Ministry of **Transport**
TE MANATŪ WAKA

Understanding Transport Costs and Charges

Phase 2 – Value of statistical life: a meta analysis
Is the current value of safety for New Zealand too low?

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1 Introduction

Like most countries, New Zealand faces the fundamental economic problem of scarce resources. One of the economic assessment tools for allocating scarce resources and ranking alternative schemes or projects is cost-benefit analysis (CBA).

The New Zealand Treasury has recommended that, when carrying out CBAs, analysts should assign monetary values to the benefits and costs wherever possible.

For the assessment of road safety programmes, the value of statistical life (VOSL) has been used by many developed countries as the economic measure of the value of a human life. The VOSL is one of the major components of the social cost of road crashes and injuries in New Zealand.

The VOSL currently used in New Zealand is the valuation of the prevention of a premature fatality. It is based on a willingness-to-pay survey conducted in 1991. There have been debates about the appropriateness of continuing to update this old estimate over such a long time frame.

As part of the Understanding Transport Costs and Charges (UTCC) project, this paper seeks to develop an alternative VOSL based on the official values used in other countries. The paper covers the following:

- Section 2 reviews the methodologies commonly used in determining the VOSL
- Section 3 discusses the current New Zealand practice
- Section 4 discusses the VOSL used in other countries
- Section 5 examines the relationship between the official VOSL and income
- Section 6 discusses the results
- Section 7 provides conclusions.

2 Valuing the loss of life

Determining the monetary value assigned to loss of life is a much debated subject. The value of loss of life from a premature death or from an injury can include pain and suffering, physical and mental impairment, loss of life quality and psychological distress.

Listed below are three common approaches used in measuring the value of a human life:

- *The human capital approach* – This estimates a person's earning capacity by calculating the expected net earnings lost due to a premature death.

  This approach has been heavily criticised by many researchers as it fails to consider the pain and suffering component, and undervalues children, women, the elderly and other minority groups.

  Due to these limitations, many countries (eg New Zealand, Canada, the Netherlands, France and Singapore) have moved away from the human capital approach.

- *The Willingness To Pay (WTP) approach* – This seeks to measure the amount society would pay for the avoidance of one premature statistical death.

  This approach involves asking individuals the amount they would pay for safety improvement. From the trade-off between risk and economic measures, economists then calculate the marginal rate of substitution between wealth and risk of death or injury, which forms the basis for determining the VOSL.

  This approach has been widely used by many countries and is considered the most appropriate approach for use in environmental and safety intervention analysis.

- *Health status measures* – These include quality-adjusted life years and disability-

adjusted life years, which aim to measure the relative quality of life in different health states.

Health status measures are commonly used in the health sector, and are not suitable for assessing the cost of premature deaths or injuries from road crashes. To monetise health status, the WTP-based VOSL is typically used.

3 New Zealand practice

Prior to 1991, the VOSL used in New Zealand's road safety area was based on the human capital approach. In 1991, the human capital cost of $235,000 (in 1990 dollars) was replaced by a WTP-based VOSL of $2 million (in 1991 dollars), following a Value of Safety (VOS) survey conducted during 1990/91.

At that time, the government also decided that the same VOSL for a fatality should be used in estimating the loss of life and life quality components of the social cost for road, maritime and aviation transport (New Zealand Gazette notice 4983).

This practice has also been extended to non-fatal injuries, which have been estimated at 10 percent of the VOSL for a serious injury and 0.4 percent for a minor injury. These relativities are based on the results of a 1997/98 survey and are comparable with international findings.

In 1997/98, the then Land Transport Safety Authority conducted a second VOS survey and found that the WTP of the New Zealand population had increased since 1991. As a result, the second VOS study recommended a VOSL of $4 million (in 1998 dollars). Compared to an inflation-adjusted value of $2.4 million at that time, the new estimate represented an increase of over 60 percent.

Due to some unresolved policy issues, the Government has not yet adopted the $4 million estimate.

Up until now, the official VOSL continues to be based on the value established in 1991.

The updated VOSL (obtained by indexing the 1991 value to wage inflation) is $3.5 million per fatality, at June 2009 dollars. The updated loss of life quality due to permanent impairment from serious and minor injuries is $350,000 and $14,000, respectively, at June 2009 dollars.

If the Government had adopted the $4 million value in June 1999, the updated estimate for 2009 would have been about $5.15 million (or 47 percent higher).

4 International comparison

Tables 1 and 2 list the VOSLs for other countries, in domestic and international (Figure 1) currencies.

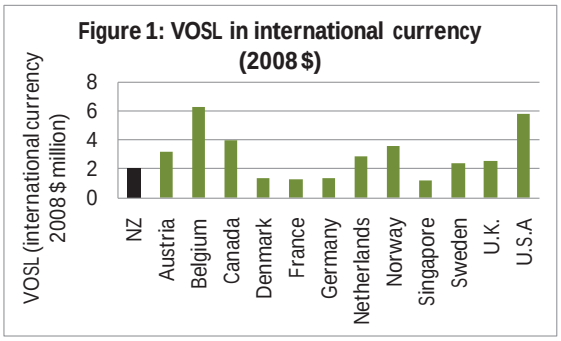
Table 1: International comparison of VOSL in domestic currency

Country	Currency	Year	VOSL million
NZ	NZ$	2008	3.35
Austria	Euros	2006	2.68
Belgium*	Euros	2006	5.60
Canada	CAD$	2007	4.60
Denmark	DKK kr	2009	12.20
France	Euros	2000	1.00
Germany	Euros	2004	1.16
Netherlands	Euros	2003	2.40
Norway	NOK	2005	26.50
Singapore	SG$	2008	1.87
Sweden	SEK kr	2006	21.00
U.K.	GBP	2007	1.64
U.S.A	US$	2008	5.80

* The value for Belgium is not an official value.

At the time of writing this paper, data on Gross Domestic Product (GDP) per capita, GDP deflators and purchasing power parity (PPP) index for 2009 are not readily available. Therefore, the data are presented in 2008 dollars. The official VOSL for New Zealand in 2008 was $3.35 million (or $2.11

million in international dollars - PPP adjusted).



The VOSL for New Zealand (Table 2) is somewhat on the low side (ranked 9 out of 13). The NZ value is lower than those of Belgium (the highest), the United States, Canada, Norway, Austria, the Netherlands, the United Kingdom and Sweden, but is higher than those for Denmark, Germany, France and Singapore (the lowest).

In terms of the ratio of VOSL to GDP per capita (Table 2), New Zealand ranks 6th (with a ratio of 79), just behind Belgium (186), the US (123), Canada (99), Austria (87) and the Netherlands (82). The lowest ratio is 37 for Singapore. The average ratio is 85.

Table 2: International comparison of VOSL in 2008 international dollars

Country	International $m (PPP-adjusted) 2008	GDP per capita (PPP) 2008$	VOSL to GDP per capita ratio $\left[\frac{\text{VOSL}}{\text{GDP per capita}}\right]$
NZ	2.11	$26,651	79
Austria	3.17	$36,617	87
Belgium	6.31	$33,997	186
Canada	3.95	$39,950	99
Denmark	1.40	$36,362	38
France	1.26	$29,936	42
Germany	1.36	$31,310	43
Netherlands	2.84	$34,760	82
Norway	3.62	$57,524	63
Singapore	1.26	$33,767	37
Sweden	2.41	$36,618	66
U.K.	2.59	$36,362	71
U.S.A	5.80	$47,186	123

Table 3: Estimating the VOSL for New Zealand using the international VOSL to GDP per capita ratio

Base country	VOSL to GDP per capita ratio $\left[\frac{\text{VOSL}}{\text{GDP per capita}}\right]$	VOSL for NZ in 2008 NZ $m
Austria	87	3.65
Belgium	186	7.84
Canada	99	4.18
France	42	2.47
Netherlands	82	3.45
Norway	63	2.66
Singapore	37	1.57
Sweden	66	2.78
U.K.	71	3.01
U.S.A	123	5.19
Average	85	3.61
Range	37 to 123	1.57 to 7.84

If GDP per capita is the sole determinant of the VOSL, the VOSL for New Zealand could vary between $1.57 million and $7.84 million[1] (Table 3). As this range is very wide, it is not straightforward to determine an appropriate value for New Zealand using GDP per capita alone.

5 Analysis

5a Methodology

Individuals' willingness to pay is subject to their ability to pay, which is affected by their disposable income. International research (eg Miller, 2000 and iRAP 2008) has found a strong relationship between VOSL and income, such as per-capita GDP.

Miller (2000) examined the effects of PPP-adjusted GDP per capita and found the following relationship between GDP per capita and PPP-adjusted VOSL:

$$\ln(\text{VOSL}) = -1.18 + 0.89 * \ln(\text{GDP per capita}) + 0.32 * \text{Dummy for WTP survey}$$

Where *ln* represents the natural logarithm of the variables, a value of 1 is assigned to the dummy variable where a WTP survey was

[1] This is done by multiplying the VOSL to GDP per capita ratio by New Zealand's GDP per capita.

used to determine the VOSL. Note that Miller's regression used data expressed in 1995 dollars. Other non-applicable variables have not been reported here.

Based on Miller's equation, and updating the value to 2008 dollars, the estimated VOSL for New Zealand would have been **NZ$4.9 million**.

On the other hand, iRAP (2008) also examined the effects of GDP per capita on WTP-based VOSL and found the following relationship:

$$\ln(\text{VOSL}) = 3.015 + 1.125 * \ln(\text{GDP per capita})$$

iRAP's regression used PPP-adjusted data expressed in 2004 dollars.

Based on iRAP's equation, and updating the value to 2008 dollars, the estimated VOSL for New Zealand would have been **NZ$2.96 million**.

This paper explores the strength of the relationship between GDP per capita and VOSL further by using more up-to-date VOSLs, and incorporates a risk measure to control for any effects of baseline risk on WTP.

VOSLs are collected for 12 developed countries (Table 1), most of which are known to have adopted a WTP approach. However, Denmark and Germany, where an avoidance cost approach was used, have been excluded from the regression analysis. This means the sample size is relatively small (only 10 observations). This is a major limitation of this analysis.

The regression equation takes the following functional format:

$$\ln(\text{VOSL}) = \alpha + \beta \ln(\text{GDP per capita}) + \delta \ln(\text{DeathRate})$$

The data on VOSL and GDP per capita are PPP-adjusted and are expressed in 2008 dollars. Annual road deaths per 100,000 population have been used as the measure of death rate (see Table 4).

Table 4: Road safety risk

Country	Annual road deaths per 100,000 population
NZ	10.0
Austria	8.8
Belgium	10.2
Canada	9.2
Denmark	7.4
France	13.6
Germany	7.1
Netherlands	6.4
Norway	4.8
Singapore	1.8
Sweden	4.9
U.K.	5.0
U.S.A	13.6

5b Results

The estimated regression equations[2] (without using New Zealand data) are:

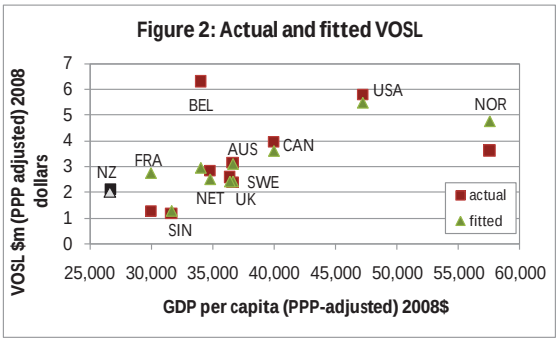
Model 1

$$\ln(\text{VOSL}) = -2.016 + 1.526 * \ln(\text{GDP per capita}) + 0.426 * \ln\left(\frac{\text{Annual road deaths}}{100{,}000 \text{ people}}\right)$$

The p-values for the coefficients are 0.79, 0.07 and 0.08, respectively. The model adjusted R^2 is 0.40, meaning that this model explained over 40 percent of the variations in VOSL.

Based on this model, the estimated VOSL for New Zealand is US$2.0 million, or NZ$3.19 million (in 2008 dollars).

The actual and fitted values of VOSL against GDP per capita are plotted in Figure 2.



[2] All the regressions have been corrected for the effects of heterogeneity of variance.

Model 2

As the constant in Model 1 is not statistically significant, it can be dropped from the model to improve its goodness of fit.

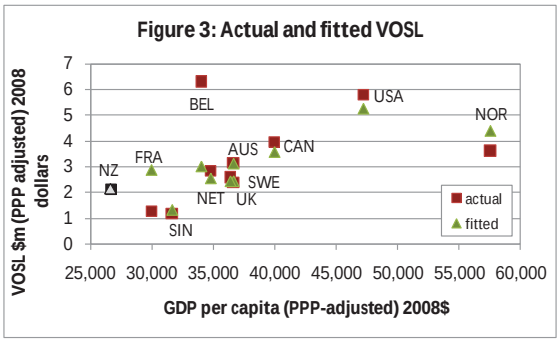
The fitted equation, without the constant, is:

$$\ln(\text{VOSL}) = 1.335 * \ln(\text{GDP per capita}) + 0.426 * \ln\left(\frac{\text{Annual road deaths}}{100{,}000 \text{ people}}\right)$$

The coefficient of ln (GDP per capita) became statistically more significant (with p-values of 0.0001). The model adjusted R^2 also increased slightly to 0.47.

Based on this model, the estimated VOSL for New Zealand is US$2.16 million, or NZ$3.42 million (in 2008 dollars).

The actual and fitted values of VOSL against GDP per capita are plotted in Figure 3.



Model 3

From Figure 3, Belgium and France appear to be the atypical cases. As a result, another model was run excluding these two countries.

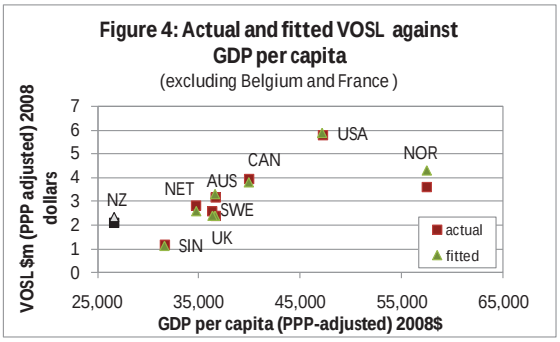
The fitted equation, after dropping Belgium and France, is:

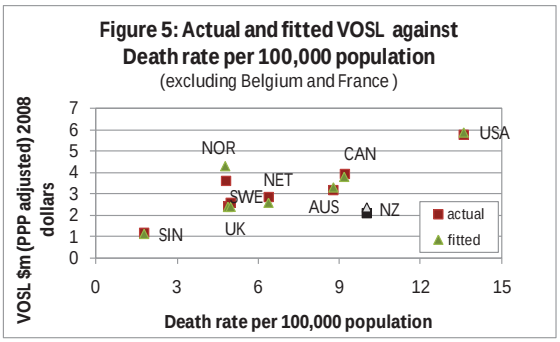
$$\ln(\text{VOSL}) = 1.315 * \ln(\text{GDP per capita}) + 0.548 * \ln\left(\frac{\text{Annual road deaths}}{100{,}000 \text{ people}}\right)$$

The p-values for the coefficients further improved to 0.00001 and 0.0001, respectively. The model adjusted R^2 increased to 0.96.

Based on this model, the estimated VOSL for New Zealand is US$2.34 million, or NZ$3.7 million (in 2008 dollars).

Figure 4 shows the actual and fitted values of VOSL against GDP per capita. This shows that the VOSL tends to increase with income. On the other hand, the plot of VOSL against death rates also shows a positive relationship between the two variables. Therefore, while the income level for New Zealand is lower than that of Singapore, due to its relatively high death rates, the estimated VOSL for New Zealand is higher (see Figure 5).





6 Discussion

The current official value of $3.35 million in 2008 dollars (or $3.5 million in 2009 dollars) is slightly higher than the value derived from iRAP (2008) ($2.96 million in 2008 dollars) but lower than the findings of the second VOS survey ($5.15 million in 2008 dollars) and that derived from Miller (2000) ($4.9 million in 2008 dollars).

This brief paper looks at the relationships between official VOSLs, GDP per capita and death rates to gauge whether the current VOSL used in New Zealand is too low by international standards.

The regression analysis confirms a significant positive relationship between GDP per capita and VOSL (with a p-value of less than 0.001). The estimated coefficient of GDP per capita is higher than that estimated in Miller (2000) and iRAP (2008). This means VOSL is more sensitive to the size of GDP per capita in our models.

The inclusion of the VOSL for developing countries in Miller and iRAP could have contributed to such a difference. The willingness to pay values for developing countries may be less than proportionate to income due to their lower ability to pay. Our analysis also found a strong relationship (for Models 2 and 3) between risk measures and VOSL.

Table 5: Summary of results – estimated VOSL for New Zealand

	VOSL NZ $m	
	2008 $	2009 $
Official value	3.35	3.50
Model 1	3.19	3.33
Model 2 – no constant	3.42	3.57
Model 3 – removed Belgium and France	3.70	3.87

After controlling for the differences in GDP per capita and road safety risk, and adjusting all estimates to 2009 dollars[3], the estimated VOSL for New Zealand is between NZ$3.33 and NZ$3.87 million (in 2009 dollars). Our current official value of NZ$3.5 million (in 2009 dollars) falls within this range.

There are some caveats about this analysis, as follows:

- As there are a limited number of countries using WTP-based VOSL for valuing the effects of road trauma, the small sample size has important implications for the robustness of the results.
- Although willingness to pay is affected by ability to pay and income, the models have not been able to explain the values for Belgium (understated) and France (overstated). Apart from risk and income, there are other factors, such as cultural and social differences, which are not captured in the regression analysis.
- Due to time constraints, the quality of the surveys behind the VOSL estimates has not been evaluated. The quality of a survey can affect the validity of the VOSL and its relationships with income and road safety risk.
- The choice of the official VOSLs could be influenced by political factors which are not captured in the regression analysis.

[3] This is done by indexing the VOSL to ordinary wage rate as per current practice.

7 Conclusion

In conclusion, there are no good grounds for suggesting the VOSL for New Zealand is too low by international standards.

On the contrary, this analysis suggests that the current official VOSL is about right, given the current road safety risk and income levels for New Zealand.

However, a revision of this analysis should be undertaken when more data become available.

8 References

Miller, T. (2000) “Variations between Countries in Values of Statistical Life”, Journal of Transport Economics and Policy, Volume 34, Part 2, May 2000.

iRAP (2008) “The True Cost of Road Crashes: Valuing life and the cost of a serious injury”, International Road Assessment Programme.

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