iRAP

INTERNATIONAL ROAD ASSESSMENT PROGRAMME

THE TRUE COST OF ROAD CRASHES

Valuing life and the cost of a serious injury

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Over 1 million people now die on the roads annually. In developing countries whole families can be thrown into poverty when a breadwinner is killed or maimed. This is more than a social disaster. Road crashes have become an economic drag that bleeds away up to 3% of global GDP.

Every government faces bottomless demands on its resources. Every government makes choices on how much it can afford to spend on one programme rather than another. But well managed economies ensure that the spending they make brings high social and economic returns.

Simple items like footpaths, pedestrian crossings, kerbing and safety fences can save lives at low cost and iRAP can estimate their potential across whole road networks in a country. The cost of providing a programme of footpaths can also be estimated in every country. But choosing the size of the programme that makes economic sense needs knowledge of the true cost of a life or a serious injury in the same country.

This paper from Dahdah and McMahon provides a practical, useable answer for any country at any point in its state of economic development. The authors are to be congratulated on their research and particularly in the way their research can be so readily used worldwide by those evaluating road casualty reduction programmes.

iRAP will adopt the recommended approach set out in this paper in its work worldwide to create targeted programmes of high return safety counter-measures where they will save the most lives for the available money.

About the authors

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In order to evaluate the benefits of programmes of engineering safety countermeasures through economic appraisal, the iRAP methodology needs to include a way of valuing the cost of a life and a serious injury. Experience in high income countries has shown that empirical estimation of values for the prevention of injury requires considerable care in order to avoid bias, and usually costly survey methods. Since such empirical estimation for every country that iRAP works in would be impractical, the purpose of this paper is to explore whether values sufficiently robust for the purposes of iRAP can be derived by consideration of results from existing studies.

This paper will:

- Discuss the background to valuation of safety benefits
- Briefly review the main methodologies that are in use
- Present recommendations for values for use in economic appraisal

Valuation of the prevention of a fatality, often termed the value of statistical life, and valuation of serious injury are discussed separately.

Background

Cost-benefit analysis of transport schemes has a long history in developed countries, particularly as a means of allocation of scarce resources and as a method for ranking the economic viability of alternative schemes. Road investment programs typically produce benefits mainly composed of time savings and crash and casualty reduction. Monetary values of these benefits are required in order that costs and benefits can be compared in a common currency.

There has been much discussion in the economic literature concerning the valuation of human life, sometimes focusing on the unethical nature of any such calculation. But for cost-benefit analysis what is in essence being valued is the benefit of an increase in safety or a reduction in risk. The value of statistical life is the level of investment that can be justified for the saving of one life. It is the valuation of a change in risk such that one life will be saved, rather than the valuation of the worth of a life of a specific individual.

One question to be addressed in determining values for use in a range of countries is whether it is appropriate to use different values depending on the level of income. Put more directly, should saving a life in a low-income country be afforded a lower value than in a high-income country? An underlying principle of economic theory is that the worth of something is determined by the price that people are prepared to pay for it. In essence safety is a commodity like anything else in that achieving a reduction in risk requires expenditure i.e. a trade off between wealth and the desired level of safety. Demand for safety as for any other good will depend both price and affordability within an income restraint. As will be seen in the following section on valuation methodologies, estimates of the value of statistical life are heavily influenced by income regardless of the method that is used. Both Willingness-to-pay and the Human Capital/Lost Output approach provide estimates that are income dependent. A study of Valuation in a range of European countries (COST 313 1993) found that about 40% of the variation between fatality values in the different countries could be accounted for by variation in Gross Domestic Product (GDP) per capita (Alfaro, Chapuis and Fabre, 1994).

Methodology for valuation of statistical life

It is not the intention of this paper to present a comprehensive review of methods for the empirical assessment of the value of a statistical life. Many such reviews exist in the economic literature (e.g. Alfaro et al., 1994; Schwab and Soguel, 1995; de Blaeij, Florax, Rietveld and Verhoef, 2003; Miller, 2000). However some brief description of the main methods is necessary in order to make recommendations on the way to obtain suitable values for iRAP countries that are generally applicable to a range of developing countries. Two main methods have been used to value the benefit of prevention of a road crash fatality: the Human Capital or Lost Output method and the Willingness-to-pay method.

Human capital or gross output method

This approach consists of valuing death in accordance with the economic impact. The main component in this ex post approach is the discounted present value of the victim's future output forgone due to death. To this are added market costs such as cost of medical treatment, and for crash costs as opposed to casualty costs, administration cost, and property damage are included. This approach has clear disadvantages, as it focuses only on the economic effects of the loss of life and does not account for the value and enjoyment of life forgone. This grossly underestimates the true value of prevention of road crashes and will produce very significantly lower values than an ex ante estimate based on willingness to pay. As a partial correction for this shortcoming, a "pain, grief and suffering" component is sometimes added that is intended to represent "human cost". Although this increases the value derived, it still results in a valuation that is generally much lower than values derived from the Willingness-to-pay method, and the human cost component is usually arbitrarily determined.

Willingness-to-pay method

The Willingness-to-pay (WTP) approach consists of estimating the value that individuals attach to safety improvement by estimating the amount of money that individuals would be prepared to pay to reduce the risk of loss of life. This ex ante approach involves some assessment of risk and the willingness of individuals to commit resources in exchange for reducing this risk to an acceptable level. This trade-off between risk and economic resources, measured in terms of the marginal rate of substitution of wealth for risk of death or injury, accords well with the fundamental principle of social cost-benefit analysis that public sector allocative decisions should be based upon the preferences of those who will be affected by the decision concerned.

Estimates of Willingness-to-pay to prevent road crash risk are generally based on surveys designed to ascertain the amount of money that individuals say that they would be prepared to pay to reduce the risk of loss of life i.e. contingent valuation methods. Both revealed preference estimates, derived from actual purchases of risk reduction devices such as airbags, and stated preference estimates from hypothetical choices determined by questionnaires have been used. Although theoretically sound, there are practical problems with obtaining precise estimates of individual Willingness-to-pay for risk reduction. The willingness to pay to avoid a lost statistical life is influenced by context effect (the perceived seriousness of a road crash) and scale effects (the number of casualties the road crash will involve). Surveys have also shown that respondents are relatively insensitive to small variations in risk, and therefore in order to increase the precision of estimates survey methodologies have been devised to address these problems (Carthy et al., 1998).

However, despite the difficulties associated with accurate estimation of individual Willingness-to-pay it is generally accepted as the most valid method for assessment of the value of prevention of road risk. Economic evaluation of road traffic safety measures was discussed at Round Table 117 of the ECMT in October 2000 and the conclusions are available at http://www.cemt.org/online/conclus/rt117e.pdf. Both COST 313 and the ECMT Round Table concluded that Willingness-to-pay is the preferred methodology as the human capital approach is not conceptually sound. The Willingness-to-pay method focuses on the right parameter and members of the Round Table agreed that "it was better to obtain an approximate measurement of the right parameter than to obtain an accurate measurement of the wrong parameter".

Rule of thumb approach

The Willingness-to-pay approach is conceptually appealing but has practical problems in being applied in developing countries as the methodological approach required to produce estimates is costly and requires sophisticated survey techniques. It is unlikely that there are existing results from Willingness-to-pay studies to value statistical life in road crashes in each of the iRAP countries. Ideally it would be recommended that each country should carry out a Willingness-to-pay survey to obtain an estimate of the value of statistical life in road crashes prior to any investment in road safety. However, given the costs and difficulties associated with such surveys, for the iRAP countries it is recommended that no new survey work would be appropriate. Carrying out Willingness-to-pay surveys in each country is not a viable option in terms of either cost or timeliness for completion of the research, quite apart from the intrinsic difficulty of producing reliable estimates.

Therefore an alternative approach has been investigated that explores the practicality of deriving a relatively simple “rule of thumb” drawing on available data and results from both Willingness-to-pay and Human Capital studies from a range of countries. This started from the hypothesis that the level of income in a country is a primary determinate of the value of statistical life. This is obviously the case for values based on the human capital approach, but is also valid for WTP values as Willingness-to-pay is influenced by ability to pay. Data were collected for a range of developed and developing countries and ratios of Value of Statistical Life (VSL) to GDP per capita were calculated.

Table 1 shows a list of official values of statistical life used in some developed countries in economic appraisal of road safety schemes. The values for New Zealand, Sweden, UK and USA are based on the Willingness-to-pay method. The rest are mainly Human Capital based, but the estimate for the Netherlands includes a significant element for pain, grief and suffering.

The ratio of the Value of Statistical Life to the per capita GDP varies between 42 and 86 with a mean and median of 63. If only the countries using WTP, plus the Netherlands and Iceland, are considered, both the mean and the median are 74.

Table 2 shows a list of values of statistical life for some developing countries. The majority of the values were based on the Human Capital approach and therefore the values are likely to be much lower than values derived from a Willingness-to-pay approach.

With the exception of Malaysia (WTP value), the ratio of Value of Statistical Life to per capita GDP ranges between 14 and 62 with a mean of 42 and a median of 40. Including Malaysia raises the mean slightly to 44. The higher Malaysian ratio is most likely to be due to the use of a Willingness-to-pay approach rather than a Human Capital approach, and although India’s value based on WTP is not as high as that of Malaysia, it is higher than average. A TRL study on valuation in developing countries recommends adding 28% for pain, grief and suffering to values obtained from human capital methods.

If we compare the ratios between developed countries (Table 1) and developing countries (Table 2), it is clear that the developed countries’ ratios tend to be higher particularly when they are based on a Willingness-to-pay approach. However, what is striking from both these tables are the relatively clustered values of VSL/per capita GDP if countries are grouped according to the methodology used, and although the ratios for developing countries are more variable, overall the range of ratios is narrower than might have been expected prima facie. This finding gives some support to the concept of a rule-of-thumb approach based on the ratio of VSL to GDP per capita for obtaining workable estimates of the Value of Statistical Life for developing countries.

Table 1: Values for developed countries

Country	Official VSL	Per capita GDP	VSL/per capita GDP	Year	Currency	Method
Australia	1,832,310	40,654	45	2003	Aus $	HC
Austria	2,676,374	31,028	86	2006	€	WTP
Canada	1,760,000	36,806	48	2002	C$	HC
France	1,156,925	27,232	42	2005	€	HC
Germany	1,161,885	26,753	43	2004	€	HC
Iceland	284,000,000	3,840,943	74	2006	ISK	HC+PGS
Netherlands	1,806,000	28,807	63	2002	€	HC + PGS
New Zealand	3,050,000	37,536	81	2005	NZ$	WTP
Sweden	18,383,000	295,436	62	2005	SK	WTP
United Kingdom	1,384,463	19,663	70	2004	£	WTP
United States	3,000,000	36,311	83	2002	$	WTP

Table 2: Values for developing countries

Country	VSL	Per Capita GDP	VSL/per capita GDP	Year	Currency	Method
Cambodia	18,864	317	60	2002	$	HC
Philippines	41,330	982	42	2003	$	HC
Thailand	2,741,064	85,890	32	2002	B	HC
Vietnam	162,620,000	7,582,788	21	2003	D	HC
Lao	4,617	336	14	2003	$	HC
Indonesia	255,733,113	8,645,085	30	2002	Rp	HC
Malaysia	1,200,000	15,811	76	2003	RM	WTP
India	1,311,000	23,578	56	2004	Rs	WTP
Myanmar	4,806,909	144,967	33	2003	MK	HC
Bangladesh	889,528	16,169	55	2002	Tk	HC
Latvia	276,327	4,807	57	2006	LVL	HC
Poland	1,056,376	27,585	38	2006	PLM	HC
Lithuania	1,018,269	16,405	62	2003	LTL	HC

Table 3: VSL in International 2004 $

Country	VSL 2004 International $	GDP/Capita 2004 International $	Method
Australia	1,304,135	28,935	HC
Austria	3,094,074	35,871	WTP
Bangladesh	71,066	1,710	HC
Canada	1,427,413	29,851	HC
France	1,252,083	29,472	HC
Germany	1,257,451	28,953	HC
Iceland	3,303,555	44,679	HC+PGS
India	147,403	2,651	WTP
Indonesia	92,433	3,125	HC
Latvia	1,042,743	18,140	HC
Lithuania	746531.5249	12,027	HC
Malaysia	722,022	9,513	WTP
Myanmar	51,245	1,545	HC
Netherlands	1,944,026	31,009	HC + PGS
New Zealand	2,033,333	25,024	WTP
Poland	573,806	14,984	HC
Singapore	924,240	25,034	HC
Sweden	2,015,680	32,394	WTP
Thailand	222,056	6,958	HC
UK	2,292,157	32,555	WTP
USA	3,000,000	36,311	WTP
Vietnam	53,063	2,475	HC

Regression analysis

The strength of the relationship between VSL and income levels was explored further using log linear regression to estimate an equation of the form:

$$\log_n(VSL) = a + b^* \log_n(GDP/Capita) + c^* Method$$

Where Method =

1 if Willingness-to-pay methodology is used to derive VSL

0 if otherwise

Local currency data were converted to 2004 International $ values for this analysis. The regression resulted in an equation with a $Radj^2$ value of 97%, and derived values of VSL/GDP per capita that averaged 53 across all countries in Tables 1 and 2.

The regression equation is:

$$\log_n(VSL) = 2.519 + 1.125^* \log_n(GDP/Capita) + 0.496^* Method$$

Although the analysis is based on only 22 countries it supports the proposal to use the ratio of VSL to GDP per capita as a rule of thumb method to derive estimates of VSL in iRAP countries.

If we set the method to be a Willingness-to-pay approach, the regression equation will be reduced to:

$$\log_n(VSL) = 3.015 + 1.125^* \log_n(GDP/Capita)$$

The shape of this equation is approximately linear which supports again the use of a ratio of VSL to GDP per Capita while estimating Value of Life for the iRAP purposes. The proportionality assumption between VSL and GDP per capita is compensated for while doing the sensitivity analysis and changing the ratio.

Another regression equation was used to derive the ratio of VSL to GDP per capita to be used as the rule-of-thumb for the iRAP Economic Appraisal Model. The regression equation used the ratio of VSL to GDP per capita as the independent variable and the Method used to derive the value of statistical life as the dependant variable.

The regression equation is:

$$VSL/\text{per Capita } GDP = a+b^* Method$$

Where Method =

1 if a Willingness-to-pay approach was used

0 if a Human capital approach was used

The regression resulted in an equation with $Radj^2$ value of 58%.

$$VSL/\text{per capita } GDP = 41+30^*Method$$

If we set the method to be the WTP, the mean value of the ratio of VSL to GDP per capita will be 71 with a 95% confidence interval of [55,89].

Conclusion

The advantage of a rule-of-thumb approach is that it will ensure consistency between the different countries and will avoid bias from surveys of unknown reliability. The disadvantage is that it has to rely on evidence from a limited number of countries for which acceptably reliable estimates of the value of statistical life are available. As discussed above, values based on Willingness-to-pay are preferable to those based on human capital, but only a handful of countries currently use such values. However, the evidence from Table 1 is that if the estimates use WTP or include an allowance for human costs, the ratio of VSL to GDP per capita is likely to lie in a fairly narrow range between about 60 and 80. This is supported by the regression analysis.

It is therefore recommended that a reasonable rule of thumb to use in the iRAP project for the default values for the economic appraisal model is 70 as a central ratio value, with a range of 60 to 80 for sensitivity analysis. This also accords with the WTP estimate of VSL/GDP per capita for Malaysia, which is one of the iRAP pilot countries.

This approach will provide values for the benefits of fatality reduction that reflect the level of income in each country, but as the estimates will be based largely on data from developed countries; the values may also reflect the higher level of demand for safety in such countries. This is considered to be appropriate since one of the aims of iRAP is to raise demand for safety improvement within developing countries.

Methodology for valuation of serious injuries

The main iRAP objective is to reduce the number of fatalities and serious injuries through mass action programs following the road inspection and its results. The economic appraisal model will take into consideration the benefit from reducing the number of both fatalities and serious injuries and therefore an estimate of the value of prevention of a serious injury is also necessary.

As for valuation of a fatality it is not practicable to attempt to provide empirical estimates for the iRAP countries. Such estimates would require good information on the range of injuries in the serious category, medical costs and lost output as well as a reliable Willingness-to-pay estimate of human costs. None of these are likely to be available.

A possible method that could be used to estimate the value of serious injury in developing countries would be to consider the relationship between fatal and serious injury values in selected countries. This would ideally need to be adjusted to reflect the distribution of injuries within the serious category in each of the iRAP countries.

Comparison of values for serious injuries used in different countries is more difficult than comparison of fatality values. The definitions of what is included as a serious casualty vary considerably, even between developed countries. In some countries an injury is defined as serious if the victim is hospitalized, whereas in other countries a wider definition is used. Injury data are often less reliable than fatality data, and more prone to under-reporting particularly of less severe injuries. This may bias the data in countries with poor data collection methods towards the more severe end of the injury spectrum. The distribution of severity in a country will also be affected by the modal split of travel, so that countries with higher proportions of pedestrians, bicyclists and motorcyclists will tend to have injury distributions that are weighted towards more severe injuries.

As a starting point it was decided to examine the relationship between the value of statistical life and the value assigned to a serious injury in each of the countries in Table 1 to see whether despite the definitional problems any consistency could be found that might inform an approach for estimating injury values in the iRAP countries. The results are shown in Table 4.

The numbers of fatalities and serious injuries are for the same years as in Table 1 and therefore the year may vary between the countries. The cost associated with the fatality and serious injury is expressed in local currency units. The value of serious injury relative to the value of statistical life as shown in the final column of the table above will be affected by the definition of serious injury used in each country. The wider the definition the lower will be the ratio, all other things being equal. This assumption is supported by the relatively low ratio for the UK where the definition of serious injury is relatively broad compared some of the other countries where only hospitalized casualties are included. Whereas for the fatality

Table 4: Serious injury data for developed countries

Country	Fatalities	Serious injuries	VSL	VSI	Serious injuries/ fatalities	VSI/VSL %
Australia	1,634	22,000	1,832,310	397,000	13.4	22%
Austria	730	6,774	2,676,374	316,722	9.2	12%
Canada	2,936	17,830	1,760,000		6.1	
France	5,318	39,811	1,156,925	124,987	7.5	11%
Germany	5,842	80,801	1,161,885	87,267	13.8	8%
Netherlands	987	11,018	1,806,000		11.1	
New Zealand	405	3,950	3,050,000	535,000	9.8	18%
Sweden	440	4,022	18,383,000	3,280,000	9.1	18%
United Kingdom	3,221	31,130	1,384,463	155,563	9.7	11%
United States	42,815	356,000	3,000,000	464,663	8.3	15%

ratios in Table 1 the highest value was just under twice the lowest value, the highest value for the injury value as a percentage of the fatality value shown in Table 4 is nearer three times the lowest value. There is also an absence of clustering by estimation methodology with the UK closest to the value for France despite the different methodologies used. This variation makes the derivation of a simple rule of thumb problematic.

Ideally an adjustment based on information about the distribution of injury type within the serious category would be required in order to correct for definitional bias and for the effect of modal split on the distribution of injury by severity. One possibility would be to obtain information on AIS distributions for a range of countries.

The Abbreviated Injury Scale (AIS) was conceived more than three decades ago as a system to describe the severity of injuries. Its original purpose was to fill a need for a standardized system for classifying the type and severity of injuries resulting from vehicular crashes. The AIS injury severity values are consensus-derived and range from 1 (minor) to 6 (fatal). See Table 5 for the AIS code and description.

Table 5: Description of AIS code

AIS Code	Description
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Maximal

The AIS does not assess the combined effects of multiple injuries. The most widely used system based on AIS is the Maximum AIS (MAIS) which categorizes casualties according to the most severe injury suffered. The MAIS is the highest (i.e., most severe) AIS code in a patient with multiple injuries. It is widely used to describe the overall injury to a particular body region or overall injury to the whole body. A person who is seriously injured in a car crash is most likely to sustain a MAIS 3, 4 or 5 injury.

Ideally, in order to value serious injury, the average value of an MAIS 3-5 should be calculated based on the distribution of the MAIS 3, 4 and 5 within this "Serious Injury" category. This requires information on the distribution of injury by MAIS and also estimates of values of prevention for each MAIS category. Such data are difficult to find even in developed countries and unlikely to be available for developing countries.

Crash Injury databases from various developed countries were examined. Data for both injury distribution and value of prevention are available by MAIS for the US from the National Automotive Sampling System NASS database. The US data also provide information for pedestrian injury by MAIS from the Pedestrian Crash Data System (PCDS). The only crash data in developing countries that were classified on an MAIS scale are the data from the Injury Surveillance Program in Thailand.

The methodology suggested to estimate the value of prevention of a serious injury in the iRAP countries is to apply the MAIS 3-5 distribution of the injuries to the US cost of MAIS and derive a relationship between the value of MAIS 6 (Fatality) and the average value of MAIS 3-5 (serious injury).

Since the majority of crash injured persons in developing countries are from the vulnerable road users category (pedestrian, bicyclists, motorcyclists), it is important to apply this methodology to a set of pedestrian crash injury data as well as a set of crash data from a developing country, therefore the two injury databases used to estimate the mean ratio of value of serious injury to the value of statistical life are the US Pedestrian Crash Data System (PCDS) and the injury data from the Injury Surveillance Program in Thailand.

The distribution of injury data for all road user casualties from the NASS-CDS database for the years 2000-2005 is shown in Table 6. Table 7 shows US injury cost values by MAIS.

Table 6: Total MAIS 3-5 injury severity distributions 2000-2005

MAIS	Number	%
3	397,241	67.1%
4	124,019	20.9%
5	71,009	12.0%
Total	592,269	100.0%

Table 7: Cost of MAIS 3-6 in the US

MAIS	Cost ($)
3	175,000
4	565,000
5	2,290,000
6	3,000,000

From Tables 6 and 7 a weighted average value for MAIS 3-5 can be derived. This value is $510,000 which is 17% of the US VOSL.

Table 8 shows the injury severity distribution of the pedestrian injuries in the US (PCDS 1994-1998) and the injuries from the Injury Surveillance Program in Thailand (2004-2006). Note that the PCDS database consists of only 512 pedestrian cases of which 147 cases are serious injuries (MAIS3+) but this sample is the biggest in depth pedestrian injury study worldwide.

It is surprising that the distribution of injuries in Thailand (Table 8) is so close to the US distribution for all road users (Table 6) since it would be expected that the proportion of vulnerable road users injured in Thailand would be higher than in the US where motor vehicles predominate and therefore that the distribution would be closer to the US pedestrian distribution. A possible explanation for this is that the higher level of motorisation in the US results in a higher proportion of car/VRU crashes at higher speeds than in Thailand where the motor traffic contains a high proportion of light motorcycles.

From Table 8 the average cost for a pedestrian MAIS 3-5 injury in the US is $826,000 which is 28% of the US VOSL. If the injury distribution in Thailand in Table 8 is used with the US costs in Table 7, the weighted average cost for a serious injury is $511,000 or 17% of the US VOSL.

It is important to note the scaling problems associated with the injury surveillance program in Thailand. This system is still using the AIS-85 coding system and needs to be updated to the AIS-2005 system. Also it was observed that there was a difference in reporting between hospitals within the system which includes 30 hospitals. If we apply the same methodology to the data from a particular hospital in Thailand (Khon Kaen regional hospital) where 48% of the seriously injured (MAIS3-5) sustained an MAIS 5 injury, the average value of serious injury will be about 40% of the value of a fatality.

To summarize these results:

1- The value of a serious injury in the US is 17% of the value of a fatality
2- The value of a pedestrian serious injury in the US is 28% of the value of a fatality
3- The value of a serious injury in Thailand is 17% of the value of a fatality (using US cost table, Table 7)
4- The value of a pedestrian serious injury in Hong Kong is 30% of the value of life (using US cost table, Table 7)

The lack of evidence on MAIS distributions for VRUs and the lack of values by MAIS make the derivation of a suitable value for prevention of serious injury difficult. Taking all of the above into consideration, and with the absence of a reliable injury crash data system and the valuation of different injuries in the iRAP countries, **it is recommended that a reasonable value of serious injury for the economic appraisal model is 25% of the value of a fatality, with a range of 20% to 30% for sensitivity analysis. The equivalent values in terms of multiplier of GDP per capita are a central value of 17 with a range of 12 to 24 for sensitivity analysis.**

It must be stressed that this recommendation is based on judgement derived from the small amount of available data, and is therefore less robust than the recommendation for the fatality valuation. Nevertheless, it should suffice for the purposes of iRAP, and does provide a consistent basis for valuation across the countries.

Estimating the number of serious injuries

The Casualty Estimation model will only generate the number of fatalities per km per year and therefore there is a need to estimate the number of serious injuries per km per year. The iRAP model will use a default ratio of number of serious injuries to number of fatalities for a given length of the network. This ratio depends on the definition of serious injury to be adopted. The wider the definition is, the higher the ratio will be and the lower the value of serious injury will be.

Table 8: MAIS 3-5 injury severity distribution in US, Thailand and Hong Kong

	Pedestrian injury severity distribution in US (PCDS database)		Injury severity distribution in Thailand		Pedestrian injury severity distribution in Hong Kong	
MAIS	**Number**	**%**	**Number**	**%**	**Number**	**%**
3	74	50.3%	49,921	67.9%	95	46.8%
4	34	23.1%	14,572	19.8%	46	22.7%
5	39	26.5%	9,010	12.3%	62	30.5%
Total	**147**	**100.0%**	**73,503**	**100.0%**	**203**	**100.0%**

In the methodology to estimate the value of serious injury explained above, it was agreed that an MAIS3+ injured person will be classified as "seriously injured". This definition is widely used among researchers who use the AIS scale to classify the severity of injury.

Table 4 shows the ratio of serious injuries to fatalities in some developed countries. The definition of serious injury differs between countries. In general, a seriously injured person from police crash data refers to a person being hospitalized. For example, a person who is slightly injured but was admitted to a hospital for few hours will be considered seriously injured from a police report and therefore the definition is wide. That definition is used in the majority of the countries of Table 4. The ratio between serious injuries and fatalities in that table ranges between 6 and 13.

For the same serious injury definition (being hospitalized), this ratio increases to 16 in some developing countries as reported in the ADB-ASEAN project shown in Table 9. The high proportion of vulnerable road users, low seat belt/helmet wearing rates, and unforgiving roads in those countries may explain these higher ratios.

The definition of serious injury adopted in the iRAP tools, is narrower than just being hospitalized because an MAIS 2 injury can be hospitalized for few minutes or hours then be released, but an MAI3+ injured person will most likely stay over night in the hospital. The ratios from the ADB-ASEAN study may therefore be higher than would be the case if a strict MAIS 3+ definition were used. The value for a serious injury recommended in the previous section is also based on this higher definition of injury, and therefore assumes a lower ratio of serious to fatal injury.

Table 9: Ratio of serious injuries to fatalities from ADB-ASEAN Project

Country	SI/F
Indonesia	14.7
Philippines	16
Thailand	14.5

It is therefore recommended to use 10 as the default ratio of the number of serious injuries to the number of fatalities and for sensitivity analysis this ratio will vary between 8 and 12.

Conclusion

Table 10 shows the values of prevention for fatalities and serious injuries as percentages of GDP per capita that are recommended for use as default values as well as for sensitivity analysis for the Economic Appraisal of the countermeasures that will be generated from the iRAP inspections. It also shows the value of serious injury and the ratio of number of serious injuries to number of fatalities to be used.

Table 10: iRAP economic appraisal model values

	Lower	Central	Upper
Value of Fatality	**60*GDP/Capita**	**70*GDP/Capita**	**80*GDP/Capita**
Value of Serious Injury	**12*GDP/Capita (20%VSL)**	**17*GDP/Capita (25%VSL)**	**24*GDP/Capita (30%VSL)**
Number of Serious Injuries to number of Fatalities	**8**	**10**	**12**

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iRAP

INTERNATIONAL ROAD ASSESSMENT PROGRAMME

Deaths and injuries from road traffic crashes are a major and growing public health epidemic. Each year 1.2 million people die and a further 50 million are injured or permanently disabled in road crashes. Road crashes are now the leading cause of death for children and young people aged between 10 and 24. The burden of road crashes is comparable with malaria and tuberculosis, and costs 1-3% of the world's GDP.

More than 85% of the global death toll and serious injuries occur in developing countries. Whereas road deaths are expected to fall in high-income countries, they are likely to increase by more than 80% in the rest of the world.

iRAP is dedicated to saving lives in developing countries by making roads safer. iRAP targets high-risk roads where large numbers are being killed and seriously injured, and inspects them to identify where affordable programmes of safety engineering – from pedestrian crossings to safety fences – could reduce deaths and serious injuries significantly.

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iRAP is grateful for the support of FIA Foundation for the Automobile and Society

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