Australasian Transport Research Forum 2022 Proceedings
28-30 September, Adelaide, Australia
Publication website: http://www.atrf.info

Sizing the road crash cost iceberg

Neil Douglas

Douglas Economics

Email for correspondence: DouglasEconomics@gmail.com

Abstract

The economic cost of road crashes in New Zealand in 2019 was $5.49 billion. 300 road fatalities cost $1.34 billion and 34,200 injuries together with 269,000 property damage only (PDO) crashes cost $4.15 billion. Fatalities were the ‘tip’, albeit the tragic tip, of a road crash cost iceberg but how reasonable was the size of the injury and property damage ‘bummock’ that cost three times more yet attracts much less attention?

New Zealand relies on 30 year old studies applied to partially reported crash data. In this regard New Zealand is not that dissimilar to Australia, Canada, Germany, Sweden, UK and USA who also rely on somewhat tenebrous statistics. What has resulted, somewhat serendipitously for New Zealand, is a road crash cost iceberg of middling size in per capita terms and shape.

To estimate values for fatalities and injuries, researchers, egged on by government, have become preoccupied of late with Stated Preference route choice (SPRC) surveys of car drivers’ willingness to pay for safer roads. Based on past performance, they are unlikely to provide much more than a scintilla of pellucidity. Even if they did, there remain car passengers, bus passengers, truck drivers, cyclists and pedestrians. Indeed, it would perhaps be more beneficial for Government to survey the general population about their willingness to pay to reduce individual risk of accident, pollution and disease and, or alternatively, commission a review of the many valuation studies already undertaken. Meanwhile, transport analysts could reset their ambitions to determining the number of road crashes by severity and estimating the community costs of road crashes (emergency and hospital services, traffic delays, pollution) whilst awaiting a new set of harmonious crash cost values to undertake project appraisal.

1. Introduction

An aim of government has been to reduce the road toll. Looking back through the rear view mirror, New Zealand can claim success with road deaths in 2015 half what they were in 1990 (319 versus 729), ITF (2020). Non-fatal crashes have fallen too but only by a quarter, declining from 12,818 in 1990 to 9,737 in 2015. As a result, the ratio of reported injury crashes to fatalities climbed from 18 in 1990 to 31 in 2015. Moreover, given police reported injury crashes only account for a third of total injury crashes, the ratio rises to 96.[1] When people rather than crashes are enumerated (since a crash can involve more than one person) the ratio of injured persons over fatalities rises to 109.

Fatalities therefore represent the tip, albeit the tragic tip, of a road crash ‘iceberg’. Much bigger in size is the injury and property damage iceberg ‘bummock’ that lies beneath and

[1] The factor to take account of unreported accidents is calculated by comparing police reports with hospitalization and Accident Compensation Corporation (ACC) insurance claims data.

seemingly passes by government, media and the public unnoticed.[2] However it is nonetheless the most major part of the social cost of road crashes accounting for three-quarters of the total. And it is the 'total cost' which has provided a cost-benefit justification for road safety investments, regulations and policing.

Like other nations, the New Zealand government aims to reduce the road toll. New Zealand's 'Road to Zero' targets a 40% reduction in fatalities and serious injuries during the 2020s. A more ambitious resolution passed by the United Nations General Assembly in October 2020 seeks a 50% reduction in global road deaths over the same period, ITF (2020).

For New Zealand, the 40% reduction would save 750 lives and 5,600 serious injuries to 'save the economy' $9.6 billion (out of a total crash cost of $45 billion) according to the New Zealand Ministry of Transport (2019). Of this saving, around 90% would be 'avoided pain, grief and suffering' of death and 'loss of quality of life' through injury. The remainder would be the costs of vehicle damage (5%), medical expenses (2%), avoided lost output from temporary disability (1%) and legal and court costs (1%).

Costs rely on thirty year old studies. The value of a fatality prevention (VSL) dates back to a 1988-89 survey by Guria and Miller (1991) who used contingent valuation (CV) questions to estimate the willingness to pay (WTP) to reduce the probability of dying in a road crash. The estimated VSL was $2 million (including the cost of emergency services) and this cost has been increased with hourly earnings to $4.42 million in 2020, New Zealand MOT (2020).

A decade later, another similar survey by Guria (1999) doubled the VSL to $4 million (1998 prices) but the value was not implemented.[3] As well as including CV questions to estimate the VSL, 'Standard Gamble' (SG) questions (developed by Jones-Lee in the UK) estimated the relative cost of a serious and a minor injury to a fatality. Percentages of 10% and 0.4% were recommended and remain the basis of current calculations. For 2020, the value of preventing a serious injury (VSSI) worked out at $442,400 and $17,700 for a minor injury (VSMI).[4] Medical, legal and court costs (including police costs) and vehicle damage costs are then added. For a fatality, the costs amounted to $40,700 in 2020 which was an increase of 1% on the VSL. For VSSI, the additional costs added $25,300 or 6% to the 'quality of life' cost and for VSMI they added $7,600 which was a significant increase of 30% in mostly property damage to vehicles.

Medical and vehicle damage costs were also based on old studies. Medical costs were sourced from Dunedin and Waikato hospitals in the mid 1990s that looked at the average cost of emergency treatment, hospital in-patient treatment and follow-on treatment by injury severity. The unit costs have been updated by applying the producers' input price index for health and community services. Vehicle damage costs were based on a 1995 study by Guria that looked at road accident insurance claims (Guria, 1995) that are updated by the consumer price index.

---

[2] Oceanographers refer to the submerged part of an iceberg as a bummock and the above water part as a hummock whereas common parlance is to refer to the visible part as the iceberg tip.

[3] The Guria report appears to have only made draft stage and a copy of the draft report was not able to be obtained as part of writing this paper. Ted Miller, who was a co-researcher in the 1989/90 study but not directly involved in the 1999 study, viewed the 1999 report as *"very academic"* and not written in the (simplified) language of policy-makers. He also criticised the report as attempting to advance policy literature as well as create a measure for practical use. https://www.rnz.co.nz/news/the-wireless/371308/working-out-the-value-of-a-life

[4] The NZ Ministry of Transport somewhat pessimistically labels the WTP costs as 'loss of life / permanent disability' (Table 2). Minor injuries should defy the description of 'permanently disabling' otherwise they should be classed as 'serious injuries'.

Only legal and court costs have been based on figures that are reasonably 'up to date' that are obtained from New Zealand Police's Road Policing Programme and Ministry of Justice.

From Ministry of Transport reports it would appear that the costs of ambulance and fire brigade attendance at accidents are not included.[5] Neither are road traffic delay costs, pollution costs, cost to pets and livestock and post-accident restoration to roads and property.

In addition to injury crashes, there were 269,000 non-injury crashes in 2019 that had a PDO cost of $0.89 billion. However this number was not based on accident monitoring but by multiplying the number of minor injury crashes by a factor of 8.4. This factor was derived by Guria in 1995. A cost of $3,300 was then applied also based on Guria (1995).

All told, the cost of road crashes in New Zealand during 2019 was $5.5 billion.[6] 300 fatalities cost $1.3 billion (24% of the total) with injuries and PDO crashes adding $4.1 billion.[7] So adding injuries and property damage produced a road crash cost iceberg 4.1 times bigger than the fatality 'tip' but how reasonable is the size of the injury and PDO bummock given it relies on 30 year old studies applied to partial police reported crash data and omits traffic delays, pollution and ambulance/fire brigade response?

To help assess the size of the iceberg, New Zealand is compared with Australia, Canada, Germany, Sweden, UK and USA. These seven countries were reviewed in a sister paper "*Valuing Safety when Roads are Increasingly Safe"* by Douglas (2021) which looked at the cost of fatalities. The rest of the paper is as follows. Section 2 dives straight in by looking at the trend in fatality and injury accidents over the last quarter century 1990-2015. Section 3 resurfaces to assess injury and PDO crash numbers relative to fatalities. Unit crash costs are then circumnavigated in section 4 and anchored to crash numbers in section 5 to calculate the size of the road crash cost iceberg. Section 6 takes a look at SPRC surveys that have mostly focused on car drivers. Section 7 looks at the bigger accident picture and Section 8 recaps on salient points made.

2. Trend in road fatalities and injury road crashes

Annual country reports published by the International Transport Forum (ITF) were used to determine the trend in fatalities and reported injury crashes between 1990 and 2015.[8]

Unfortunately, data on Australian road injury crashes was unavailable because although crash data has been collected and validated by the police and transport agencies in the eight states and territories: *"no systems were in place to reliably measure national indicators of injuries*

[5] The original Guria study in 1989 reputedly added on a cost for emergency services.

[6] Expressed in 2020 prices.

[7] It was not possible to reconcile the sum product of the fatality, injury and PDO numbers and their unit costs with the figure in the MOT update 2020 report. To reach the MOT figure, a cost of $660 million was needed which might be something to do with the factoring of unreported accidents.

[8] The International Transport Forum defines an injury crash is an accident involving a road vehicle in motion on a public or private road to which the public has right of access, resulting in at least one injured or killed person. A suicide or an attempted suicide is not an accident but an incident caused by a deliberate act to injure oneself fatally. However if a suicide or an attempted suicide causes injury to another road user then the incident is regarded as an injury accident. Accidents that are included include collisions between road vehicles, between road vehicles and pedestrians, between road vehicles and animals or fixed obstacles and between road and rail vehicles. Multi-vehicle collisions are counted as one accident. Injury accidents excluded accidents incurring only property damage. From Box 2.2 in https://www.itf-oecd.org/sites/default/files/docs/road-casualties-web.pdf

from road crashes in part due to jurisdictional differences in injury definitions and reporting arrangements"(ITF-Australia 2020).[9]

Table 1: Trend in Road Fatalities & Injury Crashes

Country	Fatalities				%C	Injury Crashes 000s^				%C	IC/F*			
	1990	2000	2010	2015	90-15	1990	2000	2010	2015	90-15	90	00	10	15
NZ	729	462	375	319	-56%	12.8	7.8	10.9	9.7	-24%	18	17	29	31
Australia	2,331	1,817	1,351	1,206	-48%	not available					not available			
UK	5,402	3,580	1,905	1,804	-67%	266	242	169	146	-45%	49	68	89	81
Germany	11,300	7,503	3,648	3,459	-69%	385	383	288	306	-21%	34	51	79	88
Sweden	772	591	266	270	-65%	17.0	15.8	16.3	14.7	-14%	22	27	61	54
Canada	3,963	2,904	2,238	1,860	-53%	182	156	126	118	-35%	46	54	56	63
USA	44,599	41,945	32,999	35,485	-20%	2,162	2,107	1,572	1,748	-19%	48	50	48	49

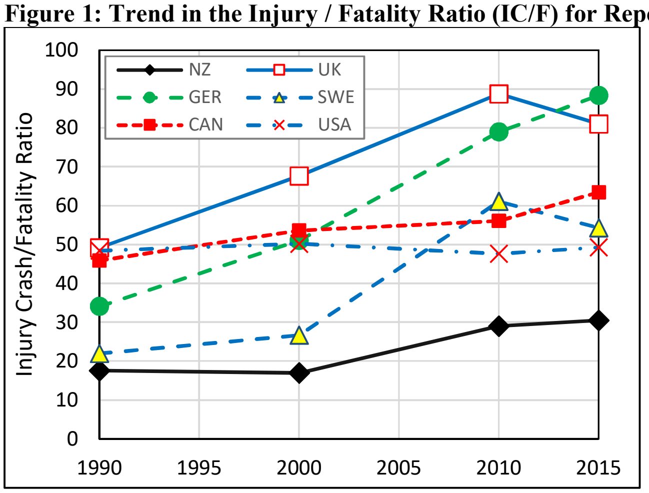
^ Reported Injury crashes: road crash where ≥1 person injured or killed and the crash is reported by the police
*IC/F Reported Injury crashes divided by fatalities; %C = Percent Change. Source: ITF Country Reports

Germany (post-unification) achieved the greatest reduction in fatalities (-69%) and the USA the lowest (-20%) between 1990 and 2015. New Zealand and Australia were in the middle with a halving of fatalities.

The declines in reported injury crashes (which include fatalities) were lower. The UK achieved the biggest reduction (-45%) and Sweden the smallest (-14%). New Zealand was again in middle (-24%).

Improved vehicle safety, mandatory seat belt wearing, more efficient emergency response and medical care have contributed to improved crash survival rates and these improvements explain the bigger drop in fatalities than in injury crashes.

Figure 1: Trend in the Injury / Fatality Ratio (IC/F) for Reported Accidents



Given these trends, the ratio of injury crashes over fatalities (IC/F) has grown as Figure 1 shows.[10] The biggest increase in the IC/F ratio was for Germany which rose from 34 in 1990 to 88 in 2015. For New Zealand, although the ratio increased from 18 to 31, the ratio has

[9] Page 14, ITF Australia Road Safety Report. The report also writes that an ongoing monitoring process linking hospital and police crash datasets was planned to be completed in 2019, DITCR (2019). https://www.itf-oecd.org/sites/default/files/australia-road-safety.pdf
[10] Ideally, the comparison would be fatalities with injuries but only injury crash statistics were available.

remained steadfastly lower than for the other six countries (Australia being an omission due to the absence of injury crash data).

Inverting the ratio gives the chance of dying in a reported crash. For New Zealand, it was 3.3% (319/9,737) in 2015 which was three times greater than Germany (1.1%) and 1.6 times greater than the USA (2%). Whether the greater chance of dying on New Zealand roads was due to worse driving, less safe vehicles, less effective emergency and medical response on the one hand or less diligent police reporting of injury crashes on the other is open to conjecture.

3. Fatalities, injuries and property damage only crashes

The number of fatality, injury and PDO crashes is presented in Table 2 for the most recent year that data was available (all were pre COVID).

Table 2: Injury, Fatality and PDO Numbers and Fatality Ratios

Country	Year	Number of injuries and fatalities in Year				PDO	Injury / Fatality			PDO/
		Minor	Serious	Fatal	Total	Crashes	M/F	S/F	(M+S)/F	F
NZ	2019	30,298	3,921	300	34,519	269,000	101	13	114	897
Australia	2015	227,572	37,964	1,205	266,741	600,000	189	32	220	498
Canada	2018	120,138	8,811	1,943	130,892	473,899	62	5	66	244
Germany	2019	346,844	68,224	3,280	418,348	1,980,746	106	21	127	604
UK	2019	275,907	68,044	1,658	345,609	1,815,517	166	41	207	1,095
Sweden	2019	11,512	1,951	221	13,684	not known	52	9	61	-
USA	2019	10,413,989	153,547	36,096	10,603,632	13,000,000	289	4	293	360

PDO Property damage only accidents. Sources: NZ MOT 2020; Australia Economic Connections (2015); Canada ITF (2020); Germany BASt (2021); UK DfT(2019); Sweden European Commission Report (2020); USA NHTSA, Blincoe (2015).

As can be seen, the figures vary considerably. A common definition is used for fatalities (a person who dies immediately or within 30 days of a road crash) and with mandatory reporting, meaning differences in numbers are not due to definition.[11] Sweden with 221 was lowest and the USA with 36,210 the greatest (principally reflecting respective population size, see section 6).

Differences in injury definition and how figures are inflated (if at all) for police non-reporting mean differences can be 'artificial' rather than real. Table 3 summarizes the injury definitions and approaches to police non-reporting. Serious injuries include 'severe' and 'critical' which were distinguished by Blincoe (2015) who used the Maximum Abbreviated Injury Scale (MAIS).[12]

[11] Death could occur after 30 days and there can be other contributing health issues. Suicides are excluded unless they cause a fatality or injury to another road user. Road accidents need to involve a road vehicle in motion on a public or private road to which the public has right of access. Collisions between road vehicles, road vehicles and pedestrians, cyclists, animals, fixed obstacles and rail vehicles (e.g. level crossings) are included. In New Zealand, there were 3 fatalities involving a collision between a rail and a road vehicle in New Zealand in 2020. All three were at level crossings, NZTA (2021). WTP surveys have glossed over the manner of death. One study that defined death (ironically a 'non-fatal injuries study) defined it as *'immediate unconsciousness followed shortly by death'*, Jones Lee et al (1995) so there would be no pain or suffering which should reduce the WTP less than one where pain and suffering occurs over a protracted period such as cancer.

[12] The original Blincoe report was dated 2010 but was updated in 2015 although the figures still refer to 2010.

Table 3: Reporting of Injuries and Property Damage Crashes

Country	Serious Injury	Minor Injury	Non Reported	PDO
New Zealand	Hospitalized medical treatment as recorded in police records.	Sprains and bruises not requiring hospital detention as recorded by police.	NZ MOT estimated 32% of minor & 56% of serious injuries not recorded by police for 2017-19.	8.4 x minor injuries based on Guria (1995)
Australia	Hospital admission irrespective of duration or medical severity.	None hospitalized injuries but no explanation for how estimated.	figures included but basis not documented	
Canada	Admitted to hospital for treatment or observation.	No immediate medical attention required / treated but not admitted to hospital.	figures included but basis not documented	
Germany	People taken to hospital for inpatient treatment lasting over 24 hours. Critically injured defined as MAIS3+.	Any other person injured	Reliant on police reports with no figures on unreported crashes	Federal Highway Research Institute BASt statistics but basis not known.
UK	National statistics use police reported crashes with injury severity determined by police. Social crash costs use accident numbers reported by respondents to National Travel Surveys.		National Travel Surveys estimate severe & slight injuries as 3x police numbers for 2017-19.	Back calculated based on total and unit costs for damage only accidents
Sweden	Police reports & hospital emergency depart. Visits (via STRADA). Use MAIS3+ to classify serious injuries	STRADA only includes slightly injured people known to police	Under reporting for minor injuries acknowledged but no factoring	no figure reported
USA	Police reports do not classify by injury severity but record crashes where someone was injured. Blincoe (2015) classified accidents by MAIS. Table 2 splits into serious MAIS3+ and minor MAIS0-2.		Blincoe factors for police under reporting of 1.68 for minor and 1.04 for serious injuries and 2.48 for PDO	PDO crashes published in annual statistics but police under-reporting of 60% Blincoe 2010

MAIS was developed in the USA in 1969 and classifies injuries into 1. Minor, 2 Moderate, 3 Serious, 4 Severe, 5 Critical and 6 Untreatable (or unsurvivable).[13] Sweden and Germany and some other European Union countries use MAIS as does the UK.[14] Australia and New Zealand have not adopted MAIS.

Irresepective of MAIS, classifying injury severity is not easy. Police usually make an assessment when filing crash reports but police are not doctors and their assessments can be wrong. A Swedish study summarised by IRTAD (2020) found police often miss-classified injuries. 15% of people the police identified as injured were assessed by hospitals as having 'no injury' and of people police assessed as injured, 47% had a MAIS score of under 2.

As can be seen by returning to Table 2, Sweden had the fewest number of serious injuries (S) with 1,951 and minor injuries (M) with 11,512 in 2019. As there were 221 fatalities (F), the S/F

[13] MAIS is an anatomical scoring system first introduced in 1969 in the USA which has been revised and updated by the Association for the Advancement of Automotive Medicine to rank injury severity. Blincoe includes a class 0 that presumably define crashes where injuries were less than minor (class 1).

[14] A 'High Level Group' EU road safety directive is for all member countries to use MAIS3+ as defining 'critically' injured persons and estimate the number from 2014 onwards. Germany has extrapolated the number from the German In-Depth Accident Study (GIDAS), ITF (2020) page 13 https://www.itf-oecd.org/sites/default/files/germany-road-safety.pdf.

ratio was 9 and the M/F ratio was 52. For the same year, New Zealand had 3,921 serious injuries, 30,298 minor injuries and 300 fatalities which produced an S/F ratio of 13 and an M/F ratio of 101 which were much greater. The reason was New Zealand factored for police under-reporting whereas Sweden did not. New Zealand factors for under-reporting by comparing hospital and Accident Compensation Corporation (ACC) motor vehicle claims data with Police Traffic Crash Report (TCR) data (MOT, 2020). For 2017-19, 32% of minor injuries and 56% of serious injuries were recorded in TCRs. Reported serious injuries were multiplied by 1.8 and minor injuries by 3.1 to adjust for under-reporting.

For the USA, Blincoe (op cit) compared police reports with hospital and insurance (H&I) data. For minor injuries (MAIS<3) the police reported figure for 2010 was 60% of the H&I data. For serious injuries (MAIS3+) the police figure was much closer at 96%. New Zealand Police would appear to be surprisingly less attentive than their American counterparts particularly regarding serious injuries or more likely they were classifying injuries differently.

Table 4: USA Police Reported and Unreported Injury Numbers (in Thousands) (2010)

Police Reported	PDO	MAIS						Fatal	Injury^	
		0	1	2	3	4	5		Minor	Serious
Reported	4,255	2,148	2,579	271	96	17	6	33	4,998	119
Unreported	6,310	2,435	880	68	4	0	0	0	3,383	4
Total	10,566	4,583	3,459	339	101	17	6	33	8,381	124
Reported %	40%	47%	75%	80%	96%	100%	100%	100%	60%	96%
Total/Reported	2.48	2.1	1.3	1.25	1.05	1.00	1.00	1.00	1.68	1.04

^ Minor = MAIS 0, 1 and 2; Serious = MAIS 3, 4 and 5. Source Blincoe (2015)

Published USA accident statistics (NHTSA) are police reported crashes.[15] In Table 2, Blincoe's Table 4 factors were applied to factor for police unreporting. Serious injuries totalled 153,547 with 10.4 million minor injuries.

For the UK, there are three sources of data: police reports (STATS19), responses to an annual National Travel Survey (NTS) and hospital episode statistics (HES).[16] The government accident statistics are based on police reports whereas the economic costs of road crashes take account of police non-reported accidents.[17] Comparison of STATS19 and the NTS survey (17,000 annual sample) showed *"a considerable proportion of non-fatal casualties are unreported",* UK DfT (2019). For the three years 2017-19, the NTS estimated three times as many serious and slight injuries than police reports.[18] For 2019, police reports estimated 23,000 serious and 93,000 minor injuries whereas the NTS gave figures of 68,000 serious and 276,000 minor injuries.[19]

[15] See US Traffic Safety Facts 2019 data https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813209

[16] The survey asks whether the respondent was involved in an accident injury during (i) the last three years and (ii) during the last year. If yes, they were asked whether they were a car occupant, pedestrian or cyclist, the severity of the injury and whether they received medical attention and whether police were aware of the accident.

[17] The unreported injury crash costs are presented as a separate lump sum below the 'police reported' figures for costed fatalities, severe and slight injuries (costed individually) in published UK DfT figures.

[18] The higher figures are shown in Table 2. Slight injuries are defined as minor in character such as a sprain (including neck whiplash injury), bruise or cut which are not judged to be severe, or slight shock requiring roadside attention. The definition includes injuries not requiring medical treatment.

[19] The PDO figure of 1.8 million crashes was deduced by dividing the total cost given in the UK DfT annual report for 2019 by the unit cost.

Looking at UK hospital figures, HES data for 2015 shows 6,000 injuries classified as MAIS3+ compared to 22,000 'severe' injuries classified by police. If the HES figure had been used in Table 2, the resultant ratio would have been 3.4 but when based on police records (22,000) it climbs to 15. With the NTS survey estimate of 68,000 serious injuries, the ratio reaches 41 placing the UK at the top of the fatality ratios shown in Table 2.

Of the seven countries, Australia has the weakest set of national accident statistics and the high injury/fatality ratio for 2015 needs to be viewed with this mind.

New Zealand injury to fatality ratio of 114 places it higher than Sweden and Canada where injuries were unadjusted for police non-reporting and lower than the UK where minor injuries were factored by a survey and the USA where very minor injuries (MAIS0) were included.

4. Fatality, injury & property damage only unit costs

Table 5 compares the unit crash costs for the seven countries expressed in NZ dollars.[20] There is an eighth observation because the state of NSW (denoted N) documents uses different unit costs to BITRE (denoted B) for Australia.[21]

Table 5: Fatality, Injury and Property Damage Only (PDO) Unit Costs in NZ dollars

Country	Year	Exchange Rate	Unit Cost $NZ 000s				Percent of Fatality		
			Minor	Serious	Fatal	PDO	Minor	Serious	PDO
New Zealand	2020	1.00	25	468	4,465	3.3	0.6%	10%	0.07%
Australia (B)	2013	1.06	21	530	2,350	12.9	0.9%	23%	0.55%
Australia (N)	2019	1.06	82	526	8,218	11.0	1.0%	6%	0.13%
Canada	2010	1.19	38	1,469	10,755	12.8	0.4%	14%	0.12%
Germany	2019	1.75	9	196	1,958	2.1	0.4%	10%	0.11%
UK	2019	1.92	52	503	4,349	4.7	1.2%	12%	0.11%
Sweden	2013	0.17	34	748	4,029	nk	0.8%	19%	nk
USA	2010	1.57	55	2,203	14,341	5.7	0.4%	15%	0.04%
Mean	na	na	39	830	6,308	7.5	0.6%	13%	0.12%
Median	na	na	36	528	4,407	5.7	0.8%	12%	0.13%

Sources: NZ MOT 2020; Australia (B for BITRE) ATAP (2013); Australia (N for NSW) TfNSW (2019) Canada ITF (2020); Germany BASt (2021); UK DfT(2019); Sweden ITS (2013); USA Blincoe (2015) na = not available.

The countries can be placed in four groups: (1) New Zealand, UK and Sweden which used Contingent Valuation (CV) to estimate their values; (2) Germany and Australia which used the Human Capital (HC) approach; (3) USA and Canada which reviewed Wage-Rate Risk (WRR) studies and (4). NSW Australia which used a Stated Preference Route Choice (SPRC) survey.

New Zealand, UK and Sweden used Contingent Valuation (CV) studies to estimate the cost of road crash fatalities and injuries. The estimates are quite old being based on surveys undertaken

[20] Where available, the same year as the respective crash numbers in Table 2 was referenced. Canada and the US give costs in 2010 prices. New Zealand applies June 2020 prices to 2019 crash numbers. For Sweden, the latest cost year for which figures were obtainable was a 2013 international comparison study, ITS (2013). The country estimates were converted into New Zealand dollars using exchange rates in Douglas (2021). The 'local' country unit costs can be determined by dividing by the exchange rate.

[21] The Royal Automobile Club (RAC) of Western Australia uses a cost per fatality of AU$7.8 million and cost per serious injury of AU$310,094 (indexed to the latest year) based on a 2017 paper by Litchfield F: https://www.aph.gov.au/DocumentStore.ashx?id=a37c13ee-72d4-47a9-904b-360d3e635caa.

in the 1980s and 1990s and the unit costs are quite similar. New Zealand's cost of a fatality cost of $4.5 million is close to the UK's $4.3 million and Sweden's $4 million. However, at $468,000 per serious injury, New Zealand has a lower serious injury unit cost than the UK ($503,000) and Sweden ($748,000). For minor injuries, New Zealand's $25,000 compares with the UK's $52,000 and Sweden's $34,000.

The UK's accident crash costs used for transport project appraisal were first estimated by Jones (1946) and Reynolds (1956). Jones used court awards. Reynolds focused on lost output, physical damage, medical and administration costs. He believed it was *"beyond the competence of economists to assign objective values to pain, grief and suffering".* The cost of fatality in 1952 was calculated at £2,000, £520 for a serious injury (40% of a fatality) and £40 (4%) for a minor injury.[22]

The UK undertook its first VSL survey in 1982. 1,150 people were asked a set of Contingent Valuation (CV) questions about how much they would be pay to reduce the chance of a fatal road accident. The VFP was £1.4 million but concerns about the approach and the policy implications (regarding road speeds versus safety) led to a much lower VFP of £0.5 million being adopted in 1987 (Jones-Lee and Spackman, 2013).[23]

A second survey undertaken in the early 1990s introduced injuries. Respondents were asked a set of 'standard gamble' (SG) questions about an accident that required hospitalization and two treatments.[24] The first treatment had a certain prognosis whereas the second had the chance of normal health if successful or death if unsuccessful. The chances of success and failure were varied until the respondent was indifferent. Analysis produced a 'cost' factor of 23% for a severe disability injury versus death, 15% for a severe slightly disabling injury, 5.5% for a severe temporary injury requiring 1-4 weeks in hospital and 2% for an injury requiring 2-7 days in hospital. However the results were not adopted as official values.

A third survey undertaken in 1997 by Carthy et al (1998) "chained together" CV questions about injury and 'modified' SG questions about death and injury risk. The survey was undertaken 'face to face' by interviewers and here Jones-Lee and Spackman (op cit) express *"serious doubts"* about any survey "*that does not involve direct face-to-face contact with respondents"*. Due to budget constraints however only 167 people were surveyed. After removing outliers, a VFP of between £0.5 and £1.6 million was estimated. It then took twelve years before for the results were adopted in 2009.[25] After updating by inflation and GDP/capita indices, the VFR reached £2.069 million in 2019 with serious injury prevention valued at 11% and minor injuries at 1% of the cost of fatality prevention. The UK DOT adds the social costs of "lost output" to the economy from premature death and injury incapacity plus ambulance and medical costs (sizeable for serious injuries) and property damage (which makes up a large portion of minor injury costs). Table 6 presents a cost profile.

[22] In 2019, taking account inflation (factor of 31) the costs would be F £62k SI £16k and MI £1.2k. These amounts should be doubled to convert to New Zealand dollars.

[23] Jones Lee of the UK and one of the world's leading safety economists preferred Value of Preventing a Fatality (VPF) rather than Value of Statistical Life (VSL) which he considered an American term.

[24] Respondents were also asked contingent variation (CV) questions about how much they would pay per year to have a set of safety features in their car that reduced their chance of an accident. It was found that the response to the CV questions gave higher values than the SG questions.

[25] The Carthy survey also produced a major difference between WTP and WTA values with the financial compensation needed to accept an injury (WTA) six times higher than respondents WTP to avoid it.

'Human costs' are taken from the CV survey but with 'consumption' from shortened life (or inactivity for an injured person) deducted. 'Lost output' is a gross figure that includes consumption (set at 80% of gross output). Therefore to get back to the CV figure, 80% of 'lost output' needs to be added to the 'human costs'. In fact there is an argument for disregarding, or at least discounting, medical and ambulance costs since these costs (alongside coroner and funeral expenses and probably some pain, grief and suffering) will be incurred eventually.[26]

Table 6: Breakdown of UK Fatality, Minor and Serious Injuries & PDO crash costs
UK pounds 000s in 2019 prices

Accident Severity Cost	Lost Output	Medical & Ambulance	Human Costs	Police	Insurance & Admin	Property Damage	Cost £
Fatality	33.1%	0.3%	65.0%	0.9%	0.03%	0.6%	2,260,633
Serious Injury	11.5%	6.9%	78.2%	1.0%	0.1%	2.4%	261,498
Minor Injury	13.5%	5.7%	64.6%	2.3%	0.5%	13.3%	26,840
PDO	0.0%	0.0%	0.0%	1.7%	2.7%	95.6%	2,425
SI/F Cost	4.0%	277.6%	13.9%	12.0%	31.73%	45.1%	12%
MI/F Cost	0.5%	23.8%	1.2%	3.0%	19.5%	26.0%	1%
PDO/F Cost	0.0%	0.0%	0.0%	0.2%	9.2%	16.9%	0.1%

Source: https://www.gov.uk/government/statistics/reported-road-casualties-in-great-britain-annual-report-2019

Sweden derived its safety values from CV surveys similar to those of UK and New Zealand. A 1998 survey put dots on graph paper with 100,000 squares to demonstrate road accident risk, Persson et al (2001). Respondents were asked how much they would be willing to pay to reduce their risk by 10%, 30%, 50% or 99%. The pretesting and representative sampling was praised by Miller although he did criticize the risk levels that led to respondents to "*giving a response that sounds reasonable in order to satisfy the interviewer rather than express uncertainty*".

Two sets of figures were presented for Australia in Table 2. One set was from TfNSW's Cost Benefit Appraisal guidelines (TfNSW, 2020) which derived from a Stated Preference Route Choice (SPRC) survey undertaken by Hensher and PWC in 2007 (see section 6.2). The figure gives the "human costs" of avoiding a fatality. It does not include medical, emergency, legal, property damage and congestion costs.[27] The second set of figures was estimated in 1996 by BITRE using the 'human capital' (HC) approach (see section 7). Table 7 shows the costs under ten headings updated to 2013 prices by ATAP (2020).[28] As can be seen, Quality Adjusted Life Years (QALYs) which measure the duration and severity of a health problem account for 30% of the cost of a fatality.[29]

Adding QALYs, wage loss and reduced household productivity gives a cost for a fatality of $Aus2.2 million (NZ$2 million). For a serious injury, the cost is Aus$500,000 (7% of the VSL). These figures compare to TfNSW's fatality cost of $NZ8.2 million and serious injury cost of $NZ530,000 making the TfNSW fatality cost around four times higher but with the costs of serious injury reasonably similar. For minor injuries, 62% of the BITRE cost was property damage (vehicle repair, vehicle unavailability, other property damage and towing).

[26] As William Munny said to the Schofield Kid in Unforgiven: *"We all have it coming, kid"* https://www.youtube.com/watch?v=7lYVggyHRkY

[27] Section 6.2 looks at the Hensher-PWC study in more detail. One reason offered for why the medical etc costs were not included was because the VSL estimate was high enough without them included.

[28] The aggregation was done to try and match to Blincoe's US cost breakdown in Table 7.

[29] A QALY is one perfect year's health lost, see Gold et al (1996).

Germany has also used the HC approach in which lost income growth (including the shadow economy, housework and voluntary work) is added to humanitarian costs, medical, emergency, legal and traffic delays. At $NZ 1.96 million, Germany's VFP is similar to BITRE's $NZ 2.35 million but serious injury ($NZ 196,000) and minor injury ($NZ 9,000) are lower.

Table 7: Analysis of BITRE Unit Costs for Minor and Serious Injuries & Fatalities
Percent of Total plus Total cost in Australian dollars 000s in 2013 prices

Cost	Minor	Serious	Fatal	ALL
Emergency Services	1.7%	0.9%	0.5%	1.0%
Medical Costs	0.7%	30.6%	0.2%	22.4%
Wage Loss	0.0%	6.9%	33.0%	8.4%
Household Productivity	0.0%	5.8%	27.5%	7.0%
Work Disturbance	4.2%	2.6%	0.6%	2.6%
Insurance	0.4%	11.4%	2.1%	8.6%
Legal	10.4%	6.7%	1.7%	6.8%
Property Damage	62.4%	3.0%	0.8%	12.9%
Congestion	0.6%	17.8%	3.3%	13.4%
QALYs	19.6%	14.4%	30.3%	16.9%
Total Cost Aus $000	20	500	2,217	98
Accident Share (2015)^	85.3%	14.2%	0.5%	100.0%

^ Australia Economic Connections (2015)

The USA has based its VSL on wage-rate risk studies and has applied QALYs to calculate serious and minor injury costs. Canada is presumed to have based its VSL on the USA. The USA figures are based on a detailed study by Blincoe (op cit). Table 8 presents the Blincoe analysis in 2010 US dollars but with figures weighted by 2019 accident figures. Reduced Quality Adjusted Life Years (QALYs) accounted for 85% of the fatality cost. Wage loss and reduced household productivity increases the percentage to 98%.

Table 8: Breakdown of Unit Costs by Injury Severity, Fatalities and PDO Crashes
US dollars 000s in 2010 prices

Cost	PDO	MAIS						Minor	Serious	Fatal	Injury + Fatal
		0	1	2	3	4	5				
Emergency Services	1.0%	0.9%	0.2%	0.1%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.1%
Medical Costs	0.0%	0.0%	6.4%	2.9%	4.9%	5.6%	6.9%	4.4%	5.4%	0.1%	3.0%
Wage Loss	0.0%	0.0%	6.2%	4.8%	6.5%	5.8%	6.1%	5.2%	6.2%	10.2%	7.4%
Household Prod#	1.0%	1.0%	2.0%	1.8%	2.3%	1.5%	1.7%	1.8%	2.0%	3.2%	2.4%
Work Disturbance	1.0%	1.1%	0.8%	0.7%	0.6%	0.3%	0.2%	0.7%	0.4%	0.1%	0.4%
Insurance	3.1%	3.3%	7.5%	1.2%	1.5%	1.2%	1.3%	4.4%	1.4%	0.3%	2.2%
Legal	0.0%	0.0%	2.7%	0.8%	1.2%	1.1%	1.5%	1.7%	1.3%	1.2%	1.4%
Property Damage	59.2%	61.5%	18.1%	2.1%	1.6%	0.7%	0.3%	13.9%	1.1%	0.1%	5.8%
Cong/Pollution	34.6%	32.3%	3.2%	0.4%	0.2%	0.1%	0.0%	3.9%	0.1%	0.1%	1.6%
QALYs	0%	0%	53%	85%	81%	84%	82%	64%	82%	85%	76%
Total Cost $000	6.1	4.4	44	400	993	2,432	5,580	37	1,405	9,146	92
QALY Factor^	-	0%	0%	4%	10%	26%	59%	0.3%	15%	100%	1%

^ using a 3% discount rate (but noting factor largely insensitive to the discount rate). Source: Blincoe (2015)
2019 accident figures used to weight injury & fatality costs; + Congestion & Pollution; # Household productivity

In calculating the costs, a VSL of US$8.1 million was used (from wage rate risk studies) but was adjusted down to US$7.75 million to avoid double counting.[30] The injury values were calculated by multiplying the VSL by QALY factors (bottom row). For serious injuries, the QALY factor was 15% and for minor injuries it was negligible at 0.3% (these factors compare with 10% and 0.4% for New Zealand). Blincoe also included traffic delays, pollution and CO2 emissions. For PDO accidents they accounted for a third of costs but accounted for small shares of fatal and serious injury costs.

5. Total fatality, injury and PDO costs

Table 9 presents the total crash costs for each country in NZ dollars. The costs were calculated by multiplying the annual number of fatalities, injuries and PDO crashes (Table 2) by their respective unit costs (Table 5). For New Zealand, the cost was $5.49 billion in 2019 (2020 prices). Fatal crashes cost $1.34 billion with injury and PDO crashes costing three times more at $4.15 billion.

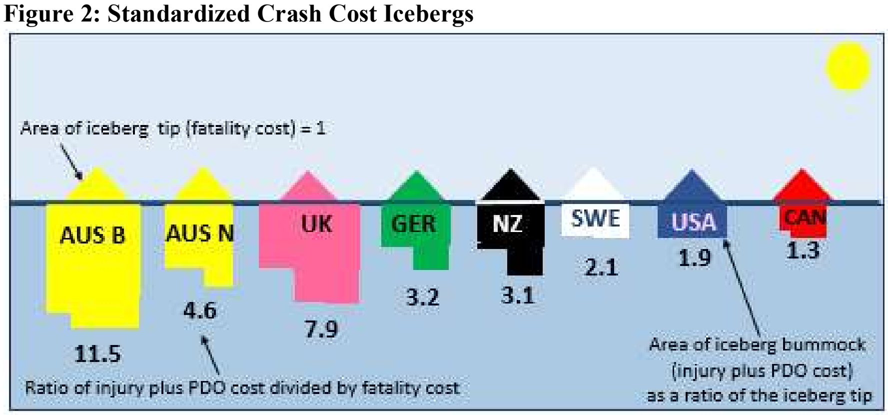
Table 9: Total Fatality, Injury and Property Damage Only (PDO) Costs

Country	Year		Total Cost in $NZ million							Ratio
	#	Price	Minor	Serious	PDO	Misc^	Non-Fatal	Fatal	Total	NF/F*
New Zealand	2019	2020	767	1,834	888	660	4,148	1,339	5,488	3.1
Australia (B)	2015	2013	4,717	20,119	7,759	-	32,595	2,832	35,427	11.5
Australia (N)	2015	2019	18,688	19,955	6,575	-	45,218	9,903	55,121	4.6
Canada	2018	2010	4,590	12,939	6,072	3,220	26,821	20,897	47,719	1.3
Germany	2019	2019	3,001	13,402	4,085	-	20,488	6,421	26,909	3.2
UK	2019	2019	14,248	34,234	8,471	-	56,953	7,211	64,164	7.9
Sweden	2019	2013	391	1,459	nk	-	1,851	890	2,741	2.1
USA	2019	2010	572,660	338,221	73,981	-	984,861	517,650	1,502,511	1.9

^ Cost for crashes not reported by Canadian police. Residual cost to match total in NZ annual report.
* ratio of nonfatal (NF) costs divided by fatal (F) costs; (B) BITRE unit cost estimate; (N) TfNSW unit cost estimate

The total cost was 50% that of Sweden ($NZ 2.7 billion) but only 0.3% of USA's NZ$ 1.5 trillion. Figure 2 shows the costs as 'standardised' cost icebergs.

Figure 2: Standardized Crash Cost Icebergs



---

30 In Feb 2013, USDOT updated the VSL to $9.1 million in 2012 prices which was equivalent to $8.1 million in 2010 prices.

The part above water is the iceberg tip representing fatalities and the submerged part is the iceberg bummock representing injury and PDO costs. The icebergs have been standardised so that the iceberg tip is one unit.[31] The ratios shown on the graph are also given in the right hand column of Table 9. In comparing the icebergs it is important to note that a big bummock is not all bad news. It may reflect lives being saved from air bags, crash barriers and median strips etc but at a cost of more injuries.

New Zealand's injury/PDO bummock is 3.1 times the fatality tip and is similar in shape to Germany's. Both are larger than the USA and Canada with ratios of 1.9 and 1.3. Using BITRE costs gives Australia the largest bummock with a ratio of 11.5 due to a combination of low VSL and high injury numbers. Using TfNSW's VSL reduces the bummock ratio to 4.6. The UK also has a large bummock from the inflation of accidents for police under-reporting.

Table 10 expresses accident costs in relation to vehicle kilometres, population and GDP .For New Zealand, accident costs amounted to 11 cents per kilometre (c/km), $1,120 per person and 1.7% of GDP in 2019. Australia depends on unit cost. With TfNSW's, the cost per kilometre at 22c/km was twice New Zealand's but with BITRE's, it fell to 14 c/km.

Table 10: Crash Cost per kilometre, capita and percent of GDP

Country	Year		Statistical Indices^			Fatality Cost*			Total Crash Cost*		
	#	Price	bvkm	Pop m	GDP $b	$/km	$/Pop	% GDP	$/km	$/Pop	% GDP
NZ	2019	2020	48.5	4.9	320	0.03	273	0.4%	0.11	1,120	1.7%
Australia (B)	2015	2013	250	23.8	1926	0.01	119	0.1%	0.14	1,489	1.7%
Australia (N)	2015	2019	250	23.8	1926	0.04	416	0.5%	0.22	2,316	2.7%
Canada	2018	2010	392	37.1	2301	0.05	563	0.8%	0.12	1,286	1.7%
Germany	2019	2019	707	82.9	5881	0.01	77	0.1%	0.04	325	0.3%
UK	2019	2019	574	66.8	4285	0.01	108	0.1%	0.11	961	0.8%
Sweden	2019	2013	83.7	10.3	854	0.01	86	0.6%	0.03	266	1.9%
USA	2019	2010	5306	328.3	21400	0.10	1,577	1.5%	0.28	4,577	4.5%
Mean						0.03	403	0.5%	0.13	1,543	1.9%
Median						0.02	196	0.5%	0.12	1,203	1.7%

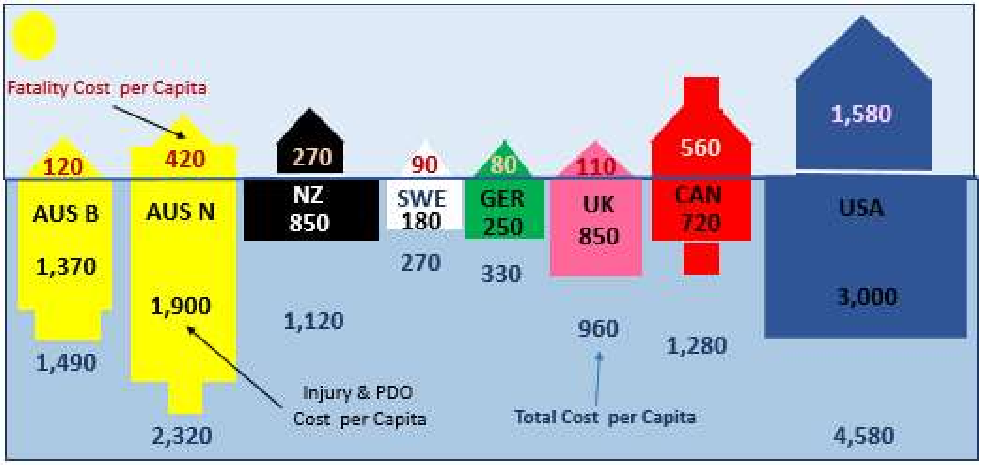
^ Year of accident numbers. GDP in local currency * $/km and $/pop in NZ dollars.(B) = BITRE, (N) = TfNSW

Figure 3 presents per person iceberg crash costs. Unlike the standardized icebergs of Figure 1, size varies enormously from $270 per person for Sweden to a scarily high figure of $4,580 per person for the USA.[32]

New Zealand is similar to UK and Canada with a per capita cost of $1,120 but has a smaller tip and bigger bummock than Canada. Australia is twice as big when estimated on TfNSW's costs but the fatality tip shrinks to a third of New Zealand's when BITRE's 'human capital' VSL cost is used. A larger injury bummock keeps both Australian icebergs bigger than New Zealand's.

[31] The fatility cost iceberg tip is two back to back right angle triangles that sum to an area of size 1.0.
[32] The figures were rounded to the nearest 100 NZ dollars and were calculated by multiplying the fatality and injury/PDO cost proportions in Table 9 with the respective cost per capita figure in Table 10.

Figure 3: Crash Cost per Capita Icebergs (NZ dollars) – various years (See Table 10)



Source: calculated from figures in Table 9 and 10.

6. Stated Preference Route Choice (SPRC) surveys

New Zealand, UK and Sweden have based values on contingent valuation (CV) and standard gamble (SG) surveys undertaken in the 1990s. In the late 1990s, an alternative approach of Stated Preference route choice (SPRC) questions was pioneered by Rizzi and Ortuzar in Chile. Similar surveys were then undertaken in Australia, Singapore and Germany and in 2019, New Zealand piloted a survey and Australia began a national survey.

6.1 Pioneering Chilean Surveys by Rizzi, Ortúzar & Hojman 1999-2005

Rizzi and Ortúzar applied SPRC to individual interurban routes. In 1999-2000 they surveyed car drivers about Route 68, a 120km road linking Santiago with Valparaiso.[33] In 2000, they surveyed car drivers about a 100 km section of Route 5 linking Santiago and Rancagua.[34] A path breaking decision was not to give accident probabilities which had been a cornerstone of previous CV surveys. Instead they just gave the number of crashes per year.[35] The researchers decided that if all respondents considered the same trip then their exposure to an accident would be the same and it could be expressed in terms of the vehicle flow. So if they showed 10 fatal crashes per year on route A and 11 on route B, the difference would be 1 fatal crash per year. If the annual vehicle flow was 1 million, the difference in accident risk would be 1 in one million. ($10/10^6 – 11/10^6$). They decided not to give the vehicle flow in the route descriptions. It also did not matter whether they analysed the number of accidents and multiplied by the vehicle flow or put the accident probability directly into their regression equations. The answer would be the same. Rizzi and Ortúzar assumed it was the actual flow that mattered not the perceived flow since this would vary enormously from respondent to respondent (if respondents had any comprehension of what the annual flow was).[36] For the WTP measure, they used toll and set the toll higher on the safer route. They also included travel time. They varied the times, tolls and accident numbers between the two routes in a controlled manner.

---

[33] Samples were non-representative. The R68 survey was handed out amongst government agency staff, universities and companies and *"cannot be catalogued as strictly random"* Rizzi and Ortúzar (2003).

[34] In 2004, drivers on Route 5 were surveyed by graduate students.

[35] In some regards, by looking at numbers rather than statistical chance or probabilities, the approach moved away from the very concept of VSL as defined by Schelling (1968) which was the statistical chance of death.

[36] The vehicle flow was 2.2 million for route 68 and 4.4 million for route 5 in the 2000 surveys.

For Route 68, 900 government agency, university and company staff were given a questionnaire of which 38% responded. 44% failed to 'trade-off' always choosing on the basis of only one attribute (eg safer route) and were removed which reduced the sample to 192.[37] In 2003, Routes 5 and 68 were surveyed again by Hojman et al (2003) with samples of 124 and 99. 'Severely injured' was included as Figure 4 shows. In 2003, an urban SPRC survey of 300 car users was undertaken using an internet survey, Iraguen and Ortúzar (2004).

Figure 4: SPRC Show card used by Hojman et al (2005)

	Route 1	Route 2
Toll	4.2	6.7
Travel Time	85	75
Fatalities	20	8
Severely Injured	44	65

The VSL ranged from US$ 290,000 (NZ $0.145 million) for the urban survey to $1.5 million (NZ $2.25 million) for Route 5. The average was US$0.6 million (NZ$0.9 million). How reasonable would the average be for a national value? Can urban and inter-urban journeys of different lengths be averaged in this way?

Table 11: Value of Statistical Life & Injury from Chilean Stated Preference Surveys $US, 000

Value	R68* 1999-00	R5* 2000	R68^ 2003	R5^ 2003	Urban* 2003	Average
Fatality (VSL)	612	1492	305	302	290	600
Serious Injury (VSSI)	-	-	125	150	-	138
VSSI as percent of VSL	-	-	41%	50%	-	45%#

* Values taken from Rizzi and Ortúzar (2006) ^ values from Hojman (2005) # mean of 41% and 50%

The value of avoiding a severe injury was 45% of VSL which was four times more than New Zealand (10%) and UK (12%). The higher value may reflect the definition of injury. It can also be seen that by including injuries, the VSL reduced fourfold for R5 and halved for R68.

6.2 NSW Australia Hensher-PWC 2007 Survey

In 2007, the NSW Roads and Traffic Authority commissioned a SPRC survey to estimate fatality and road injury costs. The survey, undertaken by Hensher-PWC (2007), surveyed 213 residents of Sydney and Bathurst.[38] Compared to Rizzi and Ortúzar, the task was far more onerous with respondents given travel time, car running cost, number of deaths and the number of severe permanent injuries, injuries requiring hospitalization and minor injuries per year for two routes to consider.

By analyzing response and dividing the death and injury parameters by the cost parameter, 'Subjective Values of Crash Reduction' (SVCR) per trip were estimated. For an urban fatality the SVCR was $0.85 and $3.91 for a rural trip as shown in Table 12. The car running cost parameter (not tabulated) caused most of the difference. For urban trips averaging 38kms, the cost parameter was -0.322 whereas for rural trips which were twice as long at 76 kms, it was -0.09. By contrast, the fatality parameter was reasonably similar at -0.27 for urban and -0.35 for

[37] By not trading off, they always selected either the low toll option, low accident option or quickest option.

[38] A SPRC was undertaken of pedestrians but the results were not given in the TfNSW CBA manual.

rural respondents. Cost was therefore the main reason for the difference in SVCR not accidents.[39]

Unlike the Chilean study there was no obvious way to convert the SVCR estimates to values of fatality and injury risk reduction.[40] Indeed, Douglas (2021) describes the reported VSLs of Aus$5.6m urban and Aus$6.1m rural as "*mercurially factored*".

Table 12: Hensher-PWC Stated Preference Survey Results for NSW (Australian dollars)

Incident	SVCR $/trip		VRR $		% of Death SVCR		% of Death VRR	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Death	0.85	3.91	5,582,130	6,123,981	100%	100%	100%	100%
Severe-PI^	0.16	0.41	410,821	571,693	19%	11%	7%	9%
Hospitalized Injury	0.12	0.28	131,561	211,594	14%	7%	2%	3%
Minor Injury	0.12	0.24	42,398	57,278	14%	6%	1%	1%

^ Severe - Permanent Injury SVCR Subjective Value of Crash Reduction, VRR Value of Risk Reduction

Each respondent answered in terms of their own perceived risk exposure which would have varied for all sorts of reasons (trip length, vehicle flow, flow composition, speed, time of day etc) and unfathomable to researchers (without asking it). Whatever conversion the researchers chose (which is unknown) should have kept the injury to death SVCR ratios the same but this was not the case. The SVCR percentage for serious injury to death was 19% for urban and 11% for rural respondents but after conversion to VRRs, the urban percentage halved and the rural percentage fell a fifth. For minor injuries, the reduction was starker dropping from 14% to 1% for urban and 6% to 1% for rural respondents.[41]

6.3 Singapore Le et al 2011 Survey

Four years later, Le et al (2011) undertook a similar survey in Singapore. They used CV and SPRC questions. The CV questions were similar to the NZ, UK and Sweden 1990s studies and were included because the SPRC method was viewed as *'not having been widely applied'* and *'risky'*. The sample sizes were large (1,350 car users and 150 motorcyclists) and conducted by household interview. Respondents were put through a preliminary test to see whether they understood risk. 96.6% passed and proceeded to the CV questions which asked how much respondents would pay to have the chance of being killed in a road accident reduced from 40 deaths to 20 deaths per million car users (i.e. a 50% reduction in fatality rate). Half the respondents answered this question and half answered one a 20% reduction i.e. from 40 deaths to 32 deaths per million car users. There was only S$3 difference in the mean WTP for the two questions: S$29 for the 50% reduction and S$26 for the 20% reduction so it was concluded that respondents were unable to differentiate between the two probabilities.[42] The resultant VSLs were markedly different however. For the 50% reduction, the VSL was S$1.4 million and for the 20% reduction, it was S$3.3 million.

[39] Respondents probably considered cost in percentage terms: the greater the cost, the less the sensitivity to a dollar difference Other studies have also shown the sensitivity to a dollar varies according to whether toll (as it was used in the Chilean route surveys), petrol costs, parking costs or some composite 'running' cost are used.

[40] For a fatality, the Value of Risk Reduction (VRR) is synonymous with Jones-Lee's Value of Preventing a Fatality (VPF) and the Value of Statistical Life (VSL).

[41] Whereas the Chilean researchers used the same vehicle flow for injuries as they did for fatalities, the implied vehicle flow used by the Australian researchers for urban respondents was 6.6 million for fatalities and 359,000 for minor injuries and for rural respondents it was 1.6 million for fatalities and 234,000 for minor injuries.

[42] Singaporean dollar S$

The SPRC featured three attributes: number of accidents, travel time and cost (electronic road price). Three designs were developed: car fatal accident; car serious accident and motorcycle fatal accident. Just under a quarter of respondents were excluded for not-trading off. The estimated fatality SVCR was S$0.46/trip with a serious injury SVCR of S$0.35/trip for car users. The SVCR for motorcycle fatalities was S$0.35/trip. To calculate the VSL, the trip values were multiplied by the annual average traffic volume of 4 million. The resultant VSL was S$1.8 million for car users and $1.7 million for motorcyclists with a value of avoiding a serious injury of S$1.43 million.[43] At three quarters of the VSL, the serious injury cost was judged too high. 13% was recommended instead and 1% for minor injuries based on the UK and Sweden CV/SG studies.

6.4 New Zealand Denne-Kerr 2018 Pilot Survey

A SPRC pilot survey to estimate values of safety and travel time was undertaken in 2018 by Denne-Kerr. The questionnaire was similar to the 2007 NSW survey except it was decided that accident rates had to be shown to respondents so the researchers included a reference statistic *'per 100 billion kilometres travelled'* on the show cards. However '100 billion' should have been just a 'billion'. The researchers, peer reviewers and client failed to spot the error which made it all the way to the final report, Douglas (2021). The 83 respondents were inadvertently told roads were 100 times safer than they actually were.[44] At $8.3 million to $9.8 million, the estimated VSL was more than double the 'official' value of $4 million. Despite being included as an attribute, no value for injuries was given in the final report.[45]

6.5 Germany Obermeyer 2020 Conceptual Survey

Obermeyer (2020) undertook a 'conceptual' survey in Germany featuring choices about a hypothetical motorway trip. The sample comprised 214 respondents (mainly students (55%) or university employees (36%) possibly from the transport research group and/or psychology department) and the report includes a warning: "*it should be emphasized that this sample is not representative of the German population and, therefore, the determined willingness to pay cannot be used for project appraisal.*" Severe, serious and minor injuries were included with fatalities. The report translates schwersfverletzt (abbreviated to SSV) as 'severe' but a more accurate categorization would be 'critical'. Cost and travel time were the trade-off variables.

Figure 5 presents an example. The trips were quite long taking around 2 hours and costing €20 but the differences were very narrow at 2 minutes and €1. In terms of crashes (which took up two-thirds of the show card), a rate of per one million trips and the number per number was given. Thus for critical injuries (SSV), there was one per 0.57 million vehicles or 17 per year on Route A and one per 1.33 million or 1 per year on route B. The implied vehicle flow was therefore 9.5 million a year for both routes (as it was for the other crash attributes).[46]

---

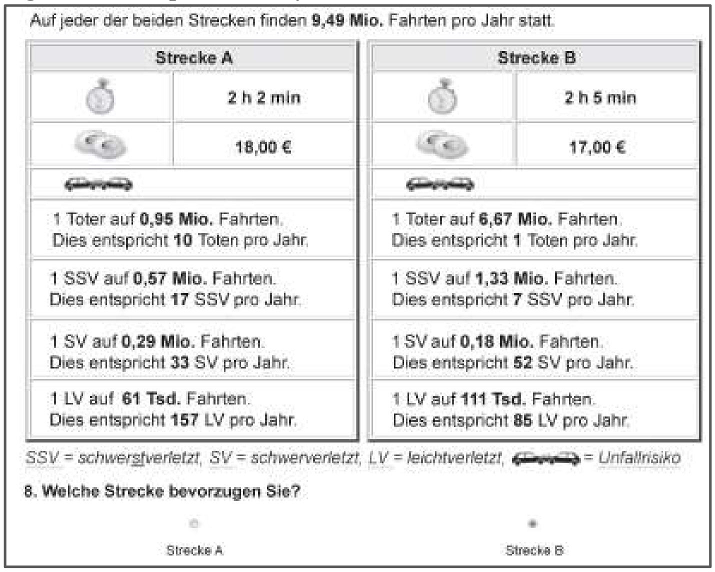
[43] In 2022, 1 Singapore dollar equalled 1.14 $ NZ dollars so the VSL converts to $NZ 2.1 million. The WTP of S$1.8m compared with $1.1m reported by Li et al (2011) calculated using the 'lost output' method which is presumed to have been the official VSL at the time.

[44] The respondents were comparing 2 deaths divided by 100,000,000,000 on one route versus 1 death divided by 100,000,000,000 on the other for a trip of 200 kilometres. Both chances of death are infinitesimally small so they should not have influenced the response.

[45] Denne Kerr fixed the ratio of the number of injuries to fatalities in their SPRC design. They also used different sets of questions with different injury to fatality ratios. However given no estimated values for injuries were presented in their report it is unlikely that the results were acceptable.

[46] There is an inconsistency with fatalities on route B where the implied vehicle flow was 6.7 because of the rounding down of fatalities to 1.

Figure 5: Example Obermeyer Show card



Auf jeder der beiden Strecken finden **9,49 Mio.** Fahrten pro Jahr statt.

Strecke A		Strecke B	
	2 h 2 min		2 h 5 min
	18,00 €		17,00 €
1 Toter auf **0,95 Mio.** Fahrten. Dies entspricht **10** Toten pro Jahr.		1 Toter auf **6,67 Mio.** Fahrten. Dies entspricht **1** Toten pro Jahr.	
1 SSV auf **0,57 Mio.** Fahrten. Dies entspricht **17** SSV pro Jahr.		1 SSV auf **1,33 Mio.** Fahrten. Dies entspricht **7** SSV pro Jahr.	
1 SV auf **0,29 Mio.** Fahrten. Dies entspricht **33** SV pro Jahr.		1 SV auf **0,18 Mio.** Fahrten. Dies entspricht **52** SV pro Jahr.	
1 LV auf **61 Tsd.** Fahrten. Dies entspricht **157** LV pro Jahr.		1 LV auf **111 Tsd.** Fahrten. Dies entspricht **85** LV pro Jahr.	

SSV = schwerstverletzt, SV = schwerverletzt, LV = leichtverletzt, = Unfallrisiko

8. Welche Strecke bevorzugen Sie?

Strecke A Strecke B

Respondents faced the same exposure level (vehicle flow) so the values of fatality and injury reduction could be derived in the same way as the Chilean and Singapore studies. A VSL of €3.6 million (NZ$ 6.3 million) was estimated with a critical injury valued 12% and serious injury valued 6% of a fatality.

6.6 Europe Schoeters et al 2021 Internet Panel Survey

Schoeters et al (2021) undertook an internet panel survey covering Belgium, France, Netherlands and Germany that obtained a large response of 8,003 to estimate WTP values for fatality, serious injury and travel time. The SPRC was about a 50 kilometre motorway trip for car drivers travelling alone for a non-work trip. A serious injury was described as "*must be hospitalized for treatment*" with injuries that *have short and/or long term consequences for daily functioning and are sometimes even life-threatening. For example concussion with loss of consciousness, (partial) amputations, skull fracture, open fractures, spinal cord confusion or severe organ injuries."*[47] The description accorded with a MAIS3+ injury with respondents also told that the risk *"was to be hit by another driver"* in order to avoid *"thinking they could control the risk by driving more carefully"*.

Around four times as much space was devoted on the show card to describing safety than describing time or cost as can be seen from Figure 6. Route A had 22 fatalities per year and 3 serious injuries. Given 20 million car vehicles travelled the 50 kilometres, annual car kilometres were one billion. The resultant rate of 22 fatalities per billion vkm was five times the rate for Germany in 2019 (4.6) but the serious injury rate was only a third of the national rate (96).[48] Route B had one fatality and 138 serious injuries. Cost was "*the cost to make the trip (operating costs, fuel, toll, etc.)".* Professional trips' where respondents might not pay the costs were excluded.[49] At 107kph, the average speed on route A was twice route B (58kph) so

---

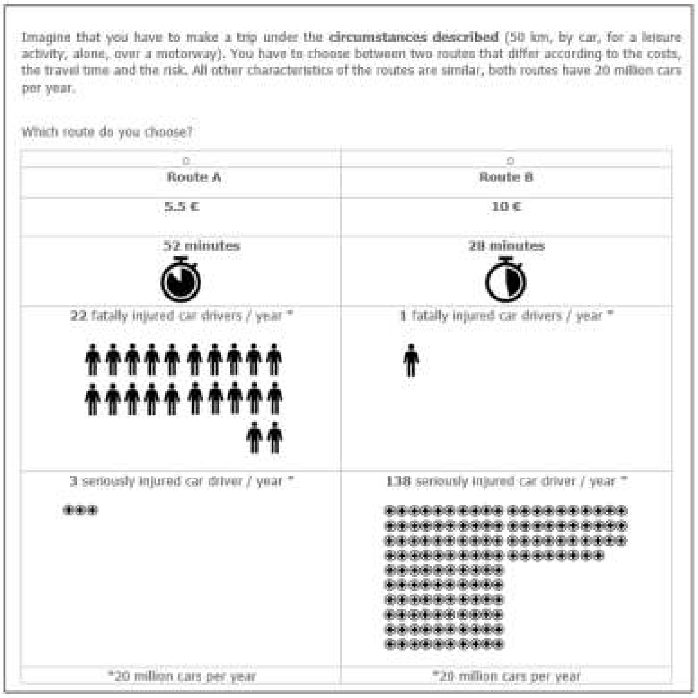
[47] Taken from Figure 1 in Schoeters et al (2021) report. Underlining was as per the text of Figure 1.

[48] Germany's national road safety figures report 3,280 fatalities and 68,224 serious injuries in 2019 (Table 2) with 707 billion vehicle kilometres (bvkm) driven (Table 10) which produce accident rates of 4.6 fatalities and 96.4 serious injuries per billion vkm.

[49] In the example, driving 50kms cost €5.5 on route A and €10 on route B which indicates a petrol price of $NZ 3.50/L compared to a pump price in New Zealand in 2019 of $NZ 2/L.

if you were trying to convince yourself the choices were realistic then a devastatingly fatal black spot on route A or appalling emergency and hospital services on route A might be your reasoning.

Figure 6: European VALOR Show card example



The differences in time, cost and accident between the two routes were wide. For fatalities, the difference was 22:1. By comparison, the differences in Denne-Kerr were 4:1 and 2:1 for Ortúzar and Rizzi (Figure 4). The wider ranges may have encouraged respondents to take account of the attributes but the magnification might have caused some not to take the task seriously.[50] In fact, 445 (6%) of the 8,003 responses were discarded because response was 'irrational to a 'dominant' choice included on the questionnaire.[51] A further 33% failed to 'trade-off' as they always ticked the quicker route (13%) the cheaper route (7%) the route with fewer fatalities (9%) or the one with fewer serious injuries (4%). Therefore 37% of the respondents did not complete the survey as ideally desired.[52] The estimated VSL for Germany based was €7.4 million with a VSSI of €1.1 million. The VSL was calculated in a similar fashion to Rizzi and Ortúzar.[53] When converted to NZ dollars the VSL was NZ$12.8 million

---

[50] The survey was an internet survey using an internet panel which broke the cardinal rule of Jones-Lee of 'face to face' surveying by trained interviewers.

[51] One of the eight choices was 'dominant' in that cost (€7) and fatalities (1) were the same for both A and B but the travel time was 7 minutes quicker (36 v 44 minutes by route A) and serious injuries were 45 less (48 v 93 by route A than route B). All 8,003 respondents were given this choice. Of course, answering randomly (by ticking any box without giving the times, costs or accident variables any attention) would have a 50:50 chance of producing a 'rational' response. So some people who ticked A could have done so by chance.

[52] 483 'lexicographic' responses (non-traders) were included because they answered some additional questions appropriately. The estimated values were based on 5,527 responses with 1,441 responses for Germany alone.

[53] The VSL was calculated by dividing the fatality parameter (-0.082) by the cost parameter (-0.223) then multiplying by the risk exposure (20 million cars per year). The same calculation was done for serious injury (parameter of -0.012).

with a VSSI of NZ$1.9 million. These were 6 and 10 times higher than the official values and would move Germany from bottom in Table 5 to second place if implemented.

6.7 Summary

Table 13 presents a summary of the SPRC 'studies' undertaken over a 20 year period.

Table 13: Summary of SPRC Surveys

Study	Chile	Australia	Singapore	New Zealand	Germany	Europe
Researchers	Rizzi-Ortuzar	Hensher-PWC	Le et al	Denne-Kerr	Obermeyer	Schoeters
Year (4)	1999 - 2005	2007 (3)	2011	2018	2020	2021
Sample	Car drivers (5 surveys) R68 sample = 342.	213 Car users (Drivers & pax)^	1,500 Car and Motorcycle users	83 Car drivers	214 mainly students / Uni employees	8003 car drivers Germany 1,441, plus Belgium, France, Holland
Method	Self-completion (R68 Survey 38% responded)	Interviews	Household Interview	Interviews	Interviews	Internet Panel
Question	Hypothetical Interurban & an urban study	Context of actual urban or rural trip	Hypothetical trip. National scope	Context of actual longish trip	Hypothetical 2hr m.way trip	Hypothetical non-business 50km m.way trip
Attributes (1)	3: T,C,F or 4: T,C,F,Is	11: 5T, 2C, F.Is,Ih,Im	3: T,C,F or T,C,Is	7:3T,C, F,Is,Im	6: T,C,F,Ic,Is,Im	4: T,C,F.Is
Exclusions (6)	44% non-traders (7)	not known	3.6% failed risk calc. test. 24% non-traders	11 speedsters (8)	none excluded	6% irrational, 33% non-traders
Fatalities	Number pa (route flow eg 2.2-4.4 mpa)	Number pa (vehicle flow unknown)	Number pa (flow 4 mvpa)	Number per 100 bvkms & % of Nat Av	Number per mv - Implied (flow 9.5 mvpa)	Number pa (flow 20 million cars pa)
VSL $NZm	Av $0.6m wide range	Urban $5.9m Rural $6.5m	Car $2.1m M.Cycle $2m	$8.3m-9.8m	$6.3m	$12.8m(9)
% of Official	na	≈350% (5)	160% (2)	230%	≈300%	≈600%
Injury Cost Percent of Fatality	Is 45% - -	Is U19% R11% Ih U14% R7% Im U14% R6%	Is 75% = -	not known	Ic 12% Is 6% Im 4%	Is 15% (9) -

(1) T time, C Cost, F fatality, Ic Critical Injury, Is Serious Injury, Ih Hospitalized Injury, Im Minor Injury (2) Lost output value as in Li et at (2011) (3) injury cost ratios for SVCR i.e. before factoring (4) as per reference year (5) percent of BITRE estimate in Table 5 (6) respondents excluded from main analysis (7) Non-traders are respondents who always chose a route on one attribute e.g. lowest fatalities (8) speedsters (respondents who did the survey in under 5 minutes).(9) Estimate for Germany.

Sample size varied from 83 in the New Zealand pilot survey to 1,500 in the Singapore study which was closest to a representative sample. The Chilean survey was a self-completion survey, the Europe study used an internet panel and the other surveys were interviewer led.

The simplest design was the first Chilean survey and the most complex was the Australian. The Chilean, Singapore and European studies used a standardized route enabling values to be estimated in a straightforward way but the New Zealand and Australian surveys referenced the question in terms of an actual trip that made calculating the VSLs problematic since risk exposure was unknown.

Where responses were monitored, between a quarter and a half failed to 'trade-off'.

The estimated values of fatality prevention were much higher than the prevailing 'official' values ranging from 160% in the Singapore study to 600% in the European study.

Injuries were included except the first Chilean surveys but descriptions varied considerably. The highest values (percentage of the VSL) were Chile 45% and Singapore 75%. Only the European survey used MAIS3+ as a classification. The value of avoiding a serious injury was 15% of the VSL but in dollar terms was ten times greater due to the high VSL.[54]

7. There's more than car drivers' lives to value

SPRC surveys have focused on car users and car drivers in particular. Car passengers, bus passengers, truck drivers, cyclists and pedestrians have been left by the way-side yet they contribute to the road toll. There are also rail, aviation and maritime transport accidents so if, as government has decreed, VSL and VSSIs should, for equity reasons, be the same for all transport modes then shouldn't all modes be surveyed? What about death and injury from pollution and disease and accidents at work, home or at play? Shouldn't a common value be used across all government sectors?

The New Zealand Fire Service commissioned a fire-related VSL in the mid 2000s. The study was undertaken by BERL (2007) who chose to pivot off the road VSL (notwithstanding the fact that the road value was estimated 20 years previous). They surveyed 750 people by telephone and asked the question: *"Suppose that the Government could increase funding to safety programs 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?"* Analysis of response came up with 12.4 lives saved from car accidents and 7.6 from residential fires. On this basis, BERL concluded the VSL for residential fires was 61% that of road crashes. They then raised the percentage slightly closer to unity (66%) for 'policy purposes'. How much did BERL's question have to do with measuring VSL? The public's answer could have reflected less pain and suffering from dying in a residential fire or perversely, a higher property value of their car than their house. More likely it reflected their view on the cost efficacy of fire and road safety programs and the impact of informational campaigns.

A similar survey had been undertaken five years earlier in the UK by Chilton et al (2002). They estimated a percentage of 84-93% and concluded that the *"great majority of people"* did not have differential death prevention rates for different hazards". Three years earlier, the UK Health and Safety Executive recommended a common value throughout with only cancer as an exception (UK HSE, 1999).[55] How should common values for fatality and injury prevention be derived? Surveying only car drivers about their WTP to reduce accident risk on a hypothetical trip seems too specific for the basis of a common value.

In a study to calculate the *'Value of rail in New Zealand'* consultants EY used fatality and injury costs published by the Ministry of Transport that derived from Guria-Miller's 1991 survey of car users. These values might be appropriate for assessing accident costs of diverted car kilometres (from no longer having rail passenger services) transferred rail freight and level crossing removal but less suitable for accidents that do not involve road.

Across the Tasman, the BTRE estimated the economic cost of rail accidents in Australia for 1999 (BTRE, 2003).[56] The study followed road and aviation studies. BTRE acknowledged the *"quite low"* quality of rail data in reporting a cost for rail accidents of Aus$196 million of

---

[54] The VSSI was $NZ1.9 million compared to an official value of $NZ 196,000 (Table 5).

[55] A VSL for cancer twice that of other deaths was recommended. Cancer will usually involve a period of ill-health before death which could be separately valued from the WTP to avoid death itself.

[56] I thank George Karpouzis, who on retiring as RailCorp Chief Economist gave me his signed copy of report 108.

which 69% were 'human, 29% 'property' and 3% 'other' costs.[57] These costs resulted from 79 fatalities, 47 serious injuries and 103 minor injuries. 19 fatalities were at level crossings so overlapped with road fatalities and 31 were suicides where there is debate as to whether they should be included. The average economic unit costs, calculated using the human capital approach was Aus$1.9 million for a fatality, $27,000 for a serious injury and $2,000 for a minor injury. When compared to road, the number and cost of rail accidents was very small. For 1996, BTRE estimated 1,970 road fatalities, 22,000 seriously injured and 213,300 minor injuries costing $15 billion (BTRE, 2000) which was 765 times the cost of rail accidents. At $1.5 million per fatality, $325,000 per serious injury and $11,611 per minor injury (1999 prices) road fatalities were a fifth less than a rail fatality but a serious road injury was twelve times more and a minor injury six times more costly.[58]

Would WTP surveys of rail passengers have produced similar values to the NSW survey of road users? Would dread of a fatal rail crash together with lower perceived personal control have increased the WTP? For the UK, Chilton et al (op cit) found that although dread was higher but lower baseline risk more than compensated to produce similar VSLs.[59]

A pragmatic approach would be for all public agencies to adopt the same value for the 'human' component of VSL (covering QALY, wage loss, reduced household productivity). Property damage and other costs (emergency and medical, work disturbance, traffic delays and pollution, legal/institutional) could be tailored to particular agencies and applications.

For Australia, the Department of Prime Minister and Cabinet (2021) recommends a VSL of Aus$5.1 million. For injuries, a set of disability factors published by the Australian Institute of Health and Welfare for diseases and injuries is recommended.[60]

The recommended values are based on a 2008 review by Abelson (Abelson, 2008) who reviewed 21 studies that cited 166 surveys (some surveys may have been included more than once) undertaken between 1991 and 2005 covering at least nine countries. Most were undertaken in the USA with wage rate risk studies accounting for three quarters of the studies.[61] Abelson gave the estimated VSLs in US dollars in the year of reporting but he did not provide summary statistics. From the figures tabulated, the mean VSL was US$4.2 million and the median US$3.6 million with a range from $US 0.4 million to $19.1 million. The median VSL converts to Aus $5.5 million using the exchange rates in Table 5.[62] This figure is close to

---

[57] In fact the number of fatalities and injuries changed through the report due to different databases and whether or not level crossing accidents and suicides were included. Information on injuries was not available for every State and Territory and NSW was *"atypical because of the large number of minor injuries (57) in the Glenbrook accident"*. There is also no mention of rail station accidents (e.g. people falling down stairs).

[58] This is despite the Rail report (108) saying the minor injury cost was taken from road (presumably report 102).

[59] Their study also helped counter the view that the public had a preference for fatality reductions at large scale multiple fatality events than at small scale single fatality events. This was based on their second of two surveys which had been undertaken shortly after a major rail accident at Ladbroke Grove near London's Paddington station in October 1999 and in which 29 passengers and 2 train drivers died.

[60] Disability weights for most diseases and injuries have been calculated. They can be used to adjust the VLY (Mathers et al 1999, pp. 186-202) knowing the VOSL, life (years) and private time preference rate. Abelson assumed 40 years and 3% to compute a VLY of Aus$151,000 from a VSL of $3.5 million. If an amputated foot had a weight of 0.3, the cost would be Aus$43,500 a year (0.3 x $151,000).

[61] Abelson mentions a review by de Baij et al (2003) but does not include the results in his Table. The review cited 18 Stated Preference surveys of the value of road safety with the authors commenting that SP surveys produced slightly higher VSLs than Revealed Preference studies.

[62] Using the exchange rates in Table 5 (1.56 x (1/1.06)).

the Hensher-PWC SPRC value for urban car users of Aus$5.6 million but is much higher than the BITRE value of Aus$1.5 million (1999 prices).

On ‘consideration of the study findings as a whole’, Abelson recommended a VSL of Aus$3.5 million in 2008 prices. This VSL was *‘for avoiding an immediate death of a healthy individual in middle age (about 50) or younger’*. Age-specific VSLs for older persons equal to the present value of future Value of statistical Life Years (VLYs) of Aus$151,000 discounted by 3% a year were recommended. Taking account age distribution would mean an average VSL less than Aus $3.5 million but this aspect does not appear to have been taken onboard by the Australian Department of Prime Minister and Cabinet. Nevertheless, the general approach was sound and it offers a sensible course for New Zealand to take with say, the Treasury, providing values for other government agencies, including transport, to use.

7. Recap

A road crash cost ‘iceberg’ is the sum of fatalities, injuries and property damage only (PDO) crashes multiplied by their respective unit costs. Only the number of fatalities is known with any exactitude. Injuries vary enormously in severity and classifying and counting them is difficult. Non-severe injuries and PDO crashes often go police unreported thereby factors or surveys are needed.

New Zealand uses up to date factors to adjust for non-reported injury crashes but a move to the MAIS system adopted in North America and Europe for injury classification would be sensible. New Zealand estimates PDO costs based on a factor applied to injury numbers. Given the factor was derived in the mid-1990s it should be re-estimated.

Unit crash costs are more problematic; they are an amalgam of human, property and other costs but with the main component being the ‘human costs’ of pain, grief and suffering, wage loss and reduced household productivity. New Zealand relies on a value for ‘human costs’ estimated in 1989 and this value needs re-estimating. At the time of writing, both New Zealand and Australia have been using stated preference route choice (SPRC) surveys to estimate new values. Unfortunately past SPRC surveys have not been convincing especially for valuing injuries. Even if they were convincing, they would only provide values for car users. There remain bus users, pedestrians, cyclists and truck drivers who could have distinctly different valuations. Moreover, how relevant are car values for rail, air and water transport?

Egalitarians in government now demand common values. Assuming car values are that ‘common value’, as has been done in New Zealand, is a heroic assumption but surveying all transport modes, activities, environmental and disease risks would be a herculean task. A more pragmatic solution would be to review completed valuation studies (including overseas ones) that have assessed different risks and used different estimation methods. This has been the basis of the Australian Premier and Cabinet value but bafflingly, it has not been used in road and rail transport safety evaluations.

For the human costs of injuries, a detailed study using disability factors derived from medical research as in Australia and the USA or by detailed interviewer led surveys as undertaken in the UK should be done and this study has no reason to be limited to injuries caused by road crashes .

Human costs are the biggest component of road crash cost iceberg but there are other significant costs which for New Zealand are based on old figures or have not been included at all. Medical costs and PDO costs were estimated in the 1990s and need re-estimating. It is not clear whether ambulance and fire brigade costs are included but road traffic delays, pollution, pets and livestock and post-accident restoration to roads and property are not included. Studies undertaken in the USA for road and in Australia for road, rail and air could be undertaken to estimate these costs.

So taking all this into account how reasonable is the size of New Zealand's road crash cost iceberg? Well, it is comfortingly middling in size and shape. At $1,120 per person, it is much smaller than the USA and somewhat smaller than Australia and Canada but bigger than the UK, Germany and Sweden. It is also average in shape with an injury and PDO cost 'bummock' three times larger than the fatality cost 'tip' making it similar in shape to Germany but with a relatively big 'bummock' compared to Sweden, Canada and the USA and a noticeably smaller 'bummock' than Australia or the UK. But lest you forget, size and shape of the road crash iceberg reflects the counting and costing methods used and these methods differ from country to country.

Acknowledgements

I would like to thank Mark Harvey for pointing out some potholes in my first draft, Alan Nicholson for making me aware of what the data implied, Charles Sullivan for his knowledge of German and survey design and Vartguess Markarian for captaining my presentation.

References

Abelson, P. (2008), "Establishing a Monetary Value for Lives Saved: Issues & Controversies" Working Paper 2008–02, Office of Best Practice Regulation, Dept of Finance & Deregulation, Canberra.https://obpr.pmc.gov.au/sites/default/files/2021-06/Working_paper_2_Peter_Abelson.pdf

ATAP (2022) *"Australian Transport and Planning Guidelines - M2 Roads"* report dated April 2022. https://www.atap.gov.au/parameter-values/road-transport/4-crash-costs

BASt German Federal Highway Research Institute Road Crash Statistics 2005-2020.https://www.bast.de/DE/Statistik/Unfaelle/volkswirtschaftliche_kosten.pdf?__blob=publicationFile&v=16

BERL (2007) *"The Value of Statistical Life for Fire Regulatory Impact Statements"* Fire Research Report dated February 2007https://fireandemergency.New Zealand/assets/Documents/Research-and-reports/Report-79-Value-of-Statistical-Life.pdf

Blincoe, L.J., Miller, T.R., Zaloshnja E., & Lawrence, B.A. (2015) *"The economic and societal impact of motor vehicle crashes 2010."* Revised report Number DOT HS 812 013). Washington DC: National Highway Traffic Safety Administration https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812013

BTRE (2000) *"Road Accident Costs in Australia"* report 102 published by Bureau of Transport and Regional Economics, Canberra, Australia. https://www.bitre.gov.au/sites/default/files/report_102.pdf

BTRE (2003) *"Rail Accident Costs in Australia"* report 108 published by Bureau of Transport and Regional Economics, Canberra, Australia.

Carthy T., Chilton S., Covey J., Hopkins L., Jones-Lee M., Loomes G., Spencer, A. (1998). *"On the Contingent Valuation of Safety and the Safety of Contingent Valuation: Part 2 - The CV/SG "Chained Approach"*. Journal of Risk and Uncertainty, 17(3), 187–214. https://doi.org/10.1023/a:1007782800868

Chilton S, et al (2002). *"Public perceptions of risk and preference-based values of safety"*. Journal of Risk and Uncertainty. Volume 25, Issue 3, pages 211-232

de Blaeij, A., Florax, R. Rietvald, P. and E.Verhoef, 2003, "*The value of statistical life in road safety: a meta-analysis"*, Accident Action and Prevention, 35, 974-986

Denne-Kerr et al (2018). *"A pilot study to determine the relative value of non-market transport impacts of investment"* report by Tim Denne, Geoff Kerr, David Glover, Michael Winder and Louis Wright. NZ Transport Agency research report 648 dated December 2018.https://www.New Zealandta.govt.New Zealand/assets/resources/research/reports/648/648-a-pilot-study-to-determine-the-relative-value-of-non-market-transport.pdf

Department of Prime Minister and Cabinet (2021) *"Best Practice Regulation Guidance Note Value of Statistical Life"* by Department of Prime Minister and Cabinet, Office of Best Practice Regulation Australian Government.https://obpr.pmc.gov.au/resources/guidance-assessing-impacts/value-statistical-life

DITCR (2019) *"Review of National Road Safety Governance Arrangements Final Report"* report by Road Safety Taskforce Department of Infrastructure, Transport Cities and Regional Government June 2019 https://www.roadsafety.gov.au/sites/default/files/2019-11/stp_review_of_national_road_safety_governance_arrangements.pdf

Douglas N. (2021) *"Valuing Life when Roads are Increasingly Safe"* paper presented (virtually) at ATRF 2021 Brisbane. https://www.researchgate.net/publication/357256233_Valuing_Life_when_Roads_are_Increasingly_Safe
Click Link for video presentation: https://www.youtube.com/watch?v=Ow0jlBlPQKg

Economic Connections (2017) *"Cost of Road Trauma in Australia"* Report to the Australian AA https://www.aaa.asn.au/wp-content/uploads/2018/03/AAA-ECON_Cost-of-road-trauma-summary-report_Sep-2017.pdf

European Commission (2021) *"European Road Safety Observatory National Road Safety Profile – Sweden"* https://road-safety.transport.ec.europa.eu/system/files/2021-09/erso-country-overview-2021-sweden_en.pdf

EY (2021) "The Value of Rail in New Zealand" Report for the Ministry of Transport Feb 2021 https://www.transport.govt.nz/assets/Uploads/Report/EY-Report-Externality-value-of-rail-2020.pdf

Gold, M. R., Siegel, J. E., Russell, L. B., & Weinstein, M. C. (Eds.). (1996). *"Cost-effectiveness in Health and Medicine: Report of the Panel on Cost-Effectiveness in Health and Medicine"*. New York, NY: Oxford University Press.

Guria J. (2020) *"Estimating the Human Cost of Transportation Accidents: Methodologies and Policy Implications"*, Book published by Elsevier.

Guria J. (1995) *"Estimates of vehicle damage costs"*. Report to NZ Land Transport Safety Authority.

Guria, J and Miller, T. R (1991). *"The Value of Statistical Life in New Zealand Market Research on Road Safety"*. Wellington, Land Transport Division, Ministry of Transport. https://www.researchgate.net/publication/308395966_The_value_of_statistical_life_in_New_Zealand_Market_research_on_road_safety

Guria, J., Jones, W., Jones-Lee, M., Keall, M., Leung. J., and Loomes G., (1999), *"The Values of Statistical Life and Prevention of Injuries in New Zealand"*. Report prepared for the New Zealand Road Safety Trust and the Land Transport Safety Authority, New Zealand.

Hensher Group Pty Ltd (2007) *"RTA NSW road safety project. Estimating the willingness-to-pay for road safety improvements"*. In PwC Report for Roads & Traffic Authority of NSW.

Hojman P, Ortúzar J de D and Rizzi LI (2003) *"El valor de la reduccion de accidents fatales y no fatales graves en carretera"*. Actas XI Congreso Chileno de Ingenieria de Transporte, Sociedad Chilena de Ingenieria de Transporte, Santiago (in Spanish)

Hojman P, Ortúzar J de D and Rizzi L.I (2005) *"On the joint valuation of averting fatal and severe injuries in highway accidents"* Journal of Safety Research 36 (4), 377-386

Iraguen P and Ortúzar, J de D. (2004) *"Willingness to pay for reducing fatal accident risk in urban areas: an internet-based web page stated preference survey"*, Accident Analysis & Prevention 36.

IRTAD (2020) *"Reporting on Serious Road Traffic Casualties"* https://www.itf-oecd.org/sites/default/files/docs/road-casualties-web.pdf

ITF (2020) *"Road Safety Annual Report"*https://www.itf-oecd.org/sites/default/files/docs/irtad-road-safety-annual-report-2020_0.pdf

ITS (2013) *"International Comparisons of Transport Appraisal Practice Overview Report"* report by Institute for Transport Studies Leeds University for the UK Department of Transport https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/209530/final-overview-report.pdf.

Jones-Lee M.W., Hammerton M., Philips P.R. (1985) *"The Value of Safety: Results of a National Sample Survey"* Economic Journal 95 (March), 1985 pp 49-72.

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

Jones-Lee and Spackman M (2013) *"The development of road & rail transport safety valuation in the United Kingdom"* Research in Transportation Economics (43) https://faculty.wcas.northwestern.edu/ipsavage/104-03.pdf

Le H, Van Geldermalsen T. Lim W and Murphy P (2011) *"Deriving Accident Costs using Willingness to Pay Approaches – A Case Study of Singapore"*, ATRF 2011 https://www.researchgate.net/publication/268368632_Deriving_Accident_Costs_using_Willingness-to-Pay_Approaches_-A_Case_Study_for_Singapore

Litchfield F. (2017) *"The cost of road crashes in Australia 2016: An overview of safety strategies"* A report drafted for Senator Alex Gallacher, May 2017.https://www.aph.gov.au/DocumentStore.ashx?id=a37c13ee-72d4-47a9-904b-360d3e635caa.

Mathers C., Vos T., and Stevenson C. (1999) *"The burden of disease and injury in Australia"*, AIHW cat. no. PHE 17, AIHW, Canberra.

Munny W. (1881) *'The Unforgiven'* https://www.youtube.com/watch?v=7lYVggyHRkY

NHTSA (2022) *"Overview of Motor Vehicle Crashes in 2020"* Report by the US Department of Transportation National Highway Traffic Safety Administration DOT HS 813 266 https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813266

New Zealand Government (2019) *"Road to Zero New Zealand's Road Safety Strategy 2020-2030"* report published December 2019 https://www.transport.govt.NZ/assets/Uploads/Report/Road-to-Zero-strategy_final.pdf

New Zealand Ministry of Transport (2019) *"Social Cost of Road Crashes and Injuries June 2019 update"* https://apo.org.au/sites/default/files/resource-files/2020-09/apo-nid309958.pdf

New Zealand Ministry of Transport (2020) *"Social Cost of Road Crashes and Injuries June 2020 update"* https://www.transport.govt.NZ/assets/Uploads/Social-Cost-of-Road-Crashes-and-Injuries-2020_final.pdf

NZTA (2021) *"Rail safety statistics through to the period ended 31 December 2021"* https://www.NZTA.govt.NZ/assets/resources/rail-safety-statistics/rail-safety-statistics-end-31-December-2021.pdf

Obermeyer A Hirte G Korneli C Schade J Friebel P (2020) *"Willingness to pay for road safety – conceptual study and pilot survey"* BASt report July 2020.https://bast.opus.hbz-nrw.de/opus45-bast/frontdoor/deliver/index/docId/2402/file/M298+barrierefrei.pdf

Persson U. Norinder A, Hjalte K and Gralen K (2001) *"The Value of a Statistical Life in Transport: Findings from a New Contingent Valuation Study in Sweden"* Journal of Risk & Uncertainty 23(2).

Reynolds, D. J. (1956). *"The cost of road accidents"*. Journal of the Royal Statistical Society, 119(4)

Rizzi, LI and J de Dios Ortúzar (2003) "*Stated preference in the valuation of interurban road safety"*. Accident Analysis & Prevention 35, no.1: 9–22

Rizzi, LI and J de Dios Ortúzar (2006) "*Road safety under a stated choice framework",* Journal of Transport Economics and Policy 40(1), 71-96.

Schoeters, A.; Large, M.; Koning, M.; Carnis, L.; Daniels, S.; Mignot, D.; Urmeew, R.; Wijnen, W.; Bijleveld, F.; Horst, M. van der (2021) *"Monetary valuation of the prevention of road fatalities and serious road injuries - Results of the VALOR project" SWOV Publicatie.* https://swov.nl/nl/publicatie/monetary-valuation-prevention-road-fatalities-and-serious-road-injuries

Schelling, T.C, (1968) *"The life you save may be your own"*.

TfNSW (2022) *"Transport for NSW Economic Parameter Values"* report dated June 2020 https://www.transport.nsw.gov.au/projects/project-delivery-requirements/evaluation-and-assurance/technical-guidance

Trottenberg (2011), *"Treatment of the Economic Value of a Statistical Life in Departmental Analysis – 2011 Interim Adjustment."* Guidance issued by Trottenberg P. Assistant Secretary for US Transportation Policy, & R. S. Rivkin, General Council.

UK DfT (2019) *"Reported road casualties in Great Britain: 2019 annual report"* Department of Transport. Statistical Release 30 September 2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/922717/reported-road-casualties-annual-report-2019.pdf

UK Health and Safety Executive (UK HSE) (1999). "*Reducing risks, protecting people".* London: Health and Safety Executive.