes concerning consumer safety decisions by Office of Consumer Affairs*. Pers. comm., 4 April, Office of Consumer Affairs, Industry Canada..

Ives, D., Kemp, R., & Thieme, M. (1993) *The statistical value of life and safety investment (Research Report no. 13)*. Environmental Risk Assessment Unit, University of East Anglia, Norwich.

Abstract: This paper discusses the problems and advantages of using an explicit statistical value of life (VOL) in safety investment decisions, and alternatives to its use are examined. The derivation of a 'consensus' value of life estimate, from a review of willingness-to-pay VOL studies, is discussed. The results of an empirical survey, which gathered published VOL estimates (converted to £1990) to determine the range of such estimates, are presented. The potential for the application of such a review-based VOL to a variety of spheres of policy making is examined, with specific reference to the example of radiological protection in the UK.

Ives, D., Soby, B., Goats, G., Ball, D.J., Covey, J., Jones-Lee, M.W., Loomes, G., & Robinson, A. (1995) *Exploratory study of consumers' willingness to pay for food risk reduction*. Report to Ministry of Agriculture, Fisheries, and Food, London.

Johannesson, M. (1996) *The willingness-to-pay for health changes, the human-capital approach and the external costs*. Health Policy, 36(3), 231 - 244.

Abstract: In this paper, the relationship between willingness to pay for health changes, the human-capital approach, and the costs that should be included in a cost-benefit analysis of a health care programme are analysed. The costs that should be included are defined as the change in consumption minus the change in production of the individual that receives a health care programme. The size of these external costs differs depending on the institutional arrangements in society. It is shown that the net production version of the human-capital approach is an estimation of the external costs. The human-capital approach can thus be given a theoretical foundation in cost-benefit analysis if it is used to estimate the external costs.

Johannesson, M. & Johansson, P.O. (1995) *Is the value of a life-year gained independent of age?* Mimeo, Stockholm School of Economics.

Johannesson, M. & Johansson, P.O. (1996) *To be, or not to be, that is the question - an empirical-study of the wtp for an increased life expectancy at an advanced age*. Journal of Risk and Uncertainty, 13(2), 163 - 174.

Abstract: This study reports an attempt to measure the value of an increased survival probability at advanced ages. It turns out that the average willingness to pay for a program which would increase the expected length

of life by one year, conditional on having survived to the age of 75 years, is lower than \$1,500. The willingness to pay increases with a person's age, but at a low and seemingly constant rate (1-4 percent per year).

Johannesson, M. & Johansson, P.O. (1997) *The value of life extension and the marginal rate of time preference: a pilot study*. Applied Economics Letters, 4(1), 53 - 55.

Abstract: The aim of this paper is to introduce and test a new approach for the measurement of the marginal rate of time preference for life-years gained based on contingent valuation techniques. A simple binary willingness to pay question is administered in a general public sample of two age groups (34-5 years and 64-5 years). In this pilot study, the estimated marginal rate of time preference is 1.3%.

Johannesson, M., Pliskin, J.S., & Weinstein, M.C. (1993) *Are healthy-years equivalent an improvement over quality-adjusted life years?* Medical Decision Making, 13(4), 281 - 286.

Johansson, P-O. (1995) *Evaluating health risks: an economic approach*. Cambridge University Press.

Johansson, P-O. (1996) *On the value of changes in life expectancy*. Journal of Health Economics, 15(1), 105 - 113.

Abstract: Analyses of the value of changes in death risks are central in the value-of-life literature: see Jones-Lee (1976), Johansson (1995), and Rosen (1988). In this note, I go beyond the existing literature in several respects. Firstly, both the marginal rate of time preference and the death risk are age-dependent in the model used in this note. Secondly, I analyze the age-dependency of parametric changes in the survival probability, i.e., how the value of a change in this probability varies with the age of the individual. Thirdly, I present some numerical simulations, based on real data on survival probabilities. These simulations shed some light on the magnitude of the value of changes in death risks for different age groups.

Jondrow, J., Bowes, M., & Levy, R. (1983) *The optimal speed limit*. Economic Inquiry, 21(3), 325 - 336.

Jones-Lee, M.W. (1976) *The value of life: an economic analysis*. Martin Robertson, London: University of Chicago Press, Chicago.

Jones-Lee, M.W. (1977) *Some empirical rigour mortis: an empirical procedure for estimating the value of life from tyre replacement data*. Presentation to SSRC Health Economists Study Group, University of Newcastle upon Tyne.

Jones-Lee, M.W. (1989) *The economics of safety and physical risk*. Blackwell, Oxford.

Jones-Lee, M.W. (1993) *Personal willingness to pay for prevention: evaluating the consequences of accidents as a basis for preventive measures*. Addiction, 88(7), 913 - 921.

Abstract: This paper argues that if scarce resources are to be allocated efficiently and to greatest advantage then it is necessary to have explicit monetary measures of the benefits of reduced accident rates so that these benefits can be weighed against costs in the process of determining the appropriate amount to expend on alcohol-related accident prevention programmes. New conceptual issues related to the definition and estimation of monetary values of safety are discussed and the case in favour of basing such values on individual willingness to pay for safety is developed. The paper then summarises existing empirical estimates of willingness-to-pay based values for the prevention of fatalities and reports the preliminary results of recent work aimed at estimating willingness-to-pay based values for the prevention of non-fatal injuries. The paper concludes by examining the applicability of existing empirical estimates of the value of safety in the alcohol-related accident context and the transferability of estimates derived in developed countries to the developing country context.

Jones-Lee, M.W., Hammerton, M., & Abbott, V. (1983) *The value of transport safety: results of a national sample survey*. Policy Journals, Newbury..

Jones-Lee, M.W., Hammerton, M., & Philips, P.R. (1985) *The value of safety: results of a national sample survey*. The Economic Journal., 95, 49 - 72.

Jones-Lee, M.W. & Loomes, G. (1994) *Towards a willingness to pay based value of underground safety*. Journal of Transport Economics and Policy, 28(1), 83 - 98.

Abstract: Since the 1987 King's Cross fire, London Underground Ltd has given high priority to the development of its procedures for appraising proposed safety projects. A pilot study was commissioned from the authors which was designed to test the feasibility of their proposed estimation procedures and provide some initial indications of the possible magnitude of the willingness-to-pay based value concerned. The findings of this study are reported in this paper and indicate a substantial premium for the willingness-to-pay based value of Underground safety relative to that of roads.

Jones-Lee, M.W. & Loomes, G. (1995a) *Discounting and safety*. Oxford Economic Papers, 47, 501 - 512.

Jones-Lee, M.W. & Loomes, G. (1995b) *Scale and context effects in the valuation of transport safety*. Journal of Risk and Uncertainty, 11(3), 183 - 203.

Abstract: How can willingness-to-pay-based values of safety for public transport modes, such as London's Underground railway system, be expected to relate to the corresponding value for road safety? This article reports results which suggest that such values should be set at a substantial premium in relation to their roads counterpart. However, this premium appears to derive entirely from considerations of control, voluntariness, and responsibility, and, contrary to popular wisdom, apparently owes nothing whatsoever to the possibility of large-scale "catastrophic" accidents on modes such as the Underground.

Jones-Lee, M.W. & Loomes, G. (1995c) Preference-based values of safety for public transport modes. In: N.G Schwab-Christie & N. C. Soguel (eds.): *Contingent valuation, transport safety, and the value of life*. National Research Council/National Academy Press, Washington D.C.

Jones-Lee, M.W., Loomes, G., O'Reilly, D., & Philips, P.R. (1993) *The value of preventing non-fatal road injuries: findings of a willingness-to-pay national sample survey*. Contractor Report 330, Transport Research Laboratory, Department of Transport, Crowthorne, Berkshire.

Jones-Lee, M.W., Loomes, G., & Philips, P.R. (1995) *Valuing the prevention of nonfatal road injuries - contingent valuation vs standard gambles*. Oxford Economic Papers - New Series, 47(4), 676 - 695.

Abstract: In 1991, the UK Department of Transport commissioned a nationally representative sample survey with a view to estimating willingness-to-pay based monetary values for the prevention of non-fatal road injuries. The study design was somewhat unusual in that it involved not one but two main value elicitation procedures -contingent valuation and standard gambles. Although both procedures are rooted in the same conventional theoretical foundations, they produced substantially and systematically different empirical estimates of the values being sought. This paper reports the findings of the study and examines possible reasons for the disparities referred to.

Kahn, S. (1986) *Economic estimates of the value of life*. IEEE Technology and Society Magazine, June, 24 - 31.

Abstract: This paper reviews the economic literature that, for policy evaluation purposes, assigns a value to risking human lives. It argues the ethical justification for evaluating risk by observing how much people are willing to pay personally to avoid risks. Most willingness-to-pay figures are based on observations of how much compensation workers must be paid to work at a risky job. The conceptual and practical problems and biases in these figures are explained. The main studies of financial value of life calculation are reviewed in light of this discussion. The review concludes that a conservative estimate for the value of risking a life is \$8 million (1984 dollars), a figure far greater than is typically used in policy analysis. Policy-makers are often required to weigh the benefits of instating safety precautions in a project or policy alternative against its costs. Making these tradeoffs requires an evaluation of the alternative relative risk, i.e. a translation of potential risks into dollars and cents. In this article, I will summarise and critically review from an economist's point of view the literature written by fellow economists. Evaluation of nonfatal injury and illness is just as critical a part of risk evaluation; however, space constraints prevent me from including it in this discussion. VOL figures are not meant to be equivalent to what you would pay in ransom money to a kidnapper in order to save your life. when individuals make tradeoffs between money and risk decisions, they are evaluating the amount they are willing to pay for decreasing their probability of death or injury. Likewise, most risky public policies are not designed to harm specific individuals; instead, they impose a slightly higher probability on death, illness, or injury on some population. Numerical VOL refers, not to a specific person's life, but rather to a "statistical" life, e.g., the probability that one of a group of 100,000 neighbors of a toxic waste dump will develop cancer. VOL studies would be more appropriately named "value of risking a life". In the remainder of this paper, I will use the two phrases interchangeably. Evaluating the risk of life may seem like a heartless procedure, yet we as individuals and policy makers implicitly place a value on life in many of our daily decisions; when we decide which car to buy; whether or not to call a cab when we've had a few drinks, etc. In fact, when public policies affect safety and the evaluation of life is left implicit, lives are often valued a zero or at a smaller amount than they would be were

they explicitly evaluated. If you plan a hazardous waste dump without calculating VOL, chances are that you're ignoring the risks imposed on neighboring areas. How do we go about quantifying the value of risking a life? Economists answer this question in the following way: it seems intuitively ethical and fair for public policy to measure this value in the same way that people evaluate risk in their own private decisions. Government should simply mirror the values of its constituents. Therefore, economists' VOL estimates measure the value that people place on risking their own lives. An alternate standard of measure often used by courts, engineers, and some policy makers calculates VOL as the (present discounted) value of future earnings. Recent applications of this method impute values for the productivity of people who work but don't actually receive wages, e.g. housewives. (Another less accepted variation includes valuing nonwork time at the market wage; see Rabor [16]). The difference between these two methods is fundamentally a philosophical one, and economists deem the future earnings method ethically misguided. After all, is the value of a person solely based on the amount of goods he or she produces? Are the lives of people who don't produce any goods, e.g., retired people or children, worthless? Our immediate negative answer to these questions should lead us to realize that each of us evaluates our own lives, the lives of our family and friends, and even the lives of strangers, for reasons other than productive capacity. Since we comprise society, our desires and values about our own lives (and others) should form the basis of value of life estimates. A policy which uses peoples' evaluation of their own lives is also "economically efficient", or "Pareto optimal", which merely means that no-one can be made better off without making someone else worse off. An example best illustrates this point: a policy maker from the NRC conducts a cost/benefit analysis to decide what safety features should be incorporated in a nuclear power plant, but he or she places a lower dollar value on the risk to those living in the neighboring areas than they would place on risking their own lives. This is inefficient, since the neighbors would collectively be willing to pay off the power plant to increase safety features: the neighbors would be better off, since they value the safety increase more than they value the money they would have to pay, and the utility would be better off, since the money that it is paid would more than compensate for the increased cost of the safety features. While payoffs between neighbors and power plants are not politically viable, the example illustrates the efficiency aspects of measuring VOL at the amount at which the people at risk would value risking their own lives.

Kahneman, D. & Knetsch, J. (1992) *Valuing public goods: the purchase of moral satisfaction*. Journal of Environmental Economics and Management, 22, 57 - 70.

Kahneman, D. & Tversky, A. (1979) *Prospect theory: an analysis of decision under risk*. Econometrica, 47, 263 - 91.

Keeney, R.L. (1996) *The role of values in risk management*. Annals of The American Academy of Political and Social Science, 545, 126 - 134.

Abstract: Values, meaning what we care to achieve, are essential to risk management. Understanding the relevant values is critical to making good decisions about risks. Thus values should be made explicit. Conceptual ideas and a few practical suggestions for building value models are discussed. Brief descriptions of several cases in which such models have facilitated decision making about important risk management decisions conclude the article.

Kekes, J. (1994) *Pluralism and the value of life*. Social Philosophy and Policy, 11(1), 44 - 60.

Abstract: As an initial approximation, pluralism may be understood as the combination of four theses. First, there are many incommensurable values whose realization is required for living a good life. Second, these values often conflict with each other, and, as a result, the realization of some excludes the realization of others. Third, there is no authoritative standard that could be appealed to resolve such conflicts, because there is also a plurality of standards; consequently, no single standard would be always acceptable to all fully informed and reasonable people. Fourth, there are, nevertheless, reasonable ways of resolving conflicts among incommensurable values. The purpose of this essay is to defend pluralism by contrasting it with the less satisfactory alternatives of monism and relativism and by showing how it can handle conflicts involving the value of life. One reason for concentrating on the value of life is that it is particularly resistant to a pluralistic interpretation. It may be thought either that life takes precedence over all other values that may conflict with it, or that if not even life does that, then all conflict-resolutions are ultimately arbitrary. It seems, therefore, that either monism or relativism is correct, and there is therefore no room left for pluralism. What seems to be true, however, is not - or so it will be argued.

Kemp, S. & Willetts, K. (1995) *Rating the value of government-funded services - comparison of methods*. Journal of Economic Psychology, 16(1), 1 - 21.

Abstract: Respondents in four studies rated the perceived value of services provided by the government. Similar ratings were obtained in Study 1 of the total and marginal value of the services, and for rated value and rated value per dollar spent. In Study 2, the value of increasing expenditure on the individual services was strongly related to the perceived loss from decreasing expenditure on them. Study 3 showed that the contingent values were well predicted from the category ratings and existing costs of the services. Study 4 obtained two category ratings of the services separated by a 2-week interval and found some effect of

immediately prior multiattribute rating on the second ratings. Overall, although there were differences in the results obtained with the different measures, there was little practical difference for identifying services that were perceived as unusually good or poor value.

Kidholm, K. (1992) *How to put a value on safety in traffic planning*. Nationaløkonomisk Tidsskrift, 130(4), 630 - 641.

Abstract: Despite the recognition of the theoretical and empirical problems with the cost-of-illness method, it is still used to value safety in traffic planning in many countries, including Denmark. The argument used is that empirical problems make the willingness-to-pay method unusable. In this article empirical estimates of four recent willingness-to-pay studies from England, Sweden, Austria and New Zealand are examined with regard to their ability to deal with these empirical problems. The article argues that it is possible to test the validity and reliability of the estimates obtained with the Contingent Valuation method used in the studies and that these estimates are higher than cost-of-illness estimates.

Kidholm, K. (1995) Assessing the value of traffic safety using the contingent valuation technique: the Danish survey. In N.G Schwab-Christie & N. C. Soguel (eds.): *Contingent valuation, transport safety, and the value of life*. Kluwer, Boston..

Kidholm, K. (1996) *Estimation af betalingsvilje for forebyggelse af personskader ved trafikulykker*. Ph.D. dissertation, Odense University Press, Denmark.

Kidholm, K. & Elvik, R. (1996) Willingness to pay for prevention of accidents. Paper to conference on "Measuring the severity and cost of accidental injuries" , Oslo.

Kind, P. (1988) *The development of health indices*. In: G. teeling-Smith (ed.). *Measuring health: a practical approach*. John Wiley & Sons, Chichester.

Kniesner, T.J. & Leeth, J.D. (1991) *Compensating wage differentials for fatal injury risk in Australia, Japan, and the United States*. Journal of Risk and Uncertainty, 4, 75 - 90.

Koopmanschap, M.A., Rutten, F.F.H., & van Ineveld, B.M. (1995) *The friction cost method for measuring indirect costs of disease*. Journal of Health Economics, 14, p171.

Koopmanschap, M.A., & van Ineveld, B.M. (1992) *Towards a new approach for estimating indirect costs of diseases*. Social Science & Medicine, 34, p1005.

Kopjar, B. & Wickizer, T.M. (1996) *Population-based study of unintentional injuries in the home*. American Journal of Epidemiology, 144(5), 456 - 462.

Abstract: There is little current understanding of the risk for occurrence of unintentional injury in the home, The authors estimated the incidence of unintentional home injuries for an entire community, adjusting for actual time spent awake in the home and, in addition, analyzed the costs of these injuries, Cases of unintentional home injuries occurring from 1990 to 1993 among the residents of Stavanger, Norway (approximately 100,000 population) were identified through a prospective, ongoing injury registration system, Age- and sex-specific per population incidence and incidence per time spent awake at home were estimated, Time exposure data for adults were obtained from the Norwegian Time Budget Survey and were estimated directly for children, The cost of injuries was estimated based on a random sample of 289 patients. A total of 8,580 persons received medical treatment for unintentional injuries in the home (22.0 per 1,000 population annually, 71,9 per 10 million hours awake at home). The per-population incidence was highest among children age 6 years or younger and among people aged 65 or older (51.0 and 32.7, respectively, per 1,000 population annually). The high population incidence for children was not accounted for by time spent awake at home, For people aged 65-74 years, however, increased incidence was primarily a function of greater time spent awake at home. For persons aged 75 years or older, the high population incidence was due to both high exposure-adjusted incidence and greater time spent awake at home. The male-female ratio of age-standardized per-population incidence was 1.07 (95% confidence interval 1.04-1.10), and the ratio of age-standardized exposure-adjusted incidence was 1.22 (95% confidence interval 1.17-1.28). The estimated cost (direct and indirect) per injury was \$1,300 during the first year after injury. Persons aged 75 years or older accounted for 12% of the injuries but 50% of the total medical costs.

Krupnick, A.J. & Cropper, M.L. (1992) *The effect of information of health risk valuations*. Journal of Risk and Uncertainty, 5(1), 29 - 48.

Kunreuther, H. & Slovic, P. (1996) *Science, values, and risk*. Annals of the American Academy of Political and Social Science, 545, 116 - 125.

Abstract: In the context of health, safety, and environmental decisions, the concept of risk involves value judgements that reflect much more than just the probability and consequences of the occurrence of an event. This article conceptualizes risk as a game, in which the rules must be socially negotiated within the context of a specific problem. This contextualist view of risk provides insight into why technical approaches to risk management often fail with problems such as those involving radiation and chemicals, where scientific experts and the public disagree on the nature of the risks. It also highlights the need for the interested parties to define and play the game, thus emphasizing the importance of institutional, procedural, and societal processes in risk management decisions. This contextualist approach is illustrated using the problem of siting hazardous waste facilities.

Landefeld, J.S. (1979) *Control of new materials with carcinogenic potential: an economic analysis*. Unpublished PhD dissertation. University of Maryland, College Park, Md.

Landefeld, J.S. & Seskin, E.P. (1982) *The economic value of life: linking theory to practice*. American Journal of Public Health, 72(6), 550 - 566.

Lanoie, P., Pedro, C., & Latour, R. (1995) *The value of a statistical life - a comparison of 2 approaches*. Journal of Risk and Uncertainty, 10(3), 235 - 257.

Abstract: Using an original data set, this article presents the first effort to compare systematically the values of a statistical life obtained from the two main methodologies existing in the literature—the revealed-preference approach (wage-risk analysis) and the contingent-valuation approach—applied to the same sample of individuals. A survey was conducted in the Montreal area with a questionnaire containing two series of questions: one set of contingent-valuation questions and one set of questions pertaining to the information necessary for performing a wage-risk study. The results show that the values of a statistical life obtained from each method are different from each other.

Lave, L.B. (1996) *Benefit-cost analysis: do the benefits exceed the costs?* Chapter 7 In: Goldstein, B. (ed.) *Risks, Costs and Lives Saved*. Oxford University Press, London..

Leigh, J.P. (1987) *Gender, form size, industry and estimates of the Value of Life*. Journal of Health Economics, 6, 255 - 273.

Leigh, J.P. & Folsom, R.N. (1984) *Estimates of the value of accident avoidance at the job depend on concavity of the equalizing differences curve*. Quarterly Review of Economics and Business, 24, 56 - 66.

Lin, C-T.J. (1994) *Mental models: a proposed approach to improving the elicitation of monetary value of food safety from individuals*. Presented at the Society for Risk Analysis Annual Conference, Baltimore.

Lichtenstein, S., Gregory, R., Slovic, P., & Wagenaar, W.A. (1990) *When lives are in your hands: dilemmas of the societal decision maker*. In R.M. Hogarth (ed.) *Insights in decision-making*. University of Chicago Press.

London Underground (1996) *Safety Plan 1996/7*. London Underground.

Low, S.A. & McPheters (1983) *Wage differentials and risk of death: an empirical analysis*. Economic Inquiry, 21, 271 - 280.

Lutter, R. & Morrall, J.F. (1994) *Health-health analysis - a new way to evaluate health and safety regulation*. Journal of Risk and Uncertainty, 8(1), 43 - 66.

Abstract: Regulations to promote health and safety that are exceptionally costly relative to the expected health benefits may actually worsen health and safety, since compliance reduces other spending, including private spending on health and safety. Past studies relating income and mortality give estimates of the income loss that induces one death—a value that we call willingness-to-spend (WTS)—to be around \$9 to \$12 million. Such estimates help identify regulations that do not improve health and safety, and moreover, fail benefit-cost comparisons. WTS is a multiple of the willingness to pay to avert a statistical death. International data yield estimates of WTS and willingness-to-pay in different countries.

Maclean, A.D. (1979) *The value of public safety: results of a pilot-scale survey*. Home Office Scientific Advisory Branch, London.

Maclean, D. (1990) Comparing values in environmental policies: moral issues and moral arguments. In P.B. Hammond & R. Coppeck (eds.) *Valuing health risks, costs, and benefits for environmental decision-making*. National Academy Press, Washington, D.C.

Magat, W.A. & Moore, M.J. (1996) *Consumer product-safety regulation in the United States and the United Kingdom - the case of bicycles*. *Rand Journal of Economics*, 27(1), 148 - 164.

Abstract: This study analyzes the effect of bicycle safety regulation in the United States and the United Kingdom using data on monthly injury rates. Unlike many previous studies of product safety regulation, a specific product regulation is analyzed, and long data series are available. In both countries, the regulation led to a significant decrease in accidents per bicycle in use. The effect in the United States is larger than in the United Kingdom.

Magat, W.A., Viscusi, W.K., & Huber, J. (1988) *Paired comparison and contingent valuation approaches to morbidity risk valuation*. *Journal of Environmental Economics and Management*, 15(4), 395 - 411.

Abstract: This research uses an experimental approach for eliciting consumer valuations of morbidity risk reductions associated with safer chemical products and introduces the paired comparison questions approach to non-market valuation. In four applications, the paired comparisons approach yields higher morbidity valuations than the more familiar contingent valuation approach. However, both methodologies produce large values of morbidity reduction benefits in comparison to estimates derived from wage hedonic studies. Explanations for the difference in the estimates and their magnitudes are suggested along with the public policy implications.

Magat, W.A., Viscusi, W.K., & Huber, J. (1991) *The death risk lottery metric for health risk: cancer and nerve disease*. Duke University Working Paper, Duke University.

Maier, G., Gerking, S., & Weiss, P. (1989) *The economics of traffic accidents on Austrian roads: risk lovers or policy deficit*. Mimeo, Wirtschaftsuniversitat, Vienna..

Marin, A. (1983) *Your money or your life?* *The Three Banks Review*, 138, 21 - 37.

Abstract: This article discusses why it might be desirable to put a monetary value on human life, in the sense of fixing a definite amount that is worth spending to prevent a premature death. The reasons are those of consistency and explicitness in government decision-making. These might seem to require the same value to be put on all life. There is evidence, however, that we tend to be more concerned about some deaths than others. It is necessary to consider why we might value some people's lives more highly than others', whether such differences are justifiable and whether government policies should follow these differences even if they are morally objectionable. There are those who oppose any attempt to place a monetary value on life. Their arguments have to be considered, though they typically present no alternative criteria of which they do approve. If it is accepted that government decision-making requires some value to be put on saving human life, the actual value has to be estimated. For a while the estimates were based on the capital sum equivalent to the net earnings of those whose lives would be saved. This not only has the problem of treating the lives of those not working as having no value at all, but is also inconsistent with the general basis of cost-benefit studies. Most economists now favour estimates based on the amounts that people would pay to avoid a slight increase in the probability of death, though agreement on this is not unanimous. The arguments are concerned with the amount worth spending to prevent a death, when everybody's welfare is taken into account, including those who might themselves die as a result of the decision. They are not limited to the compensation to be given to relatives of a particular person who has been killed. Thus the amounts worth spending to prevent a death should be (considerably) greater than court awards to next of kin. On the basis of a recent empirical study, the article concludes that a 'value of life' of £2 million is not unreasonable for UK decision-making. Although the principle of basing decisions on how much people would pay to avoid risk is applicable to all countries, at whatever stage of development, the actual amounts will differ. In particular, the 'value of life' should increase with income.

Marin, A. & Psacharopoulos, G. (1982) *The reward for risk in the labor market: evidence from the United Kingdom and a reconciliation with other studies*. *Journal of Political Economy*, 90, 827 - 853.

Martinello, F. & Meng, R. (1992) *Workplace risks and the value of hazard avoidance*. *Canadian Journal of Economics - Revue Canadienne d'Economie*, 25(2), 333 - 345.

Abstract: This study examines the relationship between work-related hazards and individual earnings. Both fatality and injury rates are included in the analysis and we examine the role of unions in the wage-risk process. Estimates for the cost of an industrial accident and the value of life' are also calculated. The results

indicate that serious job hazards have significant positive effects on earnings. Union workers receive the same compensation for risk of fatality as non-union workers.

Mauskopf, J.A. & French, M.T. (1991) *Estimating the value of avoiding morbidity and mortality from food-borne illnesses*. Risk Analysis, 11(4), 619 - 631.

May, W.M. (1982) *Dollars for lives: ethical considerations in the use of cost-benefit analysis by for-profit firms*. Risk Analysis, 2(1), 35 - 46.

Abstract: Cost/benefit analysis is often an imprecise tool because of assumptions that must be made about matters that are difficult to quantify. The problems become especially acute when lives or serious bodily injuries are at stake because of the serious nature of that which is being risked. Furthermore, the literature on cost/benefit analysis focuses on public decision-making situations and decisions by individuals. This paper examines the distinctiveness of the use of cost/benefit analysis involving putting dollar values on human life by for-profit firms. The argument developed in the paper is that the lack of participation by the affected party (or government representative) in balancing costs and benefits raises special ethical concerns. A formula that was developed by the Ford Motor Company concerning accidents involving fuel leakage and fire with resultant loss of life and serious burn injuries is used as an example of both the imprecision of the method and the distinctive factors of the decision process that raises special ethical considerations. The paper examines why the for-profit-decision is distinct, what the special ethical considerations are, and concludes with a discussion of several alternative procedures to monitor the use of cost/benefit analysis so that it would be an effective business tool while at the same time the individual is provided maximum protection.

McDaniels, T.L. (1992) *Reference points, loss aversion, and contingent values for auto safety*. Journal of Risk and Uncertainty, 5(2), 187 - 200.

Abstract: This article is concerned with the possible role of reference points and loss aversion (as suggested by prospect theory) in subjects' judgements about the value of increments and decrements in automobile safety. The contingent valuation method is employed in two experiments, both of which consider subjects' willingness-to-pay (WTP) for increased safety and compensation demanded (CD) for decreased safety in hypothetical new vehicle purchases. The results establish that disparities exist in subjects' WTP and CD values for the same increment of auto safety, even for a close-to-market context such as hypothetical new vehicle purchases. The results also indicate that evaluations can be manipulated by changing the perception of the reference point: losses can be recast as forgone gains and forgone gains as losses, altering (or even eliminating) differences between WTP and CD values.

McDaniels, T.L., Kamlet, M.S., & Fischer, G.W. (1992) *Risk perception and the value of safety*. Risk Analysis, 12(4), 495 - 503.

Abstract: This paper examines the relationship between perceived risk and willingness-to-pay (WTP) for increased safety from technological hazards in both conceptual and empirical terms. A conceptual model is developed in which a given household's WTP for risk reductions is a function of traditional socioeconomic variables (i.e., income and base level of risk) and perceived characteristics of the hazards (i.e., dread, knowledge, and exposure). Data to estimate the model are obtained through a combined contingent valuation and risk perception survey that considers 10 technological hazards, five of which are well defined (e.g., death rates are known and the risks are relatively common) and five are less well-defined. Econometric results, using TOBIT estimation procedures, support the importance of variables in explaining WTP across all 10 hazards. When the risks are split into two groups, the results show that WTP for well-defined hazards is most influenced by perceived personal exposure, while WTP for less well-defined risks is most influenced by levels of dread and severity.

Melinek, S.J. (1974) *A method for evaluating human life for economic purposes*. Accident Analysis and Prevention, 6, 103 - 114.

Melinek, S.J., Woolley, S.K.D., & Baldwin, R. (1973) *Analysis of a questionnaire on attitudes to fire risk*. Fire Research Note 962, Joint Fire Research Organisation, Borehamwood.

Mendeloff, J.M. & Kaplan, R.M. (1989) *Are large differences in lifesaving costs justified? A psychometric study of the relative value placed on preventing deaths*. Risk Analysis, 9(3), 349 - 363.

Abstract: Government actions to reduce risks to health have varied greatly in their cost per death prevented, frequently by 10-fold or even 100-fold. This research asks whether disparities of this magnitude are justified by citizens' preferences about the relative value of reducing deaths from different hazards. Four samples were asked to rank the relative priority of preventing deaths through 8 realistic programs, each addressed to a different hazard, and then to rate how large the differences in spending should be. Subjects were not asked to give absolute values on preventing deaths and were asked only for their relative valuation of the benefits of

preventing a death, not to weigh the benefits and costs or to determine an optimal spending level. We found that in all samples the median respondent values his top-rated program 5 to 6 times more than his bottom-rated program. However, because individuals disagreed upon the relative priority for different programs, the aggregated rankings barely showed more than a 2-fold difference in the amounts that should be spent. Thus, for the important programs considered by these samples, a large variation in spending does not appear to be justified on the basis of differentials in the values placed on preventing different types of deaths. A more deliberate methodology like the one used here appears fruitful for providing insights to policymakers about preferences in this sensitive area.

Meng, R.A. (1989) *Compensating differences in the Canadian labor market*. Canadian Journal of Economics, 22, 413 - 424.

Meng, R.A. & Smith, D.A. (1990) *The valuation of risk of death in public-sector decision-making*. Canadian Public Policy, 16(2), 137 - 144.

Abstract: The unavoidable trade-off between monetary expenditures and health and safety benefits means that the risk of death must be considered in a wide variety of public sector decisions. This paper argues that this consideration should be explicit and consistent across policy areas. The most conceptually valid approach to the valuation of benefits from reduced risk is to base estimates on the required compensation for exposure to risk. An empirical estimate of required compensation is generated by measuring the statistical value of life based on data from the Canadian labour market. The estimated value of life is \$5.2 million in 1983 dollars. This is recommended as a useful lower bound estimate for a variety of public policy applications in Canada. In some applications, we argue that substantially higher values are required.

Miller, T.R., Calhoun, C., & Arthur, W.B. (1990) *Utility-adjusted impairment years: a low cost approach to morbidity valuation*. *Proceedings: Morbidity Measurement and Valuation in a Policy Context*. Association of Environmental and Resource Economists Workshop, US EPA230-08-89-065.

Miller, T.R. & Guria, J. (1991) *The value of statistical life in New Zealand: market research on road safety*. Land Transport Division, Ministry of Transport, Wellington.

Miller, T.R. & Lestina, D.C. (1996) *Patterns in US medical expenditures and utilisation for injury, 1987*. American Journal of Public Health, 86, 89 - 93.

Abstract: This article is based on data released in 1991/93 from the 1987 National Medical Expenditure Survey. Medical spending and utilization patterns are analysed for 13 major categories of injury. Medical spending on injury in 1987 was \$64.7 billion in 1993 dollars. Nonhospitalised medically treated injuries averaged \$571 in medical spending per case, \$181 per visit, and 3.2 visits per injury. The prevalence-based survey estimate of medical spending on injuries during 1987 is 10% lower than the incidence-based estimates of lifetime medical spending resulting from injuries in 1985.

Mishan, E.J. (1985) Consistency in the valuation of life: a wild goose chase? in E.F. Paul, J. Paul, & F.D. Miller (eds.) *Ethics and economics*. Blackwell, Oxford..

Mitchell, R.C. & Carson, R.T. (1989) *Using surveys to value public goods: the contingent valuation method*. Resources for the Future, Washington D.C.

Moore, M.J. & Viscusi, W.K. (1988a) *Doubling the estimated value of life: results using new occupational fatality data*. Journal of Policy Analysis and Management, 7, 476 - 90.

Moore, M.J. & Viscusi, W.K. (1988b) *The quantity-adjusted value of life*. Economic Inquiry, 26 (3), 369 - 388.

Abstract: The traditional compensating differential analysis is extended to reflect the effects on wages of the duration of life at risk and of insurance benefits to the surviving spouse and dependants. The implicit discount rate that workers use in making their life-cycle employment decisions is also estimated. The revealed discount rate ranges from 10 to 12 %, and the implicit value per year of life is \$175,000. There is also evidence of significant wage reductions resulting from higher workers' compensation benefits for fatal and nonfatal injuries, suggesting an important trade-off between ex ante and ex post compensation for risk.

Moore, M.J. & Viscusi, W.K. (1990a) *Compensating mechanisms for job risks: wages, workers' compensation, and product liability*. Princeton University Press.

Moore, M.J. & Viscusi, W.K. (1990b) *Discounting environmental health risks: new evidence and policy implications*. Journal of Environmental Economics and Management, 18, S51 - S62.

Moore, S. (1997) *Too many 'ologists make you boring*. The Independent, 4th April.

Mulligan, P.J. (1977) *Willingness-to-pay for decreased risk from nuclear plant accidents*. Working Paper no. 3, Energy Extension Programs, Pennsylvania State University.

Nathwani, J. & Narveson, J. (1995) *Three principles for managing risk in the public interest*. Risk Analysis, 15(6), 615 - 626.

Abstract: We propose three principles and a general framework of reasoning for managing risk in the public interest. Principle 1, Risks shall be managed to maximize the total expected net benefit to society -The principle that the net benefit is to be maximized across society as a whole is argued to be a sufficient and rational guide to assessing the effectiveness of efforts directed at reducing risk and thus improving health and safety. The net benefit of an activity is the excess of the totality of benefits over the totality of detriments. Principle 2, The safety benefit to be promoted is life-expectancy-The goal is to ensure that risk mitigation efforts maximize the net benefit to society in the specific terms of length of life for all individuals. The effect of an activity on life expectancy is proposed as the proper basic measure of its net safety impact. Life expectancy is a universal measure valid for comparisons both within and among countries and can be adjusted to include health expectancy and other factors such as income levels that affect the quality of life. The impact on life expectancy allows a dispassionate accounting of the good and the bad inherent in any proposal or activity that is in the public interest but has some impact on life and health. Principle 3, Decisions for the public in regard to health and safety must be open and apply across the complete range of hazards to life and health-Systematic efforts to evaluate all the important consequences, both direct and indirect, are required to improve the basis for risk management in society. Balancing of the detriments and the benefits of any given initiative is the key aspect of the undertaking. Safety may well be an important objective in society, but it is not the only one. Thus, allocation of society's resources devoted to safety must be openly and continually appraised in light of other competing social needs because there is a limit on the resources that can be expended to save lives. Maximization of healthful life for all is judged the proper basis for managing risk in the public interest, and that this is achieved when the net of the contribution to the total saving of life exceeds the loss of life.

National Consumer Agency of Denmark (1994) *Order on safety requirements for toys and products which due to their outward appearance may be mistaken for food*. 1994-121/1-164, 23 May, National Consumer Agency of Denmark.

National Radiological Protection Board (NRPB) (1977) *Cost-benefit analysis in the optimisation of radiological protection*. 9th August, National Radiological Protection Board, Chilton, Oxfordshire.

National Radiological Protection Board (NRPB) (1986) *Cost benefit analysis in the optimisation of radiological protection*. ASP, HMSO, London..

National Radiological Protection Board (NRPB) (1993) *Occupational, public and medical exposure*. Doc NRPB 1993, 4(2), National Radiological Protection Board, Chilton, Oxfordshire.

National Swedish Board for Consumer Policies (1994) *Five years with the Product Safety Act*. Report 1994:95-21, National Swedish Board for Consumer Policies.

Needleman, L. (1980) *The valuation of changes in the risk of death by those at risk*. Manchester School of Economics and Social Studies, 48, 229 - 254.

Ng, Y-K. (1992) *The older the more valuable - divergence between utility and dollar values of life as one ages*. Journal of Economics - Zeitschrift fur Nationalokonomie, 55(1), 1 - 16.

Abstract: While the utility value of life may decrease monotonically with age, the dollar value may increase dramatically until a fairly old age (by ten-fold to age 60 for one plausible set of parameters). Crucial for this result is a high enough real rate of interest (e.g. 4-5 %) which makes accumulation desirable, leading to a lower marginal utility of money when one gets older, explaining the divergence. This divergence raises perplexing questions as to which value of life should be used and whether the old should be taxed and the young subsidized.

Nord, E. (1992) *Methods for quality adjustment of life years*. Social Science and Medicine, 34(5), 559 - 569.

Abstract: Several valuation techniques are in use for quality adjusting life years in cost utility analysis. The paper gives an overview of the variability in results. A close inspection of a number of instruments with

respect to their theme, instructions, decision framing and the phrasing of questions make many of the observed differences in results understandable. When judging the validity of the different techniques, three points should be kept in mind. One is that statements about validity should be made with respect to concrete versions rather than broad categories like 'the rating scale', 'time trade-off' etc. Another point is that a valuation technique that is valid in clinical decision analysis may not be valid in health program evaluation, and vice versa. The third point is that quality weights for life years are empirically more meaningful, in the sense that they are more amenable to empirical testing, if they are interpreted simply as preference weights rather than measures of amounts of well life in the utilitarian tradition. Time trade-off with a moderate time horizon is recommended in clinical decision analysis, while a combination of time trade-off and a variant of person trade-off is recommended in health program evaluation.

Nord, E. (1993) *The relevance of health state after treatment in prioritising between different patients*. Journal of Medical Ethics, 19, 37 -42.

Abstract: In QALY-thinking, an activity that takes N people from a bad state (including 'dying') to the state of health for X years should have priority over an activity that takes M other people from the same bad state to a state of moderate illness for the same number of years (given equal costs). An empirical study indicates that this view may not be shared by the general public in Norway. Subjects tended to emphasise equality in value of life and in entitlement to treatment rather than level of health after treatment. The relevance of costs per QALY in prioritising between different health care programmes in Norway is thereby brought in to doubt. While the sample in the study is too small to support firm policy conclusions, the results should contribute to an increased interest among health economists in actually measuring people's ethical preferences in matters of prioritising, rather than taking it for granted that their own values are shared by the general public.

O'Reilly, D., Hopkin, J., Loomes, G., Joneslee, M., Philips, P., McMahon, K., Ives, D., Soby, B., Ball, D., & Kemp, R. (1994) *The value of road safety - UK research on the valuation of preventing nonfatal injuries*. Journal of Transport Economics and Policy., 28(1), 45 - 59.

Abstract: Since 1988, the UK Department of Transport has valued the prevention of fatal road accident casualties on the basis of Willingness-To-Pay (WTP). To provide equivalent information for the value of avoidance of serious injuries, a national sample WTP survey and a Relative Utility Loss study were undertaken. The studies are described and compared; the results show the value of injury in relation to the value of a fatality and the value for the prevention of serious road accident injuries which will apply in future DoT appraisals.

Olson, C.A. (1981) *An analysis of wage differentials received by workers on dangerous jobs*. Journal of Human Resources, 16, 167 - 185.

Passell, P. (1995) *How much for a life? Try \$3 million to \$5 million*. New York Times, 29th January, p3.

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Persson, U. (1992) *Three economic approaches to valuing benefits of traffic safety measures*. Swedish Institute for Health Economics, Lund.

Persson, U. & Cedervall, M. (1991) *The value of risk reduction: results of a Swedish sample survey*. IHE Working Paper, 6, The Swedish Institute of Health Economics, Lund.

Persson, U., Lugner Norinder, L., & Svensson, M. (1995) Valuing the benefits of reducing the risk of non-fatal road injuries: the Swedish experience. In N.G. Schwab-Christie & N.C. Soguel (eds.): *Contingent valuation, transport safety and the value of life*. Kluwer, Boston.

Philips, P.R., Russell, I.T., Jones-Lee, M.W. (1989) The empirical estimation of individual valuation of safety: results of a national sample survey. In M.W. Jones-Lee (ed.): *The economics of safety and physical risk*. Blackwell, Oxford.

Railtrack (Safety & Standards Directorate) (1995a) *Draft Code of Practice: Applying values to safety*. October, Railtrack, London.

Railtrack (Safety & Standards Directorate). (1995b) *Draft Code of Practice: Setting a value on preventing a fatality*. October, Railtrack, London.

Railtrack (1995c) *Memorandum to Chairman's meeting concerning investment prioritisation and safety*. August, Railtrack, London.

Railtrack (1995d) *Minutes of meeting to discuss Value of Preventing Fatalities (VPF)*. 6th Sept, Railtrack, London.

Railtrack (1997) *Railway Group safety plan 1997-98*. Railtrack, London.

Ricci, P.F. & Molton, L.S. (1986) *Health risk assessment: science, economics, and law*. Annual Review of Energy, 11, 77 - 94.

Rice, D.P. & Max. W. (1996) *The high cost of injuries in the United States (editorial)*. American Journal of Public Health, 86(1), 14 - 15.

Abstract: Injuries continue to impose a multibillion-dollar burden on the economy, as reported by Miller and Lestina in this issue of the Journal. In their analysis of data from the 1987 National Medical Expenditure Survey (NMES), they found that 1987 medical expenditures on injuries amounted to \$64.7 billion (1993 dollars), or 3% of the total personal health care spending in the US. Miller and Lestina compare their findings with those from our cost of injury study conducted in 1987 and 1988. Their estimates show that we overestimated spending for males aged 44 years and younger and for females over 64 years of age. They correctly point out that we "unavoidably" assumed that treatments did not vary by age or sex. We had estimated lifetime costs and used multiple data sets to estimate prevalence, utilization, and expenditures, which resulted in the best estimates from the data available at that time. Miller and Lestina's advantage in using data from the NMES is that expenditures are linked with illness episodes; thus their results undoubtedly have improved the estimates we made five years earlier. However, the disadvantage of the NMES is the relatively small sample and the lack of coding by external cause of injury. From a public health perspective, it is important to disaggregate injuries by cause so that prevention strategies can be designed. These new estimates of injury spending once again highlight their enormous drain on the US medical care system. In addition to the high medical costs, injuries result in losses in productivity for people who are ill and disabled and die prematurely. A national total of 62.1 million injuries with 412.1 restricted-activity days - or 6.6 days per injury - were reported in 1993. Accidents and their adverse effects were the fifth leading cause of death in the US total population in 1992. However, among children and adults below 45, accidents were ranked as the first cause of death. When children or adults in the prime of life die, their future productivity losses to the economy are enormous. Injury is a major public health problem that needs to be addressed by multiple strategies. Prevention, control, treatment, and rehabilitation are required to reduce the number of deaths and nonfatal injuries as well as the associated high costs. "Healthy People 2000" has identified the reduction of unintentional injuries as one of its priority areas. The wide objectives in this area focus on a wide range of educational, legislative, and mechanical means to reduce injury occurrence. Progress towards the year 2000 targets has been made in 12 of the 22 objectives; in five cases, the target has been equalled or surpassed. Much of the progress is in areas related to motor vehicle fatalities, injuries, and the use of vehicle occupant restraints and motorcycle helmets. But much remains to be done to attain all of the year 2000 goals and to reduce the burden of injury on individuals, families, and society. In order to achieve these national goals, better data are needed. More complete and accurate measurement of the incidence of injury and related costs are required to target injury prevention and control programs. As highlighted by Miller and Lestina, age- and sex-specific incidence and cost data are necessary for designing appropriate interventions. Timely injury data are needed to identify important shifts in rates and patterns of injury, to identify newly emerging problems, and to form the basis for the planning, analysis, and evaluation of injury control efforts. For example, hospital discharge systems should be required to use both cause- and nature-of- injury codes. Longitudinal studies, especially of severely injured persons, are needed to fully understand the long-term consequences of injury and to subsequently establish policy in the areas of prevention, treatment, rehabilitation, and research. Finally, to provide current expenditure data for the nation, medical spending should be measured periodically and the data should be made available to the research community on a timely basis.

Ringstedt, N. (1997) *Some aspects of Swedish Market Court practice as to risk assessment*. International Journal for Consumer Safety, 4(1).

Robb, J.D. (1990) *Valuing radiation detriment for optimisation purposes*. Radiation Protection Bulletin, 110, 8 - 12.

Rosen, S. (1988) *The value of changes in life expectancy*. Journal of Risk and Uncertainty, 1, 285 - 304.

Abstract: Valuation formulas for age-specific mortality risks are derived from life-cycle allocation theory under uncertainty and related to empirical estimates of the value of life. A change in an age-specific mortality risk affects all subsequent survivor functions and reallocates consumption and labour supply over the entire life cycle. The value of eliminating a risk to life at a specific age is the expected present value of

consumer surplus from that age forward. Approximate numerical extrapolations from cross-section estimates imply that values decrease rapidly in current age and in the distance between current age and age at risk.

Royal Society, The (1992) *Risk: analysis, perception and management*. The Royal Society, London.

Savage, I. (1991) *Psychological features affecting valuation of life*. Economics Letters, 35, 379 - 383.

Abstract: Economists have studied a variety of consumer, technological and workplace hazards to determine the value of life. These studies have produced widely divergent results. This paper investigates whether or not cognitive characteristics of different hazards may explain part of the diversity. Our findings are that while catastrophic hazards such as nuclear accidents engender heightened psychological fear and a high willingness-to-pay to reduce risks, the same is not true for more everyday hazards. Small sample size and dubious source data may be responsible for this counter-intuitive result, which suggests there is a need for additional joint work by psychologists and economists.

Savage, I. (1993) *An empirical investigation into the effect of psychological perceptions on the willingness to pay to reduce risk*. Journal of Risk and Uncertainty. 6(1), 75 - 90.

Abstract: A large sample of the residents of metropolitan Chicago were interviewed to investigate whether psychometric attributes by which people view hazards are related to their willingness-to-pay to reduce the hazard. One of the hazards, stomach cancer, is found to engender fear and a high willingness-to-pay. Among the other hazards, willingness-to-pay increases with the dread of the hazard but declines with degree of knowledge people have about the risk they are exposed to. When adjustment is made for perceived probability of occurrence, one can conclude that the implied valuation of life varies across hazards according to psychometric risk perceptions. This result has practical implication for policy makers when making decisions regarding spending to reduce hazards.

Schulze, W.D (1980) Ethics, economics and the value of safety. In: Schweig, R.C. & Albet, W.A. (eds) *Societal risk assessment: how safe is safe enough?* Plenum.

Schwab-Christe, N.G (1995) The valuation of human costs by the contingent method: the Swiss experience. In N.G Schwab-Christie & N. C. Soguel (eds.): *Contingent valuation, transport safety, and the value of life*. Kluwer, Boston.

Schwab-Christe, N.G. & Soguel, N.C. (1995) *Contingent valuation, transport safety, and the value of life*. Kluwer, Boston..

Schwab-Christe, N.G. & Soguel, N.C. (1996) *The pain of road-accident victims and the bereavement of their relatives - a contingent valuation experiment*. Journal of Risk and Uncertainty, 13(3), 277 - 291.

Abstract: The accurate description of the contingent market is a necessary condition for eliciting willingness-to-pay values. So far, however, the contingent market for a reduction in the risk of being the victim of a road accident has only been broadly specified. This Swiss experiment attempts to define the good to be purchased by respondents with greater precision. It concentrates on the human costs of road accidents, i.e., pain, suffering, and bereavement. Respondents were asked to consider themselves either as potential victims of a road accident or as relatives of potential victims and to state their willingness to pay to reduce the likelihood of such an accident occurring.

Schweig, R.C. & Albet, W.A. (1980) *Societal risk assessment: how safe is safe enough?* Plenum.

Shin, S., Kliebenstein, J., Hayes, D.J., & Shogren, J.F. (1992) *Consumer willingness to pay for safer food products*. Journal of Food Safety, 13(1), 51 - 59.

Slovic, P. (1987) *Perception of risk*. Science, 236, 280 - 285.

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1981) *Perceived risk: psychological factors and social implications*. Proceedings of the Royal Society of London, 376, 17 - 34.

Slovic, P., Lichtenstein, S., & Fischhoff, B. (1984) *Modelling the social impact of fatal accidents*. Management Science, 30(4), 464 - 474.

Small, K.A. & Kazimi, C. (1995) *On the costs of air pollution from motor vehicles*. Journal of Transport Economics and Policy, 29(1), 7 - 32.

Abstract: The authors present estimates of air pollution costs from various types of motor vehicles in the Los Angeles region. The costs are dominated by mortality from particulate matter, including that formed from gaseous emissions through secondary reactions. The best estimate for the air pollution cost of the average car on the road in California in 1992 is \$0.03 per mile, falling to half that amount in the year 2000. A typical heavy-duty diesel vehicle is much more costly. The cost estimates are sensitive to the assumed value of life, to the measured health effects of particulates, and to assumptions about road dust.

Smith, R.S. (1974) *The feasibility of an 'injury tax' approach to occupational safety*. Law and Contemporary Problems, 38, 730 - 744.

Smith, R.S. (1976) *The Occupational Safety and Health Act: its goals and achievements*. American Enterprise Institute, Washington D.C.

Smith, R.S. (1979) *Compensating wage differentials and public policy*. Industrial and Labour Relations Review, 32(3), 339 - 352.

Smith, V.K. (1983) *The role of site and job characteristics in hedonic wage models*. Journal of Urban Economics, 13(3), 296 - 321.

Smith, V.K. & Gilbert, C. (1984) *The implicit risks to life: a comparative analysis*. Economics Letters, 16, 393 - 399.

Smith, V.K. & Desvousges, W.H. (1987) *An empirical analysis of the economic value of risk changes*. Journal of Political Economy, 95, 89 - 114.

Soby, B.A. & Ball, D.J. (1991) *Consumer safety and the valuation of life and injury (research report no. 9)*. Environmental Risk Assessment Unit, University of East Anglia, Norwich.

Abstract: Whenever a decision is taken to allocate society's resources to reduce risk and safety, a value is implicitly placed on life. Implied values, however, are likely to be inconsistent, may be difficult to justify if challenged, and are believed to result in inefficient expenditure. Making the value explicit can contribute to increased consistency and openness and may ultimately lead to increased safety per pound invested. In this report the characteristics and frequency of home and leisure accidents and the methodologies available for estimating appropriate values for life and injury are reviewed. Based on the review, it is concluded that placing an explicit monetary value on life for use in consumer safety policy analysis is both feasible and appropriate. It is concluded that the Willingness-To-Pay (WTP) methodology in general, provides the most sound estimates of the value of life. No one WTP methodology, however, provides an unassailable valid estimate and there is question as to the context of specificity of the estimates. Thus, it is suggested that a review of values of life obtained through various WTP studies (e.g. wage differential, consumer behaviour, and contingent valuation studies) and for various sectors (e.g. transport and occupational safety) may provide a range of values which could be applied in the context of consumer safety, if consistency in expenditures on safety is preferred. If, however, it is found that the context of the risk is considered to affect the value of life, the WTP Contingent Valuation Method (CVM) is likely to provide the most appropriate estimate for the value of life for use specifically in the consumer safety sector. For estimating the value of injuries, the report indicates that the Relative Utility Loss Approach (RULA) , in combination with an appropriate value of life, can provide a practicable way forward. Values for life and injury, based on individual WTP estimates, must be augmented by the direct costs to society, for which the Social Consumption Equivalent Model provides a framework. The report emphasises the need for a comprehensive decision-making model which takes into account the context and characteristics of risks to the public across different sectors of society and into which the values of life and injuries can be placed.

Soby, B.A., Simpson, A.C.D., Ives, D.P., & Hedegard, J.B.O. (1993) *Consumer attitudes to risk and the effectiveness of home and leisure safety campaigns in the European Community (research report no. 15)*. Environmental Risk Assessment Unit, University of East Anglia, Norwich.

Abstract: Based on this review it is hard to make the sweeping generalisation that educational safety campaigns have been an effective method of reducing the number of home and leisure accidents. It does appear, however, that the educational strategy has great potential in this regard. Appropriate funding is needed so that this potential can be realised. It is recommended that a cross-section of future campaigns be selected as the target of such funds to not only implement the campaign, but also to design it properly, to undertake extensive pre-testing of materials, enter into dialogues with consumers, implement behavioural studies, and carry out a comprehensive evaluation. Such an in-depth approach is necessary to gain a comprehensive understanding of the effectiveness of the campaign in terms of both its methodology and outcome. In this way, valuable lessons can be learned for the future. From our review, we have also made recommendations on the steps necessary to implement an educational campaign with a high probability of success. These include: (i) prioritise issues for intervention; (ii) research the behavioural, sociological, and

psychological characteristics of the accident pattern, using multi-way risk communication; (ii) design an appropriate campaign for the characteristics and requirements of the target group; (iv) pre-test campaign materials and improve where necessary; (v) as the campaign is implemented, execute a comprehensive process evaluation; (vi) evaluate the campaign in terms of both short-term targets (such as sales of safety equipment or behavioural changes) and long-term goals (monitoring of accident data). Include also an economic assessment of the campaign. We suggest that some fundamental research be undertaken regarding consumer attitudes towards risk, and to investigate the process of risk communication and its application to home and leisure safety. We also believe that a catalogue of successful campaigns could serve as a useful tool for those designing future campaigns. In addition, it would be beneficial to undertake research into methodologies for valuing the costs and benefits of home and leisure activities with which accidents are associated. Provided that sufficient funding is available for comprehensive campaigns as described, we conclude that educational strategies for promoting home and leisure safety have the potential to be both economically efficient and effective, and are also likely to be found acceptable by the public at whom they are directed.

Soguel, N.C. (1995) Introduction to: N.G. Schwab-Christie & N.C. Soguel (eds.); *Contingent valuation, transport safety, and the value of life*. Kluwer, Boston.

Swaney, J.A. (1997) The basic economics of risk analysis. In V. Molak (ed.) *Fundamentals of risk analysis and risk management*. Lewis.

Tengs, T.O., Adams, M.E., Pliskin, J.S., Safran, D.G., Seigel, J.E., Weinstein, M.C., & Graham, J.D. (1995) *Five hundred life-saving interventions and their cost-effectiveness*. Risk Analysis, 15(3), 369 - 390.

Abstract: We gathered information on the cost-effectiveness of life-saving interventions in the United States from publicly available economic analyses. "Life-saving interventions" were defined as any behavioral and/or technological strategy that reduces the probability of premature death among a specified target population. We defined cost-effectiveness as the net resource costs of an intervention per year of life saved. To improve the comparability of cost-effectiveness ratios arrived at with diverse methods, we established fixed definitional goals and revised published estimates, when necessary and feasible, to meet these goals. The 587 interventions identified ranged from those that save more resources than they cost, to those costing more than 10 billion dollars per year of life saved. Overall, the median intervention costs \$ 42,000 per life-year saved. The median medical intervention costs \$19,000/life-year; injury reduction \$ 48,000/life-year; and toxin control \$ 2,800,000/life-year. Cost/life-year ratios and bibliographic references for more than 500 life-saving interventions are provided.

Thaler, R. & Rosen, S. (1976) The value of saving a life: evidence from the labor market. In N. Terleckyz (ed.): *Household production and consumption*. University Press.

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