TE MANATŪ WAKA
MINISTRY OF TRANSPORT

Social cost of road crashes and injuries

Methodology and user guide

May 2023

Contents

Tables

Preface

Te Manatū Waka Ministry of Transport undertakes annual updates to the social costs of road crashes and injuries, which can be used to assess the effectiveness of road safety interventions. This report describes the methodology used for these updates and provides guidance on how the cost estimates can be used.

The social costs estimates, and other supplementary data and graphs are provided separate Excel spreadsheets from 2023 onwards. Prior to this these estimates were provided in annual pdf reports accompanied with a quick description of the methodology. The separation of these was to make the estimates easier to extract and to make the methodology description more detailed like the 2006 update.

It is intended that this report can be applied across multiple updates, but it may be superseded overtime when there are changes to the methodology and outputs.

Social cost of road crash estimates for previous years can be found in the update reports from 2006 to 2022.

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For more information

For more information about this project, report, and associated estimates, please contact: info@transport.govt.nz.

Glossary of terms and abbreviations

Base value	The original non-inflation adjusted value of a cost.
Consumer Price Index (CPI)	Measure of inflation for New Zealand households. It records changes in the price of a basket of household goods and services.
Conversion factor	Multipliers used for scaling up reported crashes to account for unreported crashes.
Crash Analysis System (CAS)	System that captures information on where, when, and how road crashes occur.
Estimated crashes/injuries	The total number of road crashes and injuries that have occurred – includes both reported and unreported crashes and injuries.
Fatal crash	Road crash involving at least one fatality.
Fatality	Injury resulting in death within 30 days of a crash.
Government Policy Statement (GPS)	Strategic document that sets the Government's priorities for land transport investment over the next 10-year period. It also sets out how money from the National Land Transport Fund (NLTF) is spent on activities such as public transport, state highway improvements, local roads, and road safety.
Household Labour Force Survey (HLFS)	Survey carried out by Stats NZ to produce NZ's official measures of employment.
Household Travel Survey (HTS)	Ongoing survey conducted for Te Manatū Waka that records a variety of data relating to the participants travel.
Indexing/indexed	The process of using a composite cost or price index to adjust a value for price fluctuations over time
Infoshare	Open-data tool maintained by Stats NZ.
Minor crash	Crash involving at least one minor injury and no injuries of a higher severity.
Minor injury	Injury that requires first aid or causes discomfort or pain to the person injured.
Non-injury crash	Crash where there were no injuries (property damage only).
Producer Price Index (PPI)	Measures changes in the price of goods and raw inputs purchased by manufacturers.

Quality Adjusted Life Year (QALY)	Measure of health quality – one QALY is equivalent to living one year in perfect health.
Reported crash/injury	Crashes and injuries that have been reported to Police and recorded in Waka Kotahi's Crash Analysis System.
Road Safety Partnership Programme	Joint programme that provides for a three-year investment into road policing activities based on the strategic outcomes under Road to Zero. It provides a more detailed operational framework and a series of commitments made by the partners of the programme to achieve these outcomes.
Road to Zero (RtZ)	Safety strategy that sets out a vision that no one is killed or seriously injured on NZ roads. It sets the guiding principles for road and safety intervention design, the targets for 2030 and key focus areas for road safety.
Rural road	Road or area with a posted speed limit greater than 70 km/hr.
Serious crash	Crash involving at least one serious injury and no injuries of a higher severity.
Serious injury	Injury (fracture, concussion, severe cuts or other injury) requiring medical treatment or removal to and retention in hospital.
Traffic Crash Reports (TCR)	Report on a standard form (usually completed by the Police) containing details of a crash involving one or more vehicles, located in an area to which the public have access.
Urban road	Streets or areas with a posted speed limit equal to or less than 70 km/hr.
Value of Life Year (VOLY)	A measure of loss from premature death - one VOLY is the value of one year lost from a premature death.
Value of Statistical Life (VOSL)	Estimated amount society is willing to pay to reduce fatalities from road crashes by 1.
Vehicle movement	Crash contributing factors relating to the movements of vehicles involved.
Willingness to Pay (WTP)	The maximum amount a person is willing to pay to buy an additional unit of a product (in this case the "product" is a reduction is road fatalities).

1 Introduction

1.1 Overview

Deaths and serious injuries from road crashes impose economic and social costs on society. These include loss of life and life quality, loss of productivity, medical and legal resources, and damage to property. Together these comprise the social cost of road crashes and injuries. These costs are updated annually by indexing them to changes in the prices of household goods and incomes so that the social cost estimates maintain with those overtime. This report aims to explain the methodology (covered in the second part of this report) and provide some guidance on using the cost estimates (covered in the third part of this report)

To support the Road to Zero safety strategy in achieving its target of zero road deaths, we need to ensure we target our road safety resources most effectively. Investment into any safety intervention should be weighed against the resulting benefit expressed as a reduction in the social costs from fewer crashes and injuries. Similarly, these estimates can be applied in non-safety transport initiatives where applicable so that assessments of those initiatives account for any positive or negative implications on road safety. The third part of this report provides guidance on using the social cost estimates.

There are five cost components covered in this report:

- Loss of life/life quality
- Loss of productivity
- Medical resources (ambulance, emergency, and follow-up services)
- Legal system resources (investigations, court, and imprisonment)
- Vehicle loss and repairs

There are other costs of road crashes that are not captured here because we do not have access to the data/information needed to estimate them[1], because those costs are better captured outside of the social costs[2], or because they are not economic costs. As new information becomes available, we may incorporate some of these other cost components. In addition to the inflationary adjustments, there may be other revisions to the current cost components over time.

1.2 Background

The Value of Statistical Life (VOSL) was first estimated in 1991 based on questions in the NZ Household Travel Survey that enabled the estimation of society's willingness to pay (WTP) to reduce deaths from road crashes by 1 (Guria, 1991) and a value of $2 million was adopted in 1992 for assessment purposes.

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1 E.g., costs of rehabilitation

2 E.g., time costs of traffic delays caused by road crashes as this likely varies significantly depending on the location and time of days and is better modelled in specific assessments for those routes

VOSL represented the cost of suffering and grief associated with the loss of a life or permanent disability, but society also incurred several other costs from road crashes and injuries. During the 1990s other studies were conducted to establish what these other cost components were along with the methods for estimating and updating them. The current five components have been used since 1999, though the estimation behind some to them has changed due to changes in the data, updating method, or the base value.

Te Manatū Waka is responsible for updating the social cost of crashes and injuries every year by updating the various underlying inputs to reflect the most recent data and revising the methodology as needed. The estimates are publicly available for use by anyone with an interest in road safety. In most years this has taken the form of a pdf report containing the social cost estimates and a short description of how they were updated.

The last report to specify a detailed methodology behind the social cost estimates was the 2006 version. This report re-introduces the detailed methodology to help users better understand the update method and the potential limitations. To make the actual estimates more accessible, they are now provided in an Excel spreadsheet rather than expecting users to extract them from a pdf.

1.3 Other publications

Waka Kotahi NZ Transport Agency publishes the social cost of road crash and injury estimates in its *Monetised benefits and costs manual* for use in road safety assessments. These estimates use Te Manatū Waka's as inputs to estimate additional breakdowns such as by mode or crash site (Waka Kotahi NZ Transport Agency, 2020). The NZ Treasury also incorporate the VOSL and the social cost of crashes and injuries into their CBAx tool.

The VOSL specifically applies to road crashes because participant responses in the study would have been influenced by their perceptions and experiences relating to road crashes – if there were questions for deaths because of some other non-road cause, then the study would likely produce a different VOSL.

Despite this there have been no VOSLs estimated for other causes of death and instead the road crash value has been used beyond road safety, particularly for health assessments. The *Health and air pollution in New Zealand 2016 (HAPINZ 3.0)* study proposes two methods using either the VOSL or a Value of Life Year (VOLY) based on VOSL to estimate the costs of premature death from illnesses that air pollutants contribute to (Kuschel, et al., March 2022).

Similarly, the VOSL has been used to value the improvement in mental and physical health from walking and cycling[3] (Ian Wallis Associates Ltd, 2022).

[3] Based on using it to value the improvement in Quality Adjusted Life Years (QALYs)

2 Methodology

This section outlines the data and assumptions used to estimate the number of crashes and injuries, and to update the cost components. It also discusses some of the limitations and how they might be addressed in future. The working model is written in R code.

2.1 Estimating the social cost of road crashes and injuries

The average social costs are split between per injury and per crash terms. Per injury simply refers to whether the injury is fatal, serious, minor, but in a crash, there can be multiple injuries of different severities (as indicated by Table 1) so the per crash estimates scale up to account for this.

Table 1 Injuries covered in a crash by severity.

Severity	Fatal injuries	Serious injuries	Minor injuries
Fatal crash includes	Yes	Yes	Yes
Serious crash includes	No	Yes	Yes
Minor crash includes	No	No	Yes

The base values for the cost components were estimated in either per injury or per crash terms so we use crash data to convert them to their respective counterparts so that each component applies to both per injury and per crash terms.

Crashes and injuries are reported and recorded by Police in the Traffic Crash Reports (TCR), which are inputted into Waka Kotahi's Crash Analysis System (CAS), but not all crashes are reported to Police so relying solely on CAS data would underestimate the road safety risks and the benefits of safety interventions. Many of these crashes and injuries are captured in other datasets so we use hospitalisation and ACC claims data to estimate the level of under-reporting and scale up the crash numbers to reflect this.

The second part of the methodology involves updating the social cost estimates to reflect the prices of the most recently finished financial year (June ending). Most of the components use specific indices or other data from Stats NZ for indexing.

2.2 Data

2.2.1 Reported crashes and injuries.

Motor vehicle crashes that result in a person being injured are legally required to be reported to the police. The reporting officer will complete a TCR, which includes details of the person involved, vehicle details, possible contributing factors, and crash location. The TCR is examined, coded, and stored in the CAS database. CAS data is revised over-time as more information becomes available and the number of crashes and injuries will fluctuate. Finalisation of this data for a given year can lag up to a year.

Source: Waka Kotahi's CAS via Te Manatū Waka's Analytics and Modelling team

Breakdowns:

1 Year, region, road type, crash severity

2 Year, age group, crash severity

3 Year, vehicle movement, road type, crash severity

The crash data primarily used is the regional data because the hospitalisation data is regional, so it forms the basis for scaling up crash numbers to account for unreported crashes. Note that crash data without an entry for all fields is excluded as are reported non-injuries. So, this dataset does not include all reported crashes.

The age group data is used specifically to estimate the potential daily earnings lost from being hospitalised. The vehicle movement data is used to estimate the average social cost for different vehicle movements that contribute to crashes.

2.2.2 Matched and unmatched hospitalisations

Road crash injuries that require any treatment are usually taken to a public hospital in the first instance. Data on admissions and discharges is collect by the New Zealand Health Information Service (NZHIS). In some cases, admissions occur without the injury (or crash) being reported to police. Hospitalisation data can then help fill in some of the gaps of unreported crashes. To achieve this, Waka Kotahi match CAS data to hospitalisation data from Manatū Haora Ministry of Health and the residual number of unmatched hospital admissions are taken to be unreported crash injuries.

Source: Waka Kotahi (using Manatū Haora data)

Breakdowns: three-year period, region, admission duration

This is used to estimate the conversion factors for scaling up reported serious crashes[4] to account for under-reporting.

2.2.3 ACC injury claims relating to road crashes

ACC provides financial cover for road crash injuries, which can claim against. Claims can cover medical costs[5] and entitlement[6]. Each claim has a unique claim number attached to all claims relating to the injury. Claims are either new or ongoing (relating to previous years) and can cover both hospitalised and non-hospitalised injuries, so it captures injuries that are not necessarily captured in hospitalisations or CAS. ACC matches their claims data with CAS data to estimate the numbers of matched and unmatched crashes.

Source: ACC (using matched CAS data)

Breakdowns: Year, injury severity and match status

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4 Fatal crashes and injuries are assumed to have a 100 percent reporting rate.

5 E.g., general practitioner and specialist visits

6 E.g., income maintenance, childcare, transport, and other assistance

This is used to estimate the conversion factors for scaling up reported minor crashes[7] to account for under-reporting.

2.2.4 Number of sentences and imprisonment duration for road crashes

Where a person has been culpable in causing a crash that resulted in death or injury, they may receive a sentence from the courts, which sometimes results in imprisonment.

Source: Ministry of Justice

Breakdowns: Sentences are by year and offence type; imprisonments are by year and offence type.

Sentence data is used for estimating the court related costs of a crash. Imprisonment duration issued for estimating the average cost of an imprisonment for causing a crash[8].

2.2.5 Wage, consumers price and producers price indices

Stats NZ produces a range of indices relating to the costs of various goods and services faced by consumers and producers that are available publicly. They indicate how the cost of these goods and services change over time.

Source: Stats NZ Infoshare:

1 Average hourly earnings by sector and sex, ordinary time (QEM003)

2 PPI – health and community services (PPI020)

3 PPI – legal services: personal and corporate (PPI027)

4 CPI – vehicle servicing and repairs (CPI013)

Breakdowns: Year and quarter

These are used to update most of the cost components to the latest June ending quarter.

2.2.6 Income by sex, age groups, and income source

Stats NZ collects data on household earnings via the annual Household Labour Force Survey. This includes a variety of demographic data, which are available publicly. Data is only shown when it covers at least 1,000 of the population. If the population is below this, then the figures are suppressed. The specific data used covers average weekly incomes and number of people.

Source: Stats NZ's NZ.Stat.

Breakdowns: Year, age group, income source[9], sex

These are used to estimate the average daily earnings per age group, which combined with injuries by age group is used to estimate the productivity loss from crashes and injuries.

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7 It is assumed that serious injuries will mostly be captured via CAS and hospitalisations, while minor injuries would be better captured by CAS and ACC claims.

8 For fatal and serious crashes only as, minor crashes do not result in imprisonment.

9 Includes self-employment, wage and salary, and government transfers. Excludes private transfers and investment income.

2.2.7 Crash investigation costs

The Government Policy Statement (GPS) on land transport, which sets out the government's investment priorities for transport investment. GPS allocates funding via Road to Zero into the Road Safety Partnership Programme, which provides for investment into road policing activities. This includes Network Maintenance and Efficiency activities, which cover incident management and crash investigations.

Source: Waka Kotahi

Breakdowns: Financial year

These are used to estimate the average resource cost of Police investigations for crashes and injuries.

2.2.8 Average imprisonment cost

In its annual reports, the Department of Corrections reports on variety of statistics including the average annual imprisonment cost per inmate.

Source: Department of Corrections annual reports

Breakdowns: Year

These are used to estimate the average resource costs of prison sentences for road crashes.

2.3 Scaling up reported crashes and injuries

2.3.1 Summarising reported crashes and injuries

Reported crashes and injuries are summarised into rolling three-year totals. The social cost estimates are based on the most recent three-year period with complete data.

2.3.2 Estimating conversion factors

Using the hospitalisation data, we estimate the number of hospital admissions. The calculation varies by region; for Auckland, Waikato, Bay of Plenty, Manawatū/Whanganui, Wellington, and Canterbury the number of hospital admissions requiring more than 1 day is scaled up by an assumed 10 percent variance. For the other regions, their total hospital admissions overall is used instead.

The total number of matched injuries is subtracted from the admissions to give us the estimated number of unreported serious injuries. Adding this to the reported injuries gives us the estimated total injuries. The conversion factor is defined as the ratio of estimated to reported crashes and injuries:

$$(1) \quad Conversion\ factor = \frac{Estimated\ injuries}{Reported\ injuries}$$

Finding the conversion factor in the hospitalisation data for each region enables us to scale up the reported crash data. We use conversion factors at the regional level because the proportion of injury crashes reported to the police varies across regions due to differences in physical location,

size of regions, availability of facilities and other factors. Due to lack of data, separate conversion factors at the urban/rural level are unavailable.

Similarly due to lack of data the conversion factors for minor and non-injury crashes are only estimated at the national level. The minor crash conversion factor is estimated from the hospitalisation data and the matched/unmatched claims from ACC. Based on this, The non-injury conversion factor is estimated by multiplying the minor crash conversion factor by 8.4 (Guria, 1994).

2.3.3 Estimated crashes and injuries

The reported crashes and injuries data is scaled up by multiplying the crashes and injuries under a specific crash severity by that crash severities respective conversion factor. For example, fatal crashes do not have a conversion factor so all fatal crashes and fatal, serious, or minor injuries that result from fatal crashes remain the same as their reported numbers. Serious crashes and injuries for a given region are multiplied by that respective region's conversion factor, all minor crashes and injuries are multiplied by the minor crash conversion factor.

Non-injury crashes are estimated by multiplying minor crashes by the non-injury crash conversion factor. While there are non-injury crashes reported to CAS it is assumed that most non-injury crashes are not reported, and we have no alternate data source that would capture the unreported non-injury crashes, so we adopted a method proposed by (Guria, 1994).

2.4 Updating the cost components

2.4.1 Loss of life and life quality

The VOSL is used as the per injury proxy measure of the suffering and grief due to a loss of life from a road crash. It is people's estimated willingness to pay to reduce deaths from road crashes by 1. The base value for VOSL is $12.5 million in June 2021 prices and has multipliers for serious and minor injuries (0.055 and 0.0052 respectively) that represent the loss of life quality from those injuries (Denne, et al., 2023).

As mentioned previously, the VOSL was originally estimated at $2 million in 1991 (Guria, 1991). The loss of life quality multiplier for serious injuries was originally estimated to be 0.08 in 1993 (Guria, 1993) and 0.1 after 1999. For minor injuries it was originally estimated at 0.04 (Guria, 1993). Though it has been updated annually by indexing it to average wages, this only addressed the inflation effects and not any of the other factors that might have changed people's WTP overtime.

A study conducted in 2021 by Denne et al, surveyed 7,000 participants to determine an updated WTP to reduce road fatalities by 1. The estimated range was $8.1 million to $16.9 million per fatality (in 2021 prices) depending on whether participants were for individuals (maximum) or out of a household budget (minimum) (Denne, et al., 2023). Due to a lack of information to tell which side of that range was more likely, the steering group for the study[10] decided to adopt the midpoint of the range, which was $12.5 million per fatality, as the new base value for the VOSL.

To estimate the VOSL in other years' prices, we take the *average hourly earnings by sector and sex* data from Stats NZ and estimate each year's multiplier as the ratio between the average hourly

[10] Consisting of officials from Te Manatū Waka, Waka Kotahi, and the Treasury

wage in that year, and the average hourly wage in the base year (June 2021). We multiply VOSL by the multiplier for the current price year to get the loss of life per injury. The same values are used for urban and rural roads.

To estimate the loss of life per crash we multiply each the estimated total number of injuries for each crash severity by their respective per injury value and then divide this by the number of crashes. This calculation is done using crashes on rural, urban and all roads separately so the per crash estimates will differ for each.

Loss of life accounts for about 96% of the total social costs making it by far the largest cost component. Any future adjustments to the WTP for the VOSL are likely to have a substantial impact on the total social costs.

2.4.2 Loss of productivity

Loss of productivity is the cost of a person not being able to work temporarily because of being injured[11]. Loss in non-labour market activities is not included.

The level of worker output lost can vary by a range of factors such as the type of work carried out, level of internal labour reserves and level of unemployment. In the short-term there may be a loss of production if the work cannot be covered by other resources, if production costs increase the production level reduces or the production level reduces because of the absence. In the longer-term, work may be taken over by reallocating existing or hiring new workers (Te Manatu Waka Ministry of Transport, 2006).

Loss of time per injury consists of:

- time spent in hospital and
- time off-work after discharge from hospital

It is assumed that the time lost can be estimated by the average length of hospitalisation, which implies that the bias from including the length of stay for injuries with permanent disabilities will offset the bias from excluding the outside-of-hospital recuperation time (Guria, 1991).

Waka Kotahi estimates and provides the average number of days hospitalised for serious and minor injuries[12]. The per injury values are estimated by multiplying the average daily earnings by the average number of days hospitalised.

The average daily earnings is estimated using the *income by sex, age groups, and income source* and *reported crashes by age group and sex* datasets. The former has the estimated average weekly incomes and number of people by sex and age group. These are used to estimate the average daily earnings for all age groups and both sexes separate and combined.

The *reported crashes by age group and sex* is used to estimate the total number of days people were incapacitated due to road crashes. This is done by multiplying the total serious and minor injuries for each age group by their respective average days hospitalised. These are then multiplied by their respective average daily earnings to get the total earnings lost per age group.

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11 We assume that permanent impairment is covered under VOSL as the survey did not explicitly separate this from suffering and grief so respondents may have allowed for permanent impairments in their responses.

12 We assume there is no loss of output due to temporary incapacitation for fatalities.

This is all summed up and divided by the total number of days lost to get a single value for average earnings lost per day.

To estimate the average output loss per injury for serious and minor injuries, the average earnings lost per day is multiplied by the average number of days hospitalised per injury.

To estimate the average output loss per crash we multiply each the estimated total number of injuries for each crash severity by their respective per injury value and then divide this by the number of crashes. This calculation is done using crashes on rural, urban and all roads separately so the per crash estimates will differ for each.

Loss of output typically accounts for less than one percent of the total social costs making it the smallest cost component.

2.4.3 Medical resource costs

Medical costs are the resource costs of the health system responding to and treating injuries from road crashes. They include in-patient treatment, emergency services and follow-up treatment.

The base value for the in-patient treatment for a serious road crash injury was estimated to be $6,260 in 1992 based on Dunedin Hospital for the period April 1988 to March 1990 (Langley, Phillips, & Marshall, 1993) and Waikato Hospital data for the period May 1990 to March 1992 (Guria, 1993).

The emergency and follow-on costs for a serious road crash injury were estimated as a proportion of the in-patient costs. Table 2 shows the estimated multipliers.

Table 2 Scale of serious injury medical costs relative to the in-patient cost

Medical cost	Serious injury
In-patient cost	1.00
Emergency treatment	0.12
Follow-on treatment	0.49

The medical costs for fatalities and minor injuries from road crashes were estimated as proportions of the serious injury medical costs. Table 3 shows the estimated multipliers.

Table 3 Scale of medical costs for fatal and minor injuries relative to their serious equivalents

Medical cost	Fatal injury	Minor injury
In-patient cost	0.405	0.014
Emergency treatment	2.70	0.6
Follow-on treatment	0	0.024

To update these to the latest prices, each medical cost component is indexed using the PPI for health and community care services. They are then summed together to get the medical cost per injury for each severity.

To estimate the average medical cost per crash we multiply each the estimated total number of injuries for each crash severity by their respective per injury value and then divide this by the number of crashes. This calculation is done using crashes on rural, urban and all roads separately so the per crash estimates will differ for each.

Due to the base values for medical costs being estimated over 30 years ago, it is likely that even the inflation-adjusted values do not fully reflect how these costs have changed over time, however medical costs only account for about one percent of the total social costs so the impact of this is likely to be relatively minor.

2.4.4 Legal and justice resource costs

Legal costs are the resource costs of:

- crash attendance and investigation by Police,
- court costs relating to traffic offences and
- imprisonment costs for traffic offences

The method used to calculate them differs from the prior cost components in that we first calculate the per crash costs and then use those to calculate the per injury costs.

Crash attendance and investigation costs for a given financial year is estimated by dividing the annual spend relating to crash investigations[13] by the number of estimated equivalent serious crashes for that same year. The use of equivalent serious crashes for this calculation comes from an Australian study (Atkins, 1981) and proposes the following multipliers in Table 4:

Table 4 Serious crash relative factors for legal costs

Crash severity	Scaling factor
Fatality	6.92
Serious injury	1.00
Minor injury	0.46
Non-injury	0.05

The number of injuries for the selected price year are multiplied by their respective factors to estimate their equivalent serious injuries. The total of this is used to divide the crash investigation funding for the same price year to get the average cost per investigation for a serious crash. This is then multiplied by the Table 4 factors to get the average costs for the other crash severities.

The court costs per crash were originally estimated by Guria (1993) using 1992 prices as shown in Table 5.

[13] Which is extracted from the Road Safety Partnership Programme reports

Table 5 Court costs per crash by severity (July 1992 prices)

Crash severity	Court cost per crash ($)
Fatal	2922
Serious injury	331
Minor injury	152
Non-injury	17

These are updated to the selected price year by indexing them to the PPI for legal and accounting services.

To get the average imprisonment cost per crash, we estimate the total cost of imprisonment for fatal and serious crashes[14] based on the number of sentences, the average duration of those sentences and the average annual cost per inmate for the most recent three years. For each crash severity these are multiplied together, summed up and divided by 12 and then divided by the estimated total number of crashes.

Data for sentences and the average duration for those sentences is sourced from the Ministry of Justice. The average annual cost per inmate is extracted from the Department of Corrections annual reports, however it is assumed that some proportion of this average includes fixed costs that would not vary with the number of imprisonments (Barnett & Clough, 1998). As a result, we assume about 2/3 of the average annual cost relates to variable costs and make this scaling in the above method.

All three components are summed up to get the legal cost per crash for each severity. To get the legal cost per injury, we first estimate the legal cost per minor injury by multiplying its respective legal cost per crash by the estimated number of minor crashes and then dividing this by the estimated number of minor injuries.

For the legal cost per serious injury, we do a similar calculation, but we also use the legal cost per minor injury to estimate the total legal cost of minor injuries caused by serious crashes. This is subtracted from the total legal cost of serious crashes before we divide it by the number of serious injuries. We do the same for the fatal injury estimate - removing the costs of serious and minor injuries from fatal crashes. Formula-wise this process looks like:

$$(2) \quad LI_M = \frac{LC_M * C_M}{I_{MfM}}$$

$$(3) \quad LI_S = \frac{LC_S * C_S - LI_M * I_{MfS}}{I_{SfS}}$$

[14] Minor crashes do not incur imprisonment sentences

$$(4) \quad LI_F = \frac{LC_F * C_F - LI_S * I_{SfF} - LI_M * I_{MfF}}{I_{FfF}}$$

Where:

L = legal cost

I = injuries

C = crashes

F = fatal

S = serious

M = minor

f = from

Due to the base values for the court costs being estimated over 30 years ago and the scaling factors being estimated 40 years ago, it is likely that even the inflation-adjusted values do not fully reflect how these costs have changed over time, however legal costs only account for about one percent of the total social costs so the impact of this is likely to be relatively minor.

2.4.5 Vehicle servicing and repair costs

Motor vehicle crashes cause damage to property whether it is to the vehicles involved, items inside the vehicles or other roadside structures (such as fences). We only estimate the costs associated with vehicles due to a) the lack of information on damage to other types of property and b) the likely case that the proportion of crashes that cause damage to other types of property (and the associated costs) is small.

Like with legal costs, we estimate the per crash costs first and then convert these to per injury cost estimates. The base vehicle damage costs for each crash severity were first estimated in 1995 using insurance claim data. These accounted for “excess” and adjusted for uninsured and unclaimed cases. Table 6 shows these original estimates.

Table 6 Vehicle damage cost per crash (June 1994 prices)

Crash severity	Vehicle cost per crash ($)
Fatal	5100
Serious injury	3300
Minor injury	2900
Non-injury	1500

These are updated to the latest price year by indexing them to the CPI for vehicle servicing and repairs.

To convert them into per injury estimates, we use the process described in section 2.4.4 - replicating equations (2), (3) and (4) with vehicle costs substituted in for legal costs.

Due to the base values for the vehicle costs being estimated about 30 years ago it is likely that even the inflation-adjusted values do not fully reflect how these costs have changed over time, however vehicle costs only account for about two percent of the total social costs so the impact of this is likely to be relatively minor.

2.5 Average social costs

After the cost components have been updated, they are summed up and rounded to the nearest $100 to get the average social cost in per injury and per crash terms by severity and road type. The final step is to adjust these for the level of unreported crashes so that any analysis using them also accounts for the social costs associated with unreported crashes[15].

To achieve this, we multiply the estimated number of crashes and injuries by their respective average cost at the road type and severity level to get the total social cost. This total social cost is then divided by the reported crashes and injuries by road type and severity. This provides the per reported crash and per reported injury estimates for the average social costs that account for the estimated unreported crashes.

Similar calculations are performed at the regional and vehicle movement level to get average social costs for each region or vehicle movement code. These are provided in the accompanying Excel spreadsheet (*social_cost_of_road_crashes_and_injuries_<year>_update_<three-years>_data*) and their use is explained in section 3.

2.6 Limitations

There are several limitations with this methodology. The key limitations are addressed in this section. This is not an exhaustive list:

1 The reported crash data used excludes values where one or more fields are blank, so it does not cover all reported crashes and injuries. This has a flow on effect to the estimated crashes and injuries.

2 The conversion factors being based on matched hospitalisations and ACC claims means that there will likely be unreported serious and minor crashes that are not captured in either dataset.

3 As the ACC claims at is only at the national level, the minor conversion factor produced is a single number, which means it does not account for any regional variations in reporting like the serious conversion factors do.

4 As discussed earlier, these estimates do not canvas all possible costs associated with road crashes and injuries, but instead the ones that can be estimated based on studies and available data.

5 The social cost estimates are broad averages that apply to a range of crashes and due to data limitations, we do not specify breakdowns for many factors that may in fact have very

[15] Unless that analysis also attempts to estimates unreported crashes

different average costs. For example, they do not distinguish by transport mode (such as pedestrian and cyclists) and the estimated values will lean towards crashes involving light vehicles[16].

6 The medical, court and vehicle damage cost components are based on values first estimated in the 1990s and the inflation adjusted values may not reflect the actual change in the value of those costs over time. These components account for less than 5 percent of the total social cost so any adjustments to them are not likely to make any substantive change.

7 Investigation costs are calculated from a funding category that covers other activities in addition to crash investigations so this component will be overestimated.

8 The imprisonment cost workings assume 1/3 of the average cost per inmate relates to fixed costs that do not scale with number of prisoners or sentence duration, which may differ from the actual proportion.

[16] Waka Kotahi provides modal breakdowns in its *Monetised Benefits and Costs Manual*

3 Using the social cost of crashes and injuries

This section provides guidance on the social cost estimates found in the Excel spreadsheet: *social_cost_of_road_crashes_and_injuries_<year>_update_<three-years>_data* available on our website, and how/where to apply them in transport assessments. The following sub-sections refer to the tab names, and the table numbers reference those found in the spreadsheet.

In most cases cost estimates have been provided in both per crash and per injury terms. The estimates to use will depend on the data you are working with and the type of assessment. The per crash estimates are useful where:

- the initiative changes the number of crashes but does not change the average number of injuries per crash (e.g., safety interventions that prevent crashes from occurring).
- you know the total number of crashes, but do not know the total number of injuries, which the per crash estimates are scaled for.

The per injury estimates are useful where:

- you know or can estimate the change in the total number of injuries.
- the initiative shifts injuries to a different severity (e.g., features like seatbelts and air bags that make what be a fatality, a serious or minor injury instead).

3.1 Total social cost

This tab provides tables and figures for total social costs derived by multiplying the average social costs per injury by the estimated injury numbers. *Table 1* provides the estimated total social costs per year while *Figure 1* is an area graph of *Table 1.*

Figures 2, 3 and 4 are graphs of the estimated total social costs by region per year. *Figure 2* is for crashes on rural roads, *Figure 3* is for crashes on urban roads, and *Figure 4* is for crashes on all roads.

3.2 Crash and inj per year

This tab provides the reported and estimated crashes and injuries per year that were used in the workings by road type and crash severity.

Table 2 contains the reported crashes and injuries from CAS while *Table 3* contains the estimated crashes and injuries calculated for the workings.

3.3 VOSL

Table 4 shows the VOSL across different price years for different injury severities. The base year for the current VOSL ($12.5 million) is June 2021. VOSL is given here because it has wider applications outside of road crashes such as injuries in other transport modes or non-transport areas such as health – for example VOSL is used in estimating the health costs of air pollution (Kuschel, et al., March 2022).

3.4 Cost per injuries & crashes

This tab contains estimates of the average social costs per crash and per injury and contain breakdowns by cost component. These estimates are not adjusted for under-reporting, so they are only suitable for cases where the total number of crashes and injuries is known.

Tables 5-7 provide the average social costs per injury for different road types. *Tables 8-10* provide the same in per crash terms and includes estimates for non-injury crashes.

3.5 Cost per reported inj & crash

This tab provides estimates of the average social costs per reported injury and reported crash, which have been adjusted for under-reporting. The estimates that use a combination of severities can be used for assessing safety risks that could cause severe injury to road users, but have a low probability of occurrence (e.g., situations where the crash and injury numbers are small).

Table 11 provides the average social costs per reported injury. *Table 12* provides the same but excludes vehicle damage costs for initiatives where the number of injuries may change, but not the number of crashes. *Table 13* provides the average social costs per reported crash.

3.6 Cost per vehicle movement

This tab contains estimates of the average social costs per reported crash by vehicle movement code and road type (*Table 14*). These estimates are adjusted for under-reporting and are useful for assessment or analysis that looks at specific vehicle movements in crashes.

3.7 Average costs by region

This tab contains estimates of the average social costs by reported crashes and injuries for each region and road type. Average costs are assumed to differ regionally due to:

- differences in physical locations
- regional size
- road safety infrastructure
- hospital facilities
- level of reporting
- mix of urban and rural roads

These estimates have been adjusted for under-reporting and are useful for analysis or assessment of initiatives that target specific regions.

Tables 15-17 provide the costs per reported crash by road type. *Tables 18-20* provide the costs per reported injury by road type.

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Social cost of road crashes and injuries

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