Fire Research Report

The Value of Statistical Life for Fire Regulatory Impact Statements

BERL

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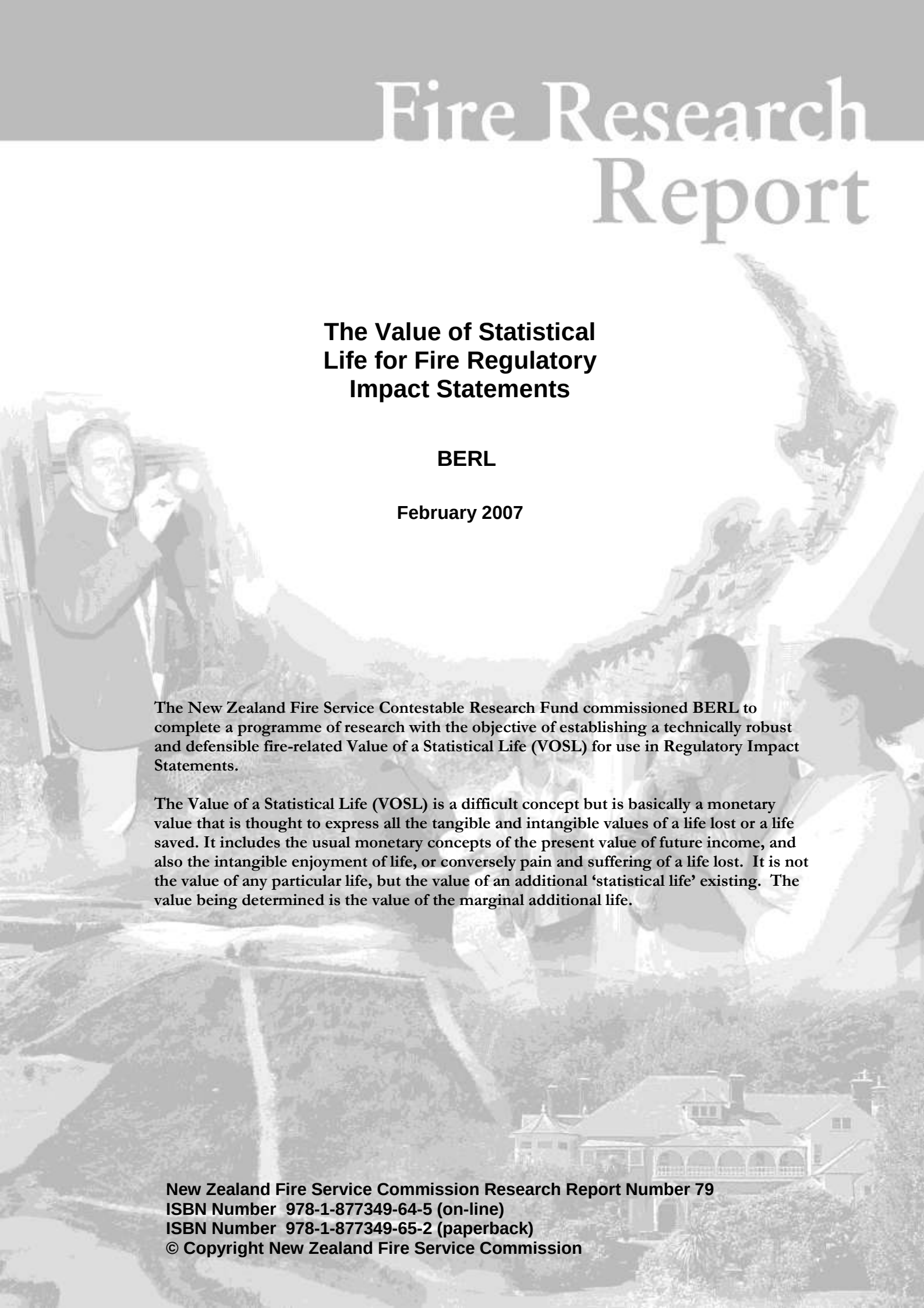

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THE VALUE OF STATISTICAL LIFE FOR FIRE REGULATORY IMPACT STATEMENTS

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The Value of Statistical Life for

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1 Executive summary

The New Zealand Fire Service Contestable Research Fund commissioned BERL to complete a programme of research with the objective of establishing a technically robust and defensible fire-related Value of a Statistical Life (VOSL) for use in Regulatory Impact Statements.

The Value of a Statistical Life (VOSL) is a difficult concept but is basically a monetary value that is thought to express all the tangible and intangible values of a life lost or a life saved. It includes the usual monetary concepts of the present value of future income, and also the intangible enjoyment of life, or conversely pain and suffering of a life lost. It is not the value of any particular life, but the value of an additional 'statistical life' existing. The value being determined is the value of the marginal additional life.

When measuring relativities between perceived values of VOSLs applied to lives lost from different hazards like fire and road hazards, the relativity therefore applies to the number of additional lives saved and not to a percentage of present deaths from each hazard that may be saved.

1.1 Methodology

The main stages in the methodology followed by BERL were to:

1. Review the considerable literature on the determination of VOSLs, and to assess these valuation methods in terms of their suitability for estimating a VOSL for use in fire regulatory impact statements in New Zealand. This assessment should include whether a stand-alone VOSL should be estimated for fire, or whether a relativity with the road VOSL should be determined;

2. Use information from an analysis of the empirical literature to provide an indicative range for the likely value of the fire VOSL in New Zealand;

3. Complete a survey based on our recommendations and following consultations with the New Zealand Fire Service Commission; and

4. Estimate a technically robust and defensible fire VOSL for use in fire regulatory impact statements in New Zealand from the survey findings.

1.2 Review findings

1.2.1 Recommended method of measuring a VOSL

The review of methodologies found that there are three main approaches to measuring a VOSL, these approaches being the human capital method, the revealed preference method, and the stated preference method. The human capital method does not measure intangible values and so will underestimate the economic value of reduced risk from death.

The revealed preference method relies upon values from wages in the labour market or prices in the final product/service markets, which imply a value that has been placed on increased occupational risk or increased product safety/performance. However, there are very few (if any) situations in these markets where there is a 'natural experiment' that reveals the full value that should be placed on reduced risk of fire fatalities.

The method assessed by BERL as most suitable for determining the VOSL for fire fatalities in New Zealand is the stated preference method using contingent valuation (CV) techniques. This is also the method that has been used for determining the road VOSL in New Zealand. It is the value of the additional (marginal) life saved or lost from the road hazard. It has become an accepted value and is widely used to assess regulatory impacts. This is particularly so for various transport regulatory impacts, but applies also in some health areas.

1.2.2 Purpose and approach to measuring New Zealand fire VOSL

The purpose for which the New Zealand fire VOSL is required is for fire regulatory impact statements. By definition these statements are likely to be used to justify public sector funding of certain fire activities, and therefore in comparison or competition with funding of other death-avoiding/life-saving activities in other sectors such as the transport sector.

For the fire VOSL to be fit for purpose it is therefore important that it be measured in a way that makes it directly comparable with the other VOSL in use for regulatory impact statements, namely the existing New Zealand road VOSL.

There are two possible approaches to measuring a fire VOSL in New Zealand and these are to determine a stand-alone fire VOSL or to determine the relativity of a fire VOSL to the existing road VOSL.

The existing road VOSL was determined by survey fifteen years ago and the value has been adopted in use across the transport sector and in some selected other applications. Our investigation of international studies indicates that the value is in the range to be expected from those studies. Also, in New Zealand the road VOSL has not attracted strong challenges and

this indicates that it is broadly accepted by society. A stand-alone fire VOSL could be determined by survey now and adopted in comparison with the 15 year-old, updated value of the road VOSL. If the fire VOSL was found to be different from the present value of the 15 year-old road VOSL there would be considerable room for discussion as to whether that difference was due to present day preferences between road and fire or not.

The differences between the old road VOSL and new fire VOSL could be argued to be due to:

- differences in survey methodology in the two surveys;
- differences in overall value of statistical life preferences between then and now;
- the method used to bring the road VOSL from 1991 values to present day values.

The second approach available to determine a value for a fire VOSL is to take the present, accepted present value of the road VOSL as a given, and to measure the present day relativity between that road VOSL and a fire VOSL. The relativity ratio can then be applied to the present value of the road VOSL to estimate the present value of the fire VOSL.

This method has the strong advantage that whereas there can be discussion as to the actual value of a fire VOSL, in this case the relativity between the fire VOSL and the road VOSL has been measured empirically at the present time and reflects present preferences. The fire regulatory impacts measured using this fire VOSL will thus be demonstrably comparable with road regulatory impacts measured using the existing road VOSL.

Therefore, we recommended to the New Zealand Fire Service Commission that we proceed with a survey to specifically measure the 'relativity' between a fire VOSL and the existing road VOSL in the New Zealand context.

1.2.3 Indicative range of values of New Zealand fire VOSL

The international literature contains a broad range of VOSL values across different risks; different measurement techniques; and for different populations. Unfortunately there are few estimates of fire VOSLs.

The values based on CV techniques are generally in a narrower range than those based on labour market revealed preference methods. From a number of studies, BERL found that the modal value for a VOSL was US$3.0 million to US$3.9 million, expressed in 2001 dollars. On this same basis, the New Zealand road safety VOSL is between US$1.7 million and US$ 2.4 million. In present day NZ$ terms, the New Zealand road VOSL is valued at $3.05 million.

Taking into account other factors such as relative risk of death related to each VOSL, it would appear that the existing NZ road VOSL is within the expected range. Although, arguably, it may be a fraction lower in that range than could be expected.

The implications from the literature are that the value of any particular VOSL will fall within a range. The actual level to be used in regulatory impact statements will then be selected within that range. That was so for the New Zealand road VOSL and also for the road and related VOSLs recently determined in UK.

This process is illustrated by the recent research on the road VOSL in UK. The existing road VOSL used by the Department of Environment, Transport and Regions (DETR) was £900,000. This was explored and confirmed in a substantial programme of work that then proceeded to develop relativities between the road VOSL and a fire VOSL (and others).

The research team found that survey-derived results .. *point towards a roads VPF (value of a preventable fatality or VOSL) in a range from about £500,000 (based on median responses) to between £1,000,000 and £1,600,000 (based on trimmed means)*. Following some judgement discussion the report concluded: *All things considered, any figure in the range £750,000 to £1,250,000 in 1997 prices could be regarded as broadly acceptable. This range clearly encompasses the current DETR roads VPF of some £900,000*.

Since there exists a New Zealand road VOSL, the need is to find the relativity between the road VOSL and a fire VOSL. There are again few studies of the relativity between road VOSLs and fire VOSLs. The one stand-out study is from the same programme of work in UK. From final phases of work in this programme, the VOSL for domestic fires was estimated to fall within the range of 0.84 to 0.93 times the road VOSL.

The risk preferences between the NZ and UK populations may differ, perhaps quite widely. The peoples' living environment is quite different as urban density is lower in New Zealand with presumably lower incidence of significant urban fires, and car ownership and usage in New Zealand is higher than UK, and public transport usage lower. The annual baseline risk of death from fire in New Zealand is about 0.1 per annum per 10,000 people and risk of death on the roads about 0.93 per annum per 10,000. Our reading of the UK raw data is that both of these risk rates are significantly lower in UK, with risk of death from fire about 0.05 per annum per 10,000 people and from road about 0.5 per annum per 10,000 people. This difference in baseline risk could well affect the relative preferences in each population.

Preferences are affected by a number of risk factors including perceptions of level of dread, and level of control or involuntariness in the cause of death. The considerations of people stating their relative preferences can be expected to be different in the two countries. There is evidence

from recent NZFS-funded research that 63% of New Zealanders agreed that most causes of serious household fires are within the householder's control. There is further NZFS-funded research analysing coroners' inquiries into unintentional residential fire deaths that found that in 50% of these deaths, those involved were agents in some capacity of fire ignition, and their deaths to some extent a consequence of their behaviours. Such behaviours included unattended cooking, careless smoking and unattended lit candles. Also 58 of the 131 deaths investigated (44%) had alcohol involved, with blood alcohol levels measured as above the legal driving standard of 80mg/100ml, indicating again presumably a contributing behaviour.

These coroners' inquiries are reported in the media, and so presumably New Zealanders' perceptions of risk of death from fire will take account of this degree of personal control in fire deaths, and presumably perceive that they can exercise this control. While there is a similar element of control for the at-fault driver in road deaths, there is the involuntary factor for others killed on the road. Since this risk of death is involuntary, and it is a higher level of death rate it could be perceived to present a greater potential personal risk. This could well increase New Zealanders' relative preference for preventing road deaths.

Therefore, although the general findings from the UK study are that their people expect the ratio between VOSLs for preventing deaths due to different risks to be not greatly different from one, we could expect the fire VOSL in New Zealand to perhaps be a somewhat lower ratio to the road VOSL than is the case in the UK. Nevertheless we would broadly expect the fire VOSL to fall in the range of 0.5 times to 1.5 times the road VOSL.

1.3 Estimates of New Zealand fire VOSL

BERL commissioned a survey firm (DigiPoll Ltd) to complete a survey of 750 people. The survey was based around the key question as follows:

Suppose that the Government could increase funding to safety programmes, which would result in 20 accidental deaths being averted per year. How many of these 20 lives would you prefer to be saved from reduced car accidents and from reduced residential fire accidents?

The sample of 750 people covered the range of demographics in the New Zealand population, and the responses for each demographic were weighted so the survey results are reflective of the whole New Zealand population. The headline results from the survey are that the 653 people who gave a priority for saving 20 lives indicated, on average, that 12.4 of those lives saved should be from car accidents and 7.6 from residential fire accidents. (The unweighted responses were that 12.35 of those lives saved should be from car accidents and 7.65 from residential fire accidents. This indicates that the weighting process has not significantly affected the overall average response.)

Taking account of the standard errors for this sample, there is a 95% probability that the population's stated preference for saving lives/averting deaths from car accidents would lie in the range 12.03 to 12.77. Similarly, there is a 95% probability that the population's stated preference for saving lives from fire accidents would lie in the range 7.23 to 7.97. This in turn implies that there is greater than 95% probability that the population's stated preference for saving lives from road accidents is significantly different from, and greater than the population's stated preference for saving lives from fire accidents.

The results of this survey have been explored statistically and no anomalies have been discovered. The survey demonstrates that the average relativity between the population's stated preference for saving lives from fire accidents is 61.3% of the value of saving lives from road accidents. There is a 95% probability that this relativity falls in the range 56.6% to 66.2% of the value of saving lives from road accidents.

In turn this means that the survey shows the New Zealand individuals perceive and state that the value of fire VOSL falls in the range 56.6% to 66.2% of the value of the road VOSL. Specifically, the relativity survey has shown that the value of an additional life saved from fire causes is perceived by the New Zealand public to be worth 56.6% to 66.2% of an additional life saved from road causes.

1.4 Judgement considerations

The consistency of the survey results are such as to give confidence that the population's fire VOSL relativity falls within this range. However it is possible that there is some externality or imperfection whereby the preference of the community or nation is different from the stated preference of individuals. In this case the true relativity between the fire VOSL and the road VOSL for all of New Zealand could fall outside the range determined by the survey of individuals.

The relativity determined by the survey of 56.6% to 66.2% is a somewhat greater differential than the relationship determined in the UK study. In the latter the VOSL for domestic fires was estimated to fall within the range of 84% to 93% of the road VOSL, and in their overall programme these UK researchers have concluded that "*the great majority of people do not favour rates of trade-off between preventing deaths from different hazards that are greatly different from 1:1.*"

As we discussed above, it is likely that the perceptions of people in New Zealand are somewhat different from those of people in the UK because of the lower risk of death from both causes, higher urban density in UK, with risk of fire events with multiple deaths, and the somewhat lesser car usage in UK. Within New Zealand the presumably known incidence of personal

behaviour and control in fire deaths and involuntariness in many road deaths may also shift preferences. These factors may, together lift the relative preference for saving lives from road in the New Zealand compared with in UK.

We also note that the sample in New Zealand who had the perception that a residential fire would be more likely than a car accident to kill a larger number of people in a single event was 31.8% (nearly one-third) of the respondents to that question. This 31.8% then had a preference for 8.6 lives to be saved from fire, namely 75% of the 11.4 road lives they wished to be saved. This may well imply that should awareness increase of the possibility of multiple death fires in New Zealand, which could happen if there was one such event, then the relativity preference of the general population for saving lives from fire could lift towards this 75%.

Taking these factors into consideration we suggest that there could well be some justification for expecting the true VOSL relativity to be high in the range as determined. The probability is 95% that it could fall anywhere in the range, and we therefore suggest that judgement indicates that the fire VOSL could be set at 66% or two thirds of the road VOSL in New Zealand.

1.5 Recommended VOSL for fire regulatory impact statements

The main finding from the survey is that the New Zealand population's stated preference for saving lives/averting deaths from fire accidents is 56.6% to 66.2% of the value of saving lives from road accidents. The value of the New Zealand WTP road VOSL is updated on a regular basis, and currently set at NZ$3.05 million expressed in present dollar terms.

BERL therefore recommends that the VOSL for fire regulatory statements be set in the range of NZ$1.7 million to NZ$2.02 million in 2006 prices. Judgement indicates that the fire VOSL in New Zealand be set at two-thirds of the road VOSL, namely $2.04 million in 2006 prices, and that this figure be revised with reference to the periodical adjustment in the value of the New Zealand road VOSL.

2 Critical overview of methods

BERL's research programme first involved an assessment of the full range of potential valuation methods rather than just the VOSL measure, which was then followed-up by an assessment of the range of techniques available to establish a specific and robust value for fire-related fatalities under the preferred method.

These assessments were based on a review of the literature (as provided in chapter 3) and discussions with experts in this field. Our key conclusions from these early stages of the broader research programme are outlined in the remaining sections of this chapter.

The next stage of BERL's research programme involved the preparation of a survey designed to elicit peoples 'relative preferences' in a similar manner to previous research undertaken in the UK as discussed in sections 2.5 and 3.3 The survey methodology, results, and findings are discussed in chapters 4 and 5.

2.1 The Value of a Statistical Life

The Value of a Statistical Life (VOSL) is a difficult concept but is basically a monetary value that is thought to express all the tangible and intangible values of a life lost or a life saved. It includes the usual monetary concepts of the present value of future income, and also the intangible enjoyment of life, or conversely pain and suffering of a life lost. It is not the value of any particular life, but the value of an additional 'statistical life' existing.

Although not usually mentioned in texts or papers dealing with the VOSL, the VOSL is a marginal concept. By the way it is measured it becomes clear that the VOSL is the value of the one marginal additional life lost or saved. This is certainly so for VOSLs measured as a stated preference. The person being interviewed at that time is stating preferences that relate to a life, and by inference probably the value of their life. The value being determined is the value of the marginal additional life.

The similar principle applies when measuring relativities between perceived values of VOSLs applied to lives lost from different hazards. The method of measurement ensures that we are measuring the relativity of additional lives saved. The relativity therefore applies to the number of lives saved and not a percentage of present deaths from each hazard that may be saved.

Another point to mention is that there is an alternative terminology that is gaining some currency and with a meaning synonymous to the VOSL. This term is the Value of Preventing a statistical Fatality, the VPF. This is used in particular by a UK group of researchers whose work is

referred to frequently in this report. They state that this term is arguably more appropriate and accessible.

The same VOSL is generally abbreviated to VSL in the US literature.

2.2 Potential methods of valuation

There are essentially three main types of methods that can be used to determine the value that people collectively place on saving a life or averting a fatality. These are known as the Human Capital (HC), revealed preference, and the stated preference methods.

The HC method calculates the present value of economic costs associated with fatalities including direct expenditure (e.g. hospital care) and lost present and future income. The HC method does not measure intangible costs of pain and suffering, or the loss of the quality of life. Thus, other methods that include monetised values for intangible impacts have an inherent conceptual advantage over the HC method.

The revealed preference method measures peoples' preferences by their 'real world' actions such as their willingness to pay for risk reduction (e.g. purchasing safer products) or to be compensated for increased occupational risk (e.g. via higher wages). Unfortunately, revealed preference methods do not tend to contain the depth of information required to calculate a robust VOSL for fire fatalities. And even in the case of specific product market analyses (e.g. household smoke alarms) the method will only likely generate a lower-bound estimate.

The stated preference method also has strong conceptual foundations based on welfare economics and in life-cycle utility theory. The method is also preferable to the HC method because it includes intangible costs, and to the revealed preference method because it is able to generate a VOSL that is directed specifically at fire fatalities rather than generic risk.

It is also BERL's view after reviewing the current international literature that 'best practice' is beginning to strongly favour the stated preference approach.

2.3 VOSL values across different mortality risks

There is little consensus in the literature about what factors have a bearing upon the peoples' Willingness to Pay (WTP) for mortality risk reduction, which in turn determines the size of the VOSL value. Much of the debate has centred on the influence of psychological/risk perception factors such as the level of control or involuntariness with respect to the nature of the risk, or the level of dread associated with the hazard.

Since the mid-1980s there have been Contingent Valuation studies reporting different VOSL values for different types of mortality risk. The underlying source of this difference remains a matter of debate, but may indeed reflect genuine differences in preferences between WTP for one mortality risk relative to another.

There is a large body of research carried out by various workers in the United Kingdom (UK) since the early 1990s, including Michael Jones-Lee, Graham Loomes, (the late) Jane Beattie, Judith Covey, Trevor Carthy, Susan Chilton and others. This group carried out pilot work moving to a Contingent Valuation survey to estimate a VOSL for road fatalities in 1997.

They went on to calculate VOSL values for rail, domestic fire, and public place fire risk based on a 'relativities' survey approach that elicited peoples' preferences for risk reduction in these areas relative to road risk. Their results indicated that a VOSL for domestic fire fatalities could range between 0.84 and 0.93 times the value of the VOSL for road fatalities.

This debate over whether or not there is a genuine difference in WTP for different mortality risks has been clouded by broader issues in this field of research. For example, the issue is not helped by the fact that there is a very large range of VOSL values in the international literature, and that VOSL values based on CV techniques can often have wide confidence intervals.

Our review of the literature indicates that VOSL values tend to fall within a range of about NZ$1 million to NZ$6 million although even substantial organisations such as the US EPA use a VOSL of NZ$10 million. The New Zealand road safety VOSL calculated in 1991 is an example of a with a relatively wide confidence interval. The mean value of $1.9 million reflected a range of between $1.4 million and $2.3 million, but nevertheless the single value adopted has been used quite widely and has not attracted strong challenges. This indicates that it is broadly accepted by society.

2.4 Purpose and approach to obtain a value for fire mortality in NZ

Our core assessment is that the preferred method for estimating a VOSL for fire fatalities in New Zealand is to adopt the stated preference (or Willingness to Pay) method using some form of Contingent Valuation technique. The question then arises as to whether to use this method to measure a stand-alone fire VOSL, or to measure the relativity with the existing road VOSL.

The purpose for which the New Zealand fire VOSL is required is for fire regulatory impact statements. By definition these statements are likely to be used to justify public sector funding of certain fire activities, and therefore in comparison/competition with funding of other public sector activities including death-avoiding/life-saving activities in other sectors such as the transport sector.

For the fire VOSL to be fit for purpose it is therefore important that it be measured in a way that makes it directly comparable with the other VOSL in use for regulatory impact statements, namely the existing New Zealand road VOSL. At first glance it could seem preferable to generate an entirely new VOSL value specifically for fire fatalities. The New Zealand Fire Service Commission and other users of such a VOSL could be fully confident of the veracity of the method used to estimate the VOSL for fire-related uses. However this approach would not necessarily deliver a fire VOSL that is comparable with the road VOSL.

The existing road VOSL was determined by survey fifteen years ago and the value has been adopted in use across the transport sector and in some selected other applications. Our investigation of international studies indicates that the value is in the range to be expected from those studies. Also, in New Zealand the road VOSL has not attracted strong challenges which indicates that it is broadly accepted by society. A stand-alone fire VOSL could be determined by survey now and adopted in comparison with the 15 year-old, updated value of the road VOSL. If the fire VOSL was found to be different from the present value of the 15 year-old road VOSL there would be considerable room for discussion as to whether that difference was due to present day preferences between road and fire or not.

The differences between the old road VOSL and new fire VOSL could be argued to be due to:

- differences in survey methodology in the two surveys;
- differences in overall value of statistical life preferences between then and now;
- the method used to bring the road VOSL from 1991 values to present day values.

The second approach available to determine a value for a fire VOSL is to take the present, accepted value of the road VOSL as a given, and to measure the present day relativity between that road VOSL and a fire VOSL. The relativity ratio can then be applied to the present value of the road VOSL to estimate the present value of the fire VOSL.

This method has the strong advantage that whereas there can be discussion as to the actual value of a fire VOSL, in this case the relativity between the fire VOSL and the road VOSL has been measured empirically at the present time and reflects present preferences. The fire regulatory impacts measured using this fire VOSL will thus be demonstrably comparable with road regulatory impacts measured using the existing road VOSL.

Therefore, we recommended to the New Zealand Fire Service Commission that we proceed with a survey to specifically measure the 'relativity' between a fire VOSL and the existing road VOSL in the New Zealand context. This will provide greater confidence in the fire-related VOSL value, and explicitly ensure complementarity with the road safety VOSL.

2.5 Methods to determine a relativity between fire and road

A number of potential methods for calculating the relativity between fire and road mortality risk were considered by BERL in its review stage. For example, it appears that a similar approach is regularly adopted in the U.S. where it is termed 'benefits transfer'. However, it appears to have met with limited success in the U.S. as the key challenge has been to find an appropriate scale factor that is relevant to the various risks being assessed and the factors that influence them.

One potential method that was initially considered by BERL was 'disability weights' as are used in the construction of health status indices such as DALYs and QALYs. These weights measure social preferences for a specified health state. For instance, the disability weights used in the Ministry of Health's publication *The Burden of Disease and Injury in New Zealand* (2001) came from Stouthard (1997). In this instance the disability weights were derived using a person trade-off methods (the raters' being panels of health professionals and lay people). Thus, these weighs have the strength of being based on a stated preferences methodology.

However, our review of the literature and communications with others in this field (e.g. Des O'Dea *pers comm.* 2006) have led us to the conclusion that disability weights offer a potential scale factor but only as a broad-check of the magnitude of any VOSL relativity that is established through primary research. Disability weights are also only one-dimensional (e.g. health status) and thus would not allow for other potentially important factors such as psychology and risk perception factors to enter into the determination of relativity.

BERL's preferred method of establishing the relativity between fire and road accidents was to adapt a 'matching questions' approach developed by the UK team referred to as Chilton S, Covey et al (2002) and discussed in detail in section 3.3. Essentially, these matching questions seek to establish the number of fatalities in one context whose prevention the respondent would regards as being 'equally as good' as the prevention of a given number of fatalities in another context over the same period and at the same cost.

BERL's reasons for adapting this methodology included that:

- it was applied to generate relative valuations for exactly the same purposes as we require (i.e. from a WTP estimated road VOSL to a domestic fire VOSL);
- it allows for a range of factors (including psychological and risk perception factors) to play a role in determining the fire-road relativity;
- it was been developed and tested by a large group of eminent authorities in the field, and has had significant piloting to refine the approach; and

- by following their general approach, we can generate relativities that could also be compared with those obtained in similar context in the UK.

The quantitative stage of BERL's research programme involved the preparation of a survey designed to elicit people's relative preferences. The survey methodology, results, and findings are discussed in chapters 4 and 5.

3 The Value of Statistical Life measure

This chapter provides a review of the international literature on the VOSL measure and on related methods for establishing a VOSL for fire-related fatalities. This review helped guide BERL's decision to progress with the research programme by using a survey approach to directly elicit people's stated preferences.

3.1 Potential methods for valuing loss of life

There are essentially three main types of methods that can be used to determine the value that people collectively place on saving a life or averting a fatality. These methods are the:

1. Human Capital method;
2. Revealed preference methods; and
3. Stated preference methods.

The Human Capital method calculates the present value of economic costs associated with fatalities including direct expenditure (e.g. hospital care) and lost present and future income. The Human Capital method does not measure intangible costs of pain and suffering, or the loss of the quality of life.

The revealed preference method measures peoples' preferences by their 'real world' actions such as their willingness to pay for risk reduction (e.g. in purchasing safer products) or to be compensated for increased risk (e.g. through higher wages).

The stated preference method applies Contingent Valuation (CV) techniques that involve directly asking a representative sample of people their willingness to pay for improved safety (or for reduced risk) under a specified scenario or set of scenarios. And sometimes the CV technique involves asking people their willingness to accept compensation for increased risk.

3.1.1 The Human Capital method

The Human Capital (HC) method does not result in a VOSL as such but calculates the economic cost of fatalities in terms of direct expenditure (e.g. hospital care) and lost present and future income. An overview of the HC method and related approaches is provided in a previous BERL report entitled 'Measuring the Total Cost of Injury in New Zealand: a Review of Alternative Cost Methodologies'. TriData Corporation also provide an example of the HC method in practice in their report to the U.S. Department of Commerce on 'The Economic Consequences of Firefighter Injuries and their Prevention'.

The HC method has a strong appeal because it is grounded in actual cost data and earnings projected into the future. What it does not measure is the intangible costs of pain and suffering or loss of quality of life, or life itself. This can make a significant difference to the size of the value of life. Miller and Guria (1991) compared their new VOSL measure to the HC measure estimated Brown, Copeland (1986) that was prevailing in New Zealand at the time. Miller and Guria stated that these "human capital costs are embarrassingly conservative. The current value of $235,000 is an eight of the $2,000,000 value from our market research."

The HC method could be a sound basis for estimating the monetised cost of injury, and for that, specific attention would have to be paid to labour market changes in behaviour, and the selection of an appropriate discount rate. In the last six years or so the labour force participation rate in mature age groups has increased strongly, especially females over 30 years and all people aged over 55 years. Measurement of the HC method by techniques such as micro-simulation would have to project these behaviour changes forward. Also the discount rate applied by most agencies (including The Treasury) during the 1990s has been 10%. This is considerably higher than the 'social' or 'public' discount rates used in many comparable jurisdictions, and is being subject to scrutiny, or in fact reduced in some uses in New Zealand. (The higher discount rate significantly penalises expected future earnings, and may be one reason why the Brown, Copeland estimate was so low.)

While the accuracy of the HC method can benefit from incorporating these factors and from improved labour market data, it is still only able to quantify already monetised values. It does not measure or take account of the intangible costs of changes in the quality of life, the pain and suffering, or the lost joy of living of those directly or indirectly involved in the fatality. The omission of intangible costs can be a significant omission, and our experience indicates order-of-magnitude increases above the HC estimate when intangible costs are included.

To be more succinct, other methods that include or incorporate monetised values for intangible impacts have an inherent conceptual advantage over the HC method.

3.1.2 Revealed preferences method

The revealed preference method measures peoples' preferences by their 'real world' actions such as their willingness to pay for risk reduction (e.g. in purchasing safer products) or to be compensated for increased risk (e.g. through higher wages). The main sources of data are the labour market; housing and product markets; regulatory applications, and the Courts.

Labour market methods use income data obtained from large samples (such as the Census or administrative data) and relative risk factors indicated by mortality rates in different occupations. Econometric analyses are then conducted to attempt to ascribe values of the amount people are

willing to pay (in terms of reduced income levels) to achieve reduced risk of death at work. This wage-risk ratio is used to generate a VOSL as revealed by peoples' actions in the labour market and the wages they require to accept higher-risk or lower-risk jobs.

A similar approach is taken with product markets methods where different products have a different known risk level, and therefore can be shown to command measurable price premia or discounts. These analyses include preferences revealed by purchasing decisions in relation to automobiles, etc.

A specific case is the safety product market, representing a small set of consumer goods whose exclusive purpose is to provide protection from harm (e.g. safety helmets). These products provide an opportunity to measure specifically the cost of achieving a given risk-reduction, however, there is a relatively small number of such products and fewer analyses of them.

Perhaps the most comprehensive work on revealed VOSLs is the work by W K Viscusi and co-workers, whose critical review in Viscusi and Aldy (2003) covers the main sources of revealed VOSLs and values of statistical injuries. He reports on 60 studies of mortality risk premiums, and 40 studies of injury risk premiums.

This gives a useful framework and orders-of-magnitude for comparison with the stated preference methods. Most of the studies reported on in Viscusi and Aldy (2003) are also included in the meta-analysis of studies tabulated by Neumann J et al (2001). This tabulation allows some comparison of parameters as between VOSLs generated by Revealed Preference methods and those estimated by Stated Preferences, mainly Contingent Valuation (CV). The Neumann J et al (2003) tabulation is shown at Appendix 1 below.

A major problem with revealed preference methods based on product market analyses (e.g. purchases of smoke detectors) is that they reveal only the lower bound on the willingness to pay to reduce a risk, because they are discrete choices rather than a continuum of price-risk reduction opportunities.

Willingness to pay estimates based on wage equation analyses are also technically difficult to complete comprehensively, and would not provide the depth of information required in this instance (e.g. in relation to fire risk). There are few such studies that have included fire-risk (apart from two studies of the market for smoke detectors discussed later), we have not found studies that show revealed preferences of a willingness to pay for reduced fire risks.

In summary, most revealed preference methods would not contain the depth of information required to calculate a robust VOSL for fire fatalities. Even in the case of specific product market

analyses (such as with the purchase of household smoke alarms) the revealed preference method will only likely generate a lower-bound estimate.

3.1.3 Stated preference method

The stated preference method applies Contingent Valuation (CV) techniques that involve directly asking a representative sample of people their willingness to pay for improved safety (or for reduced risk) under a specified scenario or set of scenarios. And sometimes the CV technique involves asking people their willingness to accept compensation for increased risk.

The CV technique generates scenarios of risk to be described to respondents, and the WTP approach asks them the amount they would be willing to pay for an intervention that would reduce the risk by a known amount. The WTA approach asks them how much they would be willing to accept as compensation for being subjected to the unmitigated risk.

Most CV technique studies have used the WTP approach but it is important to consider the WTA approach when assessing approaches most appropriate to estimate a fire-related VOSL for New Zealand. In New Zealand the road safety VOSL was determined first in 1991 (based on a survey in 1989/90) using the WTP approach. The main author of this work, Jagadish Guria, then carried out a survey using the WTA method in 1997/98, and worked with other authorities to generate WTA-based values in a 2003 report.[1]

The WTA-based VOSL was found to be three to five times the WTP-based value.

There is clearly room for debate on the use of WTA-based VOSL, as indicated by the fact that although this survey was completed in 1997-98, the value derived has not been accepted as the VOSL in common usage. There is apparently also debate among the authorities as to the relationship between VOSLs measured by WTP surveys and those measured by WTA surveys. The US authority Kip Viscusi holds that WTP VOSLs should have the same values as WTA VOSLs, but Guria maintains that they are measuring different values that people hold. (Guria J Pers. Comm. (2006)).

The updates of the WTA-based VOSL are still published by Ministry of Transport at three times the WTP VOSL value. However the WTP-based value is the one in general use in New Zealand, and so is the logical value on which to base relative fire-related VOSLs.

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[1] Guria, J, Jones W, Jones-Lee M, Keall M, Leung J, and Loomes G (2003) *The value of Statistical Life and Prevention of Injuries in New Zealand*. Wellington: Draft Report, Land Transport Safety Authority.

Overall, the stated preference method is preferable to the HC method, because it includes intangible costs, and to the revealed preference method because it is able to generate a VOSL that is directed specifically at fire fatalities rather than generic risk.

The stated preference method also has strong conceptual foundations based on welfare economics and in life-cycle utility theory, as discussed in the next section. It is also BERL's view after reviewing the international literature that 'best practice' is beginning to strongly favour the stated preference approach.

3.2 Theory and evidence on the VOSL

The Value of Statistical Life (VOSL) or the Value for the Prevention of Statistical Fatality (VPF) is a convenient way to summarise the value of small reductions in mortality risks. The VOSL is not meant to be applied to the value of saving the life of an identified person but is used as an economic value for use in public policy and regulation. In very simple terms:

$$\text{The value of risk reduction} = \frac{\text{Willingness to pay for risk reduction}}{\text{Amount of risk reduction}}$$

For example, suppose a person is willing to pay $10 to reduce the risk of death to 1 life in 1 million lives from 5 lives in 1 million lives (i.e. a 4 in 1 million risk reduction). The VSL is then calculated as $2.5 million. The amount that the person is willing to pay is often termed the 'auction price', which represents the maximum a person is willing to pay that keeps them indifferent between the gamble and the next best alternative.

The amount that people are Willing to Pay (WTP) can be estimated from the revealed value of real world choices made by people in market settings (e.g. wage rates for jobs with higher risk levels) or by asking people about their stated preferences.[2] In BERL's view, the international literature is beginning to favour these stated preference methods.

[2] A more detailed discussion of WTP based on revealed and stated preferences can be found in BERL (2002) or Kuchler (1999).

The WTP approach has gained momentum in the risk reduction literature because it is based on the utility theory of welfare economics. Krupnick (2001) notes "welfare economics, in particular the life-cycle utility model, lies at the heart of the theoretical modelling"[3].

However, it would be wrong to conclude that there is a consensus in the literature when it comes to what factors have a bearing on WTP in the field of mortality risk reduction. Table 1 lists some the main factors that are thought to have an influence on WTP for risk reduction. Krupnick, the original author of this table, notes that there is no universally accepted list.

Table 1 Influences on WTP and VOSL estimates

Elements	Features
Nature of risk	Mortality/morbidity: - symptom type - severity - frequency - jointness Disease qualities: - dread - controlability - etc
Risk change	Baseline Timing Size
Population characteristics	Health status Age Income Education Race
Other	Public versus private good Altruism Avoidence possibilities Causal agent

Source: Krupnick (2001)

Many of the factors listed in the table above can vary depending on the type of mortality risk being investigated, and this suggests that the populations WTP (and consequently the size of the VOSL) may also vary according to the type of mortality risk. This theme has been a matter of considerable debate within the literature.

Empirical studies of WTP for mortality risk reduction in different areas have been undertaken since the mid-1980s at least. For example Jones-Lee (1985) reported a significant premium for

[3] Page 96, Krupnick (2001).

heart disease and cancer relative to motor vehicle accidents. However, despite this extended length of time, there is surprising little consensus in the literature.

Much of the debate centres on the impact of underlying psychological factors (such as peoples' perception of 'dread' hazards, and the influence of control/involuntariness) upon VSL values. For example, Jones-Lee (1995) report that VOSL values for public transport modes such as the London Underground should be set at a substantial premium in relation to their roads counterpart.

They state "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".[4] By the same token, Massen (2000) notes that domestic fires may be regarded as less 'involuntary' than say air pollution insofar as they greatly depend on the actions of the individual.

Vassanadumrongdee (2005) draws a comparison between air pollution and road accidents with the conclusion that "WTP to reduce air pollution risk is influenced by degrees of dread, severity, controllability and personal exposure, while WTP to reduce traffic accident risk is influenced by perceived immediate occurrence. Nevertheless, the value of a statistical life (VOSL) for both air pollution and traffic accidents are comparable (US$0.74 to $1.32 million and US$0.87 to $1.48 million, respectively)".[5]

Covey (2001) makes an interesting contribution in suggesting that some of the difference in relation to 'dread' incidents, public passenger transport, etc, could be due to people believing that a higher number of deaths is an indicator that more people are likely to be exposed to that hazard. More generally, there appears to be much more agreement in the literature in relation to other risk factors. In summary, hazards with low baseline risks are more difficult to measure accurately, and it may be inappropriate to transfer (or scale up/down) VOSL values from one hazard to another when risks factors are substantially different.

There has been an ongoing body of research carried out by various workers in UK since the early 1990s, including Michael Jones-Lee, Graham Loomes, (the late) Jane Beattie, Judith Covey, Trevor Carthy, Susan Chilton and others. This group carried out pilot work moving on to a survey to estimate a WTP-based roads VOSL (or VPF) using the CV/'standard gamble' (SG) chained approach in October-November 1997. They then did pilot work moving on to a

[4] Page 184, Jones-Lee (1995)

[5] Page 261, Vassanadumrongdee (2005)

'relativities' study in October-November 1998. This relativity study had the objective of determining the value relative to preventing car driver/passenger deaths, of preventing deaths in domestic fires; of preventing rail passenger deaths; and preventing deaths in fires in public places.

The results from these studies are discussed in some detail in section 3.5. However, generally speaking, the results indicated that a VOSL for domestic fire fatalities could range from 0.84 to 0.93 times the value of the VOSL for road fatalities. They conclude "the great majority of people do not favour rates of trade-off between preventing deaths from different hazards that are greatly different from 1:1." They also note the "impact of perceptions upon the trade-offs between preventing deaths in different hazard contexts was a good deal less pronounced than has been suggested by the value differentials that are currently implicit-and in some cases, explicit-in public policy making."

Nevertheless perceptions play a significant part in tradeoffs by individuals and communities.

Finally, a large part of the empirical literature on WTP is devoted to assessing differences in VOSL values due to the methodology employed. Blajaeij et al (2000) concludes "the magnitude of estimates of the VOSL depends on the research method, as there is a significant difference between stated and revealed preference studies. (The analysis) also shows that VOSL estimates cannot simply be averaged over studies, as the magnitude of a VOSL estimate is directly related to the initial level of risk to be caught up in a fatal traffic accident as well as the risk decline implied by the research set-up"[6].

Perhaps the most comprehensive work on revealed VOSLs is the work by W K Viscusi and co-workers. His critical review in Viscusi and Aldy (2003) covers the main sources of revealed VOSLs and values of statistical injuries. The main sources of estimates are the labour market; housing and product markets; regulatory applications; and the Courts. He reports on 60 studies of mortality risk premiums, and 40 studies of injury risk premiums. This gives a useful framework and orders-of-magnitude for comparison with the preferred CV estimates.

3.3 VOSL relativities in the United Kingdom

Our review of the literature indicates that there has been an ongoing body of work carried out by various workers in UK since the early 1990s, including Michael Jones-Lee, Graham Loomes, (the late) Jane Beattie, Judith Covey, Trevor Carthy, Susan Chilton and others. This group carried out pilot work moving on to a survey to estimate a WTP-based roads VOSL (or VPF)

[6] Page 1, Blajaeij (2000).

using the CV/'standard gamble' (SG) chained approach in October-November 1997. They then did pilot work moving on to a 'relativities' study in October-November 1998. This relativity study had the objective of determining the value relative to preventing car driver/passenger deaths, of preventing deaths in domestic fires; of preventing rail passenger deaths; and preventing deaths in fires in public places.

The initial study was followed in January-February 2000 to test for any effects on the relativities as a result of the Ladbroke Grove rail accident in October 1999 in which there were 29 passenger fatalities. This overall programme of work is described in a number of publications including Valuation of Benefits and Health Safety Control : Final Report (Carthy T, Chilton S et al ,2000); Valuation of Benefits of Health and Safety Control : Follow-up Study (Burton T, Chilton S, Covey J et al, 2001); and Public Perceptions of Risk and Preference-based Values of Safety (Chilton S, Covey J, Hopkins L, Jones-Lee M et al, 2002).

This body of research has strong relevance to this present report because:

Firstly research in cognitive psychology and economics strongly suggest that considerations of voluntariness, control, dread, etc, which may enter into the public's perception of risk will mean that preference-based VOSLs may not be automatically transferable between different contexts. There may be a premium or discount between say, fire and roads, and for policy purposes it is important to establish whether such premia (or discounts) exist.

The second reason for the relative valuation work was that in contexts such as rail and fires in public places there are comparatively low baseline levels of risk, and this would render direct estimation of WTP-based VOSLs for such contexts problematic and prone to error.

The approach was to estimate a relative valuation ratio between, say, domestic fires and roads, and combine this with the absolute estimate of the roads VOSL in order to arrive at an indirect estimate of the domestic fires VOSL. This method is potentially valuable as an approach to developing fire-related VOSLs in New Zealand and so we outline the methodology in more detail.

A methodology generally called 'Matching question' or 'equivalence question' was used to estimate the relative valuation ratios for domestic fires, rail and public fires all relative to roads. Essentially, these questions sought to establish the number of fatalities in one context whose prevention the respondent would regard as being "equally as good as" the prevention of a given number of fatalities in another context over the same forthcoming period and at the same cost. Notably, this approach is similar in principle to the "person trade-off" technique that has been advocated as a way of estimating the relative values of different health care interventions (Nord, 1992).

In generic form, the key matching question put to respondents to elicit their preference-based values of safety for rail, domestic fires and fires in public places-relative to the corresponding value for roads-was as follows:

Suppose that there were some extra money available to spend on safety improvements, and suppose this money could either be spent in a way that would prevent 10 deaths from cause X during the next few years, or else could be spent in a way that would prevent 10 deaths from cause Y during the same period. Given that there is only enough extra money at present to undertake one of those programs, do you have a preference about where the money should go? And if so, how many deaths would the other program have to prevent in order for you to consider both programs to merit equal priority?

In turn, suppose that the respondent indicates that the programs would merit equal priority when the safety improvement for cause X would prevent 10 deaths, while that for cause Y would prevent 15. The value of preventing a death by cause X would then be taken to be 1.5 times the value of preventing a death by cause Y.

In that case 10 deaths from cause X are taken to match 15 deaths from cause Y, and so the relative valuation ratio for cause X were taken as 1.0, the relative valuation ratio for cause Y would be 1.0*(10/15) or 0.67.

As such, these matching questions are clearly, in a very real sense, "first cousins" to the "risk-risk" tradeoff questions employed in the study reported in Viscusi, Magat, and Huber (1991). However, while risk-risk questions involve an explicit tradeoff of risk in one context against risk in another, matching questions focus on the tradeoff between the number of deaths prevented in one context relative to the number prevented in another. They are in a sense a 'willingness to pay' for saving a number of deaths in one context, as equivalent to saving a different number of deaths in another context with the same payment.

3.4 The New Zealand road safety VOSL

The value of VOSLs used in New Zealand were generated by the Land Transport Safety Authority (LTSA) from studies published in 1991 (the WTP study), and in 2003 (the WTA study), using international best practice, namely Contingent Valuation (CV). . The value of the road safety VOSL in New Zealand was initially established at $2 million in 1991, following the WTP survey carried out during 1989/90 by Jagadish Guria of the LTSA. This estimate is indexed to average hourly earnings (ordinary time) to express the value in current prices The value of the

WTP VOSL at June 2006 prices has been updated by Ministry of Transport to be NZ$3.05million per fatality at June 2006 prices.[7]

The VOSL is used by the transport-related organisations namely Land Transport NZ, Transit NZ, Civil Aviation Authority, and Maritime Safety Authority.

In addition it has been used directly, and as a base for estimating the value of a statistical life year by other organisations, or in other uses. For example it is being used in an economic impact assessment of health effects of pollution levels in Christchurch (2004). It is incorporated in the Ministry for the Environment *Proposed National Environmental Standards for Air Quality* (2004). In a study completed for the Ministry of Health on an Economic Valuation of the Quitline Nicotine Replacement Therapy (2004) it was used as the basis for estimating the value of a statistical life year.

In New Zealand the road VOSL has not attracted strong challenges, which indicates it is broadly accepted by society. The acceptance of this road VOSL in a number of regulatory contexts for impact statements and assessments makes it a sound basis from which to measure the relativity of a VOSL for fire regulatory impact statements.

3.4.1 NZ road safety VOSL relative to a fire VOSL

We have noted above that it could be possible to determine a stand-alone fire VOSL , or to determine the relativity between a fire VOSL and the present road VOSL.

The purpose for which the New Zealand fire VOSL is required is for fire regulatory impact statements. By definition these statements are likely to be used to justify public sector funding of certain fire activities, and therefore in comparison or competition with funding of other public sector activities including death-avoiding/life-saving activities in other sectors such as the transport sector.

For the fire VOSL to be fit for purpose it is therefore important that it be measured in a way that makes it directly comparable with the other VOSL in use for regulatory impact statements, namely the existing New Zealand road VOSL.

[7] Ministry of Transport (2006). The Social Cost of Road Crashes and Injuries June 2006 Update.

There are a number of uncertainties that could be levelled at a fire VOSL determined in a survey today, used in comparison with the road VOSL determined in a survey fifteen years ago. (See section 2.4). We were advised that there could also be some statistical questions raised around the confidence intervals of the two VOSLs.

We have therefore adopted the method of determining by survey the present day preferences and thus relativity ratio between fire and road VOSLs. This method has the strong advantage that whereas there can be discussion as to the actual value of a fire VOSL, in this case the relativity between the fire VOSL and the road VOSL has been measured empirically at the present time and reflects present preferences. The fire regulatory impacts measured using this fire VOSL will thus be demonstrably comparable with road regulatory impacts measured using the existing road VOSL.

3.4.2 Scaling from the road VOSL to the fire VOSL

Given the difficulties of obtaining demonstrably comparable measures of the VOSL on a stand-alone basis, we wish to now test whether it is feasible to scale the fire VOSL from the road VOSL in New Zealand.

There appears to be some agreement in the literature about the importance of baseline risk in determining the level of the value of the VOSL. There is also the general acceptance that assessing the WTP for mitigating hazards with low baseline risks are more difficult to measure accurately. For this reason it may be thought inappropriate to transfer (or scale up/down) VOSL values from one hazard to another when the risks factors for the two hazards are substantially different.

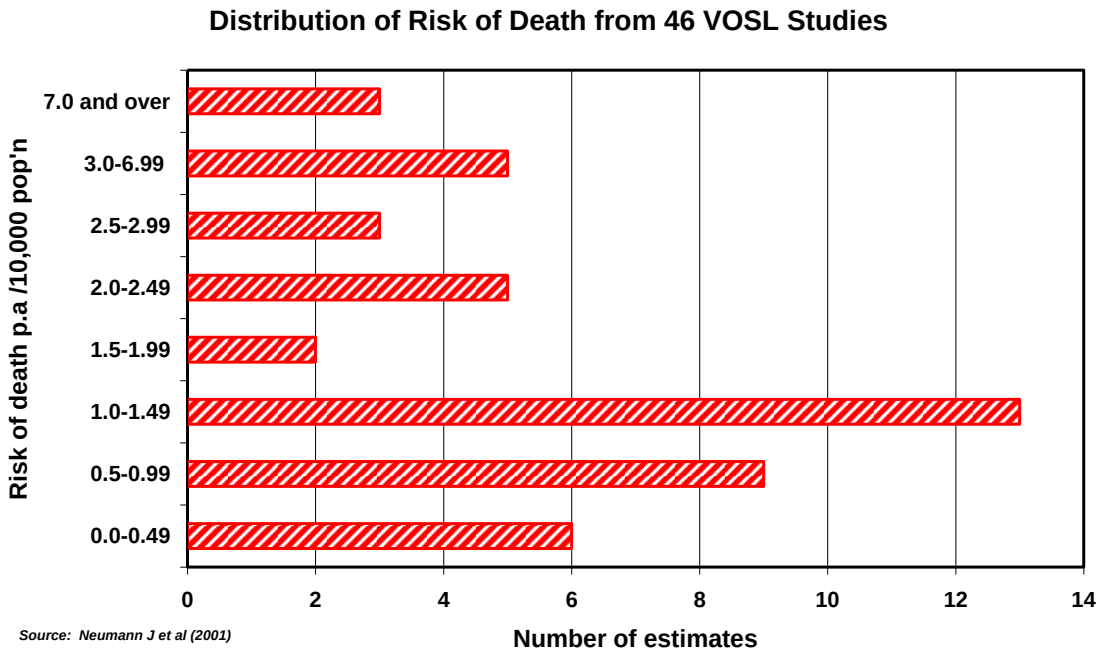
To test whether it is feasible and desirable to generate scale factors or ratios to derive the fire VOSL from the existing WTP road safety VOSL, it is therefore useful to explore the relative level of baseline risks. We do note in advance that there is no guide in the literature as to what constitutes 'substantially different' risks between two hazards.

Deaths on the roads in New Zealand are declining and the 387 deaths in 2006 was equivalent to a baseline risk of death on the roads of 0.93 per 10,000 people. (This contrasts with the baseline risk of death on the roads in New Zealand when the road safety VOSL was estimated in 1991 as given by Miller and Guria (1991) of about 2.1 per 10,000 people.)

On the other hand the average annual risk of fire deaths was 0.1 per 10,000 people over the five-year period 1997-98 to 2002-03.

The indication is that it would be inappropriate to scale-up or scale-down a VOSL from one context to another if these numbers were at opposite extreme ends of the range of annual risks

of death. The annual risk of death was one of the characteristics of the 60 studies described and tabulated in the paper by Neumann J, Leggett C, Penumalli P (2001). They are included in the table reproduced in the Appendix, and we have generated a bar chart to show the distribution of the level of risk of death per annum per 10,000 people in the population for those 46 studies that recorded this information.



The table in the Appendix shows that the annual risk from these studies fell within the range 0.02 deaths p.a./10,000 to 123 deaths p.a./10,000 people. The highest risk of death is thus over 6,000 times the lowest risk of death recorded in these studies. Ignoring the one highest figure of 123 per 10,000, the next highest recorded was 11 deaths per 10,000 people and this risk is 550 times the lowest risk of death recorded. The New Zealand figures for risk of death by road (0.93) is just nine times the risk of death by fire (0.1) and so these risks of death are clearly not at the opposite extreme ends of the overall range of risk of death. In fact they are both low in the range, and in adjacent size classes on this chart, both below the modal range of 1.0 to 1.49 per 10,000 people.

A further indication from the literature as to whether these risks are so 'substantially different' as to preclude scaling from road VOSL to fire VOSL comes from the UK situation. Our reading of the UK raw data is that the risk of death from fire is about 0.05 per annum per 10,000 people and from road about 0.5 per annum per 10,000 people. The road risk is thus apparently ten times the fire risk, and the large body of research by a large, respected research team has focused its efforts on measuring the relativity between the road VOSL, and the fire (and other)

VOSLs. This leads us to the presumption that the risks are not seen to be substantially different by this research team. It would therefore appear to be reasonable in New Zealand to similarly determine the relativities between the stated preference for road and fire, and then to obtain an estimate of the value of the fire VOSL by scaling up or scaling down from the value of the road VOSL.

3.4.3 Value of NZ road safety VOSL in context

As we have noted there is a very large number of studies estimating VOSLs, and some idea of the range of values derived is given by a tabulation of the values from a number of meta-analyses. These meta-analyses were described and main characteristics tabulated in the same paper by Neumann J, Leggett C, Penumalli P given to a US EPA workshop in 2001. The characteristics are shown in the table below.

Summary of VSL Average Estimates from Literature Reviews
Source: Neumann J, Leggett C, Penumalli P. USEPA (2001) p 80

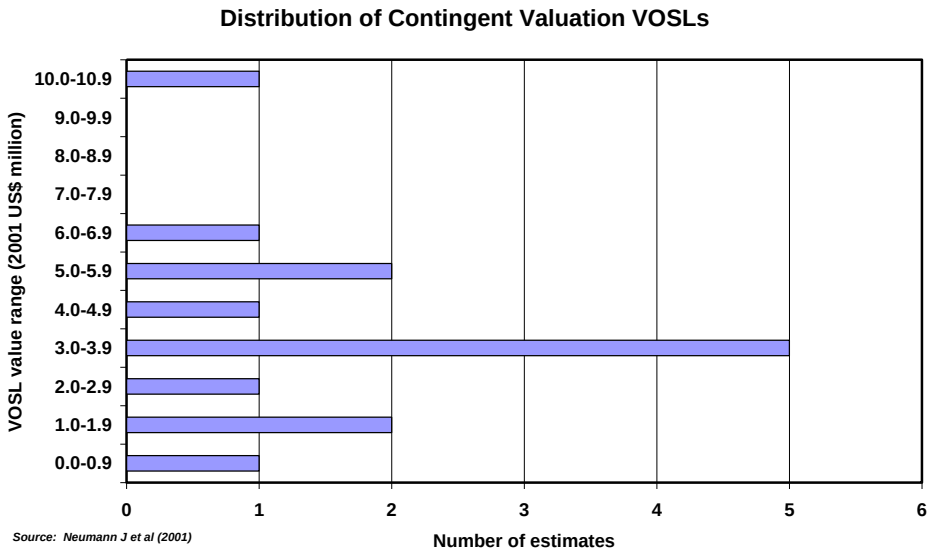
Study	Type of Review	Types of Studies Included	Recommended VSL *(millions of January 2001 $s)*	Comments
Fisher et. Al (1989)	Narrative	WR, CV, CM	$2.6 to $13.6	Excludes consumer market studies in developing a recommended range for VSL.
Miller (1990)	Narrative	WR, CV, CM	$3.30	Adjusts VSL estimates for age, risk perceptions, taxes, and other factors.
Viscusi (1993)	Narrative	WR, CV, CM	$4.0 to $9.4	Excludes consumer market and contingent valuation studies in developing a recommended range for VSL.
Desvousges et al. (1995)	Meta-Analysis	WR	$4.10	Uses compensating differential (rather than VSL) as dependent variable.
Takeuchi (2000)	Meta-Analysis	CV	No overall estimate	Uses willingness to pay (rather than VSL) as dependent variable. Uses multiple estimates from each study.
Miller (2000)	Meta-Analysis	WR, CV, CM	$4.30	Assumes best practice study is wage-risk study in obtaining recommended VSL estimate. Adjusts wage-risk VSLs down to obtain after-tax estimates.
Kochi et al. (2001)	Empirical Bayesian Meta-Analysis	WR, CV	$6.40	Estimation approach incorporates precision of VSL estimate. Uses multiple estimates from each study. Excludes studies conducted in developing countries.
Mrozek & Taylor (2001)	Meta-Analysis	WR	$2.10	Uses multiple estimates from each study. Assumes best practice study includes industry dummies and use BLS data (rather than NIOSH data).

Note: WR = Wage-risk, CV = Contingent valuation, and CM = Consumer market

Many of the individual studies have been done in the US, and have included a dominance of Wage-risk econometric revealed preference studies. Nevertheless most of the Meta-study groupings included also consumer market revealed preference studies, and contingent valuation, stated preference studies.

The recommended VOSL values (all shown in January 2001 US$s) in the five studies that recommended single values ranged from $2.1million to $6.4 million. The other two meta-analyses recommended VOSL ranges of $2.6 to $13.6 million, and $4.0 to $9.4 million respectively. We do not know the extent to which the upper values in these ranges of $13.6 and $9.4 million are outliers, but in general the recommended figures, and a greater part of the ranges quoted in the seven papers that gave overall recommended estimates fall in the range from US$2.1 million to about US$6.5 million. This would seem to be a guide as to the expected reasonable range of VOSL values.

The contingent valuation (CV) studies are of more interest to us than those using other methodologies. Looking separately at the 14 separate CV studies seems to imply that CV studies yield estimates of VOSLs in a slightly more narrow range, and a range a little lower than the wage-risk VOSLs. The meta-analyses and the distribution of the VOSLs from these separate studies indicate a reasonable range for VOSLs of between about $1 million and $6 million. We have omitted one valued at $30 million.



The distribution of these CV VOSLs is very largely concentrated at values below $5.9 million. In fact in this set of CV estimates there is a symmetrical distribution around the modal value range of $US3.0 to $US 3.9 million 2001$s. The distribution pattern of the CV studies perhaps tightens our view of likely VOSL values to an indicated modal range from $3.0 to $3.9 million.

The ranges for the VOSL estimates we have studied are:

Meta-analyses	core range	US$2.1 to $6.5 million
Separate studies all methods	56% of studies	US$0.0 to $5.9 million

CV separate studies	Range	US$0.0 to $5.9 million
	Modal range	US$3.0 to $3.9 million
US regulatory agencies' analyses		US$1.0 to $6.2 million.

The value of the New Zealand road safety VOSL estimated by the WTP survey expressed in the comparable 2001US$s is between $1.7 and $2,4 million, which puts it low in the overall range. It would therefore seem that this present road safety VOSL, could be somewhat lower than the general range of relevant VOSLs.

However the only immediate alternative is the WTA VOSL of Guria (2003). This is three times the WTP level, and even at the US$1.7million figure for the WTP, the WTA would be over US$5 million. This would put it high in the range, if not above a reasonable range. Nevertheless there could be some justification at a national level to consider in some detail whether the WTA value weighted in with the WTP estimates may be more relevant than the present WTP estimate.

3.5 Indicative fire-related VOSL measures

There is not a broad literature on fire-related VOSLs. Two interesting early studies determined VOSLs by estimations from the safety product market, and examined purchases of smoke detectors. They are Dardis (1980) and Garbacz (1989) and we return to these below.

There are only a few studies internationally measuring the cost of fire-related injuries and fatalities, and our literature review found no studies that specifically derived an independent or 'stand alone' VOSL for fire fatalities. Most studies either used a VOSL derived elsewhere (e.g. for road accidents or air pollution) or the Human Capital Method (HCM).

The HCM does not generate a VOSL but calculates the economic cost of fatalities in terms of direct expenditure (e.g. hospital care) and lost income. An overview of the HCM and related approaches is provided in BERL's 2002 entitled 'Measuring the Total Cost of Injury in New Zealand: a Review of Alternative Cost Methodologies'. TriData Corporation provide an example of the HCM in practice in their 2004 report to the U.S. Department of Commerce on 'The Economic Consequences of Firefighter Injuries and their Prevention'.

3.5.1 Safety product VOSLs

A number of studies have estimated VOSLs from studying purchase or use of safety products - the small set of consumer goods whose exclusive purpose is to provide protection from harm.

In her examination of smoke detector purchase and use Dardis (1980) collected information on smoke detector costs (purchases and maintenance) and the reduction in the probability of fire

death and injury that smoke detectors provide. (National Bureau of Standards found that smoke detectors provide 45% protection against death, and 30% against injury.) Dardis estimated the VOSL in the range $0.1 million to $0.68 million in 1976 $s. The Garbacz (1989) study extended Dardis' research by improving the estimate of effectiveness of smoke detectors. He concludes that only about 9% of fire deaths would be offset if all households had smoke detectors. With these adjustments he concludes that the single Dardis figure of $0.15 million would be increased to $1.07 million (both in 1976$s).

Apart from the two smoke detector studies, the other studies of include a 1979 paper by Blomquist which analyses seat belt usage; a study by Carlin and Sandy (1991) of usage of child car seats; and Jenkins R, et al (1999) who estimated a VOSL based on children's bicycle safety helmets.

The safety product VOSLs, adjusted by Jenkins R et al (1999) to 1997 $s are shown in the table below.

Study	Nature of Risk	Year	VOSL $US million	
			Current US$s	***1997 US$s***
Dardis (1980)	Fire fatality, no smoke detectors	1974-9	$0.15	$0.72
Garbacz (1989)	Fire fatality, no smoke detectors	1968-85	$1.07	$2.40
Blomquist (1979)	Auto deaths, no seat belts	1972	$0.37	$1.44
Carlin, Sandy (1991)	Auto deaths, no child's carseat	1985		$0.75
Jenkins et al (1999)	Cycle deaths, no helmet	1997	Child: Adult:	$2.12 $3.92

The 1997 US$s shown in the table will not be greatly different in value from the 2001 US$s reported from Neumann (2001) above. This then indicates that the Garbacz estimate of the fire-related VOSL at US$2.4 million in 1997$s as estimated from the cost of smoke detectors, is close to the modal range of VOSLs determined by Contingent Valuation. This modal range was US$ 3.0 million to US$ 3.9 million.

3.5.2 Fire VOSLs relative to road VOSLs in UK

Since we have few stand-alone studies of fire-related VOSLs, the main opportunity to estimate indicative fire-related VOSLs for New Zealand comes from using the New Zealand road safety VOSL adjusted with relativities estimated in other jurisdictions.

The most robust study, or set of studies of relativities as between different contexts of risk of death is the ongoing body of work carried out by various workers in UK since the early 1990s These workers included Michael Jones-Lee, Graham Loomes, (the late) Jane Beattie, Judith Covey, Trevor Carthy, Susan Chilton and others. This group carried out pilot work to estimate a WTP-based roads VOSL (or VPF) using the CV/'standard gamble' (SG) chained approach in October-November 1997, and then did pilot work and moved on to a 'relativities' study in October-November 1998.

This relativity study had the objective of estimating ratios of the VPFs (or VOSLs) for other contexts like fire, rail etc relative to the roads VPF. The research aimed to measure those ratios using the relative valuation approach.

Having available a road VOSL, these ratios of the value relative to preventing car driver/passenger deaths, of preventing deaths in domestic fires; of preventing rail passenger deaths; and preventing deaths in fires in public places could then be used to estimate VOSLs for lives lost or saved from these other hazards .

The overall programme of work is described in a number of publications including *Valuation of Benefits and Health Safety Control : Final Report* (Carthy T, Chilton S et al ,2000); *Valuation of Benefits of Health and Safety Control : Follow-up Study* (Burton T, Chilton S, Covey J et al, 2001); and *Public Perceptions of Risk and Preference-based Values of Safety* (Chilton S, Covey J, Hopkins L, Jones-Lee M et al, 2002).

The relativities data in summary is shown in the Follow-up study Burton, Chilton, Covey et al (2001) page 10-11. These data are expressed as the relative valuation ratios between the expected VOSL (or in their terminology VPF) in each context. The *ratio* $V_{dom\ fire} / V_{road}$ is the ratio between the VOSL for domestic fires over the VPF for road safety.

Data from main study:	$V_{dom\ fire} / V_{road}$	=	0.88 to 0.93
	$V_{pub\ fire} / V_{road}$	=	0.92 to 0.92
Data from follow-up study:	$V_{dom\ fire} / V_{road}$	=	0.84 to 0.89
	$V_{pub\ fire} / V_{road}$	=	0.91 to 0.96

The indications from these results are that if the perceptions in New Zealand value fire-related deaths relatively less highly than in the UK, the fire VOSL in New Zealand could be less than 0.8 times the road VOSL. If the perceptions in New Zealand value fire-related deaths relatively more highly than in the UK, the fire VOSL in New Zealand could be more than 1.0 times value of the VOSL for road safety.

3.5.3 Other relativity studies: disability weights

We have indicated that we think that disability weights may give a broad order-of magnitude cross-check on relativities as between fire deaths and road deaths to the extent that this may be a similar relativity to that between fire injury and road injury.

In the New Zealand scale of disability weights, the weight for 'burns/fires/scolds' is 0.172 and the disability weight for 'road traffic/other transport injuries' is 0.149.[8] This potentially suggests a small premium in the order of 15% for fire injuries relative to road injuries. The downside is that the disability weights cover health status, which includes a range of different physical impairments, rather than just mortality as in the case of most Contingent Valuation studies. Similarly, risk and other elements are not included within this health status scale.

However this cross-check does indicate that we should not expect the fire VOSL in New Zealand to be orders-of-magnitude greater than, or less than the road safety VOSL.

3.5.4 New Zealand perceptions of relativities

We now return to the factors of public perception that are likely to affect the relativity between the road VOSL and the fire VOSL in New Zealand. There is very little research on relative public perceptions and attitudes towards different types of risk in New Zealand, and certainly no empirical research that we are aware of on this issue.

We have information on the relative perceptions between road and fire in the UK, but the risk preferences between the NZ and UK populations may differ, perhaps quite widely. The peoples' living environment is quite different as urban density is lower in New Zealand with presumably lower incidence of significant urban fires, and car ownership and usage in New Zealand is higher than UK, and public transport usage lower. The annual baseline risk of death from fire in New Zealand is about 0.1 per annum per 10,000 people and risk of death on the roads about 0.93 per annum per 10,000. Our reading of the UK raw data[9] is that both of these risk rates are significantly lower in UK, with risk of death from fire about 0.05 per annum per 10,000 people and from road about 0.5 per annum per 10,000 people. This difference in baseline risk could well affect the relative preferences in each population.

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[8] Page 36, Ministry of Health (2001).

[9] Pages 1, 190, 208. *Mortality statistics : cause, Series DH2 no.32*. National Statistics, London 2005.

Preferences are affected by a number of risk factors including perceptions of level of dread, and level of control or involuntariness in the cause of death. The considerations of people stating their relative preferences can be expected to be different in the two countries.

There is evidence from a recent study completed by CM Research for the New Zealand Fire Service Commission Contestable Research Fund that provides some interesting insights into public perceptions of fire and fire risk in the broader context.[10] The findings of this study included that:

- 63% of respondents disagreed that most causes of serious household fires are beyond the householder's control;
- 43% of respondents agreed that taking risks with fire is part of human nature; and
- 53% of respondents agreed that if they had a fire at their property that the Fire Service would arrive in time to save their life.

There is further NZFS-funded research on the issue of controllability, Hemidall Consulting Ltd which recently examined the contribution of human behaviour to unintentional residential fire deaths by analysing coroners' inquiries.[11] One of the main conclusions from this research was that careless acts and acts of omission are involved in nearly half of the fire ignitions. The four main causes of these fires were unattended cooking (accounting for 16.9% of unintentional residential fires causing death), careless smoking (13.1%), unattended burning candles (10.0%), and children playing with fire (9.2%). In other words those involved in about 50% of these deaths were agents in some capacity of fire ignition, and their deaths to some extent a consequence of their behaviours. Also the study found that 58 of the 131 deaths investigated (44%) had alcohol involved, with blood alcohol levels measured as above the legal driving standard of 80mg/100ml, indicating again presumably a contributing behaviour.

These pieces of research arguably add some weight to Massen's view (2000) that domestic fires may be regarded as less 'involuntary' than say air pollution as they greatly depend on the actions of the individual.

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[10] CM Research, A Strategy for Developing Greater Community Responsibility For Fire Safety and Prevention, 1999.

[11] Dr Ian Miller, Human Behaviour Contributing to Unintentional Residential Fire Deaths 1997 – 2003, Hemidall Consulting Ltd, 2005

The coroners' inquiries, the subject of the research by Dr Miller, are reported in the media. Therefore presumably New Zealanders' perceptions of risk of death from fire will take account of this degree of personal control in fire deaths and perceive that they can exercise this control. While there is a similar element of control for the at-fault driver in road deaths, there is the involuntary factor for others killed on the road. Since this risk of death is involuntary, and it is a higher level of death rate it could be perceived to present a greater potential personal risk. This could well increase New Zealanders' relative preference for preventing road deaths.

Therefore, although the general findings from the UK study are that their people expect the ratio between VOSLs for preventing deaths due to different risks to be not greatly different from one, we could expect the fire VOSL in New Zealand to perhaps be a somewhat lower ratio to the road VOSL than is the case in the UK. Nevertheless we would broadly expect the fire VOSL to fall in the range of 0.5 times to 1.5 times the road VOSL.

3.5.5 Indicative fire-related VOSLs for New Zealand

The material presented above indicates that the present widely-used (WTP) road safety VOSL value of NZ$3.05 million in June 2006 prices is broadly within an expected range. This is consistent when assessed relative to VOSLs from meta-analyses; from separate CV studies; when considered relative to baseline risk; and when compared with fire-related safety product VOSL. If there is a tendency in any direction, it could be that the present WTP is a small fraction lower than would be expected.

As to relativity between the fire VOSL and the road VOSL, the general findings for the UK population are that fire VOSLs are of similar orders of magnitude to road VOSLs. The indications from the literature are that a particular VOSL will be found to fall within a range. The actual level to be used in regulatory impact statements must then be selected within that range.

An example of this process is illustrated by the contingent valuation work on the UK road VOSL by Covey et al. The road VOSL for the UK could be thought to have some parallels with New Zealand, although car ownership and usage relative to public transport would be greater in New Zealand. The existing road VOSL used by the UK Department of Environment, Transport and Regions (DETR) is about £900,000, which converted to about NZ$2.7 million is quite close to the New Zealand road VOSL of NZ$3.05 million. This existing value was explored and confirmed in the substantial programme of work that then proceeded on to develop relativities between the road VOSL and a fire VOSL.

The programme of work generated survey-derived results that .. *point towards a roads VPF* (value of a preventable statistical fatality or VOSL*) in a range from about £500,000 (based on median responses) to between £1,000,000 and £1,600,000 (based on trimmed means)*. Following some judgement discussion the report concluded: *All things considered, any figure in the range £750,000 to £1,250,000 in 1997 prices could be regarded as broadly acceptable. This range clearly encompasses the current DETR roads VPF of some £900,000*.

Given this wide survey-based confidence range and the UK fire:road relativities, we could therefore expect that the relativity of the fire VOSL to the road VOSL in New Zealand could be from one-half to one-and-a-half times the road VOSL. An indicative value for the fire-related VOSL in New Zealand would then be somewhere in the range NZ$1.5 million to NZ$4.5 million at June 2006 prices.

3.6 A contrast with the Australian VOSL situation

For reasons perhaps of economy a number of countries and regulatory agencies have opted to adopt someone else's VOSL, or made an assessment from the range of international values rather than derive a VOSL relevant to their specific use with their particular population. This can lead to uncertainty and arbitrary adoption of a range of VOSL values as found in Australia.

In Australia there has been no specific survey completed to determine a VOSL for Australia in any particular risk context. Therefore there is no empirical measure of the VOSL in Australia that can be related from one risk to another. Consequently in the past, most road authorities base their costs of a fatality on the Cost of Injury (COI) approach, by which the NSW Road and Traffic Authority estimated the VOSL at $827,400 in 2000.

The Department of Ageing and Health (DAH) in *Guidelines for Economic Evaluation of Environmental Health Planning* in 2003, recognised that the COI method underestimates the VOSL in Australia, and made a judgement based on two international figures, namely the US EPA figure of US$6.1 million in 1999 prices, and the UK Department of Environment and Transport figure of £850,000 in 1996 prices. The DAH translated the UK figure to A$2.5 million at 2001 prices and used that 'as a realistic value' for the VOSL in Australia.

In 2004 the Govt of Western Australia in estimating the Costs of Accidental Drowning quote values adopted as A$1.3 million in two road contexts, $1 million in a public health context, and the DAH figure of $2.5 million quoted above. They appear to have 'split the difference' again, and adopt a figure of $1.5 million. In a working paper on health impacts of transport emissions in 2005 the Bureau of Transport and Regional Economics adopted a VOSL of A$2.5 million for a healthy individual of 40 years, and reduced it to $1.9 million for rail accident deaths, based on

the age profile of those fatalities. It also appears to be influenced by a European transport VOSL that converted to a range of A$1.9 million to A$2.3 million.

Finally in a submission on a regulation change for Births, Deaths and Marriages, the Department for Victorian Communities in 2005 noted that in lieu of Australian research on VOSLs overseas studies should be drawn upon, and concluded that a VOSL estimate of $2.5 million can be regarded as a minimum.

It becomes clear that because there have been no empirical values for a VOSL determined in Australia, all VOSLs there are derived in some way from VOSLs estimated elsewhere. There consequently continues to be arbitrary adjustment on the basis of 'judgement' for each use. It appears that in recent years VOSL values used have covered a range at least as wide as $1 million to over $2.5 million, with no reported empirical measurement of relativities to support the various values.

We believe this adds strength to the recommendation that New Zealand explicitly measure the relativity of a fire VOSL to the existing road VOSL. The New Zealand road VOSL was empirically measured, and therefore has been determined relative to other costs and benefits in New Zealand. The value has been adopted in use for some time without attracting strong challenges, indicating that it is broadly accepted by society. As we have seen in previous sections this value is in the range to be expected from international studies. The empirically-measured relativity will broaden to fire the contexts in which there is the ability to use sound empirical VOSLs in measuring regulatory impacts in New Zealand.

This is in contrast to the situation in Australia where life-saving impacts measured for regulatory reduction of one hazard bear no particular relation to other costs and benefits in Australia, nor to life-saving benefits for reduction of another hazard valued by some different, arbitrary VOSL value.

4 A survey of risk perception and relativity

Our research programme was directed towards completing a survey of relativities between revealed preferences for saving lives by reducing road deaths, or by reducing fire deaths.

The objective of the survey process was to estimate the ratio of a VOSL for a life saved from fire, relative to the roads VOSL.

A supplementary objective was to see of people who had particular perceptions of key psychological/risk factors gave responses to the fire:road ratio that differed from the responses from the total sample.

One approach to this would be to follow very closely one of the methodologies used by Chilton et al, e.g. using Safety Priority Questionnaires (SPQs) in a group discussion format. This approach as used by Chilton et al involved a substantial professional team, and high level of application of survey methods to a relatively small sample of people.

We investigated using an alternative approach with a simple set of questions including those canvassing perceptions of the psychological/risk factors, and a key question to measure the stated preference for prevention of deaths from road accidents or deaths from fire. The psychological/risk factors were those found relevant and tested by Chilton et.al, and were perceived level of risk; uneasiness (dread); personal control, and the scale (number of deaths per event).

In our approach we surveyed a much larger sample than Chilton et.al. with the intention to reduce the likelihood of obtaining overlapping confidence ranges.

4.1 The survey process

The survey agency was DigiPoll Ltd, of Hamilton, New Zealand. DigiPoll provides survey fieldwork for a range of studies and surveys, using advanced Computer Assisted Telephone Interviewing (CATI) technology. The objective was for DigiPoll to complete 750 interviews between 1 November 2006 and 10 November 2006.

The questionnaires included the four questions on perception of the psychological/risk factors, a question to measure relativity between saving deaths from road compared with fire, and a round-off question of opinion as to whether government should put more funding to prevent road or fire accidents. A series of questions then recorded the demographics. These enabled DigiPoll to provide demographic representation weights.

4.2 Survey content

The survey content was developed by BERL with reference to the findings of Chilton et al. Specifically the survey contained four questions to test perceptions of psychological/risk factors:

Question 1. the base risk of dying in a car accident or residential fire;

Question 2. the personal control over the risk of dying in a car accident or residential fire;

Question 3. unease about the risk of dying in a car accident or residential fire;

Question 4. number of people likely to be killed in a single car accident or residential fire event.

Following a linking introduction the respondent was then asked the main question, Question 5: *Suppose the Government could increase funding to safety programmes, which would result in 20 accidental deaths being averted per year. How many of these would you prefer to be saved from reduced car accidents, and from reduced residential fire accidents?* The numbers given were constrained to a sum of 20.

Finally, the demographic questions recorded the gender, age, ethnicity, household size (adults), urban/rural, and household income.

The complete questionnaire is shown in Appendix II.

4.3 Survey outcome

DigiPoll was able to achieve the objective to complete 750 interviews between 1 November 2006 and 10 November 2006. Of these 750 respondents, just 12.9% responded 'Don't know' to the Question 5, on relative priorities between saving fire deaths and saving fire deaths. For the four questions on perceptions of risk, the 'Don't knows' were higher being in the range 19.6% to 30%.

DigiPoll have stated that for a survey sample of 750 questionnaires, the margin for error is +/- 3.6%, and for the 653 with responses to Question 5, the margin for error is +/- 3.8%.

5 Discussion of survey results

5.1 Headline results

The headline results from the survey are that the 653 people who gave a priority for saving 20 lives indicated on average that 12.4 of those lives should be from car accidents and 7.6 from residential fire accidents. The raw responses have been adjusted with weights to reflect the demographic composition of the New Zealand population, and therefore indicate the response to be expected from the whole New Zealand population. (The unweighted responses were that 12.35 of those lives saved should be from car accidents and 7.65 from residential fire accidents. This indicates that the weighting process has not significantly affected the overall average response.)

There is a 95% probability that the actual number of each will fall in the range of the mean +/- 1.9 times the standard error. The standard error of the coefficients for the total sample in the survey is 0.193. Therefore, there is a 95% probability that the population's stated preference for saving deaths from car accidents would lie in the range 12.4 +/- (1.9 x .193), or 12.4 +/- 0.367, namely 12.03 to 12.77. Similarly there is a 95% probability that the population's stated preference for saving deaths from fire accidents would lie in the range 7.6 +/- (1.9 x .193), or 7.6 +/- 0.367, namely 7.23 to 7.97.

This in turn implies that there is greater than 95% probability that the population's stated preference for saving lives from road accidents is significantly different from, and greater than the population's stated preference for saving lives from fire accidents. The relativity between the population's stated preference for saving lives from fire accidents as measured by this survey is in the range 56.6% to 66.2% of the value of saving lives from road accidents.

The average relativity between the population's stated preference for saving lives from fire accidents as measured by this survey is 61.3% of the value of saving lives from road accidents.

5.2 Exploration of results for demographic sub-samples

The measure of the relativity between preference for saving lives from fire compared with saving lives from roads holds quite closely for the sub-samples of the survey by gender, age, income, location, and ethnicity as shown in the following table. There were some outliers for very small sub-samples, i.e. for groups numbering less than 20. These were the ethnicities other than the three largest: NZ of European descent, NZ of Maori descent, and European. Also the age group 18 to 20 years had only 17 respondents.

Apart from these outliers, the averages for all sub-samples fell in the range 12.0 to 13.4 for road accidents, and consequently 8.0 to 6.6 for fire accidents. Looking more closely there were two sub-samples that ranked car accidents over 13, and these were Maori who ranked cars 13.1, and 61 to 70 year-olds who ranked cars 13.4. Apart from these groups the averages were all in the tight range 12.0 to 12.6 for car accidents and 7.4 to 8.0 for fire deaths.

Table 2 Questionnaire responses by population characteristics

	Weighted responses (excluding don't knows)			
	preference for 20 saved lifes save from death in:			
	Car accident	**Residential fire accident**	***n*=**	**% of 750**
By gender				
male	12.2	7.8	*251*	
female	12.5	7.5	*402*	
TOTAL	12.4	7.6	*653*	87.1%
By age				
18 - 20	10.4	9.6	*17*	
21 - 30	12.5	7.5	*81*	
31 - 40	12.6	7.4	*138*	
41 - 50	12.0	8.0	*153*	
51 - 60	12.5	7.5	*118*	
61 - 70	13.4	6.6	*77*	
70+	12.5	7.5	*62*	
TOTAL	12.4	7.6	*646*	86.1%
By income				
Under $21,000	12.3	7.7	*67*	
$21,000 - $33,000	12.4	7.6	*82*	
$33,001 - $52,000	12.4	7.6	*134*	
$52,001 - $77,000	12.0	8.0	*145*	
$77,000 and over	12.5	7.5	*165*	
TOTAL	12.3	7.7	*593*	79.1%
By location				
Urban	12.5	7.5	*502*	
Rural	12.1	7.9	*148*	
TOTAL	12.4	7.6	*650*	86.7%
By ethnic group				
NZ of European descent	12.6	7.4	*480*	
NZ of Maori descent	13.1	6.9	*48*	
European	12.3	7.7	*58*	
Samoan	13.0	7.0	*4*	
Cook Island	10.7	9.3	*5*	
Other Pacific Islander	10.4	9.6	*6*	
Chinese	8.7	11.3	*10*	
Indian	11.7	8.3	*13*	
Other Asian	12.6	7.4	*12*	
South African	6.6	13.4	*4*	
Other	11.2	8.8	*11*	
TOTAL	12.4	7.6	*651*	86.8%

Source: BERL

5.3 Exploration of results by perceptions of risk

Chilton et al completed a regression analysis in their study to assess the correlation between a set of explanatory factors from their research and the relativity ratios they derived for domestic fires and rail accidents. The explanatory factors included demographic, behavioural (e.g. annual car mileage), and psychological/risk perception factors.

The main psychological/risk perception factors to emerge as significant in the Chilton study using bivariate correlations were the household-benefit, age-groups-affected, and number-per-year considerations. In their full regression model (containing 17 explanatory variables) personal risk emerged as a significant factor - a result which indicates that respondents' relativities corresponded with whichever of the two hazards they perceived themselves to be at greater risk of dying from. There is also some discussion that the correlation results for some of the other factors such as number-per-year may, in fact, be a variation on the personal risk theme.

BERL has performed a similar analysis to the significance of the risk perception factors as contained in the questionnaire (namely questions 1 to 4).

Table 3 Questionnaire responses according to perception of risk

	Weighted responses (excluding don't knows)			
	preference for 20 saved lifes save from death in:			
	Car accident	**Residential fire accident**	***n*=**	**% of**
Q1: By perception of higher risk of dying in a:				
Car	12.5	7.5	*554*	*95.0%*
Fire	10.5	9.5	*29*	*5.0%*
TOTAL	12.4	7.6	*583*	77.7%
Q2: By perception of less personal control of risk of dying in a:				
Car	12.6	7.4	*479*	*80.2%*
Fire	11.9	8.1	*118*	*19.8%*
TOTAL	12.5	7.5	*597*	79.6%
Q3: By feeling of more unease about risk of dying in a:				
Car	12.6	7.4	*384*	*73.1%*
Fire	12.0	8.0	*141*	*26.9%*
TOTAL	12.5	7.5	*525*	70.0%
Q4: By perception of large number of deaths in single event dying by:				
Car	12.9	7.1	*411*	*68.2%*
Fire	11.4	8.6	*192*	*31.8%*
TOTAL	12.4	7.6	*603*	80.4%
Q6: By more government funding to prevent accidents in				
Car	13.5	6.5	*424*	*67.2%*
Fire	8.9	11.1	*86*	*13.6%*
Equal	11.3	8.7	*121*	*19.2%*
TOTAL	12.5	7.5	*631*	84.1%

Source: BERL

The measure of the relativity between preference for saving lives from fire compared with saving lives from roads holds quite well for samples based on responses to these lead-up questions relating to risk perception, as shown in the table. Note the table also includes a sample based on question 6 where participants were asked where Government should put more funding to prevent accidents. As might be expected, responses favouring more funding in the prevention of fires tended to be matched with a priority towards saving lives from fire accidents.

5.3.1 Robustness of results

We have estimated standard errors and the 95% confidence intervals for each of the sets of data in the table above. These are shown in Table 4.

Table 4 Questionnaire responses and confidence intervals

	Weighted responses (excluding don't knows)			Significance of survey responses		
	preference for 20 saved lifes save from death in:					
	Car accident	Residential fire accident	*n=*	Std error of estimate	95% confid interval	Is preference car signif. diff. from fire?
By gender						
male	12.2	7.8	*251*	0.37	0.73	yes
female	12.5	7.5	*402*	0.21	0.41	yes
TOTAL	12.4	7.6	*653*	0.19	0.38	yes
By perception of higher risk of dying in a:						
Car	12.5	7.5	*554*	0.21	0.41	yes
Fire	10.5	9.5	*29*	0.96	1.88	no
TOTAL	12.4	7.6	*583*			
By perception of less personal control of risk of dying in a:						
Car	12.6	7.4	*479*	0.23	0.44	yes
Fire	11.9	8.1	*118*	0.46	0.90	yes
TOTAL	12.5	7.5	*597*			
By feeling of more unease about risk of dying in a:						
Car	12.6	7.4	*384*	0.27	0.52	yes
Fire	12.0	8.0	*141*	0.38	0.75	yes
TOTAL	12.5	7.5	*525*			
By perception of large number of deaths in single event dying by:						
Car	12.9	7.1	*411*	0.23	0.45	yes
Fire	11.4	8.6	*192*	0.38	0.75	yes
TOTAL	12.4	7.6	*603*			
By more government funding to prevent accidents in						
Car	13.5	6.5	*424*	0.23	0.46	yes
Fire	8.9	11.1	*86*	0.53	1.03	yes*
Equal	11.3	8.7	*121*	0.34	0.66	yes
TOTAL	12.5	7.5	*631*			

Source: BERL * borderline

We found that for questions 2, 3 and 4 whether the factor tested by the question was perceived to be greater for road or for fire, the preference for saving more lives from death on roads was significantly higher at the 95% confidence interval than the preference for saving lives from fire. In most cases the significance would remain at confidence intervals well above 95%.

For Question1, the perception of which type of accident had the higher risk of dying, for the 554 who answered that they perceived there was a higher risk of dying in a car accident, the preference for saving lives from cars was very significantly greater than for saving lives from fires, at the 95% confidence interval. (The difference was 12.09 road to 7.91 fire.)

However for the 29 who answered that they perceived there was a higher risk of dying in a fire than a car accident, the preference for saving lives from cars on average was slightly higher (10.5) than for saving lives from fires (9.5). At the 95% confidence interval the ranges overlapped being 12.38 to 8.62 for road, and 11.38 to 7.62 for fire. An interpretation could be that for people who think the risk of death from fire is higher than from road, they nevertheless have a preference that as many lives are saved from death on roads as are saved from fire.

The significance of the answers from Question 6 is also interesting. The people who thought that government should provide more funding to save lives from preventing fires than preventing road accidents, understandably had a preference for more lives to be saved from fire than from road. The average level that this sample of 86 people wanted saved from fire was 11.1 and from road was 8.9. However, at the 95% confidence interval these averages were only just significantly different. The lower bound of the fire range was 10.07, and the upper bound for the road range was 9.93. This implies that even those who wanted to see government spending more on preventing fires are statistically speaking, close to having a preference for the saving the same number of lives from death by road as by fire.

5.4 Conclusions from the survey

These statistical interpretations and exploration of the survey data have not exposed anomalies that would lead one to question the headline results.

We therefore conclude that there is at least a 95% probability that the New Zealand population's stated preference for saving lives from fire accidents as measured by this survey falls in the range 56.6% to 66.2% of the value of saving lives from road accidents.

The consistency of the survey results are such as to give confidence that the population's fire VOSL relativity falls within this range. However it is possible that there is some externality or imperfection whereby the preference of the community or nation is different from the stated preference of individuals. In this case the true relativity between the fire VOSL and the road VOSL for all of New Zealand could fall outside the range determined by the survey of individuals.

On an assumption that there are no externalities the fire VOSL for the New Zealand population has been shown to fall in the range 56.6% to 66.2% of the road VOSL. Specifically, the relativity

survey has shown that the value of an additional life saved from fire causes is perceived by the New Zealand public to be worth 56.6% to 66.2% of an additional life saved from road causes.

5.5 Judgement considerations

The relativity determined by the survey of 56.6% to 66.2% is a somewhat greater differential than the relationship determined in the UK study. In the latter the VOSL for domestic fires was estimated to fall within the range of 84% to 93% of the road VOSL, and in their overall programme these UK researchers have concluded that "*the great majority of people do not favour rates of trade-off between preventing deaths from different hazards that are greatly different from 1:1.*"

It is likely that the perceptions of people in New Zealand are somewhat different from those of people in the UK because of the higher urban density in UK, with risk of fire events with multiple deaths, and secondly the somewhat lesser car usage in UK. These factors may, together lift the relative preference for saving lives from fire in the UK compared with in New Zealand.

We also note that the sample in New Zealand who had the perception that a residential fire would be more likely than a car accident to kill a larger number of people in a single event was 31.8% (nearly one-third) of the respondents to that question. This 31.8% then had a preference for 8.6 lives to be saved from fire, namely 75% of the 11.4 road lives they wished to be saved.

This may well imply that should awareness increase of the possibility of multiple death fires in New Zealand, which could happen if there was one such event, then the relativity preference of the general population for saving lives from fire could lift towards this 75%.

Taking these factors into consideration we suggest that there could well be some justification for expecting the true VOSL relativity to be high in the range as determined. The probability is 95% that it could fall anywhere in the range, and we therefore suggest that judgement indicates that the fire VOSL in New Zealand could be set at 66% or two thirds of the road VOSL in New Zealand

6 Recommendation

The main finding from the survey is that the New Zealand population's stated preference for saving lives/averting deaths from fire accidents is 56.6% to 66.2% of the value of saving lives from road accidents.

The value of the New Zealand WTP road VOSL is updated on a regular basis, and currently set at NZ$3.05 million expressed in present dollar terms.

BERL therefore recommends that the VOSL for fire regulatory statements be set in the range of NZ$1.7 million to NZ$2.02 million in 2006 prices. Judgement indicates that the fire VOSL in New Zealand be set at two-thirds of the road VOSL, namely $2.04 million in 2006 prices, and that this figure be revised with reference to the periodical adjustment in the value of the New Zealand road VOSL.

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8 Appendix I

Base data from Willingness to Pay for Reductions in Fatal risk: Meta-analysis of VOSL literature

Source: Neumann J, Leggett C, Penumalli P. USEPA 2001

ID	Author and Year	VSL (million Jan 2001 $)	Method	Country	Risk of death p.a. /10,000	Sample size (n)
1	Arabsheibani and Marin (2000)	28.7	LM	GB	nr	3,608
2	Arnould and Nichols (1983)	1.2	LM	US	10.00	nr
3	Atkinson and Halvorsen (1990)	5.4	CM	US	2.10	112
4	Berger and Gabriel (1991)	8.5	LM	US	2.70	*18,908*
5	Butler (1983	1.2	LM	US	0.47	468
6	Buzby, Ready , Skees (1995)	5.0	CV	US	0.50	512
7	Carthy et.al. (1999)	1.7	CV	GB	1.00	167
8	Corso, Hammitt, Graham (2000)	3.9	CV	US	2.25	264
9	Cousineau, Lacroix, Girard (1992)	5.1	LM	Canada	0.76	32,713
10	Dillingham (1985)	3.9	LM	US	1.10	514
11	Dillingham, Miller, Levy (1996)	4.8	LM	US	nr	513
12	Dreyfus, Viscusi (1995)	3.8	CM	US	1.96	1,775
13	Garen (1988)	17.7	LM	US	nr	2,863
14	Gayer, Hamilton, Viscusi (2000)	4.6	Prop'y	US	0.02	16,982
15	Gegax, Gerking, Schulze (1991) Perceived risk data	2.9	LM	US	6.50	737
16	Gegax, Gerking, Schulze (1991) BLS risk data	16.9	LM	US	nr	737
17	Gerking, de Haan, Schulze (1988)	4.5	CV	US	6.50	861
18	Gill (1988)	4.9	LM	US	0.54	2,139
19	Hammitt, Graham (1999)	6.0	CV	US	2.00	973
20	Hammitt, Liu, Liu (2000)	3.5	CV	Taiwan	2.00	*8,502*
21	Herzog, Schlottman (1990)	16.8	LM	US	nr	2,954
22	Ippolito, Ippolito (1984)	1.0	CM	US	nr	nr
23	Johannesson, Johannesson (1997)	0.1	CV	Sweden	nr	2,824
24	Johannesson, Johannesson, Lofgren (1997)	3.6	CV	Sweden	nr	1,659
25	Johannesson, Johannesson, O'Conor (1996)	10.7	CV	Sweden	nr	389
26	Jones-Lee (1989)	5.4	CV	GB	0.90	975
27	Kidholm (1995)	3.0	CV	Denmark	1.10	945
28	Kim, Fishback (1999)	0.8	LM	S. Korea	4.90	321
29	Krupnick et.al. (2000)	2.2	CV	Canada	123.00	930
30	Lanoie, Pedro, Latour (1995)	30.3	CV	Canada	1.26	162
31	Lanoie, Pedro, Latour (1995)	22.7	LM	Canada	1.26	63
32	Leigh (1987)	14.2	LM	US	nr	*1,350*
33	Leigh (1995): BLS data	12.8	LM	US	1.30	1,528
34	Leigh (1995): NIOSH data	9.6	LM	US	1.10	1,505
35	Leigh, Folsom (1984)	12.0	LM	US	1.34	*977*
36	Liu, Hammitt (1999)	0.7	LM	Taiwan	5.10	546
37	Liu, Hammitt, Liu (1997)	0.5	LM	Taiwan	2.90	*18,119*
38	Low, McPheters (1983)	2.5	LM	US	3.30	72
39	Marin, Psacharopoulos (1982)	5.6	LM	GB	0.20	5,509
40	Martinello, Meng (1992)	7.2	LM	Canada	2.50	4,352
41	Meng (1989)	4.1	LM	Canada	1.90	718
42	Meng, Smith (1990)	6.9	LM	Canada	1.20	777
43	Miller, Guria (1991)	1.7	CV	NZealand	*2.10*	308
44	Miller, Mulvey, Norris (12997)	14.5	LM	Australia	0.70	18,850
45	Moore, Viscusi (1988): NIOSH data	8.3	LM	US	0.79	1,349
46	Moore, Viscusi (1988): BLS data	3.4	LM	US	0.52	1,349
47	Moore, Viscusi (1988)	9.6	LM	US	0.59	317
48	Moore, Viscusi (1990)	7.8	LM	US	nr	nr
49	Olson (1981)	12.6	LM	US	0.95	5,993
50	Sandy, Elliott (1996)	53.2	LM	GB	0.45	440
51	Scotton, Taylor (2000)	20.1	LM	US	0.49	4,891
52	Seibert, Wei (1994)	13.0	LM	GB	0.38	2,062
53	Seibert, Wei (1998)	1.9	LM	HongKong	1.30	8,414
54	Shanmugan (1997)	1.0	LM	India	1.00	522
55	Smith (1974)	9.1	LM	US	nr	3,183
56	Smith (1976)	13.6	LM	US	nr	3,183
57	Thaler, Rosen (1975)	1.0	LM	US	11.00	907
58	Viscusi (1978)	5.5	LM	US	1.18	496
59	Viscusi (1981)	8.7	LM	US	1.00	3,977
60	Viscusi, Magat, Huber (1991)	3.5	CV	US	nr	195

nr = not recorded

9 Appendix II

DigiPoll Questionnaire (conducted using advanced Computer Assisted Telephone Interviewing (CATI) technology.

Introduction

Hello , I'm ..... from DigiPoll in Hamilton,
the public opinion polling company,
calling on behalf of a government service.

We want your opinion about prioritisation of safety programs
and you general feeling about what risks should be given
priority over others.

Can we talk now?

IF ASKED: It will take less than 5 minutes

Q1

Do you think that you have a higher risk of dying in a
car accident or a residential fire?

1 Car
2 Fire
99 Don't know

Q2

Do you think that you have less personal control over the risk
of dying in a car accident or a residential fire?

1 Car
2 Fire
99 Don't know

Q3

Do you feel more uneasy about the risk of dying in car accident
or a residential fire?

1 Car
2 Fire
99 Don't know

Q4

Do you think that a car accident or residential fire would be more likely
to kill a larger number of people in a single event?

1 Car

2 Fire
99 Don't know

There are a large number of arguments, such as the ones we have discussed, that might be made for prioritising safety programmes.

You no doubt have a general feeling about what risks should be given priority over others.

Q5

Suppose that the Government could increase funding to safety programmes, which would result in 20 accidental deaths being averted per year.
How many of these 20 lives would you prefer to be saved from reduced car accidents and from reduced residential fire accidents?

# of lives saved from reduced car accidents _____
# of lives saved from reduced fire accidents _____
Total must add up to 20

Q6
Where should the government put more funding, should it be to prevent..

1 Road accidents
2 Fire accidents
99 Don't know/refused

d-gender
And finally, before we finish up,
just a few questions to ensure
we have a cross section of people in our survey.
We keep this information strictly confidential.
Interviewer: select gender

1 Male
2 Female

d-age permission
Can you tell me in what year were you born?

1 Yes d-year born What year?
2 No

d-
With which ethnic group do you most closely relate?

-Check List Open- (Number of items: 11 Min: 1 Max: 1)
1 New Zealander of European descent
2 New Zealander of Maori descent
3 European
4 Samoan
5 Cook Island

6 Other Pacific Islander
7 Chinese
8 Indian
10 Other Asian
99 Refused
9 Other «»

d-household size
How many adults in total,
18 years and older, and including yourself
have lived in your household in the past week?

d-urban/rural
Do you live in an urban or rural area?

1 Urban
2 Rural
99 Don't Know

d-income Would you estimate your total combined household income before tax to be over or under $33,000 per year?

if UNDER: would it be over or under $21,000 ?

if OVER: would it be less than $52,000 ? .....
or more than $77,000 ? .....
or between $52,000 and $77,000 ?

1 Under $21,000
2 $21,000 and over
3 Under $52,000
4 Between $52,000 and $77,000
5 $77,000 and over
97 Don't Know/Refused