TE MANATŪ WAKA
MINISTRY OF TRANSPORT

Domestic Transport Costs and Charges Study

Working Paper D1
Costs of Road Traffic Accidents

Prepared for Te Manatū Waka Ministry of Transport (NZ)
ViaStrada Ltd, in association with Ian Wallis Associates Ltd
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Research, Economics and Evaluation

The Research, Economics and Evaluation team operates within the System Performance and Governance Group of Te Manatū Waka Ministry of Transport. The team supports the Ministry's policy teams by providing the evidence base at each stage of the policy development.

The team is responsible for:

- Providing sector direction on the establishment and use of the Transport Evidence Base (see below) – including the collection, use, and sharing of data, research and analytics across the transport sector and fostering the development of sector research capabilities and ideas.
- Leading and undertaking economic analyses, appraisals and assessment including providing economic input on business cases and funding requests.
- Performing the evaluation function for Te Manatū Waka, including designing monitoring and evaluation frameworks and approaches, developing performance metrics and indicators, and designing, conducting and procuring evaluations.

The Transport Evidence Base

The Transport Evidence Base Strategy creates an environment to ensure data, information, research and evaluation play a key role in shaping the policy landscape. Good, evidence-based decisions also enhance the delivery of services provided by both the public and private sectors to support the delivery of transport outcomes and improve wellbeing and liveability in New Zealand.

The Domestic Transport Costs and Charges study aims to fill some of the research gaps identified in the 2016 Transport Domain Plan (Recommendation R6.2), which forms part of the Transport Evidence Base.

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For more information

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

Executive summary

Background

This working paper summarises the methodology and calculations to derive estimates of the Total (Social) Costs, Average Costs, Marginal Costs and Marginal Externality Costs of road transport-related accidents in New Zealand. As well as aggregate cost calculations, the analysis considers the various inter-relationships between the funding and charging for costs related to accidents. This includes the roles of the Accident Compensation Corporation (ACC) and private insurance to cover many of the medical, work-interruption, and property damage costs associated with road accidents and other transport mode accidents (otherwise largely borne by individuals, employers and the public health service).

Following a review of the relevant literature and available data, the paper first explores the overall costs associated with road accidents (to both motorised and non-motorised users) in New Zealand, and the average costs per vehicle-km, net tonne-km or person-km where possible.

The next part looks at the marginal costs and charges (i.e. the unit variable costs of changes to the current transport volumes) and also explores further the payment streams (i.e. who ultimately pays for the costs involved with transport accidents).

Note that rail and maritime accidents are covered in separate working papers (DTCC WP C11.6 and C14 respectively).

Total and average social costs of motor vehicle accidents

The total annual social costs (in year 2018/19) for road accidents involving motor vehicles (i.e. at least one of the parties recorded in the accident report was a motor vehicle) was $5.65 billion (at June 2019 prices)[1]. The following table provides a breakdown of these costs (in terms of costs caused[2]) by user type and road type. The average costs (in cents) per vehicle-km travelled (VKT) and person-km travelled (PKT) are also presented.

[1] Note that this total figure is consistent with the estimate derived by the Ministry of Transport in its most recent assessment (MoT 2020a).

[2] Where costs are assigned according to the vehicle/user judged to be primarily at fault, based on the crash reports.

Table ES.1 Yearly costs and usage rates for road accidents involving motor vehicles – by user type

	Road type	Bicycle	Pedestrian	Cars, light commerc'l, other	Motorcycle including moped	Bus	Truck	Total
Costs **caused**[2] ($m/year)	Open (≥80km/h)	18	37	2,871	352	42	256	**3,576**
	Urban (≤70km/h)	69	162	1,587	168	23	59	**2,069**
	All	87	199	4,459	520	65	315	**5,645**
Cost caused per distance travelled by vehicle (c/VKT)	*All*	*28.3*	*28.2*	*10.1*	*125.4*	*21.4*	*10.4*	***11.6***
Cost caused per distance travelled by person (c/PKT)	*All*	*28.3*	*28.2*	*6.5*	*125.4*	*2.4*	*10.4*	***7.4***

It is evident that, in terms of costs "caused" (i.e. where costs are assigned according to the vehicle/user judged to be primarily at fault, based on the crash reports), motorcycle accidents involve by far the highest personal risk on a per veh-km or person-km basis for motorised accidents, followed by bicycle and pedestrian accidents. The comparisons of costs caused with an allocation based on costs "shared" (i.e. where costs are assigned equally to all users involved in the accident) indicate little change in these figures. However, comparisons with costs "suffered" (i.e. where costs are assigned relative to the injury and other costs suffered by each accident participant) reveal that these vulnerable travel modes have even higher relative costs suffered, mostly offset by reductions in the allocated truck accident costs. On all three cost allocation bases, bus travel appears to be the safest mode, having the lowest cost caused or suffered per person-km.

Total and average social costs of non-motorised user accidents

For accidents on the road system involving only "non-motorised" users (NMUs), including pedestrians, cyclists, wheelchair users, and users of small-wheeled powered or unpowered devices (skateboards, scooters etc), the following combined data has been obtained, based on the Crash Analysis System (CAS) and ACC datasets. The total social costs of $830 million pa (on a "costs caused" basis) shown in the following table reflect the high number of transport accidents by these modes not captured by Police crash records but reported through hospital and ACC data (e.g. falls).

Table ES.2 Parameters and costs for non-motorised road user accidents not involving a motor vehicle

	Total NMU-only
Distance travelled by person (PKT, million kms)	1014
Costs caused ($m/year)	830
Cost caused per distance travelled by person (c/PKT)	82

In terms of “costs caused”, the figure here is an upper limit (and also represents the “costs suffered”). Given that most relevant studies have noted physical road/path defects and maintenance issues as contributing to many NMU-only accidents, it is reasonable to assume that in reality only a fraction of these costs caused can be attributed directly to the users concerned (instead of, say, roading authorities). However, the same argument could also be made of the “cost caused” calculations for motor vehicle accidents (albeit to a lesser degree).

While the combined risk calculations above suggest an average accident cost per km travelled of over $1.10 per active mode user, it should be remembered that walking and cycling also present considerable health benefits from undertaking them, not to mention other environmental benefits to society (due to lack of noise, air pollution, severance, etc from walking and cycling) as well. These benefits are of a broadly similar scale to the accident costs noted above.

Breakdown of accident cost components

Bringing together the above cost estimates for both motorised and non-motorised road users results in a total annual cost (in 2018/19) of approximately $6.48 billion associated with accidents occurring on the NZ road system.

The social costs of road accidents in New Zealand include components of willingness-to-pay (WTP) to avoid loss of life or permanent disability, loss of productive output through temporary disability (for serious and minor injuries), medical costs, legal and court costs, and vehicle damage costs.

For **accidents involving motor vehicles**, the WTP to avoid loss of life or permanent disability comprises by far the bulk of the costs, although that becomes less so for more minor accidents. Other than loss of life or permanent disability, most costs are very small (<2%), particularly if non-injury accidents are ignored. Due to the sheer number of non-injury accidents (~250,000 a year) the cost component for vehicle damage is relatively large overall at over 19%.

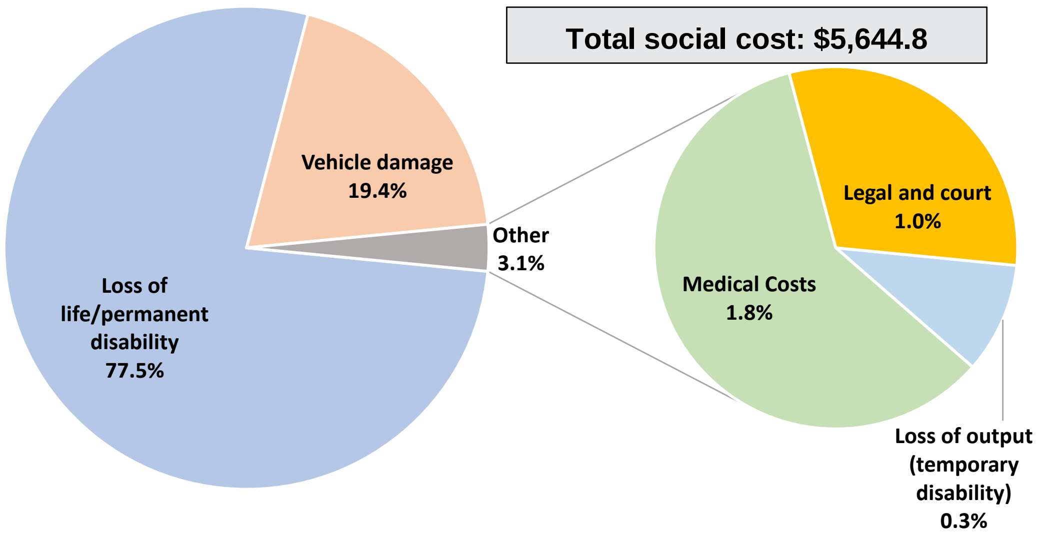

Figure ES.-1 Breakdown of annual cost components for motor vehicle accidents (2018/19) (by percentage)

For **accidents not involving motor vehicles**, the vehicle costs are much smaller, reflecting the high proportion of pedestrian injuries in this group, and the relatively low cost of any damage to bicycles, scooters, etc. The WTP costs of loss of life or permanent disability are now ~90% of the total costs, with the other components all contributing <5% each to the total cost.

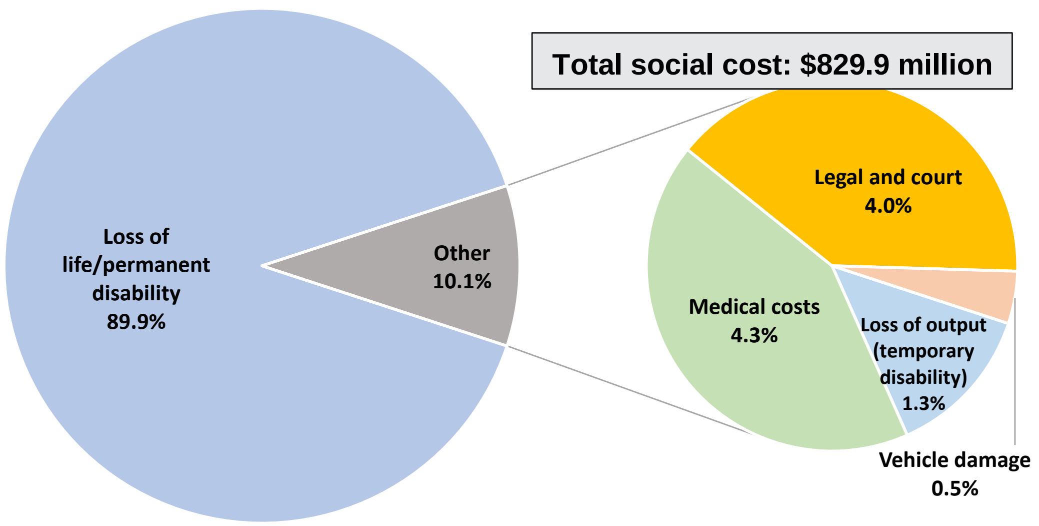

Figure ES.-2 Breakdown of annual cost components for non-motor vehicle accidents (2018/19) (by percentage)

A qualitative exploration of relevant costs and charges relating to motor vehicle accidents in New Zealand has also been undertaken. This exploration has identified the role of various financial streams, including ACC levies, health/life/vehicle insurance, public taxes and other personal costs. Some of these costs and charges are essentially “internalised” by the road user (i.e. they or their families have to “pay” for them directly, which may affect their safety behaviour) while others are external to the road user and are typically borne by society in general (e.g. through general taxation). As WTP to avoid loss of life or permanent disability is largely considered an internal cost to individual users and their close family and friends, by far the largest proportion of accident costs in New Zealand are considered to be internal costs.

Marginal costs of motor vehicle accidents

Accident prediction models (where the total vehicle-kilometres travelled VKT by the 'exposed' traffic is the key input) have been used to estimate the number of accidents, with consideration given to the variation in average costs per accident in three key dimensions:

- Higher ***speeds*** (e.g. on rural roads) are typically associated with more serious injuries (and a greater likelihood of deaths);
- ***Intersections*** involve typically different accident types than mid-block sections, again with different likelihoods of death and serious injury;
- In ***congested*** situations (e.g. rush hour), traffic speeds are typically slower than at uncongested times, reducing the average accident severity.

Three different types of road environment that contribute to New Zealand's road accidents have been modelled for motor vehicles:

- Accidents on urban streets (speed limit of 70 km/h and less)
- Accidents on rural roads (speed limit of 80 km/h and more)
- Accidents on limited-access motorways and expressways.

Within urban and rural environments, accidents are further split into those occurring at intersections and those occurring at mid-block sections (it is assumed that all motorway accidents are mid-block, with no at-grade intersections present). Pedestrian and cycle accidents do not have the same level of data breakdown available (e.g. urban vs rural VKT); therefore, for simplification, single-factor models simply based on the active mode VKT have been used for this exercise.

The following table presents the relevant marginal costs for each road environment. These have been derived from the ratio of marginal costs to average accident costs (**MC/AC**) Where applicable, uncongested and congested costs have been shown separately. Pedestrian marginal costs are presented for all accidents (including those not involving a motor vehicle) and also only for motor vehicle related accidents.

Table ES.3 Estimated marginal costs

<table>
<tr><th>Sub-model</th><th>MC/AC*</th><th>Marginal costs (c/VKT)</th><th>Combined MC (c/VKT)</th></tr>
<tr><td>Urban mid-block (uncongested)</td><td>1.00 (U)</td><td>13.2</td><td rowspan="2">Urban uncongested 17.3 (U)</td></tr>
<tr><td>Urban intersection (uncongested)</td><td>0.44 (U)</td><td>4.1</td></tr>
<tr><td>Urban mid-block (congested)</td><td>-1.40 (C)</td><td>-18.4</td><td rowspan="2">Urban congested -33.1 (C)</td></tr>
<tr><td>Urban intersection (congested)</td><td>-1.56 (C)</td><td>-14.7</td></tr>
<tr><td>Rural mid-block (uncongested)</td><td>0.80 (U)</td><td>51.3</td><td rowspan="2">Rural uncongested 56.9 (U)</td></tr>
<tr><td>Rural intersection (uncongested)</td><td>0.46 (U)</td><td>5.6</td></tr>
<tr><td>Motorway mid-block (uncongested)</td><td>1.40 (U)</td><td>5.1</td><td>5.1 (U)</td></tr>
<tr><td>Motorway mid-block (congested)</td><td>-1.85 (C)</td><td>-6.8</td><td>-6.8 (C)</td></tr>
<tr><td>Cycle all (uncongested)</td><td>0.20 (U)</td><td>8.1</td><td rowspan="3">-</td></tr>
<tr><td>Pedestrian vs MV (uncongested)</td><td>0.40 (U)</td><td>12.4</td></tr>
<tr><td>Pedestrian only (uncongested)</td><td>0.40 (U)</td><td>46.2</td></tr>
</table>

** (U) = uncongested, (C) = congested*

The results illustrate the congestion effects in urban and motorway environments where the relative increase in accident numbers with increasing VKT is partially or totally offset by the reduced cost per accident due to lower traffic speeds. The negative marginal cost estimates for urban congested situations indicate that, in such situations, increases in traffic volumes typically results in reduced total accident costs per VKT (although maybe more accidents in total) due to reduced traffic speeds and accident severity. While the relative contributions of mid-block and intersection accidents are fairly even in urban environments, mid-block accidents contribute far more in the rural environment, reflecting the relative sparsity of intersections.

Note that the VKT values for cycle and pedestrian marginal costs refer to an additional veh-km of these modes, i.e. the relative marginal cost from an additional kilometre cycled or walked. The findings illustrate the considerable costs suffered by pedestrians from accidents *not* involving motor vehicles (i.e. typically “slip, trip and fall” accidents).

PART ONE: INTRODUCTION, GENERAL BACKGROUND AND METHODOLOGY

Chapter 1 Introduction

1.1. Study Scope and Overview

The Domestic Transport Costs and Charges (DTCC) study aims to identify all the costs associated with the domestic transport system on the wider New Zealand economy including costs (financial and non-financial) and charges borne by the transport user.

The Study is an important input to achieving a quality transport system for New Zealand that improves wellbeing and liveability. Its outputs will improve our understanding of the economic, environmental and social costs imposed by different transport modes - including road, rail and coastal shipping - and the extent to which those costs are currently offset by charges paid by transport users.

The DTCC is intended to support the wider policy framework of Te Manatū Waka, especially the Transport Outcomes Framework (TOF). The TOF seeks to make clear what government wants to achieve through the transport system under five outcome areas:

- Inclusive access,
- Economic prosperity,
- Healthy and safe people,
- Environmental sustainability, and
- Resilience and security.

Underpinning outcomes in these areas is the guiding principle of mode neutrality. In general, outputs of the DTCC study will contribute to the TOF by providing consistent methods for (1) estimating and reporting economic costs and financial charges and (2) understanding how these costs and charges vary across dimensions that are relevant to policy, such as location, mode and trip type.

Robust information on transport costs and charges is critical to establishing a sound transport policy framework. The Study itself does not address future transport policy options; but the study outputs will help inform important policy development including areas such as charging and revenue management, internalising externalities, and travel demand management.

The Study has been undertaken for Te Manatū Waka by a consultant consortium headed by Ian Wallis Associates. The Study has been divided into a number of topic areas, some of which relate to different transport modes (including road, rail, urban public transport and coastal shipping), and others to impacts or externalities (including accidents, congestion, public health, emissions, noise, biodiversity and biosecurity).

Working papers are being prepared for each of the topic areas. The topic areas and specialist authors are listed in Appendix 2.

1.2. Costing Practices

The focus of DTCC is on NZ transport operations, economic costs, financial costs and charges for the year ending 30 June 2019 (FY 2018/19). Consistent with this focus, all economic and financial cost figures are given in NZ$2018/19 (average for the 12-month period) unless otherwise specified.

All financial costs include any taxes and charges (but exclude GST); while economic costs exclude all taxes and charges.

The DTCC economic and financial analyses comprise essentially single-year assessments of transport sector costs and charges for FY 2018/19. Capital charges have been included in these assessments, with annualised costs based on typical market depreciation rates plus an annualised charge (derived as 4% p.a., in real terms, of the optimised replacement costs of the assets involved).

1.3. Paper Scope and Structure

This working paper summarises the methodology and calculations to derive estimates of the Total (Social) Costs, Average Costs, Marginal Costs and Marginal Externality Costs of transport accidents (also known as "crashes" or "incidents" – see Chapter 1.5) in New Zealand.[3] The costs presented here are societal ones, i.e. any costs resulting from an accident, to whomever they may accrue. As explained later, most of the societal costs are based on willingness-to-pay (WTP) to avoid pain, grief and suffering associated with accidents.

As well as aggregate cost calculations, the analysis considers the various inter-relationships between the funding and charging for costs related to accidents. This includes the role of New Zealand's Accident Compensation Corporation (ACC) and private insurance to cover many of the medical, work-interruption, and property damage costs associated with road accidents and other transport mode accidents (otherwise largely borne by individuals, employers and the public health service).

This first part of this working paper sets out background literature and contextual information, as well as the methodology used to obtain the relevant values.

The second part explores the overall costs incurred from road (both motorised and non-motorised users) transport-related accidents in New Zealand, and the average costs per vehicle-km, tonne-km or person-km where possible. It also explores further the payment streams (i.e. who ultimately pays for the costs involved with transport accidents)

The third part looks at the marginal costs and charges (i.e. the unit costs of changing the current transport volumes).

Finally, the fourth part briefly considers further areas for data analysis and makes some recommendations regarding data sources for this whole exercise. Note that rail and maritime accidents are covered in separate working papers (DTCC WP C11.6 and C14 respectively).

[3] It should be noted that the purpose of this exercise is *not* to identify the key factors that cause these accidents (or how to reduce them), such as road user, vehicle and road environment inputs. It is possible however, that any changes to the way that the costs and charges related to safety are implemented could have some influence on the behaviour of transport users, vehicle owners, road designers, and other participants in the transport system.

1.4. Task outline

The following steps have been undertaken in preparing this working paper:

1) A literature review of methodologies from previous studies and more recent work. Development of a conceptual cost/charges flow model for each sub-mode. Selection of a comparable and repeatable methodology for each cost and charge item and for each mode. {Chapter 2}
2) Obtain the latest safety and usage data from relevant agencies and adjust for under-reporting. Identify other related costs of accidents. {Chapter 3}
3) Analyse the total and average road accident costs for motor vehicles, having regard to accident rates and unit valuations, and new valuation methods. Investigate the extent to which road accident rates/costs vary in different conditions, especially in regard to traffic volumes (e.g. quiet vs congested road networks), traffic speeds (e.g. urban vs rural roads), and user-type involvement (e.g. single-user accidents vs multi-party collisions). {Chapter 4}
4) Analyse the total and average road accident costs for non-motorised road users, having regard to accident rates and unit valuations, and new valuation methods. The analyses include active transport modes (walking, cycling, scooters, etc), where suitable data is available. {Chapter 5}
5) Review the safety-related benefits and costs received or incurred by individuals and other parties, and assess their relative size and whether the costs are external or internal. {Chapter 6}
6) Analyse the marginal road accident costs for motor vehicles and non-motorised users, having regard to accident rates and unit valuations, and new valuation methods. The analyses include active transport modes (walking, cycling, scooters, etc), where suitable data is available. {Chapter 7}
7) Make recommendations regarding the refinement of data analysis methods and updating or further improvement of related data sources for future re-analysis. {Chapter 8}

These steps are described in more detail in the following chapters.

1.5. Terminology

For this project, the term **"accidents"** has been chosen to describe transport incidents that lead to injuries or property damage. The authors recognise that, in some sectors, it is more common to use different terms; and note in particular the road transport industry's current preference to refer to **"crashes"**, to emphasise the responsibility of drivers to drive safely. For this project, it has been necessary to adopt a common terminology across all modes, and "accident" seems a better fit (for example, it also covers a cyclist slipping on a wet road surface, or a person tripping on a footpath). The authors do not intend that the term "accident" implies that no party was at fault in any way, but it is assumed that there was generally no specific intent to cause harm.

Note that there are a number of general transport infrastructure and promotion/policing costs that could be attributed to road safety (e.g. safety features of a new motorway, constructed predominantly to reduce capacity). While these are discussed further in Chapter 3.6, they have not been considered otherwise in the resulting calculations.

Chapter 2 Literature review

Studies elsewhere (e.g. CE Delft 2019) have noted six main components of road accident costs:

- **Human costs**: A monetary proxy for estimating the pain and suffering and loss of utility caused by traffic accidents, through injuries and fatalities.
- **Medical costs**: The costs of the victim's medical treatment provided by hospitals, rehabilitation centres, general practitioners, etc. as well as the costs of ambulances and medicines. Often partly covered through health insurance premiums and ACC levies.
- **Administrative costs**: The expenses for deployed emergency services at accident sites, as well as the administration of justice/legal costs, and administrative costs related to insurances.
- **Production losses**: The net production losses due to any reduced working time of victims and the human capital replacement costs. Partly covered by insurance and ACC.
- **Material damages**: The value of damages to vehicles/vessels, infrastructure, freight and personal property resulting from accidents, largely covered through insurance.
- **Other costs**: Includes the costs of congestion/delays resulting from road accidents, and funeral costs. May already be incorporated in other external cost categories.

While it is accepted that these costs will vary (often considerably) between different individual accidents, for analysis purposes average valuations are usually determined for various generalised accident types or categories. These valuations are typically determined by a combination of:

- **"Restitution" costs** (the resources needed to restore victims and their families and friends to the situation where the accident had not happened) – typically, "medical costs" and "material damages" are valued this way.
- **"Human capital" costs** (the value for society of the productive capacities that are lost in road accidents) – typically, "administrative costs" and "production losses" are valued this way.
- **"Willingness to pay"** (WTP) costs (the amount that individuals are willing to pay for a risk reduction) – typically, "human costs" are valued this way.

2.1 Calculation of accident costs in New Zealand

In New Zealand, WTP largely determines the Value of Statistical Life (VOSL); the value was initially established at NZ$2 million by Miller & Guria (1991). A WTP valuation technique was used to express pain and suffering from loss of life or life quality in dollar terms; the resulting estimate is the VOSL used. VOSL was last reviewed by MOT (2009), is updated annually to allow for changes in relevant cost indices, and is currently incorporated into accident cost statistics for 2019 (MOT 2020a)[4]. As of June 2019, the current VOSL is $4.527 million. A 1991 Ministerial Directive (NZ Gazette 1991) also instructed the Ministry of Transport to use the same value in evaluations across other transport modes, and that practice appears to have continued to this day.

The social cost of road accidents in New Zealand includes components of VOSL (for fatalities or permanent disability), loss of productive output through temporary disability (for serious and minor injuries), medical costs, legal and court costs, and vehicle damage costs.

[4] The NZ VOSL is currently the subject of some further market research (being undertaken by Waka Kotahi NZTA).

Each component is separately indexed to relevant price indices to update the costs each year. The resulting are detailed in the Appendix and summarised below in Table 4; they range from $4.562 million for a fatal injury to $3,200 for a non-injury accident. For fatal accidents, the non-VOSL components make up a very small part of the total cost (<1%), but they become increasingly more relevant for less severe accidents (e.g. 30% for a minor injury).

Table 4 Average social cost per injury by type or non-injury accident, June 2019 prices

Cost components	Injury severity			Accident type
	Fatal	Serious	Minor	Non-injury
WTP to avoid loss of life/permanent disability	$4,527,300	$452,700	$18,100	
Loss of output (temporary disability)	$0	$1,400	$300	
Medical (hospital, emergency, follow-on)	$7,000	$15,500	$900	
Legal and court	$21,100	$2,800	$900	
Vehicle damage	$6,600	$5,200	$5,200	$3,200
Total (including motor vehicle)	**$4,562,000**	**$477,600**	**$25,500**	**$3,200**
Total (non-motor vehicle injury)[5]	$4,555,500	$472,500	$20,300	$100

2.2 Implications for this study

The following conceptual model (Figure 3) illustrates some thinking around flows of costs and charges relating to road accidents for private motor vehicles in New Zealand (similar relationships could be developed for commercial vehicles, public transport services, active modes, and other transport modes, e.g. cyclists and pedestrians contribute to ACC via Earner and Non-Earner levies instead, but have no need for motor vehicle insurance). While not necessarily complete, the model does help to provide an overview of where the flows of costs and charges are likely to occur.

[5] Costs per injury have been calculated assuming non-motor vehicle users will incur the same costs as motor vehicle users, except for vehicle damage, for which a nominal value of $100 per crash has been applied, to account for damage to bicycles, small-wheeled devices or mobility scooters etc.

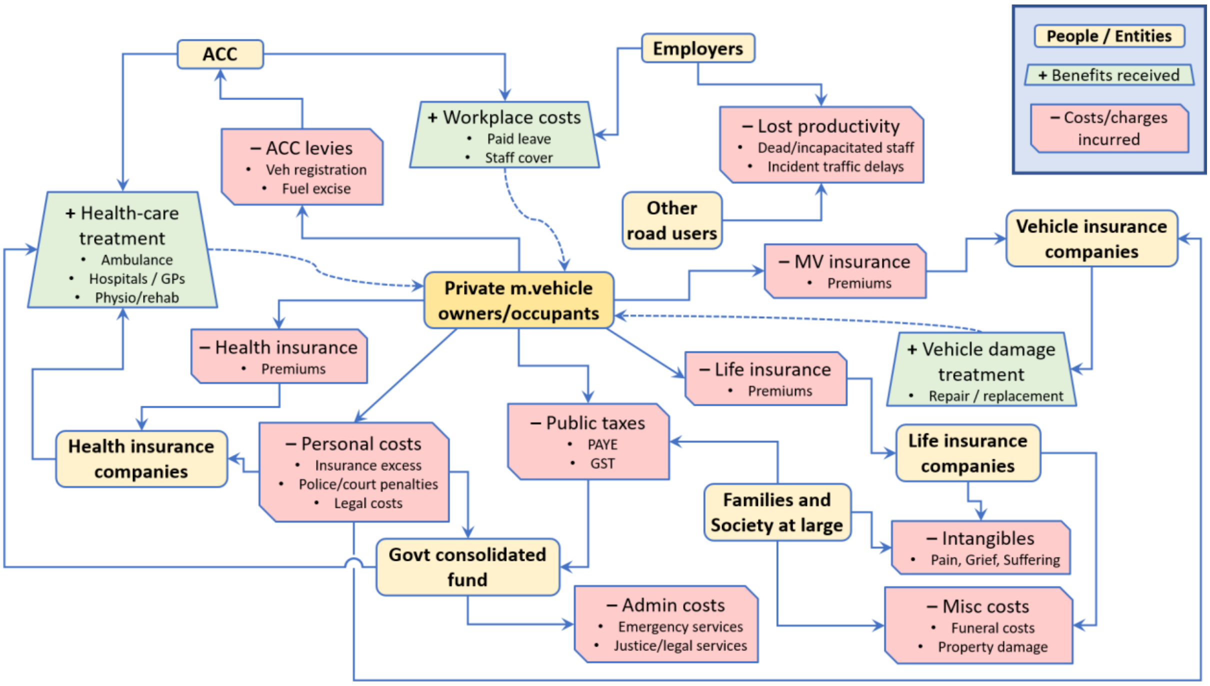

Figure 3 Indicative costs/charges flow relationships for NZ (private motor vehicles)

It should be noted that the above diagram does not show any of the “engineering investment”, “promotional campaign” or similar safety cost streams that are about *prevention or reduction* of accidents in the first place (many of these are described further in Chapter 3.6); these would add even further complexity to the above relationships. By and large, this working paper is focused on the costs of accidents once they *happen*, excluding any preventative initiatives that are nonetheless a part of the broader picture of the costs linked to transport safety.

A key issue in comparing costs and charges is assessing the perception of causality by the user, and its relationship to primary fault in multi-party accidents. For example, it may be that drivers of larger vehicles do not adequately assess the risk imposed by them on more vulnerable users (which might cause them to drive more conservatively) because the existing “price signals” don’t reflect the true costs. Previous analysis identified different cost concepts, including “perceived” costs, costs “caused”, and costs “suffered”. We have reviewed this approach, and also consider updated valuation methods (e.g. those provided in CE Delft 2019). Some different options include:

- Assigning victim costs to the vehicle type that they were in
- Assigning victim costs to the vehicle deemed to be at fault in the accident
- Assigning victim costs to the other vehicle (that inflicted the damage).

Chapter 3 Methodology, data sources and preparation

Two costing concepts (total/average costs and marginal costs) will be applied for the road accident costing analyses in DTCC. The following chapters illustrate the intended process for determining the total and marginal accident costs.

A similar approach will be employed when calculating accident costs for other modes; however, it is somewhat more difficult to obtain all the same necessary input data. A cursory investigation of alternative valuation methods for non-road accidents has been undertaken, but a simple assumption for now has been to use the same VOSL values for all modes, consistent with the 1991 Ministerial Directive.

3.1 Total and Average Costs

Total and average accident costs are calculated using a top-down approach, starting with total reported accidents, assuming under-reporting rates, and then allocating them to different road or vehicle/vessel types (knowledge of person/freight/vehicle-km data would also allow for averages against these metrics). Fatal accidents are assigned a cost based on the current VOSL; injury and non-injury accidents are assumed to cost a certain percentage of the VOSL. The flowchart in Figure 4 illustrates the basic procedure.

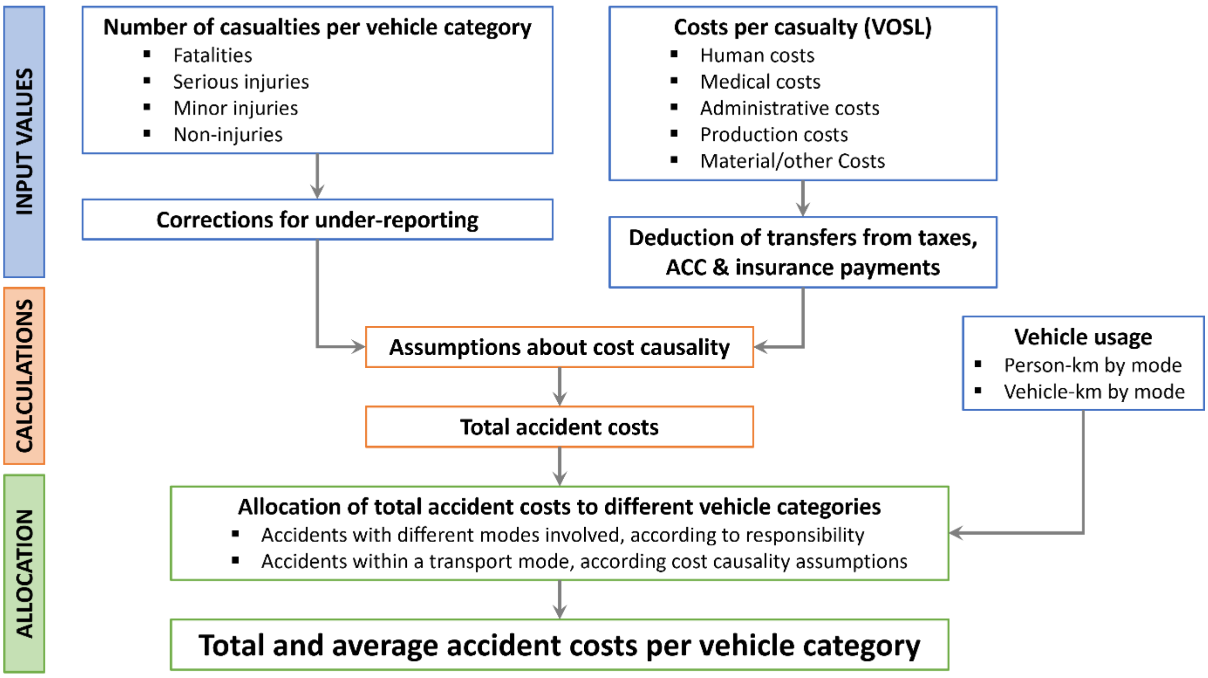

Figure 4 Methodology for total and average accident costs by vehicle category (adapted from CE Delft 2019)

Having determined total accident costs, the exercise can then be extended to consider how much the road (or other transport mode) user already contributes to these costs (through taxes, ACC levies, premiums, direct costs, etc) and how much is paid for by external parties (e.g. other road users, employers, society at large). We will then review ways of allocating these costs to different parties.

3.2 Marginal Costs

The marginal costs for road accidents represent the extra costs that adding an extra vehicle-km (or deducting a vehicle-km) to the traffic flow pattern brings. Marginal costs are typically used to determine if transport prices are set in a suitable manner to encourage more or less travel as desired, or to achieve economic efficiency or social welfare political objectives, by comparing them with the average costs derived above.

The main input values for marginal accident costs are the accident risk per vehicle type and road type, the costs per casualty and the "risk elasticity" (the change in accident risk per change in traffic flows). The costs per casualty are the same as those used for the calculation of total and average costs. The flowchart in Figure 5 illustrates the basic procedure.

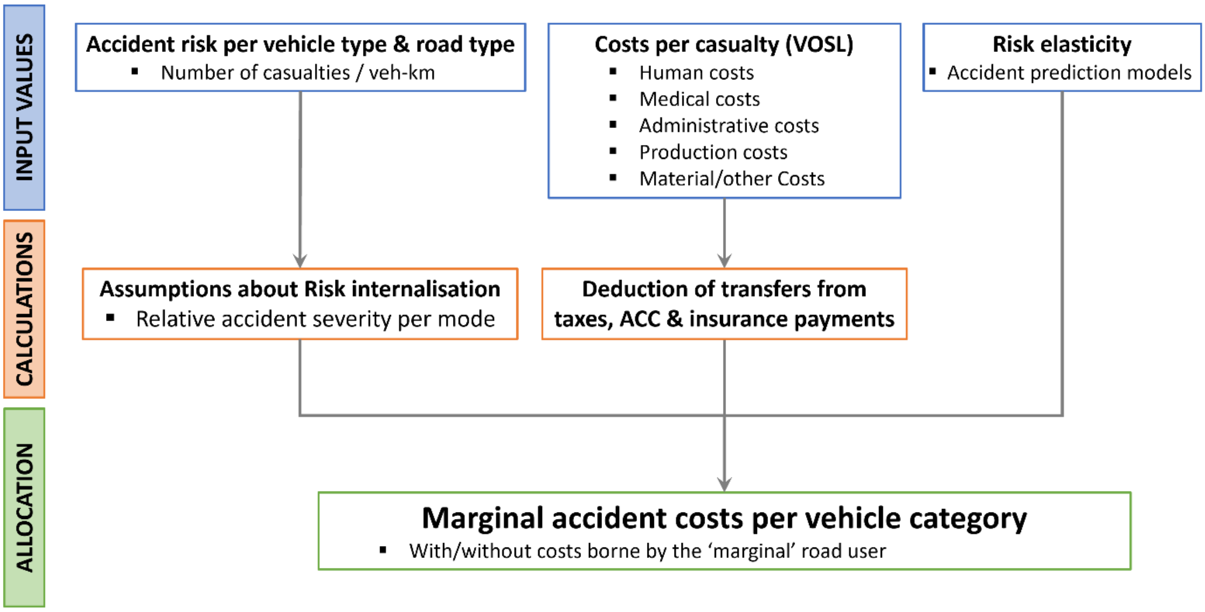

Figure 5 Methodology for marginal external accident costs (adapted from CE Delft 2019)

Risk elasticity values can be derived from either similar overseas studies or local crash prediction models, such as the work by Turner (2001) and Turner *et al* (2012); we have undertaken only limited review of the existing elasticity assumptions and tested the relative sensitivity of using different values. Risk internalisation can be estimated from an analysis of fatalities/injuries sustained across accidents involving multiple vehicle types relative to the fatality/injury rates for each vehicle type.

While similar analyses could be applied to other transport modes, it is not likely that they can be broken down to the same degree of detailed disaggregation.

3.3 Overview of data sources

The following list specifies the data sources and assumptions used in this analysis, with links to further explanation in relevant appendices. A combination of Police and health accident records have been used, as described in Appendix 3, with a comparison of their merits given in Appendix 4. Where the analysis period has not been specified for a particular dataset, this means suitable data are available for financial years 2016/17 to 2018/19 and the average of these has been used in the analysis. In some cases, particularly for modes with low accident rates, longer-term averages have been used. Where data availability is more limited, the values from the most recent year available have been used. References to publicly available documents are included in the main reference list in the Appendix.

[a] Ministry of Transport [MoT] (2020). *Social cost of road crashes and injuries 2019 update*. Wellington, NZ. August 2020. Available: https://www.transport.govt.nz/assets/Import/Uploads/Research/Documents/SocialCostof-RoadCrashesandInjuries2019.pdf (see in Appendix 3)
[b] NZ Transport Agency[6] Crash Analysis System (CAS), factored for MBCM reporting rates (see Appendix 4). (Accessed April 2020). *Note that CAS data are not available publicly and require access approval from NZTA.*
[c] ACC injury data provided to ViaStrada (April and June 2020), proportioned by injury severities from CAS (see Appendix 3 and Appendix 7)
[d] No longer used
[e] MoT dashboard RD016 – distance travelled by vehicle type. (Accessed July 2020). Available: https://www.transport.govt.nz/mot-resources/transport-dashboard/2-road-transport/rd023-vehicle-fleet-composition-by-region/rd016-vehicle-kilometres-travelled-by-vehicle-type-billion-km/
[f] Ian Wallis (September 2020) key variables based on MoT Household Travel Survey data 2011-2014
[g] MoT Household Travel Survey data FY2016-FY2018 (analysed by MR Cagney as a separate component of the Domestic Transport Costs and Charges project and provided to ViaStrada August 2020)
[h] NZTA VKT data provided to Ian Wallis – motor vehicles on urban vs rural roads (10-year dataset; only calendar years 2017-2019 were used for this project)
[i] NZTA Public Transport Performance data (Accessed July 2020). Available: https://www.nzta.govt.nz/assets/userfiles/transport-data/PTPerformance.xlsx
[j] Beca (2019). *Cook Strait Connectivity: Programme Business Case for the Wellington Ferry Terminals.* Wellington, NZ. July 2019. Available: https://www.gw.govt.nz/assets/Uploads/Cook-Straight-Connectivity-PBC-Infographic-FINAL-July-2019.pdf
[k] A conservative assumption has been made in this analysis to assume "occupancy" = 1
[l] MoT dashboard FR006 – road freight tonne-km (for calendar year 2017). (Accessed July 2020). Available: https://www.transport.govt.nz/mot-resources/transport-dashboard/5-domestic-freight-road-rail-and-coastal-shipping/fr006-road-freight-tonne-km-billion/
[m] Ministry of Transport (2019). *National Freight Demand Study 2017/18.* Wellington, NZ. September 2019. Available at: https://www.transport.govt.nz/assets/Import/Uploads/Research/Documents/NFDS3-Final-Report-Oct2019-Rev1.pdf

Table 5 shows which data sources from the above list correspond to the various transport categories considered, and types of data used.

[6] Note that the New Zealand Transport Agency (NZTA) was renamed Waka Kotahi during the course of this investigation. For now, this working paper will continue to refer to its previous name.

Table 5 Data sources (letters in brackets cross-reference to cost tables in subsequent chapters)

	Motor vehicle road transport	Non-motorised user only road transport
Costs per injury type	[a]	
Accident numbers	[b]	[b], [c]
Vehicle-kilometres travelled (VKT)	[e], [g], [h]	[g]
Person-kilometres travelled (PKT)	[f]	[k]
Nett tonne kilometres (NTK)	[l]	N/A

3.4 Cost allocation concepts

In considering current or possible changes to transport regulation and pricing policy, it is useful to identify how the existing costs of accidents are currently borne by the various transport users involved.

Table 6 outlines the various cost allocation concepts used to assign the costs per accident to the users involved; these were applied to the road-based accidents detailed in Chapters 4 and Chapter 5.

Table 6 Cost allocation concepts

Concept	Description
(Neutral) costs "shared"[7]	• Allocation of the estimated cost for each accident type (by number/type of vehicles involved) evenly across the vehicle types involved (e.g. for an accident involving 2 cars and 1 truck, 2/3 of cost allocated to cars, 1/3 to trucks). • From CAS data
Costs "caused"	• Allocation of total costs across vehicle types according to the vehicle type judged to be primarily at fault. • From CAS data, with fault allocation based on movement types as described in Appendix 5
Costs "suffered"	• Allocation of total costs across vehicle types in proportion to the people experiencing the cost (in terms of injuries received). • Based on CAS data and the methodology described in Appendix 6.

Note that the "cost shared" approach is the default method for how costs are traditionally allocated, on a "social cost per vehicle" basis; the purpose of the other two methods is to illustrate how much that under or over-estimates the cost to different modes. For this exercise, the **"costs caused"** approach shall be used as the primary metric, to illustrate how much the larger vehicles (e.g. cars and trucks) tend to impose accident costs on more vulnerable users (e.g. pedestrians and cyclists) through little fault of the latter. In all cases, the *same* total accident costs are used; they are just allocated in different ways.

[7] Note that the previous 2005 study referred to "neutral" costs; for this update we have used the term "shared" costs

3.5 ACC charges and payments

The Accident Compensation Corporation (ACC) scheme provides no-fault injury coverage (including medical treatment and ongoing rehabilitation) for anyone in New Zealand who suffers an accident of any kind, whether it be related to homes, workplaces, sport and recreation, or transport. As ACC is a relatively unique funding mechanism internationally, some discussion of its mechanism is warranted here. The scheme is funded by employee/employer levies, motor vehicle levies, general taxation, and income generated from accumulated investments. Further details about ACC claims data can be found in the Appendix.

In terms of land transport, accident injury costs that involve a motor vehicle are largely funded by ACC's Motor Vehicle Account, which derives its revenue from a levy on all petrol, an annual charge on motor vehicle licensing, and an annual "motorcycle safety levy" on all moped/motorcycle owners. Non-motor vehicle accidents (such as a pedestrian slipping while walking or colliding with a scooter rider) are also funded from other ACC accounts; as noted in Chapter 5, even this is a reasonably significant cost in comparison to injuries involving a motor vehicle. Treatment costs for injuries relating to other transport accidents (e.g. rail or maritime) are covered by ACC's other funding accounts, depending on whether the injury was work-related or not.

ACC has to manage its investments to enable it to pay both for new claims arising every year and also any ongoing costs of "active" long-term claims. Each year, the applicable ACC levies payable are reviewed to attempt to cover these. Historically, a "residual portion" of ACC workplace levies covered the cost of claims made prior to 1999; however, that was removed in 2015. Effectively now, ACC operates as a "pay as you go" system, aiming to balance its annual revenue received/earned with the required payments for that year.

For the most recent three years available (2016/17 to 2018/19), the average amount received by the Motor Vehicle Account was $471 million/yr, while the average amount paid out in claims was $552 million/yr (ACC 2019). However, it should be noted that the average levy dropped considerably from 2017/18 onwards; thus, there is currently an even greater imbalance in revenue received and paid out (the difference being covered by drawing on existing investments held).

Chapter 4 compares ACC income received from motor vehicle modes with pay-outs made to users of these modes.

3.6 Other road safety related costs

There are several other public sector expenses related to transport safety that could be considered part of the total "cost". The main categories are as follows:

- The contribution by NZTA to NZ Police towards road policing in their National Land Transport Programme (NLTP) (NZTA 2020). For the 2018/21 programme, the amount was $1.11 billion, or an average of $370 million per year (2015-18 funding was $960 million or $320m/yr).
- Funding by NZTA and local councils in the NLTP for "promotion of road safety and demand management". For the 2018/21 programme, the amount was $233 million, or an average of $78 million per year (2015-18 funding was $132 million or $44m/yr).

- Funding by NZTA and local councils in the NLTP for land transport infrastructure that addresses safety issues. It is often difficult to separate out the safety component of many transport projects from other components such as delay reduction or asset maintenance. For the 2018/21 programme, the estimated amount related primarily to safety (as reported by NZTA 2020) was $3.0 billion, or an average of $1.0 billion per year (2015-18 funding was $2.1 billion or $0.7b/yr).
- As well as its direct role in covering most medical treatment costs of road accidents, the Accident Compensation Corporation (ACC) invests in a number of road safety prevention programmes, including skills programmes for motorcyclists, cyclists and young drivers. Typically, these programmes cost around $10-12 million per annum.

Whether these are included here or not is a philosophical question; for the purposes of this exercise we have not dealt with these costs in this Working Paper. It could be argued that, without these investments, the total social and other costs of road accidents would be much greater. Care needs to be taken though that costs such as those related to infrastructure have not already been accounted for in other parts of this DTCC exercise. Overall transport expenditure and funding is being investigated in a separate DTCC working paper (WP C3).

Equally blurred is the source of this other funding. Collectively the NLTP is funded by a mixture of fuel excise duties, road user charges, motor vehicle registration charges, land sales/rentals, local rates, and contributions from the Crown. Separating out the road safety component from the other components is difficult by any means other than simple proportional allocation of the costs to the charges incurred. Again, for the purposes of this exercise, this has not been explored in this Working Paper. Note that, as described in Chapter 3.5, the ACC components of fuel and registration charges go towards the payment of road injury treatment costs, and do not contribute to NLTP funding.

Road safety-related costs incurred by individuals, families, employers, and society at large are discussed further in Chapter 6.2.

PART TWO: TOTAL AND AVERAGE COSTS OF ROAD ACCIDENTS IN NEW ZEALAND

Chapter 4 Motor vehicle road accidents

This chapter covers road accidents involving motor vehicles, except for those also involving trains (which are covered in a separate working paper). It includes accidents occurring between motor vehicles and non-motorised users (such as pedestrians or cyclists), but not road accidents involving only non-motorised users.

4.1 Social cost of motor vehicle road accidents

Table 7 shows the usage metrics used to assess the annual social costs associated with road accidents involving motor vehicles (but not involving trains) along with references to the data sources as presented in Table 5.

Table 8 and Table 9 present the accident costs as per the total/average cost methodology described in Chapter 3 and the cost allocation concepts outlined in Chapter 3 and the various metrics presented in

Table 7. It should be noted that the total social costs presented here ($5.7 billion) match those derived by the Ministry of Transport in their most recent assessment (MOT 2020a).

Where applicable data are available, an urban vs open split is used, according to the NZTA split for VKT measures, i.e.:

- Urban – roads with a speed limit 60 km/h or less
- Open – roads with a speed limit 70 km/h or greater

This split involves several undesirable limitations, as it is not uncommon to have roads with 70 km/h speed limits in what are effectively urban situations, and the "open" category includes not only rural roads, but also urban motorways (hence the use of the term "open" as opposed to "rural"). Ideally, motorways should be considered as a third distinct category, for better correlation with crash prediction models; however, our analysis is limited by what data categories currently are available.

Also, ViaStrada notes that the NZ Transport Agency does not employ a consistent split across different datasets: CAS data are coded so that roads with 70 km/h speed limits are considered urban (the urban vs rural row in Table A3.2 of Appendix 3 explains that the CAS data were reclassified according to the abovementioned urban vs open split).

For accidents on the road network involving motor vehicles (but excluding those also involving trains):

- Motorcyclists experience by far the greatest cost suffered per vehicle-km or person-km travelled, with the values for pedestrians and cyclists also being significantly higher than for the remaining modes (cars / other light vehicles, buses, trucks) – this indicates the vulnerability of motorcyclists, pedestrians and cyclists.

- Motorcyclists also *cause* the greatest costs per vehicle-km or person-km travelled, again followed by bicycling and walking. Comparisons of costs shared vs costs caused indicate little change in these figures, with a higher degree of similarity between the remaining modes.
- Comparisons with costs *suffered* reveal that these vulnerable modes (motorcycle, bicycle, walking) have even higher relative costs suffered, mostly with truck accident costs benefiting by comparison.
- Bus travel appears to be the safest mode, having the lowest cost suffered per person-km.

Table 7 Yearly usage (distance travelled) by vehicle, person and cargo for road transport [sources relating to Table 5 in brackets]

			Bicycle	Pedestrian	Cars, light commercial, other	Motorcycle including moped	Bus	Truck[%]	Motor vehicle subtotal	Total Road Users
Usage parameters	Vehicle distance travelled (VKT, million kms)	Open (≥80km/h)							26,743 [h]*	
		Urban (≤70km/h)							19,493 [h]*	
		Total	309 [g]	705 [g][f]	44,115 [e]	415 [e]	303 [e]	3,022 [e]	46,236 [h]*	**48,869**
	Distance travelled by person (PKT, million kms)	Total	309 [k]	705 [k]	68,819 [f][§]	415 [k]	2,731 [g][±]	3,022 [f][#]	74,987	**76,001**
	Distance travelled by cargo (NTK, million kms)	Total						25,293 [l]		

Notes:

VKT = vehicle-kilometres travelled; PKT = person-kilometres travelled; NTK = net tonne-kilometres

[%] While some VKT data is available that breaks “trucks” down into various sub-categories, CAS crash data makes no such distinction, simply grouping crash vehicles as “cars, vans, light commercial vehicles”, “trucks”, and “50MAX trucks” (a relatively small group of crashes). Therefore our analysis has similarly combined results for all heavy trucks (normal and 50MAX) as one group.

** this total vehicle-kilometres travelled as supplied by NZTA for the urban vs. open split is for motor vehicles only, i.e. including cars, motorcycles, buses and trucks but not including pedestrians or cyclists. Note that, because of the different data sources, this total does not match the total of the individual motor vehicle types presented here.*

[§] the PKT has been derived based on applying an occupancy ratio of 1.56 to the VKT; with the occupancy ratio having been derived from the 2011-14 HHTS data. Light commercial vehicles are not included in the HHTS category for light 4-wheeled vehicles, but are included in the categories applied to the crash costs and VKT. It has been assumed that the occupancy ratio for light commercial vehicles will be similar enough to that of private 4-wheeled vehicles. Further work is recommended to review these figures in light of current trends.

[±] based on an occupancy ratio of 9.0 PKT per bus-km, as assumed by Ian Wallis based on knowledge of 2011-2014 HHTS data.

[#] based on a conservative assumed occupancy of 1.0 per truck

Table 8 Yearly costs and usage rates for road accidents involving motor vehicles – by user type (relates to usage from and data sources from Table 5)

	Road type	Bicycle	Pedestrian	Cars, light commercial, other	Motorcycle including moped	Bus	Truck	Total Motor Vehicles	Total Road Users
Costs **shared** ($million/year)	Open (≥80km/h)	26	42	2,809	329	52	317	3,508	**3,576**
	Urban (≤70km/h)	85	177	1,539	182	25	62	1,808	**2,069**
	All	110	219	4,349	511	77	380	5,316	**5,645**
Cost shared per distance travelled by vehicle (cents/VKT)	*(Open / Urban)*							*(13.1 / 9.3)*	
	All	*35.7*	*31.0*	*9.9*	*123.1*	*25.5*	*12.6*	*11.5*	***11.6 c/VKT***
Cost shared per distance travelled by person (cents/PKT)	*All*	*35.7*	*31.0*	*6.3*	*123.1*	*2.8*	*12.6*	*7.1*	***7.4 c/PKT***
Costs **caused** ($m/year)	Open	18	37	2,871	352	42	256	3,522	**3,576**
	Urban	69	162	1,587	168	23	59	1,837	**2,069**
	All	87	199	4,459	520	65	315	5,359	**5,645**
Cost caused per distance travelled by vehicle (cents/VKT)	*(Open / Urban)*							*(13.2 / 9.4)*	
	All	*28.3*	*28.2*	*10.1*	*125.4*	*21.4*	*10.4*	*11.6*	***11.6 c/VKT***
Cost caused per distance travelled by person (cents/PKT)	*All*	*28.3*	*28.2*	*6.5*	*125.4*	*2.4*	*10.4*	*7.1*	***7.4 c/PKT***
Costs **suffered** ($m)	Open	47	91	2,843	428	40	126	3,437	**3,576**
	Urban	154	344	1,280	278	3	11	1,571	**2,069**
	All	201	435	4,123	705	43	137	5,008	**5,645**
Cost suffered per distance travelled by vehicle (cents/VKT)	*(Open / Urban)*							*(12.9 / 8.1)*	
	All	*65.1*	*61.7*	*9.3*	*170.1*	*14.2*	*4.5*	*10.8*	***11.6 c/VKT***
Cost suffered per distance travelled by person (cents/PKT)	*All*	*65.1*	*61.7*	*6.0*	*170.1*	*1.6*	*4.5*	*6.7*	***7.4 c/PKT***
Ratio: cost suffered / caused	All	2.30	2.19	0.92	1.36	0.66	0.43	0.93	**1.00**

Table 9 Yearly costs and cargo unit cost rates for road accidents involving trucks (relates to usage from

Table 7 and data sources from Table 5)

	Road type	Truck
Cost **shared** per distance travelled by cargo (c/NTK)	Total	1.5
Cost **caused** per distance travelled by cargo (c/NTK)	Total	1.2
Cost **suffered** per distance travelled by cargo (c/NTK)	Total	0.5

(c/NTK = cents per net tonne-km)

The above results are largely in line with what one might expect in terms of average costs by modes. The main motor vehicle modes (car, truck, bus) are relatively safer than the more vulnerable modes (motorcycle, cycle pedestrian) on a cost per-VKT or per-PKT basis. However, motor vehicles also tend to be the parties who *cause* more crash costs than they suffer themselves, compared with the vulnerable modes where the average costs suffered are often double those caused.

Unfortunately, the limitations of the available data did not allow the analysis to disaggregate the various modes by road environment as well; this could only be done on a collective basis. The higher speeds on open roads (and thus higher accident severities) largely explain the higher average costs there in comparison to urban roads; certainly for motor vehicles, higher-speed roads should be the key focus to reducing the cost of deaths and serious injuries.

4.2 Disaggregation of motor vehicle accidents

4.2.1 Effect of congestion

For urban roads at least, congestion can have a notable effect on relative traffic speeds and corresponding crash severities. Table 10 shows the cost breakdown for accidents involving a motor vehicle during congested vs. uncongested conditions (based on the reasoning presented in Chapter A.2.6), for the four levels of accident severity. The rightmost columns show the percentages each condition (congestion or no congestion) relating to accidents of a given severity.

Table 10 Average yearly cost of road accidents and percentage by severity for congested vs non-congested conditions

	Average yearly accident cost ($m)		Percent of accidents by severity	
Accident severity	Congested	Not congested	Congested	Not congested
Fatal	$ 58	$ 1,667	4%	96%
Serious	$ 179	$ 1,919	9%	91%
Minor	$ 107	$ 845	12%	88%
Non-injury	$ 86	$ 787	10%	90%

It can be seen that accidents occurring in congested conditions are less likely to result in fatality or serious injury than those in uncongested conditions (7% compared with 11%), reflecting the lower relative vehicle speeds in congested conditions. However, at the lower end of the scale, accidents occurring in congested conditions are more likely to result in a minor injury rather than non-injury compared with uncongested conditions.

4.2.2 Vehicle usage

In 2019, a new field, “vehicle usage” was introduced to CAS, which gives useful information on broad categories of travel, such as taxis, school buses, tour buses, work travel etc. CAS administers have indicated that attempts have been made to adjust accident records retrospectively, however interrogation of the data suggest that this has not been done sufficiently as there is a much higher instance of “null” entries in the vehicle usage field prior to 2019. Thus, a summary of vehicle usage by accident severity crashes has been prepared for calendar year 2019 only; it is assumed that the proportions involved would be reasonably representative of the wider analysis sample used in this research.

An attempt has been made to incorporate the vehicle type, and present accident data for only light 4-wheeled vehicles (cars, vans etc) according to vehicle usage (private vs work) and accident severity, with values in parenthesis representing the proportion of all accidents for the given severity (see Table 11).

Table 11 Number and proportion of accidents of given severity by various vehicle usages for light 4-wheeled vehicles, calendar year 2019

	Accident severity			
Vehicle usage	**Fatal**	**Serious**	**Minor**	**Non-Injury**
Private	260 (73.5%)	1,943 (78.9%)	10,837 (79.2%)	32,999 (83.2%)
Work	94 (26.5%)	519 (21.1%)	2,855 (20.8%)	6,677 (16.8%)
Grand Total	**354**	**2,462**	**13,692**	**39,676**

Note that Table 11 presents **accident** severities, i.e. the worst outcome per accident, as opposed to the total number of **injuries** involved in these accidents, due to it not being possible to correlate the vehicle usage and total injuries directly in CAS without considerable extra analysis.

Private vehicles are by far the greatest contributor to accidents, which is not surprising given that they are the most likely vehicle role. However, work-related trips are somewhat more likely to feature more severe outcomes (such as fatal and serious injuries), which perhaps reflects the greater likelihood for work trips to include long-distance travel on high-speed roads.

4.3 Comparison with ACC charges

DTCC Working Paper C4 (Paling 2020) presents the total ACC revenues from vehicle levies, which comprise of vehicle licence (registration) fees, petrol levy and motorcycle safety levy. Table 12 show these costs can be distributed across the main motor vehicle categories used:

Table 12 Distribution of ACC levies to main motor vehicle classes

	Cars, light commercial, other					Motorcycle including moped		Bus			Truck		TOTAL
Vehicle sub-category	**Petrol private**	**Petrol commercial**	**Pure electric**	**Diesel private**	**Diesel commercial**	**≤600 cc**	**> 600 cc**	**Petrol**	**Diesel**	**Electric**	**Petrol**	**Diesel**	
Average ACC vehicle licence levy for 2018/19 (a)	$41.17	$36.54 (b)	$41.17(b)	$100.74	$36.54 (b)	$259.05	$345.37	$170.79 (d)			$170.79		
Number of vehicles registered in 2018 (e)	3,157,190	161,011	8,816	297,079	486,288	82,901	93,381	192	11,215	92	3,023	150,373	**4,451,561**
Total Vehicle licence levies ($m)	$130.0	$5.9	$0.4	$29.9	$17.8	$21.5	$32.3	$1.9			$26.2		**$265.8**
	$183.9					$53.7		$1.9			$26.2		**$265.8**
Vehicle licence levies adjusted ($m) (f)	**$160.9**					**$47.0**		**$1.7**			**$22.9**		**$232.5**
VKT (million km) (e)	31,979	1,548	77	3,690	7,580	414		1	310	2	9	3,065	**48,675**
Fuel consumption rate (L/100km)	8.98 (g)		N/A for electric	N/A for diesel		4.87 (h),(h)		32.3 (j)	N/A for diesel	N/A for electric	38.6 (j)	N/A for diesel	
Petrol consumption (million L/year)	3,012					20		0.3			3.5		**3,036**
Petrol levy ($m)	**$188.2**					**$1.3**		**$0.02**			**$0.22**		**$189.7**
Motorcycle safety levy ($m)						**$2.4**							**$2.4**
TOTAL LEVIES ($m)	**$349.1**					**$50.7**		**$1.7**			**$23.1**		**$424.6**

Notes:

(a) *The average ACC levies for 2018/19 come from DTCC Working Paper C4, which is cited to have been supplied by ACC. As noted by WP C4, the levy structure changed in mid-2019; as vehicle fleet data comes from 2018, the 2018/19 structure has been used, with the assumption that, for light vehicles, the average levy across the four bands (based on vehicle risk rating) is appropriate.*
(b) *For the purposes of paying Motor Vehicle Levies, ACC classes hybrid and electric vehicles as petrol vehicles (these users will pay less or nothing in petrol levies at the pump).*
(c) *The ACC website currently distinguishes between petrol and diesel light commercial vehicles, but WP C4 does not.*
(d) *Neither WP C4 (Paling 2020) nor the ACC website specify levies for buses; these have been assumed to be the same as for heavy commercial vehicles.*
(e) *Vehicle fleet numbers and VKT come from MoT (2019b*
(f) *The total calculated ACC levy component of vehicle licence fee based on assumed average levies and vehicle fleet numbers is slightly different to that presented in WP C4 and thus the sub-components have been adjusted accordingly.*
(g) *MoT (2019b) a table of fuel consumption rates depending on engine size and year of first registration; it also gives an average engine size of 2288.6 cc for light vehicles in the fleet in 2018. In lieu of knowing the distribution of vehicle registration for the fleet, the average fuel consumption for light vehicles in the 2000-2999 cc band has been used.*
(h) *It has been assumed that all motorcycles on NZ roads are petrol-powered.*
(i) *MoT (2019b) gives the year of manufacture for motorcycles in the NZ fleet – in 2018 the median year of manufacture was 2002. Totalmotorcycles.com gives a list of motorcycle models and fuel efficiencies; for those manufactured in 2002 the average fuel consumption was 4.87 L/100km.*
(j) *In lieu of NZ-specific data, a value of 3.1 km travelled per litre of fuel from the Bureau of Transport Statistics (USA) has been applied (converted to 32.3 L/100km).*
(k) *In lieu of NZ-specific data, a value of 6.1 miles travelled per gallon of fuel from the Bureau of Transport Statistics (USA) has been applied (converted to 38.6 L/100km).*

The levies presented in Table 12 are thus used in Table 13 to compare with the costs suffered by vehicle category:

Table 13 Comparison of ACC charges with relevant accident costs

		Cars, light commercial, other	Motorcycle including moped	Bus	Truck	Total
Vehicle distance travelled (VKT, million kms)		44,115	415	303	3,022	**48,869**
ACC charges 2018/19	Total received ($m)	$349.1	$50.7	$1.7	$23.1	**$424.6**
	Total received (% of total)	*82%*	*12%*	*<1%*	*5%*	
	Average rate (c/VKT)	0.79	12.21	0.57	0.77	**0.87**
ACC payments 2018/19	Total claims paid out ($m)	$327.6	$103.6	$2.5	$19.1	**$452.8**
	Total paid out (% of total)	*72%*	*23%*	*<1%*	*4%*	
	Average rate (c/VKT)	0.74	24.98	0.82	0.63	**0.93**
Total received: total paid (%)		**107%**	**49%**	**69%**	**121%**	**94%**

It should be noted that the VKT stated here is as per used in the earlier cost tables – based on MoT dashboard and various other sources as outlined in Chapters 3 and 4. However, not all of these figures align perfectly with VKTs presented in Table 12 (2018 figures, with splits for fuel type).

The above figures show that motorcycle and buses continue to under-fund their relative accident treatment costs from ACC. Cars and other light commercial vehicles slightly over-pay, whereas trucks appear to also over-pay relative to their ACC claims paid out.

Note that the above figures do not include the ACC payments from the Motor Vehicle account for injuries to non-motor vehicle users, who do not pay anything directly into this account. In 2018/19 these payments were:

- Pedestrians: $42.9m
- Cyclists: $22.7m
- Other (scooter, e-scooter, skateboard, etc): $7.5m

Some costs associated with non-motorised users who injure themselves away from motor traffic also come out of other ACC accounts; in particular, the “Place of Sports & Recreation” account. Refer back to Chapter 3.5 for further information about ACC’s charges and payments system.

Chapter 5 Non-motorised user only road accidents

This chapter covers accidents involving only "non-motorised" users (NMUs), which is a transportation term covering pedestrians, cyclists, wheelchair users, users of small-wheeled devices (skateboards, scooters etc) as well as those using low-powered electric devices such as e-bikes and e-scooters.

The aim is to include accidents that occur on the road network or integrated path network, but to exclude off-road sporting activities such as mountain biking or walking on recreational trails. It is acknowledged that people may walk or cycle on the road and path network for reasons other than transportation (e.g. sport and recreation), but people also drive on the road network for such reasons (indeed, the MoT Household Travel Survey would suggest that the proportion of trips made for recreational purposes are very similar across the modes).

These accidents may involve collisions between two or more non-motorised users, or (more commonly) could involve a single non-motorised user tripping/slipping/etc while travelling or colliding with an object, which may be due to factors such as attempting to avoid collision with another road users, the conditions of the road surface, or distractions in the wider environment.

5.1 Social cost of non-motorised user only road accidents

Data for non-motorised user (NMU) accidents not involving motor vehicles or trains came from CAS plus two different ACC datasets. Appendix 7 describes the process of combining the three datasets to determine the total number of NMU-only road accidents and attributed injury severities.

Appendix 7 also outlines the various limitations of the datasets, of these, including that the ACC data relates directly to injuries rather than accidents, making it impossible to disaggregate the NMU accident data by mode, other than specifying whether or not a pedestrian was involved.

Table 14 presents the resulting social costs and usage metrics for NMU-only accidents; for comparison, the equivalent costs for accidents involving motor vehicles from Chapter 4.1 are also shown.

Table 14 Parameters and costs for non-motorised user accidents not involving a motor vehicle

	Total NMU-only	*Source*	NMU vs motor vehicle	*Source*
Distance travelled by person (PKT, million kms)	1014	*Sum of bicycle and pedestrian travel from Household Travel Survey (see item [g] in Chapter 3.3)*	1014	*Table* 7
Costs caused ($m/year)	830	*Appendix 7*	286	*Table 8*
Cost caused per distance travelled by person (c/PKT)	82	*Calculated*	28	*Calculated*

Note that the person-km travelled metrics for cyclists and pedestrians uses the same distances travelled as used for these users involved in accidents with motor vehicles. This is because the risk to non-motorised users of being involved in an accident with another non-motorised user or where they are the only person involved (e.g. slipping on loose gravel) is considered a separate risk to that of being involved in an accident with a motor vehicle.

The NMU-only costs presented in Table 14 are considerably greater than the sum of the costs for pedestrians and cyclists involved in accidents with motor vehicles (from Table 8). This may seem surprising at first, given that motor vehicles may seem to pose a greater threat to pedestrians and cyclists. However, comparison of the datasets from CAS and ACC as presented in Figure A7-3 shows that there is a large number of accidents involving pedestrians but not motor vehicles. These may include pedestrians colliding with cyclists or users of small-wheeled devices, pedestrians stumbling when trying to avoid conflict with motor vehicles, or pedestrians slipping on the road / footpath surface. Pedestrians who do require medical attention as the result of a slip / trip / fall are more likely to be vulnerable (e.g. the elderly) and thus likely to suffer serious injuries (e.g. broken hip).

In a study of non-motor vehicle injuries to pedestrians in NZ, Frith & Thomas (2010) found that most pedestrian injuries here involve no motor vehicle interaction and are therefore not reported as part of CAS traffic crash data; the difference is even more prevalent with older pedestrians. Previous research on cycle-only accidents in NZ (Munster *et al* 2001) also noted a 2:1 ratio of cyclists admitted to hospital for on-road incidents not involving a motor vehicle, compared to those with a motor vehicle.

The above social cost may even be underestimated, based on a more recent investigation of serious injuries of vulnerable road users in Auckland (ViaStrada 2021), which estimated that the cost of these in Auckland (both user-only and those involving a motor vehicle) was at least $500 million annually, more than two-thirds of which were NMU-only incidents.

For this exercise, we have simply assumed that the costs presented are “cost caused”, given that the active transport modes are the only users involved in these accidents. In practice, they would certainly represent the costs “shared” and “suffered” as well. It is not possible to calculate the costs *caused* by the individual non-motorised users because the ACC data does not record multiple users per event, and ACC is a no-fault scheme and therefore its data does not include any indication of who caused the individual accidents.

In reality, the estimate for “cost caused” is probably far too high. Most incidents were single-person events only but, in many cases, they may be a result of external deficiencies in the transport network. All the studies cited above noted physical road/path defects and maintenance issues as contributing to many injured parties’ accidents. Therefore, it is reasonable to assume that only a fraction of the total NMU-only accident costs can be attributed directly to the users concerned (instead of, say, roading authorities). However, the same argument could also be made of the “cost caused” calculations for motor vehicle accidents (albeit to a lesser degree).

While the combined risk calculations above suggest an average accident cost per km travelled of over $1.10 per active mode user, it should be remembered that walking and cycling also present considerable health benefits from undertaking them, not to mention other environmental benefits to society (due to lack of noise, air pollution, severance, etc from walking and cycling) as well. Smith *et al* (2009) noted that these (conservative) health benefits per km are of a similar scale to the accident costs noted above.

Chapter 6 Discussion of accident costs

This chapter reviews the costs derived in the previous two chapters and analyses ways they can be broken down.

6.1 Breakdown of accident costs by components

Bringing together the above cost estimates for both motorised and non-motorised road users results in a total annual cost (in 2018/19) of approximately $6.48 billion associated with accidents occurring on the NZ road system.

As noted in Chapter 2.1, the social costs of road accidents in New Zealand include components of VOSL (for fatalities or permanent disability), loss of productive output through temporary disability (for serious and minor injuries), medical costs, legal and court costs, and vehicle damage costs. Table 15 summarises the breakdown of annual accidents involving motor vehicles (from Table 8) by MoT cost components.

Table 15 Breakdown of annual cost components for motor vehicle accidents ($'000s per year)

Ave. number of casualties / year	378	4,392	37,351	272,942	315,063
Cost Component	**Fatal Injuries**	**Serious Injuries**	**Minor Injuries**	**Non-Injury Accidents**	**TOTAL ACCIDENTS**
WTP: Loss of life/permanent disability	$1,712,002	$1,988,227	$676,055	$ -	**$4,376,284** (77.5%)
Loss of output (temporary disability)	$-	$6,149	$11,205	$ -	**$17,354** (0.3%)
Medical Costs	$2,647	$68,075	$33,616	$ -	**$104,338** (1.8%)
Legal and court	$7,979	$12,297	$33,616	$ -	**$53,892** (1.0%)
Vehicle damage	$2,496	$22,838	$194,226	$873,414	**$1,092,973** (19.4%)
Total (motor vehicle accidents)	**$1,725,124**	**$2,097,586**	**$948,718**	**$873,414**	**$5,644,841**
Proportion of total costs	*(30.6%)*	*(37.2%)*	*(16.8%)*	*(15.5%)*	

As discussed elsewhere, the WTP to avoid loss of life or permanent disability comprises by far the bulk of the costs, although that becomes less so for more minor accidents – and non-injury accidents are deemed (by definition) to only have vehicle damage costs, although there may also be a small legal/court cost as well.

Figure 6 shows the breakdown of these costs by percentage. Other than loss of life or permanent disability, most costs are very small (<2%), particularly if non-injury accidents were ignored. It is interesting to note though that, due to the sheer number of non-injury accidents (~250,000 a year) the cost component for vehicle damage is relatively large overall at over 19%.

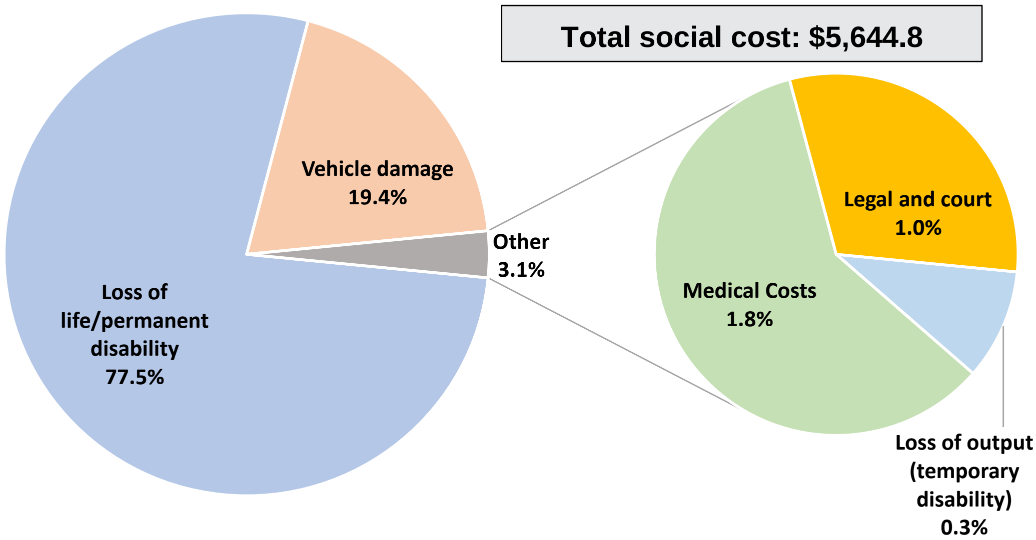

Figure 6 Breakdown of annual cost components for motor vehicle accidents (by percentage)

Table 16 summarises the breakdown of annual accidents not involving motor vehicles (from Table 14) by MoT cost components.

Table 16 Breakdown of annual cost components for non-motor vehicle accidents ($'000s per year)

Ave. number of casualties / year	1	183	36,307	1,794	38,286
Cost Component	**Fatal Injuries**	**Serious Injuries**	**Minor Injuries**	**Non-Injury Accidents**	**TOTAL ACCIDENTS**
WTP: Loss of life/permanent disability	$6,036	$83,040	$657,156	$ -	**$746,232** (89.9%)
Loss of output (temporary disability)	$ -	$257	$10,892	$ -	**$11,149** (1.3%)
Medical Costs	$9	$2,843	$32,676	$ -	**$35,529** (4.3%)
Legal and court	$28	$514	$32,676	$ -	**$33,218** (4.0%)
Vehicle damage	$ -	$18	$3,631	$179	**$3,829** (0.5%)
Total (non-motor vehicle accidents)	**$6,074**	**$86,672**	**$737,031**	**$179**	**$829,957**
Proportion of total costs	*(0.7%)*	*(10.4%)*	*(88.8%)*	*(0.0%)*	

This time the vehicle costs are much smaller, reflecting the high proportion of pedestrian injuries in this group, and the relatively low cost of any damage to bicycles, scooters, etc. This is also reflected in the breakdown of these costs by percentage, shown in Figure 7. The costs of loss of life or permanent disability are now ~90% of the total costs, with the other components all contributing <5% each to the total cost.

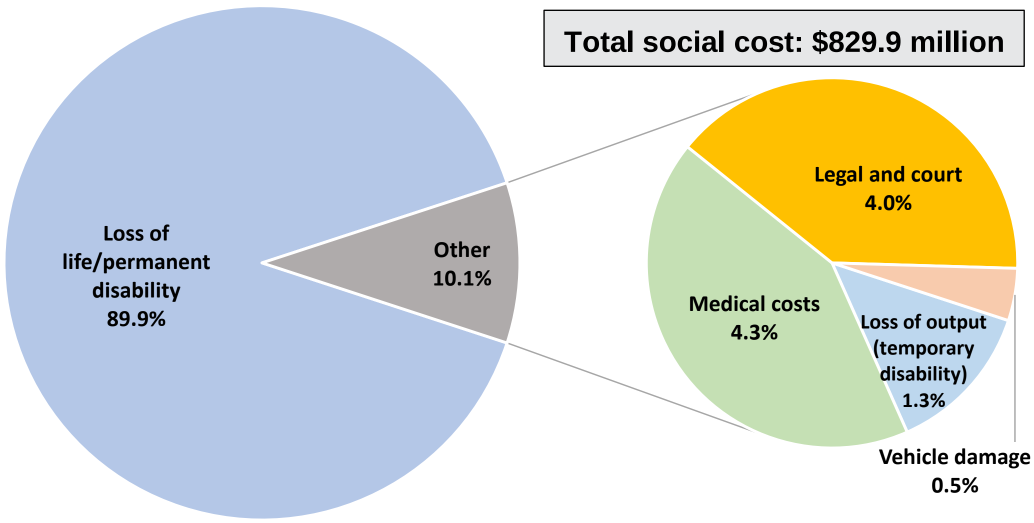

Figure 7 Breakdown of annual cost components for non-motor vehicle accidents (by percentage)

These analyses have implications when considering the relative role of different cost components and who pays for them. In practice, the WTP to avoid loss of life or permanent disability far exceeds any other costs of an accident (especially when considering injury accidents only), so the other components warrant fairly minor consideration.

6.2 Discussion of external and internal costs of transport accidents

Chapter 2.2 included an indicative diagram of flow relationships for costs and charges relating to private motor vehicle use in New Zealand (Figure 3); it attempted to identify how private motor vehicle users and other parties contribute to and benefit from the various costs associated with road accidents.

It should be noted that some of these costs and charges are essentially "internalised" by the road user (i.e. they or their families have to "pay" for them directly, either in costs and charges or through pain and suffering, which may affect their safety behaviour) while others are external to the road user and are typically borne by other parties or society in general (e.g. through general taxation). Other references, such as NZIER (2009), CE Delft (2019) and Sansom *et al* (2001) discuss these concepts in more detail.

A fuller discussion of the various costs and charges associated with road accidents is given in Appendix 8, including a consideration of their relative economic scale (where easily measurable) and inherent internal or external nature.

Taking this discussion into consideration, a breakdown can be identified of the various accident cost components aligned with the discussion in Chapter 6.1. Table 17 provides this summary; for simplicity, the focus here will be on costs associated with motor vehicle accidents, although the principles should broadly be the same for non-motor vehicle accidents. Note that some items may contribute to multiple cost components.

Table 17 Annual costs and charges associated with components for motor vehicle accidents

Cost Component	Estimated social cost (see Table 15)	Internal/ External Cost?	Main cost categories	Principal funding sources
WTP to avoid loss of life/permanent disability	$4,376 million (77.5%)	Mostly Internal *(see discussion below)*	• Intangible losses: Pain, grief, suffering (largely unfunded) • Healthcare treatment ($570 m - part) • Workplace costs	• Life insurance ($140m) • ACC levies ($450 m - part) • Personal costs • Administration costs • Public taxes
Loss of output (temporary disability)	$17 million (0.3%)	External	• Healthcare treatment ($570 m - part) • Workplace costs	• ACC levies ($450 m - part) • Health insurance (part) • Sick leave / lost productivity
Medical Costs	$104 million (1.8%)	Mostly External	• Healthcare treatment ($570 m - part)	• ACC levies ($450 m - part) • Health insurance (part) • Personal costs • Public taxes
Legal and court	$54 million (1.0%)	Mostly Internal	• Judicial and legal services	• Personal costs • Administration costs • Public taxes
Vehicle damage	$1,093 million (19.4%)	Internal	• Vehicle damage repairs	• Vehicle insurance ($2100m) • Personal costs
Total (motor vehicle accidents)	**$5,645 million**	**~80-90% Internal**		

As WTP to avoid loss of life or permanent disability is largely considered an internal cost to individual users and their close family and friends (with the possible exception of some ACC pay-outs and WINZ benefits for permanent disability), by far the largest proportion of accident costs in New Zealand are considered to be internal costs (related to pain, grief and suffering by victims, family and friends). This would suggest that road users are reasonably well motivated to behave in a manner that doesn't cause accidents and their resulting costs and trauma.

While it can be argued that external parties may be innocently involved in an accident caused by a road user, the proportion of the main WTP component that is internal is still in the majority due to:

- Approximately two-thirds of the social costs of accidents occur on rural roads where over half of all reported accidents involve only a single vehicle
- The under-reporting rates for single-vehicle accidents are greater than those for multi-vehicle ones, further increasing the total costs for sole parties involved in accidents.
- Where a "vulnerable" road user, such as a pedestrian, cyclist or motorcyclist is culpable in an accident with a motor vehicle then, due to the relative size of each user, the other party is likely to receive minimal injuries or vehicle damage.

An interesting observation is the fact that the estimated social costs of medical treatment and temporary disability (based on the current VOSL calculations) are considerably less than the estimated amounts paid out for healthcare treatment. However, it is unclear how much the cost of permanent disability (and its resulting ongoing healthcare treatment) contributes to the first cost component. Nevertheless, it may be worth reviewing the actual current social costs of medical and disability treatment.

Similarly, the above data appears to suggest that the cost of vehicle insurance is double the estimated social cost of vehicle damage. Notwithstanding some element of profit by insurance companies, again it may be that the current estimates for vehicle damage costs are too low.

PART THREE: MARGINAL COSTS AND CHARGES OF ROAD ACCIDENTS IN NEW ZEALAND

Chapter 7 Methodology for marginal costing

Accident costs typically do not vary in a linear manner with changes in traffic flows; other factors such as vehicle speeds and accident types (due to levels of vehicle interaction) also have a significant effect. Therefore average costs may not necessarily reflect the costs of making any changes to the current traffic patterns. As briefly described in Chapter 3.2, the marginal costs for road accidents represent the extra costs that adding an extra vehicle-km (or deducting a vehicle-km) to the traffic flow pattern brings. The main input values for the assessment of marginal accident costs are the accident risk per vehicle type and road type, the costs per casualty (generally assumed unchanged from average cost calculations) and the “risk elasticity” (the change in accident risk relative to change in traffic flows). Therefore an understanding of appropriate accident prediction models is required first.

The previous 2005 study (Booz Allen 2005) assumed a simple linear accident model for marginal costing, which isn’t very realistic over a wide range of values. Some of the risk elasticity values used also don’t seem to reflect the latest evidence from accident prediction models. Therefore, a somewhat novel approach has been undertaken here to estimating suitable marginal costs for this study.

7.1 Introduction to accident models

Generalised accident prediction models have been used to determine the additional cost of adding one vehicle-km travelled (per year) to the network, in terms of the likely accident implications.

For travel on the road network, the accident prediction models have been taken from the *Crash Estimation Compendium: New Zealand crash risk factors guideline* (NZTA, 2018), with some additional guidance from earlier related research (Turner 2001, Turner *et al* 2006, Turner *et al* 2012). The compendium provides five model types, summarised below in Table 18.

Table 18 Accident model types from crash estimation compendium (NZTA, 2018)

Model type	Applications
Rural Roads (2 and 3-lane mid-block sections) ≥80km/h	• Rural two-lane roads (by ONRC and terrain type) • Two-lane roads with passing lanes • Rural isolated curves* • Single lane rural bridges* • Two-lane rural bridges*
Multi-lane High Speed Roads	• Motorways • Four lane divided rural roads (expressways – with either wide grass medians or physical median barriers)
Urban Roads (Mid-block) 50-70km/h	• Urban mid-blocks (by road hierarchy) • Urban Arterials with ≥ 6 lanes (total)
Product of Flow Models – Intersections	• General urban cross and T-junction intersection 50-70km/h • General urban roundabouts 50-70km/h • General high-speed roundabout ≥ 80km/h on one approach • Urban and Rural railway crossings
Conflicting Flow Models – Intersections	• Urban signalised crossroads <80km/h • Urban roundabouts <80km/h • High-speed priority crossroads >70km/h • High-speed priority T-junctions >70km/h

** These are considered to comprise a low proportion of the total road network, thus roads with these features have been classified according to the main rural road mid-block model.*

The models utilise the following key parameters (not all are relevant to each model):

- Road Chapter Length
- Traffic volume (AADT)
- One Network Road Classification (ONRC) class
- Horizontal alignment (i.e. degree of curvature)
- Adjacent land use
- Cross-Chapter dimensions

Although some accident prediction models focus on estimating certain types of accidents or accident movements, generally for this exercise we have considered “all accident” models only for simplicity.

7.2 General theoretical approach

Typically, most accident prediction models used assume a key relationship between traffic “exposure” (i.e. the amount of relevant at-risk traffic present) and the resulting number of accidents (or related metrics, such as number of casualties or total accident costs) (Elvik *et al* 2009). The basic form of these models tends to be:

$$\{Accident\ metric\} = b_0 \times \{VKT\}^{b1}$$

where *{VKT}* is the total vehicle-kilometres travelled by the ‘exposed’ (at-risk) traffic, and b_0 and b_1 are coefficients to be determined[8]. Models for two conflicting flows (e.g. at

[8] Many accident prediction models developed are presented as a confidence interval of possible values, reflecting the inherent random nature of accident occurrence. For this exercise we will simply assume a “most likely” value.

intersections) often feature two separate VKT values for each flow[9], each with a different exponent coefficient, multiplied together. More complex models also apply additional "modification factors" (usually multiplicative) to account for the effect of various road attributes present at the site(s) of interest. For this exercise, due to the global nature of the calculations (i.e. all accident costs in New Zealand), it will be assumed that b_0 and b_1 capture the overall nature of the model with sufficient precision; the potential inaccuracies in this approach are also mitigated somewhat by introducing different model parameters for different road situations, as discussed later.

Accident prediction models are generally used to estimate the number of accidents (or a subset, like injury accidents). For this exercise we are interested in the overall accident costs. While in principle we can simply use an adjusted b_0 coefficient to calculate total costs instead of total accidents, consideration has to be given to the variation in average costs per accident in three key dimensions:

- Higher ***speeds*** are typically associated with more serious injuries (and a greater likelihood of deaths); therefore separate models with different coefficients will be needed for rural or motorway accidents compared with urban accidents.
- ***Intersections*** involve typically different accident types than mid-block sections, again with different likelihoods of death and serious injury. Therefore, separate models with different coefficients will be needed for intersection accidents compared with mid-block accidents.
- In ***congested*** situations (e.g. 'rush' hour), traffic speeds are typically slower than at uncongested times (e.g. middle of the night), reducing the average accident severity. Therefore some means of accounting for the speed/severity reduction effect with increasing VKT needs to be determined (in practice this is only likely to be a major issue for urban roads and motorways).

The coefficient b_0 determines the relative "scale" of each model, i.e. doubling b_0 will result in a doubling of the accident metric being investigated. The coefficient b_1 determines the relative "shape" of the accident relationship in the model. A b_1 coefficient less than 1 implies a decreasing or logarithmic (but still ever-increasing if greater than 0) function where, for example, a doubling of VKT results in an accident metric increase that is less than double. A b_1 coefficient of exactly 1 implies a constant linear relationship (i.e. a doubling of VKT produces a doubling in the accident metric). Finally, a b_1 coefficient greater than 1 implies an increasing or exponential relationship where a doubling of VKT results in more than a doubling of the accident metric. All three types of relationships have been found in accident models to date (see NZTA 2021), typically depending on the nature of the accidents being investigated[10]. For example, accidents from greater interactions between motor vehicles (such as overtaking accidents) often increase exponentially as the total traffic volumes increase. Figure 1 illustrates the different types of relationships when comparing total accidents costs against changes in VKT.

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[9] Strictly speaking, unlike mid-block accident models, most intersection models don't account for road length and are typically based on traffic volume metrics only, like AADT. However, for the purposes of this exercise we can assume that the b_0 coefficient provides a scalar to account for this and thus use *{VKT}* as a proxy for AADT.

[10] Note that, because our models are looking at accident costs rather than actual accident or casualty numbers, it could still be possible for additional external effects such as the interaction of traffic speeds and volumes to create negative slopes if, as VKT increased, the rate of decrease in average cost per accident exceeded the average rate of increase in accident numbers.

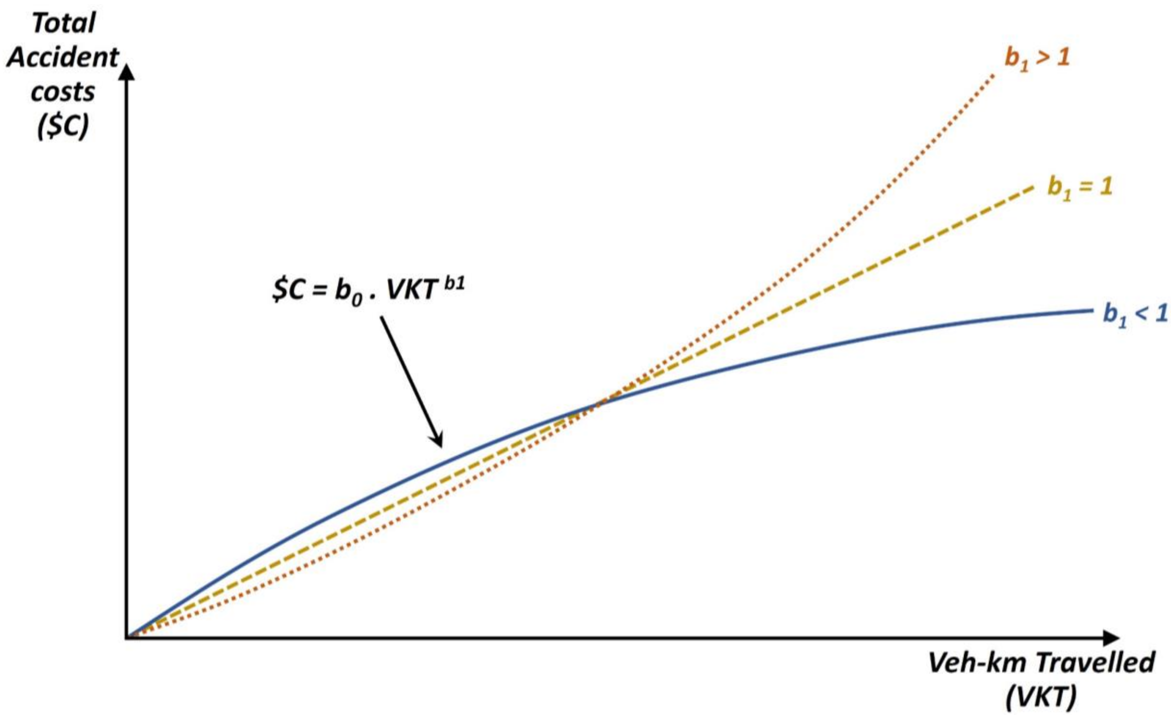

Figure 1 Different types of accident model relationships

7.2.1 Accident model relationships with traffic volume

Three different types of road environment contribute to New Zealand's road accidents:

- Accidents on urban streets (speed limit of 70 km/h and less)
- Accidents on rural roads (speed limit of 80 km/h and more)
- Accidents on limited-access motorways and expressways

Within urban and rural environments, accidents can be further split into those occurring at intersections and those occurring at mid-block sections (it is assumed that all motorway accidents are mid-block, with no at-grade intersections present). Therefore, the total motor vehicle accident costs for New Zealand can be represented by five sub-models.

Pedestrian and cycle accidents do not have the same level of data breakdown available (e.g. urban vs rural VKT). Some available research (e.g. Turner *et al* 2006) would suggest that their accident rate is also more dependent on the change in conflicting motor vehicle volumes than those of the active mode itself; therefore, a model featuring both modal VKT values (with a form somewhat like an intersection model) could be of value. For simplification at this stage, a single-factor model simply based on the active mode VKT will be used for this exercise.

For each of the road environments discussed above, previous work in this working paper has identified the total accident costs and the total VKT for that environment; the data inputs for this part of the study are elaborated on in Chapter 7.4. Within that cost, there is a component from intersection accidents and a component from mid-block accidents (remembering that motorways will only have a mid-block component). Because of the practical difficulties of splitting out VKT between accident types (because all traffic will go through both mid-block and intersection parts of the network), it is assumed that the same total VKT applies to both accident sub-models. Each component may have a different form of accident cost model, of the types discussed above, but collectively they will produce a combined "cost vs VKT" relationship. The slope of this relationship at the current VKT level (representing the marginal cost) may differ from the average accident cost presented earlier. Figure 2 illustrates these concepts.

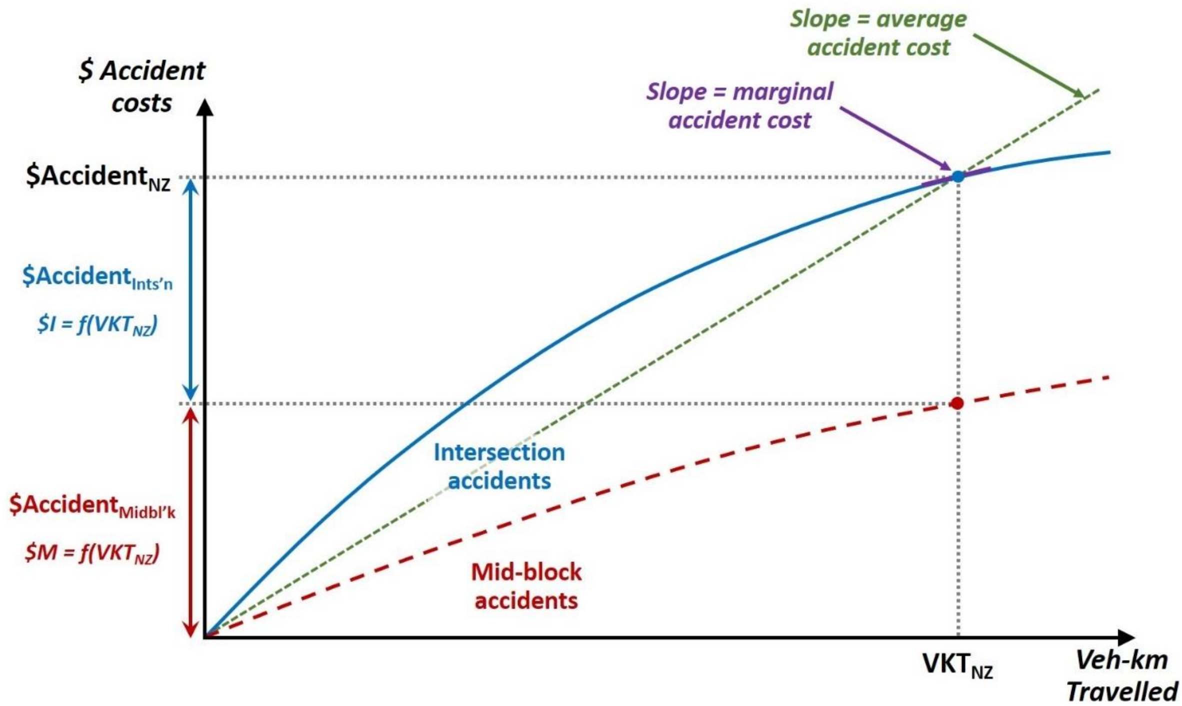

Figure 2 Combined intersection and mid-block accident costs

The challenge now is to determine the appropriate form of each sub-model to apply to each component. Based on review of the accident modelling literature (particularly from NZTA 2018, Turner 2001, and Turner *et al* 2006), an appropriate "shape" coefficient b_1 will be assumed for each sub-model. Given the known values for the relevant VKT and accident costs, then the model can be solved for an appropriate "scale" coefficient b_0.

In the case of a mid-block model (with a total accident cost of $M):

$$\$M = b_{0m} \times \{VKT\}^{b1m} \quad \rightarrow \quad b_{0m} = \$M / \{VKT\}^{b1m}$$

An intersection model requires a bit more thought, as VKT needs to be assigned to various conflicting legs. Any calculation may also need to reflect relative intersection density in different road environments (see Chapter 7.4.5). A proposed form of accident model for this (with a total accident cost of $I) is:

$$\$I = b_{0i} \times (I_1 \times \{VKT\})^{b1i} \times (I_2 \times \{VKT\})^{b2i}$$

where

I_1, I_2 represent the relative proportions of traffic found on the two conflicting intersection legs

Typically, an intersection will feature a junction of two roads with unequal traffic volumes. If it is assumed that the first component of the model represents the "major" intersection leg and the second component the "minor" leg, then I_1 would be expected to range between 0.5-0.9 and I_2 between 0.1-0.5. Again, from a review of the accident modelling literature, appropriate "shape" coefficients b_1 & b_2 can be assumed for each sub-model. By estimating average values for I_1 and I_2 then, given the known values for the relevant VKT and accident costs, the model can be solved for an appropriate “scale” coefficient b_0:

$$b_{0i} = \$I \,/\, I_1^{\,b1i} \times I_2^{\,b2i} \times \{VKT\}^{b1i+b2i}$$

The marginal cost at the current *{VKT}* is the slope of the combined relationship for *$M* + *$I*, which is determined by differentiating the above models with respect to *{VKT}*; in other words:

$$\{Marginal\ cost\} = [\, \delta\ \$M \,/\, \delta\ \{VKT\}] + [\, \delta\ \$I \,/\, \delta\ \{VKT\}]$$

$$= [b_{0m} \times b_{1m} \times \{VKT\}^{b1m-1}] + [b_{0i} \times I_1^{\,b1i} \times I_2^{\,b2i} \times (b_{1i} + b_{2i}) \times \{VKT\}^{b1i+b2i-1}]$$

Based on the above discussion, and a review of the various traffic models described in Chapter 7.1, the following coefficients are proposed for these models (b_0 values to be determined):

Table 19 Assumed accident model coefficients

Sub-model	b_1	I_1	b_2	I_2
Urban mid-block	1.0			
Urban intersection	0.5	0.7	0.3	0.3
Rural mid-block	0.8			
Rural intersection	0.5	0.8	0.3	0.2
Motorway mid-block	1.4			
Cycle all	0.2		0.5*	
Pedestrian all	0.4		0.6*	

*Inclusion of motor vehicle VKT is not being considered in these models presented. If they were, it is likely that these values would be the best estimate of the accident model coefficients.

Note that the above coefficients were determined by inspecting a selection of relevant studies for each model type and assessing appropriate ‘best estimate’ values. These coefficients could be adjusted in the final model to test other values; however, it is likely that they would need to vary greatly to get a big difference in the resulting marginal costs.

7.2.2 Effect of congestion on marginal costs

As mentioned earlier, for more congested urban and motorway environments, an increase in VKT is likely to lead to slower average traffic speeds, which may lead to decreasing accident costs (or increasing at a lesser rate) due to lower average costs per accident. Figure 3 illustrates the typical traffic speed-volume relationship[11]. It can be seen that in low-volume, uncongested situations, average travel speeds are hardly affected by marginal changes in traffic. However, as volumes approach the maximum capacity for a road, speeds fall dramatically.

[11] Strictly speaking, as traffic volumes approach maximum capacity (gridlock), the reduced throughput reduces back to zero, as fewer vehicles are able to make their way through.

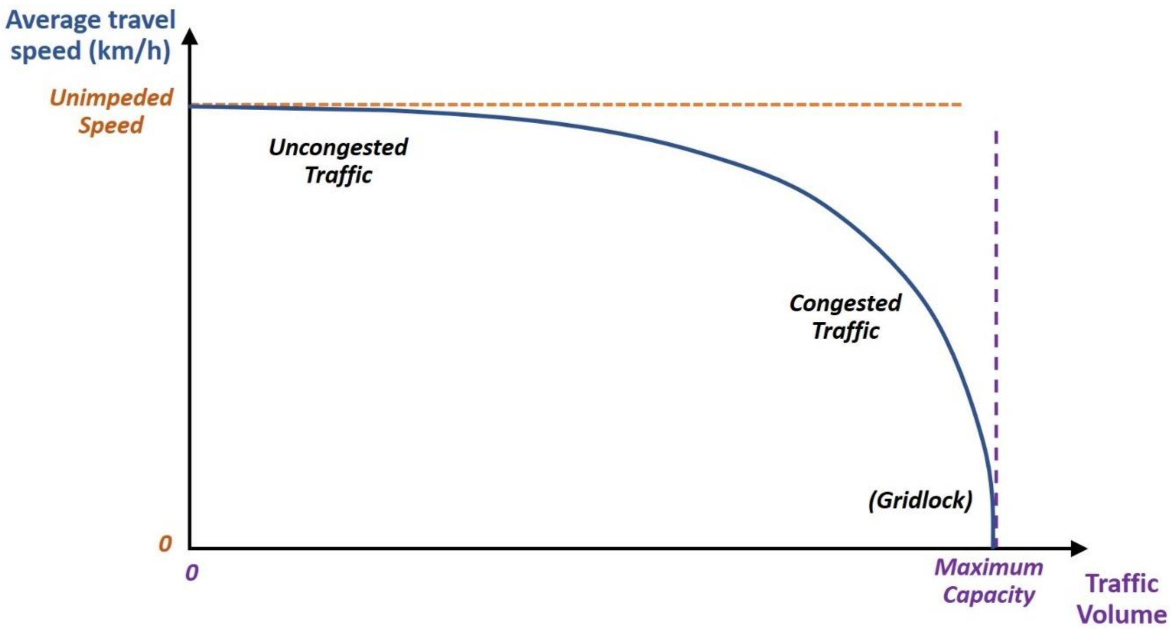

Figure 3 Effect of traffic volume on travel speeds

Average travel speed is also an important input into the relative severity of any accidents that occur. Figure 4 illustrates indicatively the approximate relationship between average travel speed and the proportions of accidents with different severity. It can be seen that at very high travel speeds (well above current maximum speed limits) virtually all accidents would be fatal. As travel speeds fall, fatal accidents become less and less prevalent as, in turn, serious, minor and non-injury accidents become the majority instead. At very low travel speeds, virtually all accidents become non-injury in nature.

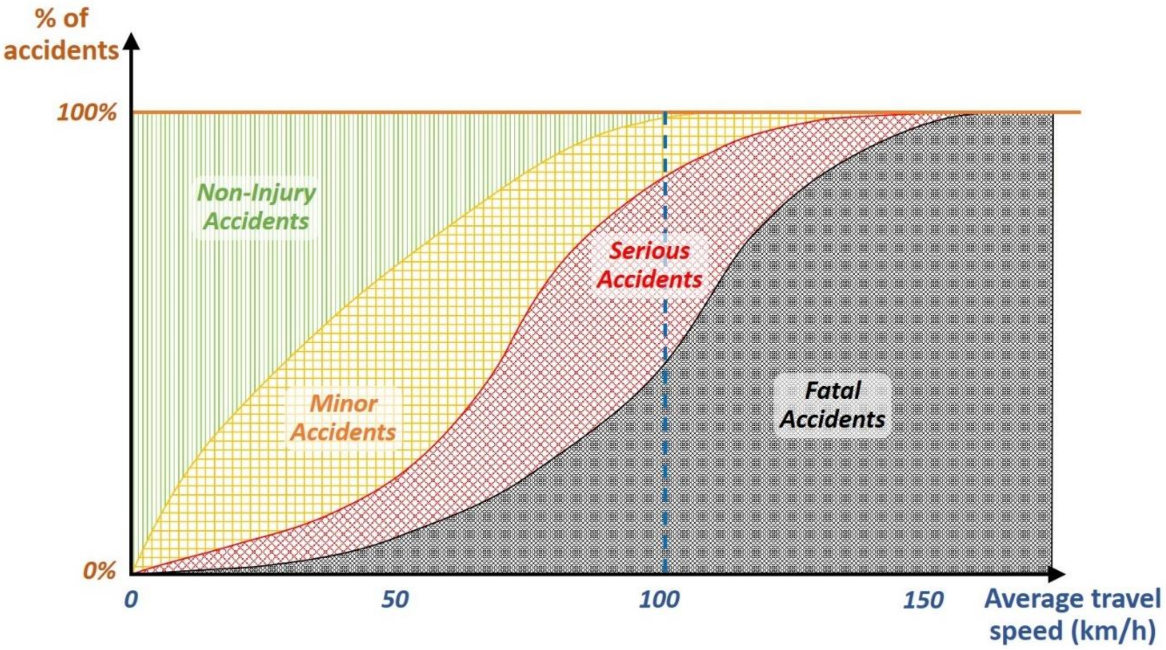

Figure 4 Breakdown of accident severity vs travel speed

The above relationships result in changes to the average accident cost as travel speeds change, as shown in Figure 5. At extremely high travel speeds, the average cost approaches that of a fatal accident. As travel speeds reduce, the average accident cost also reduces and ultimately would approach that of a non-injury accident. While the overall relationship follows a logistic S-curve, for the Chapter within legal speed limits an exponential relationship is a suitable approximation.

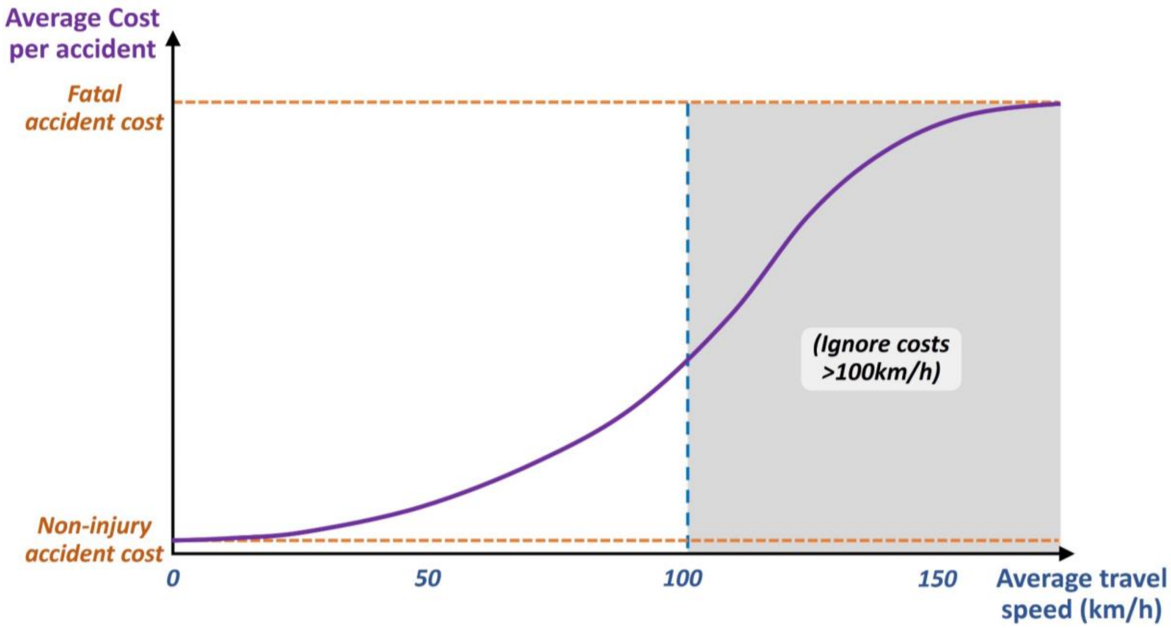

Figure 5 Average accident cost vs travel speed

From the above theoretical background, it can be seen that in a congested situation the average cost per accident could fall quite sharply and possibly at a greater rate than any overall increase in accident costs due to traffic, thus even leading to a negative marginal accident rate. The aim is to determine the relative rates of change, so as to establish appropriate marginal cost functions.

7.2.3 Calculation of marginal costs

We have followed the previous 2005 NZ costs and charges study (Booz Allen Hamilton 2005), which derived an expression for marginal costs (**MC**) in relation to average accident costs (**AC**) as follows:

Accident costs I are a function of speed (**S**) and traffic volume (**V**):

C = ***C (S,V)***, where ***S*** = ***S (V)***.

Marginal cost: $$MC = \frac{dC}{dV} = \frac{\partial C}{\partial V} + \frac{\partial C}{\partial S} \bullet \frac{dS}{dV}$$

Average cost: ***AC*** = ***C/V***

Hence **MC/AC** $$= \frac{\partial C}{\partial V} \bullet \frac{V}{C} + \left(\frac{\partial C}{\partial S} \bullet \frac{S}{C}\right) \bullet \left(\frac{dS}{dV} \bullet \frac{V}{S}\right)$$

$$= e_{cv} + e_{cs} \cdot e_{sv} \quad \text{(A)}$$

where e_{cv} etc are relevant elasticities, described further below.

In free-flow (uncongested) conditions, e_{sv} = 0 and hence **MC/AC** = e_{cv}.

This represents the Vickrey elasticity factor (from Vickrey 1968).

Traffic volume effect (e_{cv})

e_{cv} represents the elasticity of accident costs with traffic volume (all other factors being equal), i.e. the Vickrey factor. Evidence on this point is presented in Chapter 7.2.1, and varies for different road environments and road user groups between 0.2 and 1.4. For comparison, the 2005 study suggested values quoted in the available literature in the range 0.5 to 1.5, with a value of 1.25 adopted for all situations. Where speed effects of changes in traffic volume are not significant, (i.e. free-flow conditions) these values (b_1 in Table 19 or, where relevant, the average of b_1 and b_2 weighted by l_1 and l_2) would be the final coefficient used.

Traffic speed effects (e_{cs})

Where speed effects are significant (non-free-flow), the second term in equation (A) is also relevant. e_{cs} represents the effects of speed on accident costs (all other factors being equal), which itself may be broken into two components:

- Effect of speed on accident rate: Elvik (2009) is the most comprehensive recent analysis on this and indicates typical elasticity values for non-injury and injury accidents of 0.8-1.2 for urban roads (assume 1.0 average) and 1.5-1.6 for rural roads and motorways (assume 1.55 average). For example, a 1% increase in traffic speeds on urban roads corresponds to a 0.8-1.2% increase in accident numbers, etc.
- Effect of speed on average unit accident costs: A review of the average accident costs used for economic evaluation in NZ (NZTA 2021) suggests typical elasticity values in the range of 1.0 (intersections) to 1.4 (mid-block) for urban (≤70km/h) roads and 1.7 (mid-block) to 0.8 (intersection) for rural roads and motorways. For example, a 1% increase in traffic speeds on urban mid-block sections corresponds to a 1.4% increase in unit accident costs, etc.

These two effects are summed to give an average elasticity e_{cs} for each road environment scenario. For example, urban mid-block roads have an e_{cs} factor of 1.0 + 1.4 = 2.4.

Speed volume effects (e_{sv})

e_{sv} represents the effects of traffic volume on speed in urban or motorway (non-free-flow) conditions. Typical figures from previous studies indicate that, for congested NZ urban areas, typical speed-volume elasticities are around –1.0, i.e. for every 1% increase in VKT the average travel speed decreases by 1.0%. As mentioned earlier, in free-flow (uncongested) conditions, e_{sv} is assumed to be 0.

Note that it is reasonable to argue that the factor e_{sv} should be applied to all motorised traffic in congested urban or motorway situations, but not to non-motorised modes (pedestrians, cyclists, etc), for which speeds are not directly affected by the level of congestion. It is also assumed that most rural situations are not greatly affected by congestion.

7.3 Marginal cost coefficients

Given the above, we can derive values of **MC/AC** for both uncongested and congested situations, as follows:

e.g. Free-flow conditions (rural, mid-block):

$$MC/AC = e_{cv} + e_{cs} \,.\, e_{sv}$$
$$= 0.8 + (3.25)(0) = 0.8$$

Peak congested conditions (urban, intersection):

$$MC/AC = e_{cv} + e_{cs} \,.\, e_{sv}$$
$$= [(0.5)(0.7)+(0.3)(0.3)] + [(2.0)\ (-1.0)]$$
$$= [0.44] + [-2.0]$$
$$= \mathbf{-1.56}$$

The complete list of marginal cost coefficients calculations can be seen in Table 20.

Table 20 Calculated marginal cost coefficients

Sub-model	e_{cv}	e_{cs}	e_{sv} (congested)	MC/AC (uncongested)	MC/AC (congested)
Urban mid-block	1.0	1.0 + 1.4 = 2.4	-1.0	1.00	-1.40
Urban intersection	0.44	1.0 + 1.0 = 2.0	-1.0	0.44	-1.56
Rural mid-block	0.8	1.55 + 1.7 = 3.25	0	0.80	N/A
Rural intersection	0.46	1.55 + 0.8 = 2.35	0	0.46	N/A
Motorway mid-block	1.4	1.55 + 1.7 = 3.25	-1.0	1.40	-1.85
Cycle all	0.2	-	0	0.20	N/A
Pedestrian all	0.4	-	0	0.40	N/A

These coefficients can be applied to the known current VKT values and accident costs for each situation to determine the marginal cost rates. This process is described in Chapter 7.5.

7.4 Data inputs

7.4.1 Accident costs

The accident costs developed in PART TWO of this working paper were used, but with a slightly different method of aggregation applied, to correspond to the accident sub-models presented in Table 21. The process used was:

- Any accidents involving pedestrians or cyclists were removed from the dataset.
- The original CAS distinction between urban and rural (i.e. speed limits of 70 km/h and less vs 80 km/h and more) was used (as opposed to the urban / open reclassification applied in Chapter 4.1 to correspond to the NZTA definitions)
- The CAS field for road category was used to identify accidents occurring on motorways
- The CAS field for intersection was used to distinguish between intersections and mid-blocks, but with an adjustment applied to classify accidents with intersection = 1 but junction = N (“nil”) as being at mid-block locations.

Thus, the accident costs applied in the motor vehicle accident models were:

Table 21 Motor vehicle accident model costs

	Open ($m)	Urban ($m)	Total ($m)
Mid-block	$ 7,914	$ 2,982	$ 10,896
Intersection	$ 1,498	$ 2,132	$ 3,631
Motorway (mid-block)[12]	$ 404	$ 10	$ 414
Total	**$ 9,817**	**$ 5,124**	**$ 14,941**

The pedestrian and cycle accident costs were taken from those involving motor vehicles and those not involving motor vehicles (refer to PART TWO:

Table 22 Pedestrian and cycle accident model costs

	Involving a motor vehicle ($m)	No motor vehicle involved ($m)	Total ($m)
Bicycle	$ 111	$ 15	$ 126
Pedestrian	$ 219	$ 815	$ 1,034
Total	**$ 329**	**$ 830**	**$ 1,159**

For the marginal cost analysis of pedestrian accidents, separate calculations will be made for accidents involving a motor vehicle or not.

7.4.2 Congestion effects

Table 23 includes the annual costs of accidents of various severities occurring in congested versus non-congested situations, as presented in Chapter 4.2.1, plus the number of accidents in each category.

Table 23 Average annual number of road accidents by severity, road environment and assumed congestion

Accident severity	Open	Urban		Motorway	
	Not congested	Congested	Not congested	Congested	Not congested
Fatal	223	13	78	0	4
Serious	1,003	236	920	1	54
Minor	2,898	1,228	4,176	1	482
Non-injury	7,159	3,824	14,466	11	1,685
Total	**11,282**	**5,300**	**19,639**	**12**	**2,225**

These accident numbers can be converted into the equivalent costs of accidents (based on the social costs calculated in Appendix 3), as shown in Table 24.

[12] Motorways generally have “open road” speed limits. However a small number of motorway accidents occurred on on/off-ramps with lower speed limits; hence the small cost attributed to “urban” motorway accidents. In practice, all motorway accident costs will simply be aggregated together.

Table 24 Average annual cost of road accidents by severity, road environment and assumed congestion

Accident severity	Open ($m)	Urban ($m)		Motorway ($m)	
	Not congested	Congested	Not congested	Congested	Not congested
Fatal	$1,259	$58	$387	$0	$21
Serious	$1,135	$178	$728	$0.6	$56
Minor	$443	$107	$372	$0.06	$29
Non-injury	$424	$86	$326	$0.2	$38

As already noted, the severity of accidents occurring in congested conditions is, on average, less than the severity of accidents occurring in non-congested conditions; this is due to the higher travel speeds possible when there is no congestion. Table 25 shows the average cost per accident under congested versus non-congested conditions, for the three main road environments:

Table 25 Average cost per road accident by road environment and assumed congestion

	Open ($000)	Urban ($000)		Motorway ($000)	
	Not congested	Congested	Not congested	Congested	Not congested
Cost per accident	$289	$81	$92	$74	$65

For the urban environment, the cost per accident reduces by about 12% when congestion is a factor. A small proportion of accidents on urban motorway sections were classified as being in congested conditions – these had a higher average cost than the accidents assumed to be in non-congested conditions on motorways, but the difference is probably more due to the specific locations.

7.4.3 Road lengths

A GIS road network analysis was performed to determine the various lengths of NZ road that correspond to the main model categories of urban, rural and motorway.

The primary road network dataset was the national road centreline shapefile provided by the NZ Transport Agency[13]; as well as the spatial mapping of NZ public roads, it contains information regarding surface type and ONRC class. The national road centreline data contains some information on traffic volumes, vehicle-kilometres travelled and carriageway width, but only for approximately 60% of the dataset.

To supplement the national road centreline data, spatial joins were performed using two additional datasets:

- 2018 Urban Rural boundaries shapefile from Statistics New Zealand[14]

[13] https://www.nzta.govt.nz/about-us/open-data/national-road-centreline-data-request

[14] https://datafinder.stats.govt.nz/layer/92218-urban-rural-2018-generalised/

- Road accidents from CAS (see Appendix 3) – which includes a field for speed limit

The additional information from these datasets enabled a more accurate distinction of the accident prediction models relating to the roads in the dataset.

Table 26 summarises the GIS data in terms of the road surface type and the general accident prediction mode to apply, in terms of length of road (in kilometres).

Table 26 Length (km) of NZ roads applying to model and road surface types – GIS data

	Road surface type			
Accident prediction model type	**Sealed**	**Unsealed**	**Unknown**	**Total**
Urban	10 692	362	7 711	18 765
Multi-lane high speed	656	2	22	680
Rural	39 372	25 874	11 478	76 723
Unknown	865	67	831	1763
Total	**51 585**	**26 304**	**20 042**	**97 931**

For comparison, Table 27shows figures from the Ministry of Transport dashboard report RD002:

Table 27 Length (km) of NZ road network – MoT dashboard RD002

Road type	Sealed	Unsealed	Total
Local road	53 261	31 048	84 309
State highway	10 937	32	10 969
Total	**64 198**	**31 080**	**95 278**

The grand total from of 97,931 km in Table 28 accords well with the total of 95,278 from Table 27 – the former is from 2018 whereas the latter is from 2016/17, and the 3% difference between the two may be partly due to more roads being built.

Allocating the “unknown” components in Table 26 according to the known proportions in both Table 25 and Table 26 gives the figures in Table 27:

Table 28 Road lengths (km) to be used in mid-block accident prediction models

	Sealed	Unsealed	Total
Urban	16 077	2 893	18 969
Multi-lane high speed	769	11	780
Rural	48 231	29 950	78 181
Total	**65 077**	**32 854**	**97 931**

7.4.4 VKT data

The accident prediction models use a different categorisation to the VKT data (as supplied by NZTA, see Chapter 3.1) which does not include the high-speed road category, and uses 60 km/h as the upper limit for urban roads. Thus, the rural ("open") category from the NZTA VKT data will contribute to all three of the accident prediction models. Analysis of the national road centreline dataset shows 82% of roads by length have associated VKT data, which is high enough to assume the proportions from the national road centreline dataset can be applied to apportion the rural category from the VKT data. This process, including the breakdown for roads with speed limit greater than or equal to 70 km/h, is illustrated in Figure 6:

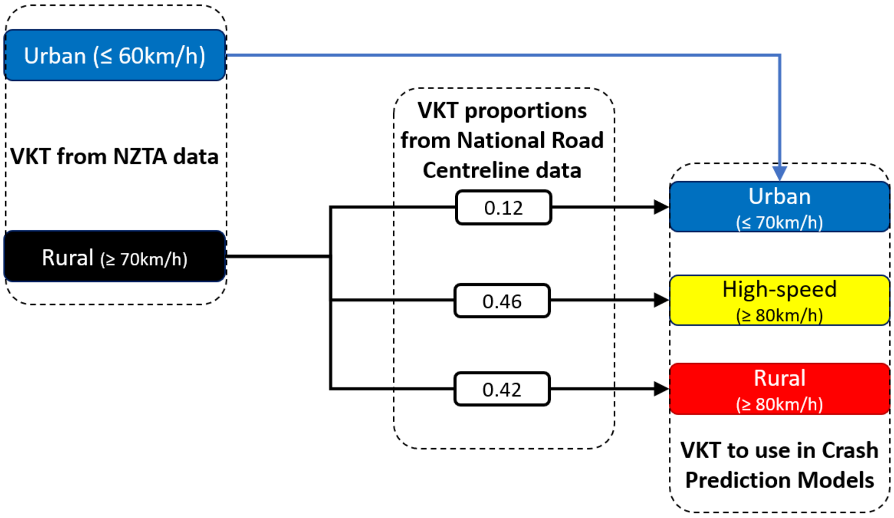

Figure 6 Process of allocating NZTA VKT data to relevant accident prediction models

Thus, the annual VKT data relevant to the accident prediction models are given in Table 29:

Table 29 VKT for accident prediction models

Accident prediction model type	Annual vehicle kilometres travelled (millions)
Urban	22 637
Multi-lane high speed	11 265
Rural	12 335

It was assumed that the VKT would be most appropriate to the mid-block models, and to establish an appropriate flow parameter for the urban and rural intersection models, the corresponding VKT values should be factored according to the intersection densities in these environments.

7.4.6 Intersection density

The road network and intersection dataset from Fowler (2007) was used in conjunction with the 2018 Urban Rural boundaries shapefile from Statistics New Zealand[15] to determine, for each "urban-rural indicator" type the number of intersections and lengths of roads, from which an intersection density in terms of number of intersections per km was established:

Table 30 Intersection density for urban and rural locations

Urban-Rural indicator	Number of intersections	Length of road (km)	Intersections per kilometre of road
Large urban area	10 203	3 375	3.02
Major urban area	28 881	8 841	3.27
Medium urban area	6 491	2 250	2.88
Small urban area	10 530	3 977	2.65
Urban sub-total	**56 105**	**18 444**	**3.04**
Rural other	15 084	57 731	0.26
Rural settlement	4 970	2 766	1.80
Rural sub-total	**20 054**	**60 497**	**0.33**

These findings illustrate that intersection accidents are likely to contribute much more to the overall costs of accidents in urban areas (due to their higher relative frequency), compared with rural areas.

7.5 Marginal cost functions

The above calculations and data sources are used to derive marginal costs for each road environment. For every 1% increase in VKT (of the relevant travel mode), the accident costs will change by **[MC/AC]**%. Therefore, the process is as follows:

Marginal cost = [Total accident costs] × [**MC/AC**] / [Total VKT]

e.g. for Urban mid-block, congested:

Marginal cost = $2,982 million × -1.40 / 22,637 million

= -18.4 c / VKT

In other words, for every unit increase in urban VKT (in congestion at the current VKT levels), the total urban mid-block accident costs will decrease by 18.4 cents.

Table 31 presents the relevant marginal costs for each road environment. Where applicable, both uncongested and congested costs have been shown. The urban and rural cost calculations for mid-block and intersection have also been combined to provide single

[15] https://datafinder.stats.govt.nz/layer/92218-urban-rural-2018-generalised/

marginal costs. Pedestrian marginal costs are presented for all accidents (including those not involving a motor vehicle) and also only for motor vehicle related accidents.

Table 31 Calculated marginal costs

Sub-model	VKT (million km)	Accident costs ($million)	MC/AC *	Marginal costs (c/VKT)	Combined MC (c/VKT) *
Urban mid-block	22 637	$ 2,982	1.00 (U)	13.2	**17.3 (U)**
Urban intersection		$ 2,132	0.44 (U)	4.1	
Urban mid-block	22 637	$ 2,982	-1.40 (C)	-18.4	**-33.1 (C)**
Urban intersection		$ 2,132	-1.56 (C)	-14.7	
Rural mid-block	12 335	$ 7,914	0.80 (U)	51.3	**56.9 (U)**
Rural intersection		$ 1,498	0.46 (U)	5.6	
Motorway mid-block	11 265	$ 414	1.40 (U)	5.1	**5.1 (U)**
			-1.85 (C)	-6.8	**-6.8 (C)**
Cycle all	309	$ 126	0.20 (U)	8.1	
Pedestrian vs MV	705	$ 219	0.40 (U)	12.4	
Pedestrian only	705	$ 815	0.40 (U)	46.2	

* (U) = uncongested (C) = congested

The results illustrate the congestion effects in urban and motorway environments where the relative increase in accident numbers with VKT increase is dampened by the reduced cost per accident due to lower traffic speeds. While the relative contributions of mid-block and intersection accidents are fairly even in congested urban environments, mid-block accidents contribute far more to the rural environment, due to the relative sparsity of intersections (as noted in Chapter 7.4.5).

There is some debate in transport economic literature about the validity of negative marginal costs, e.g. CE Delft (2019) note that *“even though [marginal external accident costs] may occasionally turn negative, this does not mean that marginal accident costs are negative.”* It does require the damping effect of speed reduction from congestion to exceed the rate of increase in accident risk from more vehicles; our analysis suggests that this may be possible in some circumstances (e.g. in congested conditions). It may also be that different road user types may be more likely to experience a negative marginal cost than others; unfortunately the available VKT data limited our ability to explore this further.

Note that the VKT values in for cycle and pedestrian marginal costs refer to an additional veh-km of these modes, e.g. what is the relative marginal cost from an additional kilometre cycled or walked. The findings illustrate the considerable cost imposed on pedestrians from accidents *not* involving motor vehicles (i.e. “slip, trip and fall” accidents); focusing just on those related to motor vehicles reduces the marginal cost rate considerably.

The above analysis does not consider the effect of changing motor vehicle VKT on cycle and pedestrian accidents. As discussed in Chapter 7.2.1, some research would suggest that the accident rates of walking and cycling are more dependent on the change in conflicting motor vehicle volumes than those of the active mode itself. However, due to the large motor vehicle VKT quantities in New Zealand (relative to the amount of walking and cycling VKT), some preliminary analysis suggests that the marginal cost on walking/cycling accidents of increasing motor vehicle VKT by one unit may be less than 1c/VKT.

Ideally, additional analysis would explore the relative marginal costs of accidents for different motor vehicle modes, i.e. car, truck, etc. At this stage, no reliable VKT data breaking these modes down by road environment has been obtained.

PART FOUR: DATA AND RESEARCH RECOMMENDATIONS

Chapter 8 Potential areas for further work

This investigation has updated the previous (2005) study on transport accident costs in two ways:

- By updating key input values such as accident numbers and vehicle travel statistics
- By introducing new accident analysis methods for the costs of non-motorised users, and for marginal cost calculations

There were still several limitations to the available analysis methods and input data, especially within the time and budget constraints of the project; potential further enhancements are discussed below.

8.1 Recommendations on data analyses

In developing some new or updated methods to assess the original project objectives, some issues were identified that warrant further exploration.

8.1.1 Further refinement of non-motorised-user (NMU) only accident costs

The current safety analysis has identified $830 million annually in social costs across NZ for accidents not involving motor vehicles by pedestrians, cyclists, and other wheeled devices (Chapter 5.1). Estimation of this figure was determined by a combination of CAS (Crash Analysis System) data and ACC claims data for these users; however, it involved some extrapolation of values from different ACC claim categories.

More recently, a separate study undertaken by the same researcher for Auckland Transport used Ministry of Health (MoH) hospital data to obtain a more accurate picture of serious injuries suffered by these users on Auckland's transport network (ViaStrada 2021). That analysis indicated that the social cost of these injuries was about $500 million in Auckland alone, suggesting that the national estimate may be conservative.

There would be value in further reviewing the national estimate, using a similar MoH data set used in Auckland for the whole country. The dataset would enable an approximate split of "serious" or "minor" injuries by considering length of hospitalisation. Some further thought could also be given to potential differences in the social cost of these injuries compared with motor vehicle accidents, including possible stratification by age of the victims.

8.1.2 Further review of the average social cost per road accident

As noted in Chapter 2.1, the current Valuation of Statistical Life (VOSL) in NZ is based on a study from over 30 years ago, with subsequent adjustments each year for cost-of-living increases. Some studies have reviewed it more recently (e.g. MOT 2009, Clough *et al* 2015), but local research to determine new values for VOSL is still slow at hand.

While a large focus of this work is looking at the current value for WTP to avoid loss of life or permanent disability, the analysis in Chapter 6.2 suggested that the relatively smaller components for medical costs and vehicle damage may also be under-estimated, based on current pay-out costs. It is suggested therefore that *all* components making up the current VOSL estimates be reviewed. This review should also examine more closely the likely proportion of each cost component that is considered internal or external to road users from an economic perspective.

8.1.3 Further refinement of the marginal cost model for road safety

The current safety analysis has developed an updated method for calculating marginal accident costs, partly based on the previous 2005 valuation approach but also incorporating more recent research regarding accident prediction models and speed/volume/cost relationships (Chapter 7.2).

While the basic approach seems sound, there has been limited opportunity to test it fully to explore the potential implications of some assumptions (especially around the economic theory of marginal costs, such as the validity of negative marginal costs, and the method of splitting intersection and mid-block costs). Ideally some way of further disaggregating the urban/rural/motorway models by vehicle type would be useful too. The models for pedestrian and cycle accident marginal costs are also currently simplified in not considering the impact of additional motor traffic on the network.

It would be preferable to further review the existing marginal cost models, both in terms of the underlying model forms and the input values used. Subject to suitable data, this could also include more refined pedestrian/cycle models, and the ability to split other motor vehicle models by vehicle type. Further feedback from transport economists specialising in this area would also be helpful to inform this review.

8.2 Recommendations on data sources

This exercise has revealed several constraints regarding the availability, coverage, and accuracy of the various data sources.

8.2.2 General

1. Accident data from CAS can be classified according to **urban / rural splits**, but there are limited options to apply such splits to other desired metrics (e.g. kilometres travelled by different modes, people, and cargo).
    a. Furthermore, there is a lack of consistency of the definitions of urban vs rural across different datasets – for example, NZTA's CAS considers a road with speed limit of 70 km/h to be rural, whereas NZTA's VKT measures classify a 70 km/h road as urban. Ideally, the CAS approach should be used, but with a third category distinguishing **motorways and other limited-access high-speed expressways**.
2. **New modes of travel** are becoming popular, and databases should be adapted to include these, in particular:
    - Low-powered electric mobility devices such as e-scooters
    - Unpowered transport devices, including kick scooters and skateboards
    - E-bikes (separate from unpowered bikes)
    - Mobility scooters

- Bike share and scooter share schemes
- Alternatives to taxi services, e.g. Uber

3. Trip-based data (such as the Household Travel Survey and Census) should account for **mode-chaining**, i.e. using multiple modes (e.g. bike – bus – walk) to achieve one trip.
4. Ideally, there should be better integration between different sectors and agencies to achieve **more consistent data formats** and reporting mechanisms to enable better cross-referencing.

8.2.3 CAS

5. CAS is biased in that up to four vehicles involved in an accident can be included and data on their type, role, contributing factors and witness statements given, but **pedestrians are not included** in this. CAS vehicle codes should be converted to user codes to include various types of pedestrians.
6. The new **CAS vehicle usage codes** (which include taxis, types of buses etc) will be helpful going forward, but these have not been (and perhaps, in some cases, cannot be) reliably updated for past records.
7. There are a number of **anomalies in the CAS vehicle codes** where the meaning of a particular code has changed. For example, "K" was previously used to denote a skateboarder but is now used for an unknown vehicle. Similarly, "X" was previously used to denote a taxi, but now represents a 50MAX truck.
8. Unlike other transport data sets, no additional detail is provided in CAS to differentiate the various **types of heavy trucks** (other than 50MAX trucks), such as rigid, B-train, etc. It would be useful for some analyses to have this additional categorisation of truck type involved.
9. CAS requires significant manipulation to relate the **injuries suffered to the specific type of vehicle** (as per the vehicle codes, rather than the simplified user type).
10. The **"role in crash" presented in CAS is flawed** and does not properly relate to the fault of the various parties involved. For example, drivers involved in an accident are always assigned a role of 1, even if they were at no fault.

8.2.4 MoT dashboard

11. The MoT dashboard provides several useful breakdowns, but the **categories presented are not always represented** in each breakdown. For example, the vehicle fleet is given in terms of light passenger, light commercial, motorcycles, buses, and heavy trucks, but metrics such as vehicle-km travelled and occupancy rates are generally only given for light vehicles. Also, some data is provided for urban/rural splits, but this is not broken down by vehicle type.
12. The existing annual MoT summary of social cost of road crashes and injuries in NZ does not consider the **cost of non-motor-vehicle injuries** incurred by pedestrians, cyclists and other non-motorised users due to slips, trips, falls, and collisions with static objects. Given the not-insignificant size of this cost, this data should be added the annual summary.

8.2.5 ACC

13. The ACC motor vehicle account data indicates the mode the claimant was using but is limited in its ability to indicate the **other vehicles / road users involved in an accident** with the claimant.
14. Similarly, the ACC general transport search revealed a high number of injuries caused by transport accidents not involving a motor vehicle, but it was difficult to identify the

claimant's mode of transport and, again, relies on non-mandatory keywords in the claim description to identify other modes.

8.2.6 Rail accidents

15. Although covered elsewhere in the DTCC study, we note that there is no reliable source of data for rail accidents (especially those not involving motor vehicles at level crossings) resulting **only in minor injuries or property damage**; the incident descriptions in KiwiRail's IRIS can sometimes be interpreted to achieve this, but it is understood that IRIS is likely to be updated if the nature of an injury becomes clearer after the event.

8.2.7 Maritime accidents

16. Although covered elsewhere in the DTCC study, we note that the Maritime NZ data was useful but limited in terms of the **cross-over between ports & harbours and the five main maritime traffic sectors**.
17. Some individual ports reported well on their injury rates, others seemed to ignore this or gloss over. It would be useful to have a consistent and transparent reporting mechanism for **accidents occurring at ports**.

Appendix 1 : Bibliography

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Appendix 2 : Listing of DTCC Working Papers

The table below lists the Working Papers prepared as part of the DTCC Study, together with the consultants responsible for their preparation.

Ref	Topic/Working Paper title	Principal Consultants	Affiliation
MODAL TOPICS			
C1.1	Road Infrastructure – Marginal Costs	David Lupton	David Lupton & Associates
C1.2	Road Infrastructure – Total & Average Costs		
C2	Valuation of the Road Network	Richard Paling	Richard Paling Consulting
C3	Road Expenditure & Funding Overview		
C4	Road Vehicle Ownership & Use Charges		
C5	Motor Vehicle Operating Costs		
C6	Long-distance Coaches	David Lupton	David Lupton & Associates
C7	Car Parking	Stuart Donovan	Veitch Lister Consulting
C8	Walking & Cycling		
C9	Taxis & Ride-hailing		
C10	Micro-mobility		
C11.2	Rail Regulation	Murray King	Murray King & Francis Small Consultancy
C11.3	Rail Investment		
C11.4	Rail Funding		
C11.5	Rail Operating Costs		
C11.6	Rail Safety		
C12	Urban Public Transport	Ian Wallis & Adam Lawrence	Ian Wallis Associates
C14	Coastal Shipping	Chris Stone	Rockpoint Corporate Finance
C15	Cook Strait Ferries		
SOCIAL AND ENVIRONMENTAL IMPACT TOPICS			
D1	Costs of Road Transport Accidents	Glen Koorey	ViaStrada
D2	Road Congestion Costs	David Lupton	David Lupton & Associates
D3	Health Impacts of Active Transport	Anja Misdrak & Ed Randal	University of Otago (Wellington)
D4	Air Quality & Greenhouse Gas Emissions	Gerda Kuschel	Emission Impossible
D5	Noise	Michael Smith	Altissimo Consulting
D6	Biodiversity & Biosecurity	Stephen Fuller	Boffa Miskell

Note:

The above listing incorporates a number of variations from the initial listing and scope of the DTCC Working Papers as set out in the DTCC Scoping Report (May 2020).

Appendix 3 : Road accident data sources and preparation

A3.1 MoT social cost of road crashes and injuries 2019 update

Table A3.1 shows the average social cost per injury per component (plus non-injury accidents, which are on a per-accident rather than a per-person rate), with disaggregation of key cost components, used for this analysis. These are based on June 2019 prices published by MoT (2020a) Social costs of road crashes and injuries 2019 update report. The final row in Table A3.1 has been added to calculate the cost of injuries for non-motor vehicle traffic accidents, assuming the only difference is the lack of vehicle damage cost.

Table A3.1 Average social cost per injury by type or non-injury accident, June 2019 prices; based on information from MoT with italicised values added

Cost components	Injury severity			Accident type
	Fatal	Serious	Minor	Non-injury
WTP to avoid loss of life/permanent disability	$4,527,300	$452,700	$18,100	
Loss of output (temporary disability)	$0	$1,400	$300	
Medical –				
Hospital/medical	$3,900	$9,600	$100	
Emergency/pre-hospital	$3,100	$1,200	$700	
Follow-on	$0	$4,700	$100	
Legal and court	$21,100	$2,800	$900	
Vehicle damage	$6,600	$5,200	$5,200	$3,200
Total (including motor vehicle)	**$4,562,000**	**$477,600**	**$25,500**	**$3,200**
Total (non-motor vehicle injury)[16]	$4,555,500	$472,500	$20,300	$100

The MoT costs are based on the Value of Statistical Life (VOSL) as discussed in Chapter 2.1.

A minor limitation of the costs presented in Table A3.1 is that all injuries or property-damage only accidents involving a motor vehicle are costed at the motor vehicle rate, i.e. include property damage to a motor vehicle. However, in the case of an accident involving a pedestrian or cyclist versus a motor vehicle, the pedestrian or cyclist would be more likely to suffer greater injuries than the motor vehicle occupant(s), but the actual level of property ("vehicle" in Table A3.1) damage to a pedestrian or a cyclist would be much lower. As vehicle damage comprises a low proportion of injury costs, this anomaly is assumed to be of insignificant consequence to the overall costs derived.

[16] Costs per injury have been calculated assuming non-motor vehicle users will incur the same costs as motor vehicle users, except for vehicle damage, for which a nominal value of $100 per crash has been applied, to account for damage to bicycles, small-wheeled devices or mobility scooters etc.

A3.2 Crash Analysis System (CAS) – road traffic accidents

A3.2.1 Dataset and key variables

The NZ Transport Agency's Crash Analysis System (CAS) was interrogated for all road accidents occurring in NZ during the calendar years 2016 to 2019 (four years). Three reporting types were employed: coded crash report, English language report, and tabulation of additional data. The reporting types and the key variables they provide for this study are outlined in Table A3.2; further information is available in the Guide for the interpretation of coded crash reports from the crash analysis system (CAS) (NZTA, 2016)[17]:

Table A3.2 Key variables obtained directly from CAS

Report type	Key variables obtained directly from CAS

Coded crash	• Crash ID
	• Crash roads
	• Date, time, day of week
	• Accident movement
	• Vehicle types, directions, and cause codes
	• Road / environment conditions
	• Junction type, traffic control, road markings
	• Speed limit
	• Accident severity (according to the worst outcome suffered by any participant in the accident):
	  ○ Fatal – when death ensues within 30 days of an accident
	  ○ Serious – injuries requiring medical attention or admission to hospital, including fractures, concussion, and severe cuts.
	  ○ Minor – injuries other than serious, which require first aid or cause discomfort or pain, including bruising and sprains.
	  ○ Non-Injury – when no injuries occur, sometimes referred to as "property damage only" (PDO) accidents
	• Numbers of fatalities, serious injuries, minor injuries, non-injured parties
	• Pedestrian and cyclist ages (where applicable)
	• Geographic coordinates, TLA

English language	• Description of events • Description of crash factors
Tabulation	• Urban or open speed zone • Road category • On State Highway • Road user type (motor vehicle driver, motor vehicle passenger, cyclist, pedestrian, skateboarder / in-line skater, wheeled pedestrian, equestrian) • Injury scale (severity of injuries linked to road user type)

Further manipulation of the CAS data was undertaken to provide certain additional categories desired for analysis, and to facilitate alignment with the format of the *Monetised Benefits and Costs Manual* (MBCM[18], NZTA 2021) which provides reporting rates, and the MoT social costs of crashes (Chapter A.1). The key variables derived from further manipulation are outlined in Table A3.3, and, where necessary, further described in the following sub-chapters.

[17] However, as noted in the Appendix, the guide is out of date regarding the vehicle codes used; additional correspondence with CAS administration was required to explain these.

[18] Note that the *Monestised Benefits & Costs Manual* (MBCM) replaced the Transport Agency's previous *Economic Evaluation Manual* (EEM) in 2020 during the preparation of this work.

Table A3.3 Key variables derived from further manipulation

Key variable	Description	See Chapter
Vehicle type adjusted	CAS vehicle code adjusted to include pedestrians where none were recorded for a pedestrian accident. Assigned to the first of the four vehicles that was left blank.	A3.2.2
Urban or open (i.e. rural) speed zone	Reclassified so that roads with a 70 km/h speed limit (or more) are considered "open speed zone".[19]	-
Year	Calendar year, extracted from date data	-
Financial year	Starting from 1 July and denoted by the year in which the period ends, as per convention.	-
MBCM priority vehicle rank	Converting the various CAS vehicle types (with additional interrogation to identify pedestrians) to corresponding MBCM vehicles (users) and denoting the rank of the vehicle of the highest priority as per the MBCM ranking. Some adjustment to account for accidents that were coded as not involving a motor vehicle, but CAS crash reports verified that a motor vehicle was actually present.	A3.2.2
MBCM priority vehicle type	The description of the vehicle (user) type corresponding to the priority ranking.	A3.2.2
MBCM road / speed category	To correspond with reporting rate tables.	A3.2.4
Index road / speed / user	To look up reporting rate tables based on the categories of road type / speed limit, user type, and accident severity.	A3.2.4
Reporting rate	Corresponding to the particular combination of road type / speed limit, user type, and accident severity.	A3.2.4
Cost factored for reporting	Cost of each accident according to MoT costs, factored up to represent underreporting of the accident severity.	A3.2.5
Peak or off-peak	Identifies whether each accident occurred during peak or off-peak period	A3.2.6
Congestion	Identifies whether each accident was likely to be during a time of congestion.	A3.2.6
Train?	Whether or not a train was involved, based on CAS crash code "QC" or vehicle type set as train – such accidents were filtered out of road accident data analysis.	-

[19] This split is to correspond with NZTA's urban / rural classification for VKT; ViaStrada suggests that, ideally, roads with 70 km/h speed limits should be considered "urban". Also, currently motorways will be considered "open"/ "rural" because of their high-speed limits, even if they are located in an urban area. Ideally, motorways should be considered as a third distinct category.

Key variable	Description	See Chapter
Non MV [motor vehicle] verification	Using vehicle codes to identify whether a motor vehicle was coded, then verification by inspecting individual traffic crash reports – to identify accidents that did not involve any motor vehicle (i.e. pedestrian / cyclist only) – eliminated from Chapter 4 and used to inform Section Chapter 5.	-
SH – corrected	Whether or not the accident road is a State Highway, based on whether it is identified as a State Highway in the CAS tabulation or (because the CAS records are not always correct) whether the road name text contained identifiers such as "SH_", "State Highway", beginning with a zero etc.	-
Heavy/Light	Heavy vehicles vs others, to compare with NZTA VKT data	-
Neutral cost veh1	Neutral cost shared (i.e. distributed evenly among vehicles involved for vehicle 1 (corresponding columns for vehicles 2-4)	-
Fault veh1	Fault attributed to vehicle 1 " see "CAS fault factor codes" tab	Appendix 5
Fault veh2	Fault attributed to vehicle 2 " see "CAS fault factor codes" tab. Note fault only attributed to up to 2 vehicles	Appendix 5
Cost caused veh1	Cost caused by Vehicle 1, based on assigned fault	Appendix 5
Cost caused veh2	Cost caused by Vehicle 2, based on assigned fault	Appendix 5

A3.2.2 Correlation of vehicle types between CAS and MBCM

The MBCM is used to interpret / inform some of the CAS data, but the two sources do not use the same vehicle categorisation. Furthermore, the MBCM uses two slightly different categorisations that apply to this project. Table A3.4 shows how the various vehicle categories from CAS and the MBCM have been aligned.

CAS uses a range of vehicle codes and corresponding descriptions, as shown in the first two columns of Table A3.4; note that these were obtained from the CAS administrator as the list of codes given in the *Guide for the interpretation of coded crash reports from the crash analysis system (CAS)* (NZTA, 2016) is incomplete. Since the analysis was undertaken, CAS have published an updated list of vehicle codes online.

The MBCM involves a more aggregated grouping of vehicle types, as shown in the third column of Table A3.4. Note that CAS does not differentiate heavy commercial vehicles in any more detail than "truck" or "truck HPMV" (50MAX vehicles). Where there is more than one vehicle type involved in an accident, the MBCM categorises the accident according to a hierarchy, with pedestrians being the highest ranking the rank is shown in the fourth columns of Table A3.4 (from MBCM Appendix 2 Definitions). Note that a seventh level was used to denote an accident were the CAS vehicle code was blank or unknown (assumed to be a typographic error); this allowed for further checking of the spreadsheet data and functions, and was treated as being in the general "all vehicles" category of the cost tables. This ranking was initially used in the accident analysis, but later replaced by use of the multiple vehicle codes used per accident, to avoid the ambiguities associated in classifying multiple user types according to the highest-ranking type (e.g. if an accident occurs between a car, a truck and a pedestrian, it will be called a "pedestrian accident").

Table A3.4 Cross-referencing CAS and MBCM vehicle (user) types and ranking

CAS vehicle code	CAS vehicle description	MBCM vehicle type	MBCM vehicle ranking
E	Pedestrian	Pedestrian	1
K	Skateboard, in-line skater[20]		
S	Bicycle	Bicycle	2
M	Motorcycle	Motorcycle including moped	3
P	Moped		
B	Bus	Bus	4
L	School bus		
T	Truck	Truck	5
H	Truck HPMV		
C	Car	Cars, light commercial vehicles and any other	6
V	Van		
X	Taxi / taxi van		
4	SUV or 4x4		
R	Train		
O	Other or unknown		
U	Ute		
Y	Uncoupled towed vehicle		
Z	Left the scene		
(Blank) / code unknown			(7)

It was found that, whilst CAS technically considers pedestrians to be a class of vehicle, pedestrians are generally not coded in the vehicle types. Thus, the CAS two-letter movement codes were also checked, with any accident involving a movement codes starting with N or P classified as a pedestrian accident[21]. CAS holds records for up to four vehicles involved in a single accident; where no pedestrian was coded for a pedestrian accident, the code for the first blank vehicle in the list was adjusted to indicate a pedestrian.

[20] As discussed in Appendix, vehicle code K was changed in 2018 to refer to an unknown vehicle, although it seems that records prior to this were not updated according to this new convention.

[21] Note that some crashes have a pedestrian age entered but this pedestrian was not involved in the crash (e.g. a rear-end crash where the lead vehicle stopped to let a pedestrian cross the road) – therefore, the pedestrian age variable was not used to identify pedestrian crashes.

A3.3 Vehicle code K

Further inspection of the CAS data and crash records for accidents where no motor vehicle coded revealed that, from 2018 onwards, the vehicle code "K" (skateboard, in-line skater) was often used incorrectly to denote an unknown vehicle (e.g. where the driver fled the scene, or information on the vehicle type or driver's details was not collected). This was confirmed by a subsequent update of the CAS vehicle codes published online.

556 accidents in the CAS dataset involved at least one K type vehicle – this represented 0.4% of the total accidents, but 10% of those accidents identified as a pedestrian accident; thus the incorrect use of vehicle code K is insignificant in the total sample, but could have a significant influence on the number of pedestrian accidents.

The only way to rectify this issue would be to review the traffic crash report for each individual accident involving a "K" vehicle; this would be highly time-intensive and therefore it was decided to simply discard the accidents with vehicle code K from the dataset, rather than risk skewing the pedestrian data.

A3.3.1 Road / speed category and reporting rates

MBCM reporting rates are given based on:

- the accident severity,
- whether or not the accident involved a pedestrian,
- five types of road type / speed limit categories:
  - 50, 60 and 70 km/h speed limit
  - 80 and 100 km/h speed limit (excluding motorways)
  - 100 km/h speed limit remote rural area
  - Motorway (usually also including limited-access expressways)
  - All (i.e. general)

An index was created for each accident based on these three variables, with the road / speed limit category being derived from the CAS road category and speed limit. This was used to look up the MBCM reporting rate from MBCM tables A18 and A19, which are re-structured in the form of Table A3.5:

Table A3.5 MBCM accident reporting rates

Road type / speed limit category	User type	Accident severity			
		Fatal	Serious	Minor	Non-injury
<70 km/h	Pedestrian	1.0	1.5	4.5	7.0
	Other	1.0	1.5	2.8	7.0
80-100 km/h excluding motorways	Pedestrian	1.0	1.9	7.5	18.5
	Other	1.0	1.9	4.5	18.5
100 km/h remote rural	Pedestrian	1.0	2.3	13.0	18.5
	Other	1.0	2.3	7.5	18.5
Motorway	Pedestrian	1.0	1.9	1.9	7.0

Road type / speed limit category	User type	Accident severity			
		Fatal	Serious	Minor	Non-injury
	Other	1.0	1.9	1.9	7.0
All	Pedestrian	1.0	1.7	3.6	12.8*
	Other	1.0	1.7	3.6	12.8*

* the MBCM does not give any reporting rates for non-injuries occurring on the general "All" roads category, for either pedestrians or other; the missing rates were therefore taken as the average of non-injury accidents occurring on roads with up to 70 km/h and 80-100 km/h speed limits.

A3.3.2 Cost factored for reporting rate

The MBCM gives reporting rates corresponding to the particular combination of road type / speed limit, user type, and accident severity. For each accident record, the accident cost was derived from the MoT injury prices (see the Appendix), the number of injuries sustained, and the corresponding reporting rates. The tabulation of non-injured parties in CAS is unreliable (i.e. Police officers don't generally bother recording all non-injured parties), non-injured parties are not included in the costs for accidents that did involve injuries, and non-injury accidents are treated on a per-crash basis, rather than a per-injury basis.

An alternative to this would have been to use the MBCM costs; these have the benefit of being disaggregated according to major vehicle types and accident movement types, but are aggregated on a per-accident basis, so do not offer the same level of detailed as the per-injury rates used in the MoT costs. Furthermore, the MoT costs are updated each year and can be easily used to update the analysis spreadsheets.

A3.3.3 Peak period and congestion

If an accident occurred during 7-9am or 4-6pm on a weekday, it was considered to be during peak period traffic, and it was further assumed that those accidents occurring during a peak period on an urban road were subject to congestion.

Note that these are broad assumptions – the actual timing of peak periods and level of congestion vary between urban roads within a locality, and between different localities. For example, the peak period experienced in Whanganui is much shorter than that experienced in Auckland. Furthermore, some roads can experience their highest traffic levels during the weekend, e.g. those serving major suburban shopping centres.

A3.4 Accident Compensation Corporation (ACC) – road transport injuries

In New Zealand, unlike many other countries, accident insurance for all work and non-work related injuries (including transport-related injuries) is covered by a sole and compulsory provider, the Accident Compensation Corporation (ACC). The ACC scheme operates on a no-fault basis, providing coverage regardless of the claimant's role in causing the injury; this also means that people who have suffered personal injury in New Zealand do not have the right to sue an at-fault party, except for exemplary damages.

A3.4.1 ACC Motor Vehicle Account data

The ACC Motor Vehicle Account covers treatment for injuries resulting from accidents on public roads involving moving vehicles. Transportation injuries that do not involve a moving vehicle are covered under other accounts (primarily the Earners' Account).

Data from the ACC Motor Vehicle Account was provided to ViaStrada on 18 April 2020 for the 2014/15 – 2018/19 financial years. Of interest were the dollar values of active claims and the number of new claims for each financial year, which indicates the average cost over a lifetime of a claim on an aggregated level. A month-by-month breakdown was also provided, allowing for conversion to calendar years.

The ACC Motor Vehicle Account data included a classification of "primary external agency (road factor)" i.e. the mode of transport the claimant was using; with the following categories:

- ATV ("All-Terrain Vehicle")
- Cycling
- Driving / passenger – bus
- Driving / passenger – car
- Driving / passenger – motorcycle
- Driving / passenger – truck
- Driving / passenger – other vehicle
- Non obtainable
- Other
- Pedestrian

Along with the data from the Motor Vehicle Account, additional data was provided for claims identified as involving motor-cycles, cycling, walking, e-scooters, and scooters. However, it was identified that this involved some double-counting with the Motor Vehicle Account data, and potential double-counting between the identified modes, therefore the additional data was excluded from further analysis.

A3.4.2 ACC transport claims including non-motor vehicles

To address the issues with double-counting of non-motor vehicles provided with the Motor Vehicle Account data, a further dataset was provided by ACC to ViaStrada on 3 June 2020 for the 2014/15 – 2018/19 financial years. This also included the cost of active claims and number of new claims lodged but was not limited to claims made under the Motor Vehicle Account. Instead, the second ACC dataset tried to identify all transport-related claims, including those not involving a motor vehicle, by including injuries incurred by all modes near / on a road or street (note that by applying this, ACC analysts have potentially omitted non-motor vehicle injuries occurring on off-road paths through parks etc) and by excluding mountain biking claims. Where different modes were involved, the claims were classified according to a priority based on that used in the MBCM for CAS accidents (columns 3 and 4 in Table A3.4 and the surrounding discussion); the priority used for the ACC data was:

1. Walking
2. E-scooter
3. Scooter
4. Skateboard
5. Cycling
6. Motor-cycle
7. Bus

8. Truck
9. Car
10. Other vehicle

So, for example, a claim involving both a cyclist and a pedestrian would be classified as a walking claim.

ACC also included the following explanation about one of the major limitations of the data:

“The data ACC collects about accidents, and the individuals injured in them, is largely reliant on the information clients provide when the ACC45 form is completed. The ACC45 is an electronic claim form. There are a variety of fields for clients to complete when filling out the ACC45 form, some mandatory, some not. For example, it is mandatory for a client to indicate when their accident occurred, whether the accident occurred at work, and their occupation. Those mandatory fields can be contrasted with the free text field on the ACC45 form, where clients are able to provide a brief description of how their accident happened. Importantly, it is not mandatory to complete this free text field and not every client does so. The reason ACC does not require that information from clients is that the ACC scheme operates on a no-fault basis. Cover is available by virtue of a person simply having suffered a personal injury and is not determined by how that injury occurred. Therefore, while that information does have an inherent value in informing our understanding of how and why accidents occur, strictly speaking, it is unnecessary for the purpose of processing claims under the Act. It also needs to be noted that even where clients do provide a description of how their injury occurred, there is a large degree of variability in the nature and quality of the descriptions that clients provide. Such inconsistency can make it difficult to search for a particular item or issue with a high degree of accuracy. Because of the limitations above, while largely representative of the claims received by ACC, the data provided should not be considered a completely definitive measure of the claims ACC received in the relevant period.”

A3.5 New Zealand Injury Query System (NIQS) – land transport injuries

The University of Otago Injury Prevention Unit collate publicly funded hospital discharge data from the National minimum Data Set and Mortality Collection data from the Ministry of Health to form the NZ Injury Query System (NIQS).

Data for this project were obtained from the NIQS on 30 March 2020, according to the following properties in Table A3.6:

Table A3.6 Data periods for injuries of various type and severity, from NIQS

Injury cause	Injury severity	
	Fatal	Non-fatal (but requiring at least an overnight stay in hospital)

• Motor vehicle traffic crashes (MVTCs)
  ○ Occupant in MVTC
  ○ Motorcyclist in MVTC
  ○ Pedal cyclist in MVTC
  ○ Pedestrian in MVTC
  ○ Other & unspecified MVTC
• Non-motor vehicle traffic
  ○ Pedal cyclist
  ○ Pedestrian
  ○ Other land transport[22]
	2016 only	2016-2018

Note that the NIQS data comes from the Ministry of Health which releases data yearly, with a delay to allow hospitals to collate their data and coroners time to complete their investigations and record their findings; hence, at the time of retrieval, data on fatal accidents were only available up until 2016, and non-fatal accident data until 2018.

The NIQS data is available for calendar years only.

[22] Note that we have been unable to obtain clarification from Otago as to what modes this category includes.

Appendix 4 : Motor vehicle accident details

A4.1 Comparison of data sources

The CAS dataset contains many fields of information for individual accidents and therefore has the most flexibility in terms of aggregating the data. The NIQS dataset only distinguishes between fatal and serious injuries, and aggregates per calendar year, but only had fatal data for 2016 and non-fatal data up to 2018). The ACC dataset gives no distinction for the level of injury and only provides mode split when aggregated by financial year. Therefore, it is not possible to compare all three datasets.

The following graphs show two comparisons of the datasets. Figure A4-1 compares the CAS data and NIQS motor vehicle traffic crash data for serious injuries of different modes (note that the general motor vehicle category from NIQS corresponds to the combination of Car, light vehicle, Bus, and Truck from CAS), by calendar year. Figure A4-2 compares the CAS and ACC data for all injuries (i.e. fatal, serious, and minor) of different modes, by financial year. In both graphs, the CAS accidents have been factored using the MBCM reporting rates.

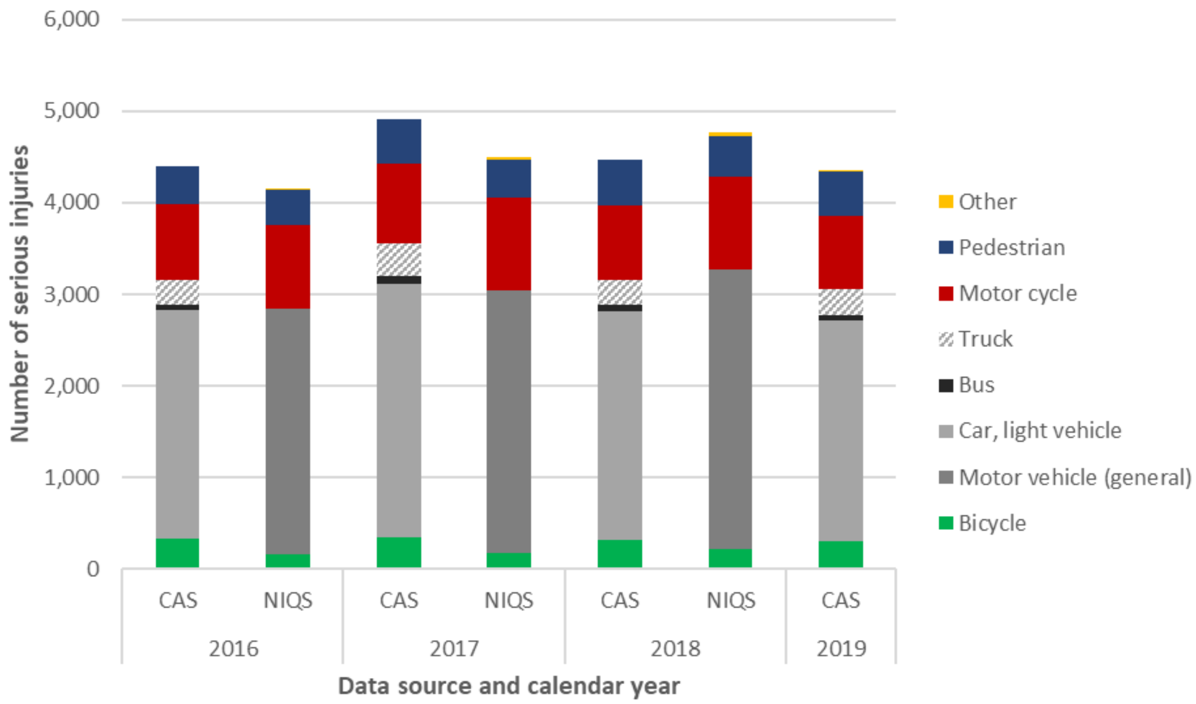

Figure A4-1 Serious injuries per calendar year for CAS (with MBCM reporting adjustment) and NIQS (motor vehicle traffic accidents)

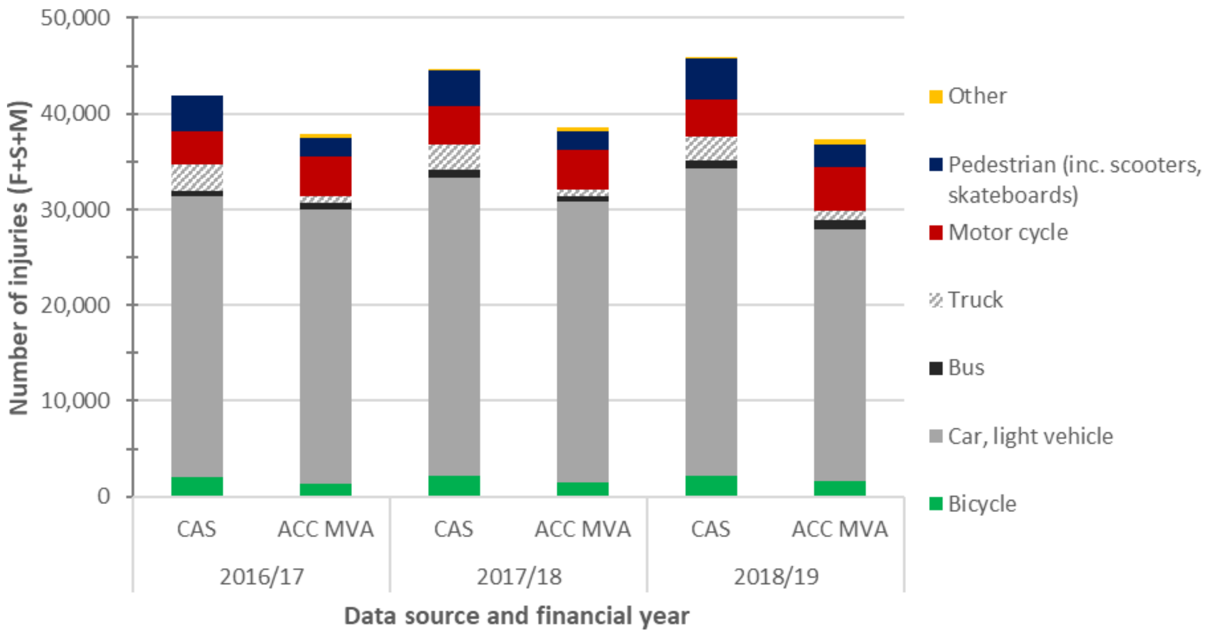

Figure A4-2 Injury accidents per financial year for CAS (with MBCM reporting adjustment) and ACC (motor vehicle account claims)

Note that CAS records have been shown to include many instances of incorrect coding of the vehicle code “K” (skateboarder, in-line skater) in place of an unknown motor vehicle – these instances have been identified and corrected where CAS coding suggested no motor vehicle was present, but have not been adjusted where another motor vehicle was included. Therefore, the number of accidents shown to involve a pedestrian (which includes users of small-wheeled devices such as skateboards and in-line skates) may be greater than the actual value.

The two comparisons show a reasonably good match between the datasets, which corroborates the use of the MBCM reporting factors. The total number of serious injuries for CAS and NIQS are within 10%, but interestingly NIQS has a higher number of injuries in 2018 but lower in the other two years analysed. The difference between the CAS and ACC injury totals is greater, and is likely due to:

- Inclusion of fatalities where people died on the scene in CAS data (people who are hospitalised but die within 30 days would be included in the ACC data)
- Definition of “minor injury” in CAS – could include both people who required some medical attention, e.g. a visit to a GP or physiotherapist (and therefore covered by ACC), but could also include those who suffered bruises, cuts etc but did not require medical assistance.

The modal split also differs between the datasets, with vulnerable users (e.g. pedestrians and cyclists) generally being overrepresented in the CAS data. This is assumedly due to the MBCM method of ranking CAS accidents by highest priority user – for example, an accident involving a pedestrian will be ranked as a pedestrian accident, but any injuries of parties involved in the accident who were using other modes would also be lumped under definition of pedestrian accident. The NIQS and ACC datasets, on the other hand, involve individual people. Figure A4-2 shows a greater proportion of pedestrian injuries in the CAS data than the ACC MVA data, which could be a function of applying the MBCM priorities (all injuries involving a pedestrian would be classed as pedestrian injuries, which may not be completely accurate). Figure A4-1 suggests the proportion of serious pedestrian injuries in the CAS data are similar to those in the NIQS data. CAS has a markedly higher proportion of bicycle injuries than both ACC and NIQS, which again could be due to the high priority assigned to cyclists in the MBCM prioritisation.

Overall, the comparisons suggest that there is reasonable correlation between the data sets (once the MBCM reporting rates have been applied to the CAS data) and that each data set can therefore be used to examine specific properties; CAS will be used primarily for motor vehicle accidents, and NIQS and ACC will be more useful for road transport accidents not involving motor vehicles.

Appendix 5 : Determination of road user fault for cost caused allocation

CAS records contributing factors, which are linked to the specific vehicles/users involved (up to four vehicles can be recorded for an individual accident), and some of these codes imply fault on behalf of the specified road user. Table A5.1 lists the CAS factor codes that were considered to indicate some fault on the part of the road user, note that in the process other codes were listed as “uncertain”, meaning that road user may have been responsible for this but the code itself does not give enough information (e.g. factor code 108 – drugs suspected, which is inconclusive regarding whether or not the driver was illegally under the influence of drugs). Pedestrian factors are generally not included as faults, as these are assigned against the conflicting vehicle and pedestrians on foot are not included in the vehicle records. In addition, experience shows that terms like “stepping suddenly onto crossing” are often incorrectly used to blame pedestrians where the onus should have been on drivers.

Table A5.1 Factor codes considered to indicate fault

Factor code	Description
101	Alcohol suspected
103	Alcohol test above limit or test refused
109	Drugs present
110	Other inappropriate speed conditions
111	Entering /on curve
112	On straight
113	Approaching a traffic control
115	When passing school bus.
116	At temporary speed limit
117	At crash or emergency
118	For road conditions
119	For weather conditions
120	Other position on road
121	Swung wide on bend
122	Swung wide at intersection
123	Cutting corner on bend
124	Cutting corner at intersection
125	Too far right
126	Vehicle crossed flush median
129	Too far left
140	Other failed to signal
141	Failed to signal in time
145	Incorrect signal
150	Other overtaking
151	Overtaking line of traffic or queue
152	Overtaking in the face of oncoming traffic
156	With insufficient visibility
157	Overtaking at an intersection
158	On left without due care
159	Cut in after overtaking
160	Vehicle signalling turn
170	Other wrong lane or position
171	Turned from incorrect lane
173	Travelled straight from turning lane or flush median
174	Turned from incorrect position on road
176	Turned into incorrect lane
177	Weaving or cut in on multi-lane roads
179	Long vehicle tracked outside lane
180	Other – too close

Factor code	Description
181	Following too closely
182	Travelling unreasonably slowly
183	Motorist crowded cyclist
184	Incorrect merging / diverging
191	Suddenly braked
192	Suddenly turned left/right
196	Swerved to avoid crash or broken-down vehicle
197	Swerved to avoid vehicle
199	Swerved avoiding emergency vehicle
200	Other – forbidden movements
201	Wrong way on road/ motorway
202	Non-compliance with regulatory device with sign or marking
204	Driving / riding in pedestrian space
208	Motor vehicle in special purpose lane
300	Other - failed to give way
301	At a priority traffic control
303	When turning to non-turning traffic.
304	When priority defined by road markings
306	To a pedestrian
308	When entering roadway from driveway
309	To traffic approaching or crossing from the right
312	Entering roadway not from driveway or intersection.
313	Failed to give way to emergency vehicle
314	Driver waved through
315	When turning right to opposing left turning traffic
316	To traffic approaching or crossing from the left
320	Other - did not stop
321	At Stop sign
322	At full red traffic signal
324	At amber traffic signal
326	At flashing red signals (railway crossing, fire stations, etc.).
327	For traffic controller
328	For school patrol/kea crossing
330	Other – inattentive
331	Vehicle slowing, stopping or stationary in front

Factor code	Description
332	Bend in road
333	Indication of vehicle in front
334	Failed to notice control
336	Failed to notice signs
339	Failed to notice road works
340	Failed to notice markings
341	Obstructions on roadway
350	Other - attention diverted by (inside or outside vehicle)
352	Scenery or persons outside vehicle
353	Other traffic
355	Trying to find intersection, house number, destination, etc
356	Advertising or signs.
359	Cell phone
361	Navigation device
362	Non cell communication device
364	Vehicle console inbuilt features: radio/heater/etc.
365	Objects under driver's pedals
366	Food, cigarettes, beverages
370	Other – did not see or look
371	Did not check/notice another party behind
375	Did not check/notice another party
377	When visibility obstructed by other traffic.

Factor code	Description
404	Overseas / migrant driver fails to adjust to NZ road rules and road conditions
410	Other fatigue
411	Long trip
412	Lack of sleep
414	Long day (working/recreation)
415	Exceeded driving hours
426	Lights not switched on
428	Parking brake not fully applied.
429	Trailer coupling or safety chain not secured.
430	Other intentional actions
431	Racing
432	Playing 'chicken'
433	Wheel spins / wheelies / doughnuts / drifting etc
434	Intimidating driving
443	Incorrectly parked vehicle
447	Not clear of rail Xing
506	Attempted suicide
510	Other intentional or criminal
511	Homicide/suicide (successful)
512	Intentional collision
514	Evading enforcement
518	Over the speed limit
534	Another party wearing dark clothing

CAS includes an accident movement code, illustrated in Figure A5-1. The first vehicle (V1) recorded in CAS is represented by the bold arrow on the movement code diagram; in many cases it can be assumed which user was at fault based on these movement codes, however this is not always the case (some depend on the nature / operation of the form of traffic control at an intersection, others depend on additional circumstances). The fault codes identified in Table A5.1 were applied to the vehicles involved in each individual accident to further inform the likely fault of vehicles involved. For the costs caused analysis, it was assumed that at least one and up to two users might be at fault.

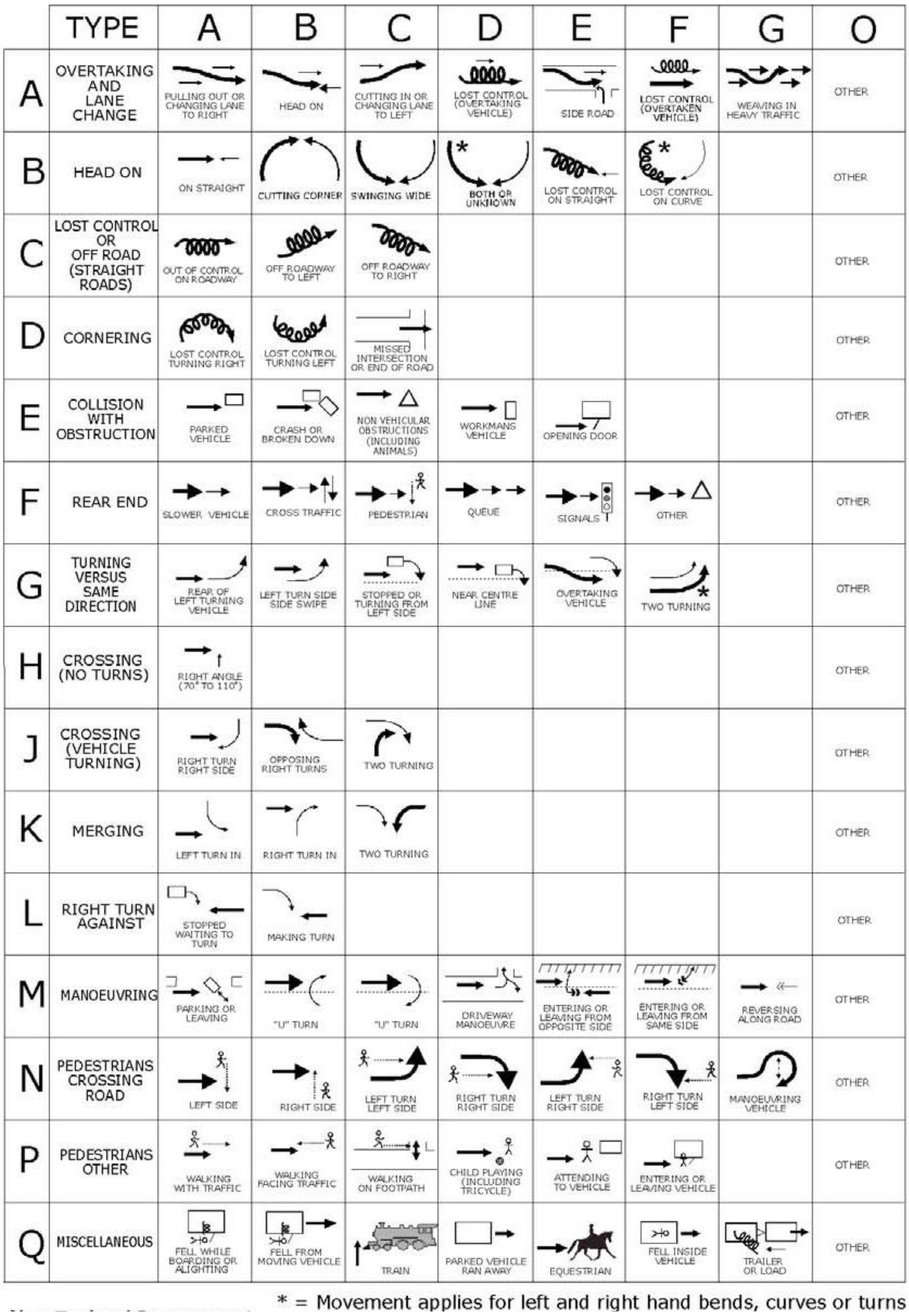

Figure A5-1 CAS movement codes

Table A5.2 shows, for each CAS movement type (column 1) the fault proportions attributed to vehicle 1 (V1 – column 2) and vehicle 2 (V2 – column 3). These were informed by the subsequent columns. Columns 4-7 show the assessment of fault codes, column 8 shows the ratio of V1 to V2 in causing the accident based on the fault codes. Column 9 shows the total number of accidents in the dataset for that movement, column 10 shows the proportion V1 makes up of the total accidents per movement. The rightmost column notes the additional considerations made in attributing the fault proportions.

Table A5.2 Attributing fault based on accident movement type

Movement	Fault prop.		Assessment of fault codes					Total accidents	V1/Total accidents	Notes
	V1	V2	V1	V2	V3	V4	V1/ (V1+ V2)			
AA	0.9	0.1	2797	392	32	3	0.88	3276	0.85	Onus is on overtaking driver, although the other driver may have been misleading
AB	1	0	184	28	10	4	0.87	189	0.97	Onus is on overtaking driver
AC	0.9	0.1	2975	303	32	5	0.91	3310	0.90	Onus is on overtaking driver
AD	1	0	514	29	6	1	0.95	635	0.81	Onus is on overtaking driver
AE	1	0	8	3	0	0	0.73	9	0.89	Onus is on overtaking driver
AF	1	0	71	35	1	0	0.67	96	0.74	Onus is on overtaking driver
AG	1	0	148	16	1	0	0.90	152	0.97	Onus is on overtaking driver
AO	0.9	0.1	1708	480	19	6	0.78	1983	0.86	Onus is on overtaking driver, although the other driver may have been misleading
BA	0.9	0.1	1811	272	23	3	0.87	1922	0.94	Difficult to tell from movement type, but fault codes suggest V1 is generally responsible
BB	0.9	0.1	968	108	3	0	0.90	1009	0.96	Difficult to tell from movement type, but fault codes suggest V1 is generally responsible
BC	0.9	0.1	1330	139	13	2	0.91	1366	0.97	Difficult to tell from movement type, but fault codes suggest V1 is generally responsible
BD	0.5	0.5	133	106	1	0	0.56	162	0.82	Difficult to tell from movement type, and fault codes suggest near-equal responsibility
BE	0.9	0.1	193	18	2	1	0.91	263	0.73	Difficult to tell from movement type, but fault codes suggest V1 is generally responsible
BF	0.9	0.1	718	83	4	0	0.90	948	0.76	Difficult to tell from movement type, but fault codes suggest V1 is generally responsible
BO	0.7	0.3	143	49	2	0	0.74	169	0.85	Difficult to tell from movement type, but fault codes suggest V1 is generally responsible
CA	0.9	0.1	1221	90	9	2	0.93	1691	0.72	Onus is on driver (although other factors e.g. road condition and vehicle may have contributed)
CB	0.9	0.1	8502	139	13	3	0.98	10030	0.85	Onus is on driver (although other factors e.g. road condition and vehicle may have contributed)
CC	0.9	0.1	4887	64	5	1	0.99	5804	0.84	Onus is on driver (although other factors e.g. road condition and vehicle may have contributed)
CO	0.9	0.1	149	9	1	0	0.94	209	0.71	Onus is on driver (although other factors e.g. road condition and vehicle may have contributed)
DA	0.9	0.1	201	13	0	0	0.94	263	0.76	Onus is on driver (although other factors e.g. road condition and vehicle may have contributed)

Movement	Fault prop.		Assessment of fault codes					Total accidents	V1/Total accidents	Notes
	V1	V2	V1	V2	V3	V4	V1/ (V1+ V2)			
DB	0.9	0.1	2627	28	1	0	0.99	3155	0.83	Onus is on driver (although other factors e.g. road condition and vehicle may have contributed)
DC	0.9	0.1	1060	11	1	0	0.99	1406	0.75	Onus is on driver (although other factors e.g. road condition and vehicle may have contributed)
DO	0.9	0.1	189	3	0	0	0.98	251	0.75	Onus is on driver (although other factors e.g. road condition and vehicle may have contributed)
EA	0.9	0.1	8555	140	21	3	0.98	9100	0.94	Onus is on driver to foresee hazards and stop safely
EB	0.9	0.1	56	10	4	1	0.85	70	0.80	Onus is on driver to foresee hazards and stop safely
EC	0.9	0.1	757	53	11	3	0.93	2254	0.34	Onus is on driver to foresee hazards and stop safely
ED	0.9	0.1	37	0	0	0	1.00	42	0.88	Onus is on driver to foresee hazards and stop safely
EE	0.1	0.9	149	243	1	0	0.38	499	0.30	Driver / occupant of parked car should not open door if not safe to do so (classic problem for cyclists)
EO	0.9	0.1	216	18	1	0	0.92	399	0.54	Onus is on driver to foresee hazards and stop safely
FA	1	0	2880	508	38	5	0.85	3229	0.89	Legally, onus is on following driver to allow sufficient following distance that they can stop safely.
FB	1	0	2417	142	11	0	0.94	2615	0.92	Legally, onus is on following driver to allow sufficient following distance that they can stop safely.
FC	1	0	681	45	6	0	0.94	719	0.95	Legally, onus is on following driver to allow sufficient following distance that they can stop safely.
FD	1	0	11488	819	512	196	0.93	12058	0.95	Legally, onus is on following driver to allow sufficient following distance that they can stop safely.
FE	1	0	2826	130	14	0	0.96	3057	0.92	Legally, onus is on following driver to allow sufficient following distance that they can stop safely.
FF	1	0	609	152	58	8	0.80	678	0.90	Legally, onus is on following driver to allow sufficient following distance that they can stop safely.
FO	1	0	187	58	4	2	0.76	255	0.73	Legally, onus is on following driver to allow sufficient following distance that they can stop safely.

Movement	Fault prop.		Assessment of fault codes					Total accidents	V1/Total accidents	Notes
	V1	V2	V1	V2	V3	V4	V1/ (V1+ V2)			
GA	0.9	0.1	730	75	4	1	0.91	790	0.92	Legally, onus is on following driver to allow sufficient following distance that they can stop safely.
GB	0.4	0.6	493	751	2	1	0.40	1224	0.40	Informed by fault codes
GC	0.3	0.7	150	387	0	0	0.28	509	0.29	Informed by fault codes
GD	0.9	0.1	2171	172	30	3	0.93	2346	0.93	Legally, onus is on following driver to allow sufficient following distance that they can stop safely.
GE	0.9	0.1	706	215	1	0	0.77	895	0.79	Onus is on overtaking driver
GF	0.7	0.3	481	207	2	0	0.70	683	0.70	Difficult to tell from movement type, but fault codes suggest V1 is generally responsible
GO	0.7	0.3	135	50	3	0	0.73	185	0.73	Informed by fault codes
HA	0.5	0.5	3840	3617	16	0	0.51	7137	0.54	Difficult to tell, depends on type of control and status of traffic signals where applicable - fault codes suggest near-equal fault
HO	0.5	0.5	50	57	0	0	0.47	101	0.50	Difficult to tell, depends on type of control and status of traffic signals where applicable - fault codes suggest near-equal fault
JA	0.2	0.8	1316	5520	20	1	0.19	6384	0.21	Difficult to tell, depends on type of control and status of traffic signals where applicable - informed by fault codes
JB	0.5	0.5	49	49	0	0	0.50	83	0.59	Difficult to tell, depends on type of control and status of traffic signals where applicable - informed by fault codes
JC	0.7	0.3	383	139	2	0	0.73	504	0.76	Difficult to tell, depends on type of control and status of traffic signals where applicable - informed by fault codes
JO	0.3	0.7	406	1206	6	0	0.25	1561	0.26	Difficult to tell, depends on type of control and status of traffic signals where applicable - informed by fault codes
KA	0.2	0.8	324	1709	8	1	0.16	1934	0.17	Difficult to tell, depends on type of control and status of traffic signals where applicable - informed by fault codes
KB	0.3	0.7	700	1481	7	1	0.32	2093	0.33	Difficult to tell, depends on type of control and status of traffic signals where applicable - informed by fault codes
KC	0.6	0.4	163	94	1	0	0.63	227	0.72	Difficult to tell, depends on type of control and status of traffic signals where applicable - informed by fault codes
KO	0.5	0.5	42	36	0	0	0.54	71	0.59	Difficult to tell, depends on type of control and status of traffic signals where applicable - informed by fault codes

Movement	Fault prop.		Assessment of fault codes					Total accidents	V1/Total accidents	Notes
	V1	V2	V1	V2	V3	V4	V1/ (V1+ V2)			
LA	0.5	0.5	43	43	0	0	0.50	85	0.51	Difficult to tell, depends on type of control and status of traffic signals where applicable - informed by fault codes
LB	0.2	0.8	1749	5761	23	0	0.23	6912	0.25	Difficult to tell, depends on type of control and status of traffic signals where applicable - informed by fault codes
LO	0.4	0.6	126	161	1	0	0.44	235	0.54	Difficult to tell, depends on type of control and status of traffic signals where applicable - informed by fault codes
MA	0.2	0.8	212	873	3	0	0.20	1112	0.19	Informed by fault codes
MB	0.2	0.8	66	351	2	0	0.16	422	0.16	Informed by fault codes
MC	0.2	0.8	342	1979	5	0	0.15	2263	0.15	Informed by fault codes
MD	0.2	0.8	226	676	1	0	0.25	857	0.26	Informed by fault codes
ME	0.2	0.8	20	104	1	0	0.16	127	0.16	Informed by fault codes
MF	0.2	0.8	74	298	1	0	0.20	375	0.20	Informed by fault codes
MG	0.2	0.8	157	704	4	0	0.18	910	0.17	Informed by fault codes
MO	0.8	0.2	3540	587	6	0	0.86	5230	0.68	Informed by fault codes
NA	0.4	0.6	470	4	3	0	0.99	1337	0.35	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.
NB	0.4	0.6	346	3	1	0	0.99	864	0.40	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.
NC	0.7	0.3	72	1	0	0	0.99	110	0.65	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.
ND	0.7	0.3	116	0	0	0	1.00	151	0.77	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.
NE	0.6	0.4	37	0	0	0	1.00	61	0.61	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.
NF	0.7	0.3	219	0	0	0	1.00	299	0.73	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.

Movement	Fault prop.		Assessment of fault codes					Total accidents	V1/Total accidents	Notes
	V1	V2	V1	V2	V3	V4	V1/ (V1+ V2)			
NG	0.9	0.1	61	1	0	0	0.98	70	0.87	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.
NO	0.7	0.3	121	1	0	0	0.99	182	0.66	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.
PA	0.8	0.2	48	0	0	0	1.00	60	0.80	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.
PB	0.6	0.4	16	0	1	0	1.00	27	0.59	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.
PC	0.9	0.1	192	11	0	0	0.95	214	0.90	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.
PD	0.2	0.8	15	1	0	0	0.94	62	0.24	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.
PE	0.7	0.3	33	1	2	0	0.97	46	0.72	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.
PF	0.5	0.5	19	3	1	0	0.86	41	0.46	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.
PO	0.7	0.3	553	7	6	1	0.99	833	0.66	Veh 1 is generally not a pedestrian, and pedestrians on foot not identified in vehicle codes (therefore not attributed fault). Informed by proportion veh1 fault / total cases for mvmt.
QA	0.7	0.3	12	0	0	0	1.00	25	0.48	Informed by fault codes for where 2nd vehicle exists
QB	0.7	0.3	46	0	0	0	1.00	95	0.48	Informed by fault codes for where 2nd vehicle exists
QC	0.9	0.1	58	1	0	0	0.98	61	0.95	Informed by fault codes for where 2nd vehicle exists
QD	0.8	0.2	266	6	0	0	0.98	410	0.65	Informed by fault codes for where 2nd vehicle exists

Movement	Fault prop.		Assessment of fault codes					Total accidents	V1/Total accidents	Notes
	V1	V2	V1	V2	V3	V4	V1/ (V1+ V2)			
QE	0.7	0.3	1	0	0	0	1.00	2	0.50	Informed by fault codes for where 2nd vehicle exists
QF	0.7	0.3	2	0	0	0	1.00	5	0.40	Informed by fault codes for where 2nd vehicle exists
QG	0.7	0.3	361	24	5	0	0.94	906	0.40	Informed by fault codes for where 2nd vehicle exists
QO	0.6	0.4	13	1	0	0	0.93	39	0.33	Informed by fault codes for where 2nd vehicle exists
ALL	**0.7**	**0.3**	**85166**	**32103**	**1028**	**258**	**0.73**			

Appendix 6 : Cost suffered allocation

A separate CAS tabulation was generated to assist the determination of costs suffered by the different user groups. This tabulation included "person attributes" to show, for each road user type, the severity of injuries sustained, and could be linked to the main CAS data via the crash ID. The road user types given in this tabulation, however, were not the same as the vehicle types used in the main coded crash report (see Appendix 4), in particular with motor vehicle users being defined as either driver or passenger, but not according to vehicle types. The road user types from the tabulation, and their corresponding MBCM vehicle types are shown in Table A6.1:

Table A6.1 Road user types for cost suffered allocation

User type (person attribute tabulation)	MBCM user type
Cyclist	Bicycle
Driver	Motor vehicle, i.e. either: • Motorcycle (including moped) • Cars, light commercial vehicles and any other • Bus • Truck
Passenger	
Pedestrian	Pedestrian
Skateboard, inline skate	
Wheeled pedestrian (wheelchairs, mobility scooters)	
Equestrian	
Other	Other
Null	Blank / unknown

Injuries sustained by pedestrians or cyclists were clearly recorded. To allocate the motor vehicle injuries among the various types of motor vehicle in the MBCM classification, the vehicle types for each accident were cross-referenced, and a vulnerability hierarchy applied:

1. If any motorcycles were involved in the accident, the most severe injuries were attributed to the motorcyclists, up to the number of motorcycles involved.
   a. This assumes a motorcycle occupancy of 1, which may not always be correct as motorcycles can carry passengers, but this is thought to be balanced by the assumption that motorcyclists would sustain the worst injuries, which would not always be the case.
2. If any cars / light vehicles were involved in the accident, the remainder of motor vehicle injuries not already attributed to motorcyclists would be attributed to the car occupants, up to a maximum of the number of cars involved multiplied by the average light 4-wheeled vehicle occupancy rate of 1.58 (from 2010-2014, the most recent MoT data available).
   a. This does not account for cases where the vehicle occupancy and resulting injury rates were greater than the average vehicle occupancy. Thus, at the end of the exercise, any un-allocated injuries were added to the car / light vehicle group.
3. If any bus was involved in an accident, the remainder of the motor vehicle injuries (i.e. not already allocated to motorcyclists or car occupants) were attributed to the bus occupants.

    a. This assumes that a bus can have infinite occupants, and that in a bus vs. truck accident, only the bus occupants would be hurt.

4. If the accident didn't involve a bus but did involve any trucks, the remainder of the motor vehicle injuries (i.e. not already allocated to motorcyclists or car occupants) were attributed to the truck occupants.
    a. This assumes that a bus can have infinite occupants, and that in a bus vs. truck accident, only the bus occupants would be hurt.
5. Injuries tabulated as "other" were retained as such.
6. As mentioned above, at the end of the exercise, any un-allocated injuries were added to the car / light vehicle group.

While the tabulation indicated non-injured users, it was considered that this information is often not reliably recorded. Therefore, in the same vein as for the other cost allocation methods, accidents not resulting in any injuries were treated on a per-accident basis, not a per-person basis, and allocated first to any non-motorised users (pedestrians or cyclists) involved, then to motor vehicles as per the above hierarchy used for allocating injuries.

The MoT costs and MBCM reporting rates presented in Appendix 3 were applied.

Appendix 7 : Non-motor vehicle transport accident details

A7.1 Comparison of data sources

It is understood that a large majority of pedestrian or a cyclist injuries from incidents not involving a motor vehicle are generally not reported in CAS, and it was assumed that other datasets would provide a better understanding of the true accident numbers. However, as for the motor vehicle traffic accidents, NIQS and ACC datasets have several limitations compared to CAS; mainly in terms of either not including injuries of lesser severities, or not distinguishing the severity level, and also regarding the level of aggregation of the data provided.

After the incorrect coding of vehicle code K had been addressed (see Appendix), 93 of 149,807 (0.06%) accidents in the CAS dataset for FY2017-FY2019 were shown to involve pedestrians and / or cyclists but no motor vehicles. Such accidents were excluded from the final CAS analysis for motor vehicle accidents. Figure A7-1 details the modes involved in each of the injuries plus non-injury *accidents*[23] recorded in CAS as not involving a motor vehicle. These are factored by the reporting rates, which are based on accidents involving motor vehicles and therefore arguably not accurate for non-motor vehicle accidents, but remain the most appropriate figures available.

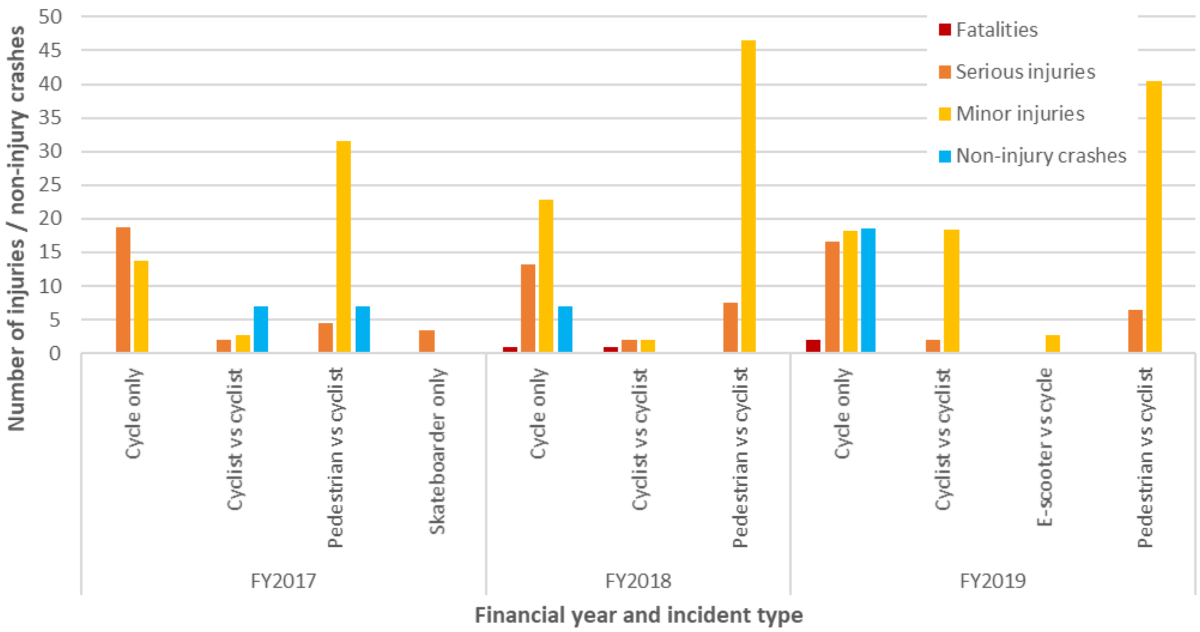

Figure A7-1 Modes involved and injury severities for CAS accidents not involving a motor vehicle (factored by reporting rate)

Note that the difference between a cycle-only accident and a cycle vs cycle accident is that the former involves only one party (e.g. a cyclist slipping on surface debris / wet road surface / tram tracks and falling off their bike) whereas the latter involves two (or more) cyclists.

[23] Per-person data has been used to represent injury types, as this is more accurate especially for non-motorised users. However, non-injury outcomes are represented on a per-crash basis, as these involve property damage only and crash data generally do not involve the number of people involved in a non-injury crash, nor are costs available on a per-person basis for non-injury outcomes.

Figure A7-2 re-categorises the CAS injuries and non-injury accidents presented in Figure A7-1 according to whether or not a pedestrian was involved. (This is to correspond to the ACC data classification, as will be discussed further on).

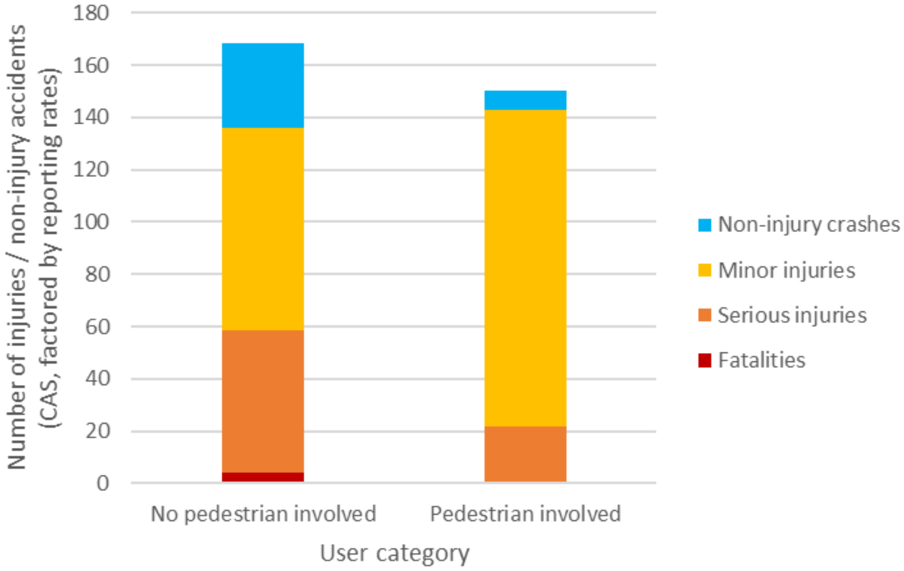

Figure A7-2 Injuries and non-injury accidents for FY2017-FY2019 classed according to whether or not a pedestrian was involved (CAS, factored by reporting rates)

The ACC general transport dataset does not distinguish whether or not motor vehicles were involved in causing the injuries presented, whereas the ACC Motor Vehicle Account (MVA) data is supposed to only include incidents involving a motor vehicle. Figure A7-3 shows the bicycle and pedestrian injuries from the two ACC datasets, plus CAS (cyclist and pedestrian injuries, including those involving motor vehicles, factored for reporting rates). The numbers for the CAS and ACC MVA data have already been presented in Figure A4-2, and note that the pedestrian category for these two datasets also includes scooters and skateboarders, which have been identified individually in the ACC transport dataset. Note also that the number of accidents involving either a cyclist or a pedestrian plus a motor vehicle recorded in CAS outnumber those involving NMUs only – by two orders of magnitude – therefore it would be pointless to display the CAS NMU-only figures separately in Figure A7-3. The premise of this comparison in Figure A7-3 is that the difference between the ACC general transport data and the ACC MVA or CAS should be the injuries to pedestrians and / or cyclists not involving motor vehicles.

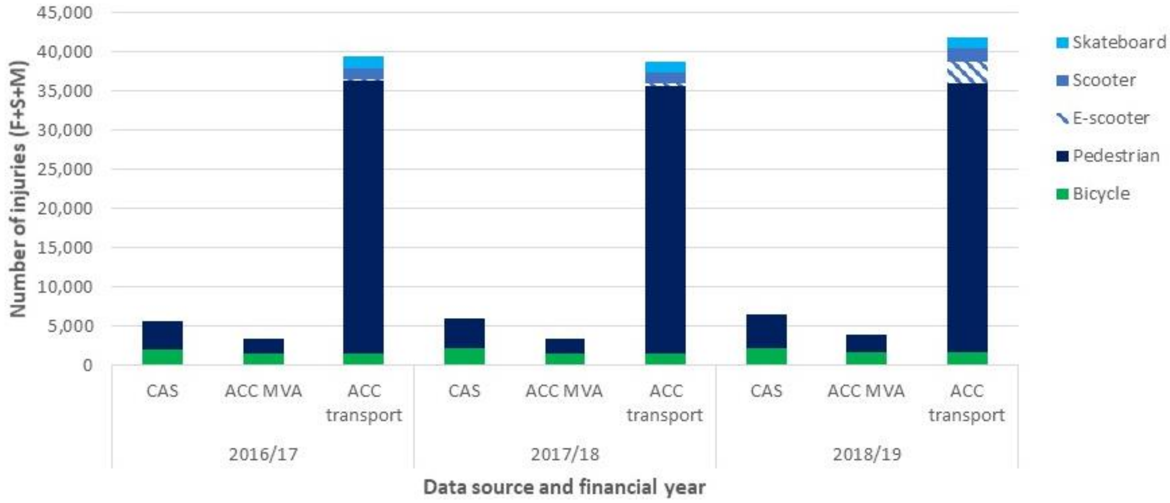

Figure A7-3 Bicycle, pedestrian injuries from CAS (factored for reporting rates and including those involving motor vehicles), ACC Motor Vehicle Account and ACC general transport data

It was originally assumed that the cycle accidents / injuries in CAS and the ACC MVA mostly involved motor vehicles, and that there would be more accidents not recorded in CAS or the ACC MVA that involved pedestrians or cyclists but no motor vehicles. Figure A7-3 shows this is clearly true for pedestrians, but the ACC data does not show this for cycling injuries. The number of cycling-related injuries in the ACC Motor Vehicle Account are practically equal to those in the ACC general transport injuries. The difference in pedestrian injuries (assumed to be from pedestrian accidents not involving motor vehicles) is shown in Figure A7-4:

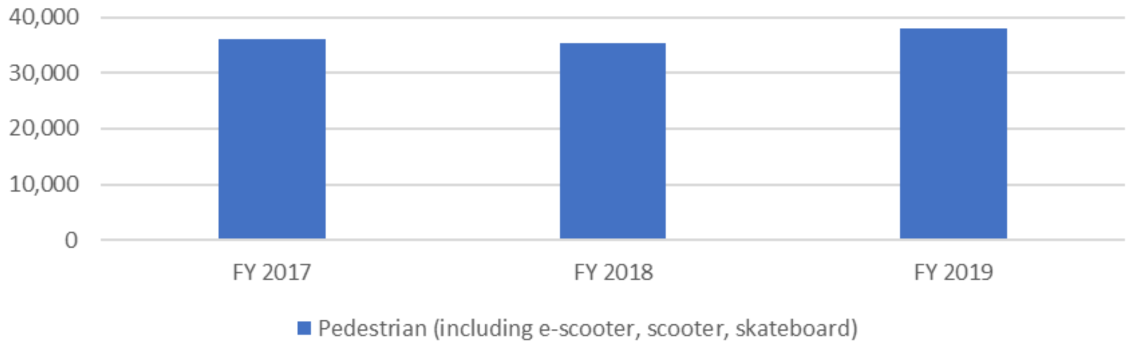

Figure A7-4 ACC injuries involving a pedestrian but not involving any motor vehicle

Another noteworthy point from Figure A7-3 (which also affects the pedestrian totals shown in Figure A7-4) is that, in FY 2019, the ACC general transport data in Figure A7-3 shows a spike in e-scooter injuries; this coincides with the introduction of e-scooter share / hire schemes (e.g. Lime) in several locations throughout New Zealand. This is not as obvious from the CAS pedestrian data in Figure A7-3, and in the CAS crash reports, only five accidents are specifically mentioned as involving an e-scooter, with only one of these not also involving a motor vehicle (crash ID 201820049, which involved an e-scooter vs a cycle).

The researchers had initially postulated that the fact that the two ACC datasets shown in Figure A7-3 don't reveal any cycle injuries not covered by the Motor Vehicle Account suggests that cycle-only accidents (e.g. cyclist slipping on surface debris / wet road surface / tram tracks and falling off their bike) or cyclist-vs-cyclist accidents may be covered under the ACC motor vehicle account. This was postulated because, while bicycles do not generally have motors, they are still legally considered a “vehicle”. However, an ACC analyst has confirmed the contrary – that the Motor Vehicle Account only covers injuries where a motor vehicle was involved. Therefore, there must be other reasons that, while CAS includes some accidents only involving cyclists, none of such are indicated by the ACC data; these could include:

- All accidents in the ACC general transport data involving a cyclist but not a motor vehicle also involving a pedestrian (or skateboarder, or scooter user) and therefore being classified as a pedestrian accident (or skateboard or scooter accident) according to the hierarchy specified (see the discussion in Appendix 5). This does not explain why the CAS records include examples of cycle-only accidents with no mention of pedestrian involvement (see Figure A7-1).
- The inclusion of cycle-only accidents resulting in minor injuries in the CAS data – where a minor injury may or may not result in medical attention and an ACC claim being lodged – again this is contrary to the data presented in Figure A7-1 which shows that some cycle-only accidents have resulted in fatalities and others in serious injuries.
- The exclusion of cycling accidents that do not occur on the road network (in an attempt to include only transport cycling – see Appendix 5). This would include people cycling on paths through parks that join up with the road network. Note that CAS includes the option of identifying off-road accidents, and only one of the 92 cycle-only accidents in the CAS data indicates that the cyclist was off-road; this suggests that off-road cycle-only transport accidents are unlikely to be reported or require medical attention and therefore the ACC data may not be significantly limited in this respect.
- Contrary to prior experience, cycle-only accidents may now be more accurately recorded in CAS, and the application of the underreporting factors based on motor vehicle traffic accidents may be inaccurate.

Overall, while there is some doubt regarding the split of cycle and pedestrian accidents not involving a motor vehicle, as the costs incurred in treating pedestrians and cyclists from accidents not involving motor vehicles are likely to be similar, it is not concerning if some cyclist injuries are included in the pedestrian categories.

As seen in Table A7.1, NIQS (2020) gives the following numbers of pedestrians suffering non-fatal injuries but requiring at least an overnight stay in hospital (taken to mean a “serious” injury by CAS conventions) resulting from traffic crashes not involving a motor vehicle:

Table A7.1 NIQS pedestrian serious injuries

	2016	2017	2018
Pedestrian non-MVTC non-fatal injuries	171	171	154

Note that the equivalent data for bicycles was not used as the figures are much higher than CAS or ACC data suggest, and are suspected to include a high proportion of off-road, non-transport related accidents (e.g. mountain biking).

A7.2 Accident numbers used in further analysis

In summary of the above section, the available datasets have the following limitations:

- CAS does not include any pedestrian-only accidents, which, based on the ACC general transport data (Figure A7-3), make up a significant proportion of pedestrian injuries.

- The ACC data does not reference the particular mode of the injured claimant; rather, it references to the user highest on the priority hierarchy presented in the Appendix.
  - To illustrate this limitation, if a cyclist vs pedestrian accident resulted in both parties being injured and making an ACC claim, they would both be classified as pedestrian-related claims according to the hierarchy.
  - Thus, it is only possible from the ACC NMU data to determine whether or not a pedestrian (as per the broader category which includes also scooter users etc) was involved.
  - This makes it impossible to distinguish the actual users affected and therefore impossible determine costs caused or costs suffered for non-motorised user accidents.
- The ACC data does not give any indication of injury severity. Individual pay-out costs for each ACC case would provide a reasonable indication of relative severities, but privacy restrictions limit our ability to obtain these.
- NIQS gives an estimate of serious pedestrian injuries from accidents not involving motor vehicles, but does not provide any information on lesser-severity accidents.

It is assumed that injuries to cyclists, walkers, skateboarders, e-scooter users etc are likely to involve the same costs. It is also assumed that CAS would record any pedestrian fatalities not involving motor vehicles occurring on the road network (i.e. that number is zero for the study period).

Based on the above limitations and assumptions), it seems most logical to:

- Aggregate all non-motorised user (NMU) types
- Use CAS data for the number of NMU injuries not involving pedestrians
- Use NIQS data for the serious injuries involving pedestrians.
- Determine the number of minor injuries involving pedestrians by subtracting the NIQS serious injuries from the total ACC claims involving pedestrians.
- Use proportions from CAS to determine the number of non-injury crashes (for which the costs not involving motor vehicles are almost negligible).

This process is set out in Table A7.2.

Table A7.2 Combining CAS and ACC non-motorised user accident data to determine costs

		Fatalities	Serious injuries	Minor injuries	Non-injury accidents	Source
CAS injuries / year	No pedestrian involved	1.3	18.1	26.0	10.8	CAS (yearly average, factored by reporting rates) – see Figure A7-1
	Pedestrian involved	0.0	7.3	40.4	2.3	
CAS non-injuries relative to injuries	No pedestrian involved				24%	Ratios from CAS injury numbers
	Pedestrian involved				5%	

		Fatalities	Serious injuries	Minor injuries	Non-injury accidents	Source
ACC average pedestrian injuries / year	Pedestrian involved	36,446.3				I.e. sum of fatal plus serious plus minor injuries. See Figure A7-3 (average of ACC general transport minus ACC MVA for pedestrians)
NIQS serious pedestrian injuries / year	Pedestrian involved		165.3			NIQS (2020) Average yearly hospital admissions with serious injuries for pedestrians in traffic crashes not involving a motor vehicle, for calendar years 2016-2018.
Injury numbers to use in costing (/year)	No pedestrian involved	1.3	18.1	26.0	10.8	From CAS data in row 1
	Pedestrian involved	0	165.3	36281.0	1783.5	Assuming any pedestrian non-MVTC fatalities would have been recorded in CAS. Serious injuries from NIQS data (serious injuries), minor injuries as balance of ACC total injury claims.
	Total	**1.3**	**183.4**	**36307.0**	**1794.3**	
Cost ($m/yr)	All non-motorised user only	$6.1	$86.7	$737.0	$0.2	Applying costs from Table A3.1
		$830.0				

The assumptions around relative proportions of different injury levels are hard to verify without more detailed inspection of ACC case data. While it is often assumed that injuries recorded in CAS will be of a higher severity, the nature of how the ACC system typically works suggests a minimum level of severity is typically required to trigger medical treatment requiring ACC subsidy. It is also notable that non-motor vehicle “slip, trip and fall” injuries are more common amongst older pedestrians, and their relative fragility makes them more susceptible to serious injuries (e.g. broken hips).

Appendix 8 : Detailed discussion of external and internal costs of transport accidents

Section 0 included an indicative diagram of flow relationships for costs and charges relating to private motor vehicle use in New Zealand; this diagram is presented again below in Figure A8-1:

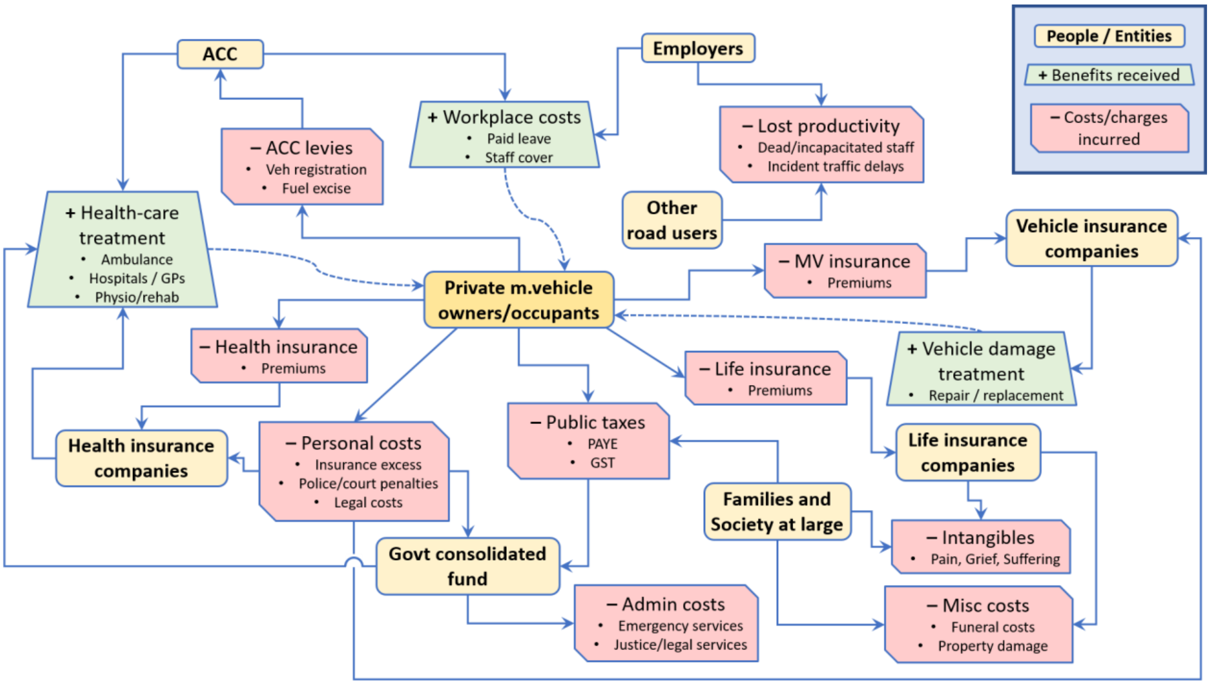

Figure A8-1 Revised costs/charges flow relationships for NZ (private motor vehicles)

Some of these costs and charges are essentially "internalised" by the road user (i.e. they or their families have to "pay" for them directly, which may affect their safety behaviour) while others are external to the road user and are typically borne by other parties or society in general (e.g. through general taxation). The various components are summarised briefly in the following sub-sections, together with a consideration of their relative financial scale (where easily measurable) and inherent internal or external nature.

A8.1 Costs and charges incurred by private vehicle owners / occupants

Costs borne by family and friends of a person involved in a road accident (e.g. grief and suffering) are often considered to also be internalised, on the basis that no-one generally wants to see their loved ones suffer on their account.

A8.1.1 ACC levies

As detailed in Chapter 4.3 and DTCC Working Paper C4 (Paling 2020), motor vehicle owners pay vehicle licence (or registration) fees, those with petrol-powered vehicles pay petrol levies, and motorcycle owners pay a motorcycle safety levy; the ACC components of these levies go into the Motor Vehicle Account, which funds health-care treatment and lost income compensation resulting from motor vehicle accidents. In recent years, typically ~$450 million is paid annually into the ACC MV Account by road users, although the amount paid out lately has often been slightly higher.

In any given year, the large majority of private motor vehicle users will not be involved in a road accident, and therefore will not directly benefit from paying the ACC levies. However, those that do suffer injury (and, possibly the family of those who die) from a road accident will receive significantly more in compensation than they had paid in levies.

ACC levies are considered **external** costs. While everyone contributes in some way, there is less of a direct link with any resulting expenditure for the benefit of a particular road user (as it is a "no fault" compensation scheme, unlike private insurance), so these costs are not likely to be internalised.

A8.1.2 Health insurance

Private motor vehicle users may opt to have private health insurance which involves payments of regular premiums and can cover treatment for a range of health-related issues. In general, ACC will cover the majority of health-care costs relating to road accidents, but in some cases, health insurance may cover certain treatments not normally funded or allow for quicker treatment.

Roughly 1.4 million people in NZ are covered by private health insurance, paying ~$1500 million annually in premiums[24]. In general, the premiums paid for private health-care are more likely to go towards funding care for issues not related to road accidents, so it is likely that the portion related to road accidents is relatively small. As for all insurance schemes, health insurance policies are structured such that some individual policy holders will pay more in premiums than they ever receive from claims, whereas others will receive more than the sum of what they've paid.

Health insurance premiums could be considered **internal** costs; the policy holder is the direct beneficiary and may have to meet certain pre-conditions to access the insurance. However, for many treatment benefits of health insurance, they are automatically covered in a similar manner to ACC treatment costs and so people may not change their risk behaviour, viewing them as **external** costs.

A8.1.3 Life insurance

Life insurance (and associated insurance for major injury) can cover payments to next-of-kin in the event of death of the policy holder, as well as cover for trauma, replacement income, permanent or temporary disability, medical costs, or debt payment; all of which could arise from road accidents.

Approximately $2700 million is received annually in life insurance and associated premiums in New Zealand[25], with ~$1400 million being paid out to claimants. Based on the National Injury Query System (NIQS) database, it is estimated that about 14% of accidental deaths and 7% of serious accidental injuries are due to road accidents; this translates to ~$140 million paid out per annum for claims related to road accident death and injury. As for all insurance schemes, life insurance policies are structured such that some individual policy holders will pay more in premiums than they ever receive from claims, whereas others will receive more than the sum of what they've paid.

[24] Health Funds Association of NZ – www.healthfunds.org.nz

[25] Financial Services Council of NZ – www.fsc.org.nz

Life insurance premiums are considered **internal** costs; the policy holder may have to meet certain pre-conditions for the beneficiaries to access the insurance.

A8.1.4 Motor vehicle insurance

Motor vehicle insurance in New Zealand is optional. Some people opt not to insure their own vehicle but to purchase “third-party insurance” that will cover damage they incur to other people’s vehicles. Since ACC provides no-fault cover for accidental injuries, it is generally not necessary for vehicle insurance policies in New Zealand to cover injuries caused to oneself or others injured in a road accident. In New Zealand, ~$2100 million is paid in motor vehicle insurance premiums annually[26]. As for all insurance schemes, vehicle insurance policies are structured such that some individual policy holders will pay more in premiums than the ever receive from claims, whereas others will receive more than the sum of what they’ve paid.

In 2009, the Ministry of Transport considered introducing compulsory third-party insurance in New Zealand (MoT, 2009b). It was found that only 7.6 % of vehicle owners were either uninsured or did not know if their vehicle was insured; this was considered to be a low proportion and comparable to the rate of uninsured vehicles in countries that do have compulsory motor vehicle insurance schemes. While insurance providers might be expected to benefit from such a requirement, they have generally opposed the proposition, suggesting there would be additional costs to the system to regulate and enforce the requirement and higher overall costs for everyone because insurance providers would no longer have the option of choosing not to cover higher-risk individuals (Heath, 2019).

As well as vehicle value, motor vehicles typically have different premiums based on the relative perceived “risk” of the vehicle and its drivers, e.g. turbo-charged vehicles or younger drivers usually attract a higher premium. People who lose their no-claims bonus for motor vehicle insurance because of an accident will incur greater premiums in the future. Certain actions and violations (e.g. drink-driving) may also void any pay-out.

All of the above factors may influence somewhat the relative behaviour of people when driving. Therefore, motor vehicle insurance premiums are considered **internal** costs.

A8.1.5 Public taxes and other Government levies/charges

Individuals (regardless of vehicle ownership or use) pay taxes on income they earn and goods or services they purchase (including fuel levies and road user charges for transport). These go into the government’s consolidated fund, which contributes to government spending in transportation and safety through various channels, primarily the National Land Transport Fund, as well as funding to District Health Boards for healthcare services, emergency service providers, legal systems etc. For the 2018/19 financial year, over $86,000 million was received by the Government from tax revenue, with expenditure areas including ~$18,000 million in health, ~$9,000 million in transport and ~$5,000 million in law and order. A reasonable portion of the transport component is paid for from fuel levies and road user charges, with only some of it being funded by other general taxation.

[26] Insurance Council of NZ – www.icnz.org.nz

Public taxes are considered **external** costs. While everyone contributes in some way, there is less of a direct link with any resulting expenditure for the benefit of a particular road user, so these costs are not likely to be internalised.

A8.1.6 Personal costs

Despite the coverage of ACC and personal insurance policies, individuals involved in an accident are still likely to incur personal costs, especially if they are at fault. Most people have an excess on their motor vehicle insurance, which would be payable by them unless they can prove another party was at fault. If the person is found to have committed an infringement of traffic law, they may incur a fine, and possibly other legal costs.

If someone in a traffic accident requires an ambulance within 24 hours of the accident, ACC will cover the cost. However, if the injuries sustained in the accident cause a need for an ambulance after 24 hours, the recipient may incur a part-charge.

Individuals suffering injuries are likely to spend money on things they wouldn't have otherwise; for example, treatments in lieu of professional services or not covered by ACC (e.g. pain killers, dressings for minor wounds) or comfort / convenience items (e.g. buying takeaways so they can rest rather than have to cook, treats to cheer themselves up). There are also opportunity costs, such as having to use sick leave or annual leave that would have otherwise been used for other purposes.

Finally, individuals will suffer intangible or indirect costs, such as the psychological trauma resulting from having been involved in an accident, perhaps including feelings of guilt for their actions, grief relating to their own or someone else's injuries or death, and fear of something similar happening again. The injuries could result in practical complications or inconveniences to their daily life, and disruptions to other family members who relied on them.

As people would generally not like to find themselves in a situation where they have to suffer these costs, personal costs of this nature are considered **internal** costs.

A8.2 Costs and charges to families and society at large

A8.2.1 Intangibles

People close to those involved in road accidents may also suffer intangible effects such as the pain, grief and suffering that comes from seeing their loved one killed, injured, inconvenienced or emotionally / psychologically affected by their experience. Similarly, members of the public who directly witness the accident or hear about it through word of mouth or the media could be adversely affected. The pain, grief and suffering experienced by certain members of society can also have a negative impact on society at large. As noted in the Appendix, the social willingness-to-pay to avoid such costs can be quite large; typically ~$4.5 million per fatality (with a lesser amount for permanent disability). As noted in Chapter 6.1, this equates to ~$5,100 million of intangible costs per annum.

As people generally don't like to have their close family or friends, or even other witnesses, suffering as a result of their misfortune, intangible costs of this nature are typically considered **internal** costs. As noted in Chapter 6.2, while some of these costs are imposed on third parties unfortunately involved in an accident caused by someone else (and hence external), overall the costs internal to road users themselves are still in the majority.

A8.2.2 Administration (and other) costs

All public and private organisations who handle funds, pay charges, receive benefits or provide services related to accident costs will have associated costs involved with administering the flow of money – in terms of the time spent by staff and the systems required to facilitate this.

Private individuals also have to spend time negotiating the system, filling in forms, speaking to those delegated to help them, attending appointments, undertaking personal rehabilitation etc. Funeral costs for people killed in road accidents may be covered (or partly so) by their private insurance or other financial assistance systems.

Many of these administrative costs are already captured by some of the previously discussed levies, premiums and taxes. However, it is likely that some are still not covered by direct charges (e.g. relating to insurance cover, court costs, etc) and thus need to be funded from other sources. Therefore this category will be a mix of **internal and external** costs.

Damage to private property inside or outside the motor vehicle(s) involved in the accident may not be covered through insurance and costs could be incurred by the property owner, vehicle owner, or driver. It may be difficult to prove the true replacement value of the damaged property. Because this damage is often at a cost to third parties not related to the road user, it could be considered an **external** cost

A8.2.3 Cost to employers of sick leave / lost productivity

Employers budget to pay employees for their leave entitlements (including sick leave, bereavement leave, and annual leave. But when an accident occurs and an employee needs to take leave without warning, and possibly for a significant amount of time, the employer may struggle to adequately cover the absent employee's work responsibilities. This could result in loss of productivity, failure to meet key deadlines (which could incur financial penalties, or simply missing out on intended revenue for that period), additional expenses from trying to find a suitable replacement at short notice or pay other staff overtime to cover the shortfall. If the employee was injured while working there could be additional monetary and time costs associated with investigations into the accident, repairs to a damaged company vehicle, and potentially health and safety penalties imposed if the company was found to be at fault in some way.

Such costs may be difficult to quantify or link directly to the road accident. Because the affected employee does not typically have to pay directly for these costs, they are generally considered **external** costs.

A8.3 Summary of social cost components

Taking the above discussion into consideration, a breakdown can be identified of costs and charges comprising the various accident social cost components listed in Chapter 2.1. Table A8.1 provides this summary; note that some items may contribute to multiple social cost components.

Table A8.1 Identification of costs and charges associated with components for road accidents

Social Cost Component	Costs and charges that contribute to this component	Internal/ External Cost?
Loss of life/permanent disability	Predominantly this covers pain, grief and suffering to victims and their family and friends, which is unfunded. However, there are some lesser costs associated with healthcare treatment and workplace costs – these are typically covered by a combination of life insurance, ACC levies (partially), public taxes, and various personal and administration costs	Mostly Internal
Loss of output (temporary disability)	The main costs here are associated with healthcare treatment and workplace costs – these are partly funded by ACC levies and healthcare insurance as well as some costs to employers of sick leave & lost productivity	External
Medical Costs	Healthcare treatment costs here are largely funded by ACC levies and some healthcare insurance, together with public taxes and some personal costs	Mostly External
Legal and court	Judicial and legal services are mostly funded by personal and administration costs, together with public taxes	Mostly Internal
Vehicle damage	Repairs to vehicles are largely covered by vehicle insurance, together with some personal costs	Internal

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