Social Cost of Road Crashes

Report for the Bureau of Infrastructure and Transport Research Economics

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At a glance

- The social cost of road crashes was estimated to have a range of between $22.2 and $30.3 billion, with a base case estimate of $27.0 billion annually between the years 2016-2020 derived using a Hybrid Human Capital approach.
- The $27.0 billion estimate was an increase of 12 per cent in real terms compared to 2006, the year of the last Australian costing study (Bureau of Transport Economics 2009).
- The total social cost of road crashes increases by $600 million or 2 per cent to $27.6 billion if a Willingness to Pay Approach is used instead of a hybrid human capital approach.
- Fatal crashes cost society an estimated $3.5 billion, injury crashes an estimated $11.8 billion and property damage only crashes an estimated $11.7 billion.
- Workplace and household losses and pain, grief and suffering costs (human losses) were 32 per cent of the cost of road crashes.
- There were an estimated 965,700 annual road crashes between 2016 and 2020 involving approximately 1.7 million vehicles, an increase of 48 per cent compared with the estimated 653,900 crashes involving approximately 1.2 million vehicles in 2006.
- 1,187 people died on average per annum as a result of road crashes between the years 2016-2020, a 26 per cent reduction from 1,602 people in 2006.
- An estimated 38,800 people injured in road crashes were admitted to hospital, 24 per cent up from 31,204 in 2006. We estimated that there were an additional 96,000 people treated for road crash injuries in 2020 who were not admitted to hospital, a 56 per cent reduction compared to 216,500 in 2006.
- We estimated that 3,819 people suffered a disability as a result of road crashes in 2020, down 17 per cent from an estimated 4,619 in 2006.
- Estimated social losses were approximately $2.9 million per fatality, losses for a hospitalised injury were approximately $241,100 per injury (including disability-related costs), and losses for non-hospitalised injury were approximately $26,000 per injury.
- Estimated lifetime losses from a person suffering a profound or severe impairment following a severe road injury were $4.1 million and losses due to a severe injury with moderate impairment were $1.1 million.
- Costs that significantly decreased compared to 2006 (in 2020 dollars) were: pain, grief and suffering (-$1.4 billion) and disability related costs (-$1.0 billion).
- Costs that significantly increased compared to 2006 (in 2020 dollars) were: repair costs (+$4.8 billion) and medical related costs (+$1.1 billion).
- The estimated average cost of a fatal crash was $3.2 million between the years 2016-2020. The average cost of a hospitalised injury crash was approximately $261,000 and the cost of a non-hospitalised injury crash was approximately $30,400. The cost of a property damage-only crash was $13,800.

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Foreword

Road crashes impose large human and financial costs on society, and substantial investments are made in infrastructure and safety programs to reduce road trauma.

The cost of road crashes is important in the safety debate in Australia, and the economic cost of road crashes informs road safety policy and road infrastructure investment decisions, particularly values for a fatality, injury and a fatal crash, which are key inputs into policy development and benefit-cost analysis for road safety programs and infrastructure programs.

The Bureau of Infrastructure and Transport Research Economics (BITRE) engaged the Australian National University (ANU) to undertake this update of the economic cost of road crashes. The objective of this project was to go beyond the scope of the last BITRE estimate (BITRE 2009) by including financial analysis to detail the financial burden of road crashes, and who bears that burden, and aid in the answering of key policy questions. As well as this report, the ANU team produced a spreadsheet model to allow BITRE to produce future updates of the social costs of road crashes.

The principle method used in valuing human costs in this report is the hybrid human capital approach, the same approach used by BITRE (2009). A national willingness to pay study for Australia is currently being undertaken by Austroads, and BITRE intends to use the results of this Austroads study to produce robust national willingness to pay estimates of the social cost of Australian road crashes.

The ANU research team members include Emily Lancsar, Ralf Steinhauser, Siobhan Bourke, Robert Breunig, Russell Gruen, Leo Dobes, Liza Munira, Liliana Bulfone, Kathryn Glass, Cameron Gordon, and Jolene Cox.

The BITRE team was Tim Risbey and Dr Gary Dolman, with key contributions from Dr Mark Harvey, Leo Soames and Simon O'Mahony, and Neil Thompson from the Office of Road Safety.

BITRE greatly appreciated the assistance of stakeholders who provided data, participated in the two project workshops, and provided comments on the draft report.

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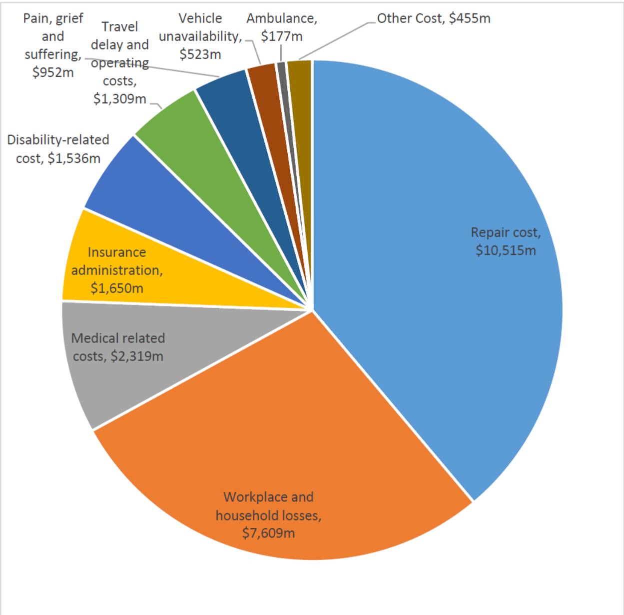
Executive Summary

The Australian National University (ANU) was engaged by the Bureau of Infrastructure and Transport Research Economics (BITRE) to develop a model to estimate the social cost of road crashes in Australia. The current study replicates and extends the previous BITRE costing study (BITRE, 2009) by using current data, improved methods and broader scope of analysis, including analysis of who bears the burden of road crashes. The current study also set out to aid in addressing three policy questions posed by BITRE by drawing on results of the costing study as well as a rapid review of relevant literature.

Best practice methods for estimating the economic cost of road crashes were adopted. Total cost of road crashes in Australia was derived in a bottom up fashion by aggregating direct costs (the opportunity cost of health and non-health resources used by crash victims as a result of a road crash), indirect costs (which account for potential productivity losses due to mortality, morbidity and informal care) and costs relating to pain, grief and suffering (which account for pain grief and suffering and lost quality of life of those injured in a crash and of those near to them for those who die in a crash). Data were collected and averaged across five years (2016–2020) to account for variation in inputs. Two approaches to valuing indirect and human costs of road crashes (or non-direct costs) were used: (a) a Hybrid Human Capital approach and (b) the Willingness to Pay (WTP) approach. Single and multivariate sensitivity analysis was used to gage the range of uncertainty in the results as well as to test key parameters (including the discount rate), assumptions and data inputs. The study benefited from engagement with key stakeholders regarding data inputs, methods and interpretation of final results.

The social cost of road crashes was an estimated $27.0 billion in 2020 (1.4 per cent of GDP) using a Hybrid Human Capital methodology. However, given uncertainty in the estimation method, the range of possible values is from $22.2 billion to $30.3 billion. Fatal crashes cost an estimated $3.5 billion, injury crashes an estimated $11.8 billion and property damage only crashes an estimated $11.7 billion. Workplace and household losses and pain, grief and suffering (human losses)[1]—were 32 per cent of the cost of crashes (**Figure 0.1**).

Figure 0.1: Social cost of road crashes by cost component (in million 2020 dollars)



[1] These two costs are sometimes referred to as human cost. The pain grief and suffering costs include both the quality of life a person would have enjoyed had they not died prematurely, and the pain, grief and suffering of relatives and friends.

The total social cost of road crashes increases by $600 million or 2 per cent to $27.6 billion if a Willingness to Pay (WTP) approach is used instead of a Hybrid Human Capital approach. The current WTP values use a general VSL and focuses on fatalities and disabilities only. A forthcoming WTP study derives road specific willingness to pay values, including values for minor injury and property damage only crashes and will be used in an up-date.

There were an estimated 966,000 road crashes in an average year between 2016 and 2020 involving approximately 1.7 million vehicles, compared with an estimated 654,000 crashes involving approximately 1.2 million vehicles in 2006, the year used in the last Australian Costing Study (published in the 2009 report - Bureau of Transport Economics 2009). Between 2016 and 2020 an average of 1,187 people died each year as a result of crashes, down from 1,602 people in 2006.

Table 0.1: Estimated number of road crashes by level of severity

Level of severity (of worst injury in crash)	Total	Proportion of all crashes (per cent)
Fatal	1,096	0.1
Hospitalised injury	33,103	3.4
Non-hospitalised injury	81,909	8.5
Property damage only	849,567	88.0
Total	**965,676**	**100**

The estimated average social cost for a crash involving at least one fatality is $3.2 million, for hospitalised injury crashes the cost is $261,000 per crash and for a non-hospitalised injury crash the social cost is $30,400 per crash. The typical property only crash cost society an estimated $13,800 per crash.

The number of estimated crashes has increased at a faster rate than population (growing at 48 and 25 per cent respectively) while the number of fatalities has fallen by 26 per cent since 2006. The increase in total crash numbers is entirely driven by a larger estimate for the number property damage only crashes. Per population, property damage only crash numbers increased by 56 per cent, whereas fatal crashes fell by 40 per cent, hospitalised injury crash per capita increased by 4 per cent and non-hospital injury crashes went down by 65 per cent.

Between 2016–2020, 39,000 people were admitted to hospital each year, and we estimated that a further 96,000 people who were injured in road crashes saw a general practitioner or were treated at the emergency department but not admitted to hospital. The hospitalised injury rate has increased since 2006, faster than population growth.

The estimated social cost from a road fatality was $2.9 million. Losses from a hospitalised injury were approximately $241,100 (including disability-related costs) and a non-hospitalised injury cost an estimated $26,000. A property only crash was estimated to cost $7 800.

We estimated that 3,819 (10 per cent) of the 38,800 people hospitalised due to road crash injuries suffered a disability, of which 1,098 people (3 per cent of people hospitalised) had severe or profound limitation. Estimated losses from a person suffering a profound or severe impairment were $4.2 million. Losses due to a moderate/mild impairment were $1.1 million.

Major costs were vehicle repair costs ($10.5 billion), workplace and household losses ($7.6 billion), and medical-related costs ($2.3 billion). **Table 0.2** provides an overview of the major cost components.

Table 0.2: Major cost components of social cost of road crashes in Australia, (in million 2020 dollars)

Cost Component	Fatalities	Injuries	Property damage only	All Crashes	Proportion (per cent)
Repair cost	$13	$1,211	$9,292	$10,515	38.9
Workplace and household losses	$2,856	$4,753	na	$7,609	28.1
Medical related costs	$19	$2,299	$0	$2,319	8.6
Insurance administration	$30	$691	$928	$1,650	6.1
Disability-related cost	na	$1,536	na	$1,536	5.7
Travel delay and operating costs	$19	$320	$969	$1,309	4.8
Pain, grief and suffering	$444	$507	na	$952	3.5
Vehicle unavailability	$1	$107	$415	$523	1.9
Ambulance	$6	$171	$0	$177	0.7
Other Cost	$89	$246	$120	$455	1.7
Total	**$3,479**	**$11,844**	**$11,730**	**$27,043**	**100.0**

Crash cost estimates are sensitive to the following factors:

- the approach to valuing losses due to death or injury (human capital approach or willingness to pay approach).
- the values assumed for key parameters such as the social discount rate. We used a social discount rate of 3 per cent in the base case in this study, consistent with its previous transport safety costing studies (BITRE 2009) and the literature.
- the way we estimate the number of property damage only crash numbers.

An analysis of the sensitivity of total crash costs to key factors suggests that:

- The unit cost of human and related losses of a road fatality—derived using the hybrid human capital approach—is estimated to be $2.4 million. Depending on the willingness to pay (WTP) approach used instead, the value of a fatality is between 106 and 224 per cent higher. Which shows that WTP methods put a much higher value on a loss of life compared to the Hybrid Human Capital approach. We found the reverse to be true for severe injuries resulting in disabilities, WTP values were 35 to 63 per cent lower.
- A lower social discount rate of 2 per cent would have increased total crash costs by approximately $1.7 billion (6.3 per cent increase in total cost).
- A higher social discount rate of 5 per cent rate would have decreased total crash costs by approximately $2.2 billion (8.1 per cent decrease in total cost).
- There is significant uncertainty with respect to the estimated number of vehicles involved in property damage only crashes. Our modelling indicates that an alternative bottom-up approach to estimation would have decreased vehicle related costs by $2.6 billion (9.6 per cent decrease in total costs).

The estimated $27.1 billion in 2020 was a real increase of 12 per cent compared to 2006 estimates (Bureau of Transport Economics 2009).

Factors contributing to the change in crash costs between this study and the last BITRE cost study include:

- increase in the incidence of property damage only crashes

- increase in the unit cost of vehicle repair
- decreased insurance administration costs for compulsory third party and vehicle damage insurance, offset in part by increasing numbers of registered vehicles
- increases in the real cost of hospital and emergency services, vehicle unavailability and repair cost
- reduced numbers of road fatalities and lower disability cases likely due to effective safety and infrastructure programs, and better vehicle technology
- reduced estimate for the number of non-hospitalised injuries
- changes to the disability costing methodology compared to the approach used in 2006 and lower statutory insurance values for impairments reducing the pain, grief and suffering costs
- Improved data sources for a variety of cost and other parameter inputs

Costs that significantly decreased compared to 2006 (in 2020 dollars) were and pain, grief and suffering (-$1.4 billion) and disability related costs (-$1.0 billion).

Compared to calculations using the methodology for pain, grief and suffering from the previous BITRE study, there was a 60 per cent reduced estimate for this cost component. Statutory values from the transport insurance scheme in some jurisdictions have not increased in line with inflation, which includes the TAC data used in this study, however increased support is provided through hospital and disability services. There are also fewer 24 per cent lower road fatalities and 17 per cent less injuries causing permanent disability.

The change in disability costs reflects better data, in particular the availability of the Australian Trauma Registry data[2] and specific claims data from Victoria's Transport Accident Commission as well as a more detailed methodology. We estimated that 17 per cent less suffer a road crash-related disability for profound, severe and moderate levels of impairment, leading to a 39 per cent lower estimate for this cost component.

Costs that significantly increased compared to 2006 (in 2020 dollars) were: repair cost (+$4.8 billion) and medical related costs (+$1.1 billion).

Repair cost has increased by more than inflation over the period since the last report. Car repairs have gone up 30 per cent in real terms, motorcyclist even more by 61 per cent. We also estimated 41 per cent more vehicles involved in crashes. Both leading to 84 per cent higher cost of vehicle repairs.

The increase in medical related costs since the BITRE 2009 report is due to better data. We used detailed claims data from the Transport Accident Commission Victoria, to measure average cost for hospital and other medical and paramedical cost. This leads to a doubling of medical related cost, despite a reduction in the estimated number of non-hospitalised patients of 56 per cent.

Road crashes impose large human and financial costs on society. The results in this report quantify such costs and provide valuable input to future cost benefit analysis of safety programs and infrastructure projects.

[2] For the 2009 report the ATR data did not exist and hence the number of injury cases which resulted in severe and profound disability had to estimate differently.

Chapter 1. Introduction

1.1. The social cost of road crashes in Australia: Study overview

The Australian National University (ANU)[3] was engaged by the Bureau of Infrastructure and Transport Research Economics (BITRE) to develop a model to estimate the social cost of road crashes in Australia.

Information on the social costs of road crashes is important for evidence-based policy making. It is required as an important input in cost-benefit analyses (CBA) that are used to estimate the social return of investments in road infrastructure and road safety, and to help in setting priorities in this area.

Previous research by BITRE estimated the cost of road crashes to society to be AUD$17.85 billion, approximately 1.7 per cent of the Australian Gross Domestic Product (GDP) in 2006 (BITRE, 2009).

The current study replicates and extends the previous BITRE study. The study aimed to use current data, improved methods. include a wider source of economic costs and move beyond the scope of the previous economic cost model by including an analysis of the resource burden of road crashes—to assess who bears the burden of road crashes. The current study also sets out to extend the economic analysis to aid in addressing three key policy questions posed by BITRE:

Policy Question 1	Policy Question 2	Policy Question 3
Which type of crash has the highest social cost?	Does the cost of crashes warrant more being spent on crash prevention?	How does the benefit of road safety investments compare with other health investments?

The proposed economic cost model in this study allows the identification of which types of crashes have the highest social burden (Policy Question 1) via the estimated cost by type of crash.

Results from the cost model provide insights into issues relating to Policy Questions 2 and 3. However, addressing these policy questions robustly requires not only information on the costs of road crashes, but also a comparison of additional social costs and social benefits of investment in crash prevention. Indeed, the unit values from the final cost model could be used as key inputs to help answer these questions, including as an input to CBA for future investment in safety.

Given information on cost alone does not allow policy makers to answer Policy Questions 2 and 3, we have undertaken a rapid review of the literature focusing on empirical studies which have been designed to address these questions. From this rapid review, we have synthesised existing evidence on these important policy questions including what has been done, what we know and remaining gaps. In addition, we also comment on the methodological approach needed to undertake future empirical analysis to robustly address these policy questions in an Australian context.

Best practice methods for estimating the economic cost of road crashes both nationally (Australian Transport Assessment and Planning, 2021b) and internationally (HM Treasury, 2018; Maria Rivera Castiñeira, 2016) are adopted. The study includes direct costs, indirect costs, and the human cost of road crashes. Non-direct costs are estimated using both the Human Capital and Willingness to Pay methods. Appropriate values for a range of parameters that can significantly affect the cost results, including the discount rate, are explored in

[3] The ANU research team members include Emily Lancsar, Ralf Steinhauser, Siobhan Bourke, Robert Breunig, Russell Gruen, Leo Dobes, Liza Munira, Liliana Bulfone, Kathryn Glass, Cameron Gordon, and Jolene Cox.

sensitivity analyses. Policy implications, including those surrounding societal costs, are explored. The research team engaged with stakeholders regarding data inputs, methods and the final results.

The **main outputs** from this study delivered to BITRE include:

1. Scoping/methods paper for consultation.
2. Stakeholder engagement workshops.
3. Economic cost model.
4. A draft and final, publishable research report on the updated economic cost of road crashes broken down by (a) type of crash and (b) who bears the cost burden in Australia.
5. Handover document to BITRE to guide and enable BITRE staff to update key parameters and outputs at regular intervals.

In addition, we have:

6. Undertaken a rapid review of the literature to provide insights into two of the three policy questions posed by BITRE:
    - Does the cost of crashes warrant more being spent on crash prevention?
    - How do the benefits of road safety investments compare with other health investments?
7. Highlighted strengths and weaknesses of currently available data that can help identify additional data that BITRE might seek to gather in the future.
8. Identified gaps in knowledge that can inform BITRE's future research agenda.

1.2. Road crash and injury definitions

The report uses the definitions described in **Box 1.1**.

A **road crash** is a crash reported to police resulting from the movement of at least one road vehicle on a public road and involving the death or injury of any person or property damage, that is not the result of a pre-meditated act. A road crash includes collision and non-collision crashes (BITRE, 2021).

A **road death**—also referred to as **fatality**—is when a person dies within 30 days as a result of injuries sustained in a road crash. A road death excludes deaths from suicide or natural causes such as a heart attack (BITRE, 2021).

A **serious injury**—also referred to as **hospitalised injury**—is when a person involved in a road crash requires medical treatment for injuries sustained in the crash and is confirmed as being admitted to hospital, irrespective of the length of stay, who does not die from their injuries within 30 days (BITRE, 2021). Alternatively, if available, a Maximum Abbreviated Injury Scale (MAIS) of 1 or 2.

A **severe injury**—also referred to as **hospitalised injury MAIS3+**— is when a person is admitted to hospital, and they meet the criteria of inclusion on the Australian New Zealand Trauma Registry of an Injury Severity Score (ISS) > 12 or death after injury (Australian New Zealand Trauma Registry, 2021). Alternatively, if available, a MAIS of 3 or more.

A **minor injury** —also referred to as **non-hospitalised injury**—is when a person involved in a road crash requires medical treatment for injuries sustained in the crash but is not admitted to hospital. This can be treatment at the emergency department or at the local GP.

Property damage only crash is a crash where no person involved required any medical treatment.

A **long-term impairment** is when a person's injuries due to road crashes has lasted or is likely to last for six

Box 1.1: Report definitions

1.3. Structure of this report

This report contains 10 chapters:

- **Chapter 1** provides an overview of this study and the outputs.
- **Chapter 2** details the methods used in this study.
- **Chapter 3** presents the social costs of road crash fatalities.
- **Chapter 4** presents the social costs of injuries due to road crashes.
- **Chapter 5** presents costs of property damage only crashes.
- **Chapter 6** presents other costs relating to road crashes.
- **Chapter 7** presents the total economic and social costs of road crashes derived under the Hybrid Human Capital approach.
- **Chapter 8** presents results using the willingness to pay approach.
- **Chapter 9** tests the sensitivity of the results through multivariate sensitivity analyses and summarises the univariate sensitivity analyses presented in the preceding results chapters.
- Finally, **Chapter 10** discusses the results, limitations, and areas for future research.

Chapter 2. Methods

This chapter outlines the approach used to calculate the social cost of road crashes, the identification of the types of costs, the cost model, and the incidence of road crashes.

2.1. Approach used to calculate the social cost of road crashes

Two approaches can be used to calculate the social cost of road crashes—a bottom-up approach or a top-down approach. As described in the previous BITRE report (BITRE, 2021a), in a bottom-up approach, cost elements are assigned a cost and then aggregated to estimate the actual cost to the nation. Conversely, in a top-down approach, all costs incurred at the organisational levels are assembled, and then apportioned subjectively to various services to those injured.

In this report, a bottom-up approach was used to (a) estimate the cost of road crashes (including estimation by cost categories), (b) explore further disaggregation of costs by remoteness and crash type (including head-on, run-off-road etc.) and (c) identify who bears the cost burden (e.g., government or individuals).

Our bottom-up costing approach included (1) identifying cost types, (2) quantifying resources used and (3) valuing them in a disaggregated way, so that each cost element is estimated individually (Byford et al., 2000; Commonwealth of Australia, 2006). To the research team's best ability, and dependent on data availability, we endeavored to produce a model that is flexible and adaptable to future conditions.

2.2. Identification of the types of costs

There were three types of costs, and they were identified as:

- <u>Direct costs</u> measured the opportunity cost of resources used by crash victims as a result of a road crash. Direct costs can be both health-related (e.g., medication, hospitalisation, outpatient consultations, ambulance, rehabilitation, coronial costs etc.) and non-health related (e.g., transport to medical appointments, cost of emergency services, cost of vehicle unavailability (care hire costs), vehicle repairs, cost of repairing damaged property etc.). Data were collected and averaged across five years (2016–2020) to account for variation around inputs.
- <u>Indirect costs</u> accounted for potential productivity losses resulting from road crashes, including productivity losses arising from morbidity, mortality and the time used to provide patients with informal care.
- <u>Costs relating to pain, grief and suffering</u> accounted for pain, grief, and suffering and quality of life of crash victims and those near them (relatives, friends, society). We used the previous report definition of pain, grief and suffering and quality of life (BITRE 2009).

The aggregation of the three types of costs (i.e., direct costs, indirect costs, and costs relating to pain, grief and suffering) provided an estimate of the total economic cost burden of road crashes in Australia. **Equation 1** below outlines the aggregation of the three types of cost.

Equation 1: Cost of road crashes

$$Cost\ of\ Road\ Crashes$$

$$Directcosts + Indirectcosts + Costsofpain, grief\ \&\ suffering$$

$$Medicalcosts + nonmedical\ costs + mortality\ cost + morbidity\ costs + costsof\ in\ formalcare \\ + quality\ of\ life\ \&\ pain, grief\ \&\ suffering$$

(Maria Rivera Castiñeira, 2016)

BITRE has previously identified 18 different cost components across the three different types of costs described above (i.e., across direct, indirect, and human costs). We were aware of the potential for double counting in costing studies and followed best practice with respect to separability and aggregation of costs to eliminate double counting in the cost model.

2.3. Cost model

The cost model in this study is consistent with the model from the previous BITRE report (BITRE, 2009).

First, we estimated and reported costs separately for:

1. Fatal road crashes
2. Road crash injuries, including post-incidence costs (cost following major and minor injuries and long-term care cost)
3. Vehicle-related costs (repair, towing, cost of vehicle unavailability)
4. Other costs (including travel delays, air pollution, insurance administration etc.)

Second, we explored further disaggregation of costs by crash type, road user category and remoteness area:

1. Head-on and side-on crashes, etc.
2. Road crashes involving pedestrians, cyclists, and motorbikes, etc.
3. Major cities[4] versus outside major cities

Finally, we identified the cost burden by stakeholder type:

1. Commonwealth and State government
2. Crash victims and their families or all road users

Results from the cost model (e.g., by type of crash, type of stakeholder etc.) have the potential to feed into and provide additional functionality to BITRE's various dashboards (e.g., serious injuries from road crashes dashboard) and generally enhance the usefulness of the BITRE data resources.

2.4. Incidence of road crashes and severity estimation

The cost of road crashes required estimates of the number of people and vehicles involved in the crash, the severity of each person's injuries, their age and gender, remoteness, mode of transport, and crash cause. The most important data source for these estimates is the National Crash Database (NCD) which contains records for casualty crashes as reported by State and Territory Transport agencies to BITRE.

The NCD however does not capture fully the true incidence of all road crashes, as it is only comprised of police-reported crashes. Hence, for a true and exhaustive number of incidences, we used data from the following sources: data on serious injury due to land transports in hospital from Australian Institute of Health and Welfare (AIHW); data on hospital release and injury severity from the Australia New Zealand Trauma Registry (ATR); data on injury classification from Victoria's Transport Accident Commission (TAC); data from insurers; and findings from studies in the literature.

2.4.1. Fatal crashes

The number of fatal crashes and injuries can be determined solely by using the incidence from the NCD. Fatal crashes always have police in attendance and are well-documented.

[4] We follow the remoteness categories in the NCD. This uses the ABS Remoteness Area category of "*Major cities of Australia*" which includes all capital cities in Australia apart from Darwin and Hobart.

2.4.2. Hospitalised injuries

The incidence of hospitalised injuries that result from road crashes was derived from the NCD in conjunction with data from AIHW. To determine the number of people among the hospitalised who have the most severe injury score and those that also suffer a lasting disability, we used data from the TAC and the ATR.

The AIHW produces a detailed annual summary of all hospitalised injuries caused by land transport, including the place of occurrence. Comparing this data over the period 2016 to 2018 with the number of hospitalised crashes in the NCD, we derived a factor of 1.84.[5] This means that the data using hospital records reports 84% more injuries from road crashes than what we find in the NCD. We use this factor to calculate the true hospitalised incidence based on the up-to-date data from the NCD.[6]

To determine the number of severely injured among the hospitalised patients, we used TAC data which include a Maximum Abbreviated Injury Scale (MAIS) classification of the severity of patients.[7] Patients with a MAIS3+ score make up 9.8 per cent of all hospitalised injuries in Victoria.[8,9] These are injuries we assume to be causing disabilities, including moderate and minor, and will lead to a noticeable time off work.

To estimate the incidence of severe injury that results in a profound or severe disability, we used data on Australian cases added to the Australia New Zealand Trauma Registry.[10] For the years 2017 to 2018, for which we also have AIHW data on total hospitalisations, we looked at the total number of patients in the ATR who were released with the indication of having incurred a lasting disability.[11] We found that this amounts to 2.8 per cent of total hospitalisations.[12] These injuries will result in a profound or severe disability with few returning to the labour market and with substantial carer cost.

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[5] The latest year of AIHW data available is 2018. We compared hospitalised cases from the NCD with road vehicle traffic crashes found by AIHW among the patients admitted to hospitals. Taking the average over 2016 to 2018, for which AIHW data is available, we get, on average, a factor of 1.80. This factor has been going up over the years. This could be the case if the AIHW is capturing more hospitalised cases associated with road crashes, or the proportion of injury crashes that are police recorded has gone down over time. We therefore used the latest year available (2018) which is also the mid-year in our 5 years NCD sample. For 2018, we found a factor of 1.84.

[6] If we are taking a most conservative approach and only count crashes where the place of occurrence is documented as crashes on streets and highways (including footpath and cycleways) in the AIHW data, we get, on average, a factor of 1.56. This factor again has the same trend over the years, such that we chose 2018 to determine the factor of 1.6. We use this as a robustness check at the end of this chapter.

[7] The Maximum Abbreviated Injury Scale (MAIS) severity score is an ordinal scale of 1 to 6 capturing how severe the injury of a patient is and how likely s/he will die. One indicates a minor injury and six indicates the maximum, an unsurvivable injury. A casualty that sustains an injury with a score of 3 or higher is classified as clinically seriously injured (MAIS3+).

[8] We derived this estimate by looking at the average MAIS3+ cases from the NCD in the years 2016 and 2017, for which we also have state-level AIHW data on total hospitalisations due to road crashes in Victoria.

[9] We get a similar estimate of 8.9% of severe injury patients using the ATR comparing the total number of patients (removing patients who die) in the ATR from 2017 to 2018 with the total hospitalisations reported by AIHW for road vehicle traffic crashes on streets and highways. We used the estimated proportion from the TAC data as we will use that data for some of the cost and hence the classification will be straightforward. Another reason is that the age groupings in the data excerpt provided by the TAC are identical to the NCD data, which allows for more accurate scaling by age.

[10] We note that the ATR records cases for 27 major trauma centres but not all centres that treat trauma and may therefore exclude a small number of MAIS3+ cases at smaller sites. The number of missing cases from the registry is said to be approximately 10 per cent (personal communication with Belinda Gabbe June 2022).

[11] More specifically, we assumed that when patients are released to either rehabilitation, residential aged care, special accommodation, hospital for convalescence or acute hospital for definitive care this indicates a severe disability, as opposed to being released home.

[12] We confirmed these findings with estimates from a population-based study by Gray and Collie (2019), which analyses the entire population of people who are absent from work for at least 5 days due to road crashes. They used workers' compensation and road traffic compensation data to look at the most complete set of reported cases. The proportion of injured people who still receive income support 3 years after the injury is 2.5 per cent. We assumed that these individuals have suffered a severe or profound disability which results in such a prolonged exit from the labour market.

2.4.3. Non-hospitalised injuries

Non-hospitalised injuries should include presentations to hospitals where the patient is not admitted as well as presentations to GPs following a road crash. The most comprehensive study on this, to our knowledge, is the study by Watson and Ozanne-Smith (1997)[13], which looked at presentations to hospitals and GPs noting the cause of injury in Victoria in 1996. Relative to police-reported hospitalised injuries, they found there are 4.34 times as many people who visit a GP or attend emergency care (but were not admitted to the hospital). Looking in more detail, this factor comprises roughly of 2.69 patients (for every hospitalisation) who attend the emergency department but are not admitted and 0.61 patients (for every hospital visit - both admitted and not admitted) who go straight to the general practitioner.[14]

As far as we are aware, Watson and Ozanne-Smith (1997) is the most comprehensive and most recent study looking at GP attendances versus hospital attendances for the Australian context. However, for part of this derived factor, we used data from Transport NSW for more recent statistics on the visits to emergency departments without being admitted to hospital. In their Road Traffic Casualty Crash statistics for 2020, we found that the ratio of injured people who attended the emergency department following a crash without being admitted relative to hospitalisations in connection with a police reported crash is 2.83:1. Adding in the additional GP visits, we got an overall multiplier for police reported crashes in the NCD of 4.55.[15] We used this factor to determine the full incidence of minor (non-hospitalised) injuries based on the NCD-reported hospitalised injuries.

2.4.4. Property damage only crashes

Property damage only (PDO) crashes are, similar to non-hospitalisations, underrepresented in the police-reported crash data. This means that property damage only crashes are hard to measure and will require an estimation. There are two approaches—a bottom-up approach and a top-down approach—to derive an estimation of the total number of crashes in this category and the total number of damaged vehicles. We applied both approaches.

The first approach involved deriving an estimate from the top-down, using insurance industry data. This approach could overestimate the number of vehicles involved in crashes as claims include off-road collisions[16]. We used APRA data for the total number of risks in force (insurance policies) in combination with data from

[13] See Table 5-2 in Watson and Ozanne-Smith (1997).

[14] We get this number by combining findings from O'Connor & KPMG Peat Marwick (1993), who studied the number of emergency department attendances in Victoria around the same time and estimates by Day, Valuri and Ozanne-Smith (1999) on the ratio of people attending an emergency department to those going to a general practice in an urban part of Victoria. Both these studies and estimates have been used in prior BITRE reports. O'Connor & KPMG Peat Marwick (1993) report a ratio of people who attended the hospital but were not admitted following a road crash of 2.69 in metropolitan areas. Day, Valuri and Ozanne-Smith (1999) reported that for all attendees of emergency departments there are 0.83 people that go to GPs across all causes of injury, but the find that "motor vehicle occupants comprised a greater proportion of emergency department than general practice presentations" (page 18). If we now take the factor of 4.34 from Watson and Ozanne-Smith (1997), which is based on the same large-scale study, this implies that the lower proportion for vehicle injuries who see a GP is roughly 0.61:1. 4.34/2.69=1.61.

[15] From the Transport NSW data (https://roadsafety.transport.nsw.gov.au/downloads/crashstats2020.pdf), we find that the factor of police-reported attendances to admitted patients is 1.54 derived over the years 2016 to 2020. We assumed that this factor is the same for the hospitalisations which were not matched to a police report. For all states and territories, the factor is therefore 1.54*1.84=2.83. To estimate GP visits, we multiplied this number by 1.61 to arrive at all non-hospitalised injuries due to road crashes. This factor (2.83*1.61=4.55) is very close to the 4.34, which Watson and Ozanne-Smith (1997) found in their study, or rather very close to the factor found by O'Connor & KPMG Peat Marwick (1993).

[16] For example, parking lot accidents, but also accidents on fire trails and, depending on the data source used, the claim numbers might include hail and fire damage or windscreen and theft claims.

the insurance industry, including data provided by Insurance Statistics Australia (ISA)[17]. The ISA provided us with the number of policies and collision claims for the years 2017-2021[18]. We found that, on average, 11.3 per cent of policies reported a claim in a given year.[19] Taking the nationwide number of policies in place reported by APRA for the year 2020, this translated into 1,816,000 vehicles involved in road crashes. As stated above, this number is likely to be an overestimate as it includes off-road collisions. We attempted to exclude off-road crashes using data from the AIHW. Among the hospitalised injury crashes, the AIHW reports the number that take place on-road and off-road, based on the methodology introduced by Berry and Harrison (2008). Previous reports have used the overall proportion of reported major injuries (64.4 per cent in our case) that take place on roads. This overall number, however, was derived independent of the mode of transportation, resulting in a bias towards finding more off-road crashes and is not appropriate to apply as a factor to all crashes (mainly low impact car crashes).[20] To avoid this bias, we looked only at the proportion of car crash injuries taking place on roads. The average proportion of on-road crashes resulting in hospitalised injury for cars, pick-up trucks, and vans over the years 2014-2018, for which we have the AIHW data, is 93.9 per cent. Given this average proportion, we derived a top-down estimate of road crashes of 1,704,000. We used these estimates as our baseline and used the bottom-up estimates explained below as robustness check and lower bound.

The second approach involved deriving an estimate from the bottom up, by looking at the reported PDO crashes in jurisdictions where these data are available. This approach will likely underestimate the number of crashes as there will always be underreporting. We used road crash data from the ACT[21]. In the ACT, all crashes must be reported to the police.[22] Although the reporting procedure is simple and can be done online, we expected that a proportion of crashes will not be reported as people might not know or do not want to spend the small amount of money and time[23] for a very minor PDO crash. In other jurisdictions, the threshold for when to report a crash is typically much higher and we don't have PDO crash data for most jurisdictions, therefore we used the number of PDO crashes from the ACT relative to the reported casualty crash number as a bottom-up proxy for the PDO crash estimation in all jurisdictions.[24]

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[17] Insurance Statistics Australia Limited, is a collaboration of several large Australian general insurers underwriting motor insurance that compiles key indicators on insurance products performance and provides it to members and researchers to enhance management and understanding of the insurance industry.

[18] These reported claims explicitly exclude hail damage, windscreen damage and theft, but still include collisions which take place off road.

[19] We received additional industry data for which we have done the same calculation for the year 2021 and get identical claims percentages as with the ISA data which confirms and is confirmation for this key input in the estimation.

[20] Motorcyclists, for example, have a much higher proportion of off-road injury crashes with 59 per cent taking place on road. Similarly, pedal cyclists have 57 per cent of road crashes occurring on road. Another way to look at this is to note that motorcyclists, pedal cyclists, pedestrians and '*other*' make up a larger proportion of the off-road crashes than on road crashes recorded by AIHW. Motorcyclists account for 39 per cent of major injury off-road crashes vs 21 per cent of the major injury on road crashes, similarly pedal cyclists, which make up 33 per cent of the off-road major injuries compared to 8 per cent on road.

[21] This data is publicly available at https://www.data.act.gov.au/Transport/ACT-Road-Crash-Data/6jn4-m8rx.

[22] The ACT road rules state "*you must report all vehicle crashes to the police as soon as possible.*". These can be found at https://www.accesscanberra.act.gov.au/s/article/act-road-rules-tab-overview.

[23] There is a fee of $15 and it states that reporting will take 15 minutes, so some cost to the reporting party remains. See https://www.police.act.gov.au/report-and-register/request-act-policing-reports/faqs-accident-reports

[24] This assumes that the ratio of the number of casualty crashes to PDO crashes is similar in other jurisdictions. Given that the ACT is largely comprised of more urban area driving this may not be the case. Another indirect assumption here is that the proportion of injury and fatal crashes which are reported is similar across all jurisdictions (the ACT doesn't distinguish between major and minor injuries in their crash data). The latter assumption seems reasonable given the reporting requirements of injury crashes which are similar across all states and territories. The alternative top-down estimate will give us a robustness check estimate for the derived costs.

We derived the ratio of all type of casualty crashes relative to PDO crashes for the ACT to be 11.34. We used this factor to estimate the nationwide number of PDO crashes.[25] We used statistics on the number of cars involved in minor injuries crashes (1.92) from the NCD to estimate the total vehicles involved in PDO and minor injury crashes. Finally, the ratio of unreported property damage only crashes to reported car crashes was used to estimate unreported property damage only crash estimates for other vehicle types. This approach resulted in an estimation of 1,369,000 vehicles involved in all crashes of all severities, with a total number of 613,000 PDO crashes. We use these estimates in the sensitivity analysis as an alternative to the top-down approach.

2.4.5. Towing

The incidence of towing was used to determine the cost of vehicle unavailability after a crash, as well as towing costs for buses, heavy rigid trucks, and articulated trucks. Data for towing is not available in the NCD but jurisdictional data for South Australia includes a measure of towing. The table below presents the proportion of towed vehicles by type of vehicle. We applied this proportion to all fatal and major injury crashes, to the reported number of non-hospitalised injury crashes, and to the estimated PDO crashes which had one vehicle involved which needed towing.

Tasmania provides data on PDO crashes, which allows us to estimate this subset of all PDO crashes. Tasmania (similar to South Australia) is a state in which towing is the minimum requirement for PDO crash reporting[26], hence the requirement to report a PDO crash in Tasmania (similar to all other jurisdictions) is much lower than in the ACT. Based on the Tasmanian data, we calculated a ratio of all reported casualty crashes to PDO crashes of 2.7. We used this factor to derive the proportion of PDO accidents, for which we applied the towing proportions reported in the South Australian data. We assumed that the remainder of the estimated PDO crashes (83 per cent) and the unreported non-hospitalised injury crashes do not involve any towing.

Table 2.3: Proportion of vehicles towed after the accident in SA reported crashes by type of vehicle

Vehicle type	Proportion towed
Cars and light commercial vehicles	58%
Motorcyclist	56%
Buses	14%
Heavy rigid trucks	32%
Articulated trucks	38%

2.5. Valuation method

After deriving the incidence of the different crash severities, we needed to find the costs associated with each of them. This chapter discusses in detail how each cost component's value was derived. We go through every cost component in turn describing the data used, the approach used and state any assumptions that were made. While the data sources are described throughout this section, they are also summarised in **Table 2.19** in the next section.

In line with the identified cost types above, we start with direct costs before moving to indirect costs and finish with costs relating to pain, grief and suffering.

[25] Over the years 2016-2020 there were a total of 2,930 fatal and injury crashes and a total of 33,235 PDO crashes in the ACT. Using a ratio of PDO crashes to fatalities to derive a multiplier is not advisable as fatalities have gone down a lot over the years and naturally fluctuate much more over different years, especially in small jurisdictions, compared to all reported casualty crashes. The latter functions as a more stable base to determine a multiplier.

[26] In Tasmania it is by law mandatory to report a crash if and only if there is either death or injury caused, one driver does not share their details and/or "*a vehicle involved in the crash is towed or carried away*".

2.5.1. Direct costs

Most of the cost components and the largest share are direct costs. There are examples in the literature (foremost Maria Rivera Castiñeira, 2016) we used as a basis to identify every cost relevant to the social costs of road crashes.

Medical and related costs

The cost of hospital, medical and paramedical treatment for road crash fatalities and injuries were estimated using data from TAC. We used the cost of hospital and medical services from the TAC over claims that happened over the five years from 2016 through 2020. These are all adjusted to 2020 dollar values. The TAC reports past payments and the estimated present value of outstanding payments per claim. Hospital and medical costs have their own cost category. For the cost of paramedical services, we used the reported past payments and estimate the proportion of future payments based on a detailed modelling of typical payment flows[27]. The average medical related cost per fatality was estimated to be $16,400, with $39,800 for a hospitalised injury and $7,900 for a non-hospitalised injury.

Long term care costs

The cost of long-term care includes all disability-related costs following an injury. The long-term care cost for severe and serious injury road crashes was estimated using claim data from TAC and calculations based on the Disability, Aging and Carers survey 2018 published by the ABS. From the TAC data we used the cost categories of long-term care[28] for claims that happened over the last five years, adjusted to 2020 dollar values. The TAC reports past payments and the estimated present value of outstanding payments per claim. We used the reported past payments for long term care and estimate the proportion of future payments[29]. The average cost for long-term care was estimated to range from $900 for non-hospitalised injuries, $1,700 for hospitalised injuries, $4,900 for a hospitalised injury with moderate disability, up to $604,000 for profound or severe disability following a hospitalised injury. The transport accident insurance data from TAC might not capture all costs to households, such as care by family members (unpaid work) which is not compensated. In order to estimate the extra cost to the family in form of unpaid work that they put in to take care of a disabled crash victim living at home, we used the survey findings on the number of hours carers spend per week ABS (2019)[30]. For severe and profound disability these are 32.8 hours a week on average and for the severe disabilities only the average carer spends 25.1 hours per week.[31] Not all disabilities resulting from accidents will be cared for at home. Some will be in care facilities and the cost will be included in TACs claims cost data. Others might have a mobile care service come by for disabled living at home being paid for by the transport accident insurance. We don't have data on the proportion of disabled people who are mainly being cared for at home by their family. For the base case we assume that all profound disabilities following road crash injuries (54 per cent of MAIS3+ with disability) will be in care facilities and fully covered through insurance payment and the

[27] TAC groups some projected future payments together. The proportions for individual cost categories within the projected but yet unpaid costs vary over time as some costs are paid out mostly at the start (for example income and dependency payments) and some costs arise much later (such as long-term care costs). We estimated the proportion for 'long term care low severity' and 'other long-term care' base on a typical draw down of benefits separately modelled by TAC for the individual claim categories.

[28] These include the cost categories of Lifetime Care – High Severity, Attendant Care: Low Severity Claims and Long-Term Care: Other.

[29] That is for two relevant TAC cost categories of 'long term care low severity' and 'other long term care cost' we use internal TAC modelling of typical payment flows (see **Footnote 27**) to estimate the relevant proportion.

[30] Table 37.1 Primary carers, age of primary carer, by time spent caring for, and disability status of, main recipient of care–2018, estimate. https://www.abs.gov.au/statistics/health/disability/disability-ageing-and-carers-australia-summary-findings/latest-release

[31] The ABS (2019) survey presents the number of carers in three ranges, we assume as the group average the mid-range or 50 hours for the group with 40+ in order to estimate an average for hours spend caring for a profound/severe disabled person living in the household.

severely disabled (46 per cent) will be cared for at home.[32] The carer responsibility that is with the family was assumed to last for the life expectancy given the age at the time of the accident and the present value of the life time care was calculated.[33] The average cost over all MAIS3+ with a resulting disability of unpaid family care was estimated to be $647,000. For the sensitivity analysis we assume no unpaid care costs for the low case and care cost for all profound and severe for the high cost case.

Cost of emergency services

Emergency services attending crash scenes include police, ambulance, and fire services. Services were costed per incident for each accident type.

Police services

Police services can spend a significant amount of time on scene conducting investigations and interviews for crash causes, traffic management and liaising with other emergency services. The costs per crash incidence for police services were based on the total cost of post-crash response of police attendance as reported in the WA Police Force Annual Report (2021). The average cost of police attendance per crash incidence was $1,858, which was calculated by dividing the total cost by the reported number of crash attendances. In the absence of data for other jurisdictions, we assumed that these per-accident costs will be similar across jurisdictions.

Police and fire services do not respond to all crashes, even hospitalised crashes, as not all cases require police or fire services. Based on police crash attendance data, we found that police attended all fatal and severe injury crashes and additionally 9.3 per cent of injury crashes that were not-hospitalised crashes.[34] This is in line with the aim of the WA police to "*respond to serious and fatal road crashes*" given the added uncertainty if a crash with an injury will be major or minor.

Ambulance services

The costs for ambulance services was taken from the Victorian government ambulance fees for both the metropolitan emergency road ambulance ($1,284) and the regional and rural emergency road ambulance ($1,894). These costs were multiplied by the average number of injured people per crash generated from the NCD data for each injury type and by metropolitan and regional and rural emergency (see **Table 2.4**). Similar to police attendance, we do not expect an ambulance to be called to the scene of a relatively minor injury but at the same time recognise that it is hard to assess the severity of an injury from afar. Based on a recent study investigating ambulance deployment to road crashes in Perth, we assumed that on average all crashes classified as fatal or major injury, as well as 60 per cent of crashes classified as minor injury have an ambulance in attendance.[35]

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[32] For this group we use the average 25.1 hours a week of unpaid care by family members and value these by the average weekly earnings, from the ABS Nov 2021 (assuming a 38-hour week) https://www.abs.gov.au/methodologies/average-weekly-earnings-australia-methodology/nov-2021.

[33] For details on the calculation see Section 2.5.2, where we used the same methodology to derive workplace losses. The estimated present value cost of unpaid home care for a 26-39-year-old crash victim were $2.4 million.

[34] Data from Western Australia in the Australian Government services report on police attendances for the year 2020 stated that 3,246 road crashes were attended. This compared to 4,977 crashes reported in the NCD and suggested that if all fatal and major injury crashes were attended that year, only a further 50 per cent per cent of what turned out to be minor injury crashes were attended that year given the NCD incidences. The proportion of non-hospitalised injury crashes attended reduced to 9.3 per cent after accounting for injury crashes not reported in the NCD.

[35] Ceklic et al (2021) identify 14846 police registered crashes in the years 2014 to 2016 where on average 1.38 ambulances were in attendance. This matched the NCD incidence of 14,951 reported crashes with fatalities or injuries during the same period and region: https://doi-org.virtual.anu.edu.au/10.1080/10903127.2020.1771487. The proportion of minor injury crashes attended reduces to 60 per cent after accounting for injury crashes not reported in the NCD.

Table 2.4: Multipliers derived from NCD database

	Major City	Outside of major cities
Fatality	1.80	1.90
Hospitalised injury	1.38	1.44
Non-hospitalised injury	1.24	1.26

In addition, at the scene of a fatal or hospitalised injury road crash, Helicopter Emergency Medical Service (HEMS) attended the accident instead of road ambulances 27 per cent of the time, as observed in BITRE trauma registry data (Australian New Zealand Trauma Registry, 2021)[36]. The unit cost of HEMS was assumed to be a fixed rate of $11,611 (Taylor et al., 2011).

Fire service organisations and state and territory emergency service

To estimate the cost for attendance by fire and emergency response services, we used data from the Productivity Commission in form of the Australian Government services reports. We looked at averages for the total road crash rescues and hours spent over the period of 2016 to 2020.[37] The state and territory emergency service data on person hours spent on road crash rescues were used to estimate the time required for road crashes (including travel time) and attending crew size. We estimated that 8.3 person hours were spent on each road crash rescue.[38] These figures were combined with the weighted hourly wage rate of firefighters and a fire captain, with the assumption that the fire captain will assume the role of incident commander.[39] Additional loadings were applied for capital (including depreciation) and other fire services expenditure relative to labour cost. All of these were available in the service report on an annual aggregated basis and were set in proportion to the overall wage costs. We estimated that a road crash rescue by state and territory emergency service cost $1,773 per attended crash.

To estimate the rate of crash attendance, we used the Australian Government services report of total road crash rescues over the years 2016 to 2020 and found that all fatal crashes and all hospitalised injury crashes required emergency services.[40]

Cost of insurance administration

Insurers provide cover that protects individual drivers against property damage and cost of injury. Road crashes lead to additional expenses associated with administering and processing claims including underwriting costs and general administration costs (BITRE, 2009; Brotherhood of St Laurence, 2017). The cost of administering insurance for road crashes was estimated using information on the relative size of the administrative cost provided by TAC. It was assumed that the administration costs of the scheme are proportional to costs paid out on road crash claims, and that, in general, a loading of approximately 10 per

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[36] We used data from the ATR from 2017 to 2020 where the mode of transport for on-road transport related severe injuries is reported. Among these, HEMS were used 27 per cent of the time.

[37] Report on Government Services 2021, https://www.pc.gov.au/research/ongoing/report-on-government-services/2021/emergency-management/emergency-services.

[38] Data on hours spent was only available for the state and territory emergency service in the report. We assume that the time spent, and the additional cost associated with it are similar for the fire service.

[39] We obtained hourly wages estimates from NSW fees and charges, see https://www.fire.nsw.gov.au/page.php?id=9168.

[40] Report on Government Services 2021, Table 9A.8 and 9A.17, lists that over the years 2016 to 2020 across all states and territories, on average 34,000 road crash incidences were attended. Comparing this with the estimated number of fatal and serious injury road crashes over the same period we find that in addition to all fatal crashes, all hospitalised injury crashes were on average attended by fire and emergency services, but fire and emergency services attended no minor injury crashes.

cent is included as appropriate allowance for these administrative costs.[41] We used TAC claim data on the total value of claims paid out for different injury severities and fatalities. The average administrative cost for fatal crashes was $24,500, while the average administrative cost for hospitalised crashes was $14,500 and for non-hospitalised crashes $2,100. For property damage, we used the total estimated vehicle repair cost as the base to which we applied the above rule of thumb that 10 per cent was calculated for administrative cost.

Cost of repairing street furniture

The cost of damage to street furniture followed the methodology used in the previous BITRE (2009) report. In BITRE (2009), the cost of repairing and replacing street furniture was based on the proportion and type of items reported damaged. Several assumptions were made for different value assets. For items that were classified as high value assets (e.g., barriers, railing), the repair cost was assumed to be 8 per cent of the replacement value. Other items, such as street signs, were assumed to require replacement. In the absence of better data, we inflate the cost estimate by the proportional increase in the number of crashes relative to the 2009 report and by CPI. According to stakeholder feedback[42] we might starkly underestimate this cost, as it might have gone up much more steeply than CPI. Hence we undertake a sensitivity analysis where we tripled the cost.

Coronial costs

A coroner inquest is held if the manner and cause of death of people who die or who are suspected to have died in circumstances specified by legislation.[43] This includes accidental deaths, such as those in road crashes. To establish the medical cause of death, a post-mortem examination may be performed. Our calculations assumed that all deaths incurred a coronial cost, which is on average, $2,118. For non-natural causes a coronial inquest is typical and we assume this to be the case for all road crash fatalities. At the end of a normal life this is much less likely to be the case. The ABS estimates that 11.9 per cent of all death receive a coronial inquest.[44] Accordingly we assume that 11.9 per cent of road crash fatalities would have endured this additional cost at the end of their natural lives. We used the same procedure as for the burial costs to determine the cost of bringing this service forward in time due to a fatal crash and derive an average cost of $2,000 per fatality.

Funeral costs

The cost of a funeral for a premature death was calculated as the cost of a funeral at the time of premature death minus the discounted future cost of a funeral at the end of a person's normal expected life, following BITRE previous estimate. The cost of a funeral was estimated to have the median value of $11,104.

In each age category, we quantified the potential years of life lost using ABS life tables, given the median age of accidents in each group. The life tables show the average life expectancy at each age of a person. This allowed us to discount costs that happened at that point and present the funeral costs for each age group. **Table 2.5** outlines the present value cost of a funeral using a discount rate of 3 per cent.

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[41] We got a very similar insurance administration cost estimate from an industry partner to the research team (C. Lucas, personal communication, November 18, 2021).

[42] Stakeholders suggested they could provide data but were not able to in the timeframe available.

[43] ACT Magistrates Court: https://www.courts.act.gov.au/magistrates/law-and-practice/coroners-court.

[44] See https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/3303.0Explanatory%20Notes12017

Table 2.5: Life span and present value cost of funeral by age cohort and gender (in 2020 dollars)

		Expected life span		Present value of Funeral cost for natural death		Net cost for bringing funeral forward	
Age category (years)	**Median age (NCD)**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
0–4	2	80	85	$1,052	$932	$12,169	$12,290
5–16	12	70	75	$1,411	$1,249	$11,811	$11,972
17–25	21	62	66	$1,832	$1,626	$11,390	$11,596
26–39	31	52	56	$2,435	$2,175	$10,786	$11,047
40–54	47	37	40	$3,814	$3,442	$9,408	$9,780
55–64	59	26	29	$5,244	$4,791	$7,977	$8,431
65–74	69	18	20	$6,691	$6,221	$6,531	$7,001
75+	80	10	12	$8,457	$8,056	$4,765	$5,165

Legal and correctional cost

Criminal legal costs result from prosecuting individuals charged with criminal offences following road crashes. Our analysis estimated the cost of culpable driving causing death charges for fatalities only. The incidence of a legal case for culpable driving causing death charges was taken from the sentencing advisory council Victoria which reported 65 cases of sentenced for culpable driving in the past five years. This is approximately 5 per cent of all fatal accidents. Of these 65 cases, 97 per cent received a custodial sentence. Custodial sentences for culpable driving causing death charges last on average 83 months. The costs of the trial ($47,177) and prison ($391 per day) were taken from a study on the cost of imprisonment (Morgan, 2018). Prison costs were discounted with a 3 per cent discount rate. The length of time an acquitted driver spends in custody and the high daily cost of prisons imply that the total cost is very high for any driver with a custodial sentence, approximately over $1 million.

Another source of legal costs is common law litigations. In states with at-fault legal systems for road crashes (such as QLD, SA, WA, and in part TAS), there are legal costs arising from lawsuits to plaintiffs and defendants. To estimate these costs, we used data from Latham and Playford (2002) on the size of the legal cost for both parties relative to the claim size. Following BITRE (2009)'s assumption that roughly 20 per cent of claims get litigated in states with an at-fault common law component regarding road crashes (4 out of 8 states), we used TAC data to assess the proportions of claims within each claim size bracket for hospitalised injuries and fatalities.

Table 2.6 and **Table 2.7** summarise the information used to assess litigation cost.

Table 2.6: Legal cost for litigation following severe hospitalised injuries

	Cost proportion of claim size		MAIS3+ injuries		
Claim Size (upper band)	**Plaintiff legal (per cent)**	**Defendant legal (per cent)**	**Claims proportion**	**Number of claims**	**Average claim size**
$50,000	10	38	39.5	1,506	$21,654
$100,000	13	25	15.1	575	$73,295
$200,000	15	18	14.7	561	$145,535
$500,000	10	12	16.4	627	$313,687
$750,000	8	10	4.3	163	$611,076
$1,000,000	7	9	2.0	76	$863,567
$1,500,000	6	8	2.0	77	$1,215,714
$4,000,000	5	8	3.5	134	$2,383,777
$7,000,000	4	9	2.6	99	$10,271,020

Table 2.7: Legal cost for litigation following fatalities and less severe hospitalised injuries

	Fatalities			MAIS 1 or 2 injuries		
Claim Size (upper band)	**Claims proportion**	**Number of claims**	**Average claim size**	**Claims proportion**	**Number of claims**	**Average claim size**
$50,000	53.0	629	$19,467	79	27,540	$11,530
$100,000	5.0	59	$68,960	8.17	2,857	$71,140
$200,000	13.9	165	$141,172	6.4	2,238	$142,473
$500,000	16.1	191	$345,534	5.56	1,945	$308,746
$750,000	7.4	87	$607,697	0.67	234	$600,567
$1,000,000	4.2	49	$846,260	0.24	84	$852,450
$1,500,000	0.5	6	$1,037,661	0.14	49	$1,185,988
$4,000,000	-	-	-	0.08	28	$2,276,029

Vehicle repair cost

To determine the vehicle repair cost, we used data provided by Insurance Statistics Australia (ISA), data provided by National Transport Insurance (NTI) and other data provided by the insurance industry[45]. From these data we determine the average repair cost of collision claims[46] over a period of five years from 2017 through 2021. The average repair cost following a collision for passenger cars and light commercial vehicles was $5,731. This is 92 per cent higher than the repair cost for 2006 and indicates that repair costs went up more than the consumer price index over this period. The average repair cost for motorcycles was $7,748, 35 per cent higher than cars and light commercial vehicles. We used data from National Transport Insurance to estimate the average claim size for buses, heavy rigid and articulated trucks.[47] Following the 2009 report, we assumed that cars, light commercial vehicles, and motorcyclists have an excess of $500, buses and heavy rigid trucks $1,000, and articulated trucks have an excess of $2,000. The excess was included in the average claim cost reported in **Table 2.8**. The excess was relevant when determining the cost to the individual for the willingness to pay estimations.

Table 2.8: Vehicles repair cost by type of vehicle (in 2020 dollars)

Vehicle type	Repair cost per vehicle
Cars and light commercial vehicles	$5,731
Motorcyclist	$7,748
Buses	$9,070
Heavy rigid trucks	$14,063
Articulated trucks	$29,338

Vehicle unavailability cost

Vehicle unavailability costs arise when the car is in repair following an accident and the owner needs to organise an alternative mode of transport to get to work, use for planned trips, and all daily needs. These will typically be for longer periods if the damage to the car is more severe. We used the indication of towing of a vehicle as a sign of more severe damage that causes longer vehicle unavailability.

We determined the cost of vehicle unavailability using vehicle hire costs as a proxy. This approach could underestimate the actual cost since it might involve a fair amount of effort to find a hire vehicle. On the other hand, not everyone will need to organise a commercial replacement as some may share a second family car, use public transport, a bicycle, or other means, or might be able to rearrange trips and jobs around the repair time without much effort. For passenger vehicles, we collected rental cost data from comparison websites for different major cities and some regional centres across a number of vehicle hire services.[48] We found an average daily cost of short notice car rental to be $174 across major cities and $139 outside of major cities. The weighted average given the crash incidences is $165. This estimate was similar to the inflated car rental

[45] Some providers of data preferred to remain unnamed.

[46] These reported claims are collision claims only and explicitly exclude hail damage, windscreen damage, and theft, but still include collisions that take place off the road.

[47] NTI data does not include cost of catastrophic crashes and major clean-up costs in their claims data, hence the actual cost might be higher than the averages reported here.

[48] We used www.rentalcars.com to search for the cost of a multi-day rental starting the next business day in all state and territory's capital cities (except for Darwin) and several regional centres across multiple states (namely Broome, Geelong, Murwillumbah, and Townsville). The reported costs are averages over the cheapest three offerings of mid-sized cars per rental car company across all companies. The driver age provided was 30-65 years and pick up was at 10:00 am on the next business day.

cost determined in the 2009 report of $162. We inflated the rental cost provided in the previous report for other types of vehicles. **Table 2.9** below provides an overview of daily rental costs.

Table 2.9: Vehicles rental cost by type of vehicle (in 2020 dollars)

Vehicle type	Rate per day
Cars and light commercial vehicles	$165
Motorcyclist[49]	$165
Buses	$299
Heavy rigid trucks	$280
Articulated trucks	$581

Following the previous report, we assumed that towed vehicles would be unavailable for seven days and untowed vehicles would be unavailable for two days. We considered this to be the case for all police-reported crashes with casualties and for reported PDO crashes, as determined in **Section 2.4.5**. We expected the damages to be smaller for unreported minor injuries and PDO crashes, which did not include towed vehicles (as per reporting requirement). We assumed, on average, one day of vehicle unavailability for these crashes.[50]

Towing cost

The cost for towing cars and light commercial vehicles is typically covered by the insurance claims and included in the vehicle repair cost above. This is often not the case for buses, heavy rigid trucks, and articulated trucks. We used data from the National Transport Insurance (NTI) to get average towing costs for each heavy vehicle type. **Table 2.10** provides an overview of the towing costs per vehicle.

Table 2.10: Vehicles towing cost by type of vehicle (in 2020 dollars)

Vehicle type	Average towing cost
Buses	$407
Heavy rigid trucks	$1,136
Articulated trucks	$3,686

[49] Motorcycle rates are the same as for light passenger vehicles.

[50] Among these unreported crashes, there will be some with a multi-day repair and many others which will not undergo repair. The one day is an assumption that tries to acknowledge that the unavailability cost for these vehicles will not be zero on average. We note that, due to a large number of vehicles falling into the group of unreported minor injury and PDO crashes, the assumption of just one day of vehicle unavailability increases the overall costs in this category by about 50 per cent.

Road crashes include a wide range of externalities, or spillover costs, such as traffic congestion and resulting delays, additional vehicle costs, and impact on the environment.

Traffic delays

Road crashes can result in significant traffic delays, impact from lane closures, police, fire, or emergency service attendance, detours, and site clean-up. The cost of traffic congestion, which results in delays, can be estimated using wage rates and the value an individual places on their free time for the number of affected individuals.

The current study followed the methodology defined in the National Highway Traffic Safety Administration (NHTSA, 2015) model to estimate the cost of traffic delays. The unit cost of traffic delays, which is reflected by the delay impact of each vehicle affected by a crash (i.e., lost capacity), per crash type. Lost capacity (LC) was estimated by calculating the sum of the net delay impact of each individual vehicle affected by crash type, using the following equation (**Equation 2**):

Equation 2. Lost capacity

$$LC = (AAHT \times CD \times PLC \times RCL) \times Duration \times Wage\ cost\ per\ hour$$

Where each of the variables that enter in the estimation of last capacity (or traffic delay cost) is described below:

- *Average Annual Hourly Traffic* (AAHT) was derived from the annual total volume of traffic passing a roadside observation point (Annual Average Daily Traffic; AADT) divided by the number of days in that year for each road type (Highway, Arterial Road, or Local Road) in major cities or outside of major cities setting. The AADT value for highways was based on the Pacific Highway in Southeast Queensland, matching the crash duration data. The other roads were the median traffic volume for road types of arterial and local roads from Victoria's 2021 traffic volume viewer (Department of Transport Victoria, 2021). The difference between major cities and outside major cities was based on a 60 per cent reduction in traffic flow as estimated by the highway AADT difference between major cities and outside major cities. As all crashes are more likely to occur during higher-than-average traffic density, we adjusted the AAHT by the factor estimated in the American context (NHTSA, 2015, Table 3-3). The exposure adjustment is the highest for PDO crashes (a factor of 1.33) and the lowest for the most severe crashes (a factor of 1.04), as the latter tends to occur during late-night hours when traffic density is lower.
- *Crash Duration* (CD) was defined as the time from the onset of the crash until the crash is fully cleared from the road. These figures were based on Tajtehranifard et al. (2016), calculated on one year of traffic crash records from two major Australian motorways in Southeast Queensland. This factor tells us how many cars will have arrived at the accident site to be affected by the lane closure.
- *Probability of Lane Closure* (PLC) was obtained from the NHTSA estimates due to the lack of Australian-specific data. Regarding a highway crash in a major city, the estimated PLC was 92 per cent for a fatality, 56 per cent for an injury, and 36 per cent for property damage only. For a crash on the same type of road outside major cities, the estimated PLC was 90 per cent for a fatality, 55 per cent for an injury, and 29 per cent for property damage only. Estimated probabilities for all road and accident type combinations (from Chin et al., 2004) can be found in **Table 2.11**.[51]

[51] Hospitalisation and non-hospitalisation injury crashes were assumed to have the same impact on PLC and RDL, as the National Highway Traffic Safety Administration does not differentiate between different types of injuries. However, the crash duration for a crash with a severe injury has a slightly longer duration, according to Tajtehranifard et all (2016).

Table 2.11: Proportion of police-related crashes involving lane closure, by road type and crash severity (Chin et al., 2004)

Road type	Fatal	Injury	Property Damage Only
Highway (major city)	0.92	0.56	0.36
Urban Arterial	0.86	0.52	0.42
Urban Other	0.92	0.60	0.47
Rural Interstate/ Principal Arterial	0.90	0.55	0.29
Rural other	0.90	0.57	0.39

- *Reduced Capacity Lane* (RCL) percentage was obtained from the NHTSA estimate due to the lack of Australian-specific data. The blockage estimates are road type-specific and derived from Fatality Analysis Reporting System data. Assumptions were made about the lane capacity of the average urban and non-urban highway, arterial or local roads to arrive at a proportion of blocked traffic given a lane closure. The following table (**Table 2.12**) lists the percentage of blockage given a lane closure by road type.
- *Duration* accounts for the length of time an affected car is stuck in the accident. As vehicles can arrive earlier or later at the end of the traffic jam, not all vehicles have to wait for the entire length of a crash duration. A simple way to account for this is to assume that cars will arrive at an equal rate throughout the crash duration. Thus, all vehicles are stuck, on average, half of the total crash duration.

Table 2.12: Percent of blockage given a lane closure[52]

Road type	Per cent of blockage
Highway (major city)	0.62
Urban Arterial	0.76
Urban Other	0.89
Rural Interstate/ Principal Arterial	0.79
Rural other	0.97

- The *Average Hourly Wage* of employed people was based on the average hourly wage of employed people from the Australian Bureau of Statistics.[53] Differential costing was used to estimate the cost of wages lost for travel to work/non-work and leisure time. The ATAP guidelines recommend that 130 per cent of wages be used for work or paid time lost due to traffic delays and 40 per cent of hourly income for commuting and personal travel.[54,55] The breakdown of costs for work and non-work-related travel was estimated from the average travel time survey from Sydney (Transport for NSW, 2019), Melbourne (Victoria Department of Transport, 2021), Brisbane (Queensland Government, 2019) and Canberra (Transport Canberra, 2017), which find that on average 25 per cent of trips are work related.

[52] Based on NHTSA (2015), Table 3-16.

[53] ABS Average Weekly Earnings, Australia Nov 2021 https://www.abs.gov.au/methodologies/average-weekly-earnings-australia-methodology/nov-2021.

[54] Values can be found in https://www.atap.gov.au/parameter-values/road-transport/3-travel-time**Table 2.14**

[55] In the sensitivity analysis we used Gwilliam et al. (1997) recommendation, accounting for the extra cost to the employer, so that 133 per cent of wages are used for work or paid time lost due to traffic delays and 30 per cent of hourly income for commuting and personal travel. This reduces the weighted hourly wage by 11 per cent.

After estimating the unit price, the total cost of traffic delays was calculated using the following equation (**Equation 3**):

Equation 3. Total travel delay costs

$$\sum Congestion\ cost = Lost\ capacity \times incidence\ of\ crash(by\ road\ type, remoteness, \&\ crash\ severity)$$

Additional vehicle operating costs

Additional Vehicle Operating Costs (VOC) are costs associated with the additional time spent in traffic. One of the significant costs from congestion is the increase in petrol use from cars being idle and the time spent travelling at low speeds in stop-start conditions. Vehicle operating costs were costed using the methodology recommended by the Australian Transport Assessment and Planning Guidelines for VOC model. This simplified model, abstracts from different operating conditions, such as road surface and gradient, and focuses on vehicle type and speed. Separate model estimates for the model will calculate VOC for uninterrupted or free flow and stop-start or interrupted flow. The two models are presented in **Equation 4** and **Equation 5** below. The difference from these two models will be the additional operation cost per kilometre resulting from congestion. Estimates for the model were taken from the ATAP guidelines and model (Australian Transport Assessment and Planning, 2021). The typical proportion of each type of vehicle in normal traffic in the major city and outside major cities can be seen in **Table 2.13** below.[56]

Table 2.13: Proportion of each type of vehicle in normal traffic

Vehicle type	Major cities	Outside major cities
Car	0.82	0.70
Bus	0.01	0.01
Light commercial vehicles	0.12	0.20
Rigid Trucks	0.04	0.05
Articulated trucks	0.01	0.05

The additional vehicle operation cost estimates assumed a speed of 10 km/h for the interrupted flow. **Table 2.14** presents the assumed speeds of the free flowing traffic by the type of road. We took the other vehicle-specific parameters as standard values from the ATAP guidelines.[57]

Table 2.14: Assumed speeds for free flowing traffic by road type (in kilometres/hour)

	Major city			Outside major cities		
	Highway	Arterial	Local	Highway	Arterial	Local
Free flow speeds	80	60	50	100	100	60

[56] These are based on BITRE (2009)

[57] Table 35 in ATAP Guidelines PV2 – Road Parameter Values, August 2016.

The equations for the ATAP models for vehicle operating cost in free flow and stop-start traffic are:

Equation 4. VOC in stop-start traffic flow

$$VOC\ (stop - start) = \ k1 + \frac{k2}{V}$$

Equation 5. VOC in free flow

$$VOC\ (free\ flow) = \ k3 * +k4 * \mathrm{V} + k5 * V^2$$

Where:

- V = Vehicle speed in km/h assumed to be 10km/h in stop-start and road specific in free flow (see **Table 2.14**)
- $k1$ to $k5$ = model parameters specific to the type of vehicle

The *additional VOC* were then calculated as the difference of **Equation 4** and **Equation 5**. The resulting vehicle operating costs gave an estimate per distance, measured in cents per kilometre. We used the lost capacity measure derived in the travel delay cost section above[58] to determine the lost vehicles hours due to congestion following a crash. As we know the average speed, assumed to be 10km/h, we know how many kilometres are driven by all cars delayed in a given crash event.

With this information we estimated vehicle operating cost according to **Equation 6**. The estimates for vehicle operating costs were broken down by type of accident, urban metropolitan or outside urban metropolitan, and road type. This was combined with the number of cars impacted and with the crash incidence by road type.

Equation 6. Value of additional car usage

$$\sum VOC = (Cars\ impacted \times additional\ VOC \times km\ driven\ in\ the\ hour) \\ \times incidence\ of\ crash(by\ road\ type, remoteness, \&\ crash\ severity)$$

Where:

- *Cars impacted* = Lost capacity measured in lost vehicles hours (see traffic delays)
- $additional\ VOC = VOC\ (stop - start) - VOC\ (free\ flow)$ for the same distance
- $Incidence\ of crash$ = based on the NCD
- $km\ driven\ in\ the\ hours = \ given\ by\ average\ speed$

Externality cost of crash-induced pollution

Externalities like air pollution have a major impact on the environment and individuals by increasing the risk of chronic obstructive pulmonary disease (COPD), cardiovascular disease, and respiratory diseases (e.g., asthma and chronic bronchitis). Aside from air pollution being the single most significant cost component among the externalities, we also accounted for costs due to greenhouse gas emissions, water pollution, up/downstream

[58] The result from Equation 3 *before* it was multiplied by hourly wage or *LC*/wage, gave us the lost vehicles hours due to congestion following a crash.

emissions (well-to-tank emissions) and 50 per cent[59] of the noise pollution.[60] The ATAP externality parameters are in cents per kilometre. We assumed that these are proportional to free flow traffic fuel usage. To derive the additional fuel usage in stop-start traffic relative to free flow, we used **Equation 4** and **Equation 5** but this time with ATAP parameters which give the fuel usage in litre/km instead of the VOC in cents/km. The ratio of the results from **Equation 4** and **Equation 5** gave us a fuel use multiplier for stop-start vs free flow traffic.

Externality costs resulting from the increase in emission output following road crashes were calculated based on the kilometres in traffic, the fuel use multiplier calculated above, the number of cars impacted for passenger cars for highway, arterial and local roads split by rural and urban roads. The externality cost was calculated using the below equation (**Equation 7**):

Equation 7. Cost of externality

$$Externality_i = UnitCosts_{externality}\ x \text{ fuel use multiplier x } (Cars\ impacted \times km\ driven\ in\ the\ hour) \times incidence\ of\ crash(by\ road\ type, remoteness, \&\ crash\ severity)$$

Where:

- $Eternality_i$ = Externality cost per crash and road type ($)
- $UnitCosts_{externality}$ = Externality unit cost per vehicle type (c/km)
- fuel use multiplier = ratio of fuel usage according to **Equation 4** over **Equation 5** minus 1
- $Cars\ impacted$ = Lost capacity measured in lost vehicles hours (see traffic delays)
- $km\ driven\ in\ the\ hours = given\ by\ average\ speed$
- $Incidence\ of\ crash$ = based on the NCD

The per kilometre externality cost of pollution resulting from congestion after crashes was taken from the ATAP guidelines (2020) environmental impact parameters for cars.[61] We made the same assumptions about the free flow speeds as detailed in **Table 2.14**. A car caught at a random point during the crash duration will then travel half the total congestion length in expectation. The number of vehicles impacted per crash type was based on the travel delay analysis results and the crash incidence taken from the NCD.

2.5.2. Indirect costs (Hybrid Human Capital approach)

The total social cost of the burden of road crashes extends beyond the direct costs. National and international guidance suggests that social impacts should be considered as far as possible.

There are several methods to value indirect and human costs of road crashes (or non-direct costs), including (a) the Human Capital approach and (b) the Willingness to Pay (WTP) approach, which is used to derive a Value of a Statistical Life (VSL) or is also referred to as Value of a Prevented Fatality (VPF) estimate. While the WTP/VPF approach is commonly used internationally, the methodology to value non-direct costs in the Australian context is not universally agreed upon. BITRE used both approaches in their 2009 cost of road crashes in Australia report. To be consistent with national and international approaches, and as requested by BITRE, we valued indirect and human costs using both the **Hybrid Human Capital approach** and the **WTP approach**.

The Human Capital Approach measures the productivity loss (value of forgone output) due to a road crash. The method values average current earnings for individuals affected by road crashes and future unclaimed

[59] We know from Delft et al (2011) that at least 45 per cent of the noise pollution lies with the passengers and it is reasonable to assume that congestion leads at least in some situation to extra noise pollution to the local population. Delft et al (2011).

[60] More details on these costs can also be found in NSW Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives guidelines 2016 and in Table 7.1 in Austroads (2014).

[61] See tables 3.3-3.6 In ATAP Guidelines PV5 – Environmental parameter values July 2020.

earnings if the worker leaves the labour market, which can be a temporary absence or absence until retirement age if the absence is permanent. In the event of mortality or morbidity due to a temporary or permanent injury from a traffic accident, average earnings are considered to measure an individual's forgone productivity.

Workplace and household output losses following a fatality

We used the Hybrid Human Capital approach that BITRE developed for their 2009 report on the cost of road crashes. The Hybrid Human Capital approach modified the generic Human Capital Approach, incorporating a notional cost for the value for the quality of life and costs of premature death for the economically inactive (children and the elderly) to ensure that negligible or zero values are not assigned to the productivity loss. We used average earnings by gender and age to estimate the cost for a particular crash victim. We used ABS wage data[62] from 2018-2019 by age categories and by gender to estimate output losses for a particular crash victim. This allowed us to derive the present value of lifetime average wage earnings across the remaining age cohorts an individual would live through if they die at the end of their statistical life of natural causes. In each age category, we quantified the potential years of life lost using the median age of accident victims within the group and the ABS Life tables[63]. This means that, for example, males aged 80 years have an average life expectancy of 9 years and females aged 80 years have an average life expectancy of 11 years. The life expectancies for the median age in each group are listed in **Table 2.16**.

We allowed for a real income growth of 0.8 per cent, which is the average annual real per capita GDP growth for Australia over the 10 years (from 2011–2020).[64] The standard discount rate used in this report is 3 per cent. Higher and lower discount rates and a 20 years average per capita GDP growth were used in sensitivity analysis. Further, we adjusted the earnings in each age category using the labour participation rate, derived from the age specific unemployment and labour force participation rates taken from the ABS.[65] The proportion in each working-age age category that is in the labour force based on these numbers can be viewed in **Table 2.16** below.[66]

To account for the household output and volunteer work losses, in addition to the workplace output losses, we referred to the statistics of paid and unpaid work[67]. The ABS collects such data from the Census and publishes it in the Gender Indicators[68]. The statistics show that males participate in 77 per cent more hours of paid work compared with females and the reverse pattern was observed for unpaid work. The overall hours worked across paid and unpaid work are almost the same for both, with females working an extra 7 minutes a day. All time spent on paid and unpaid work by gender can be found in **Table 2.15** below. Based on these ratios, we use gender specific multipliers of the amount unpaid works relative to paid work to inflate people's earnings in the age groups 17 and above to account for unpaid household and volunteer work output losses. We accounted for the fact that income taxes, which are included in the workplace output losses, are not present when measuring individuals' opportunity cost of working in the household or doing volunteer work.

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[62] ABS Employee Income by Age and Sex by State (2014-15 to 2018-19) Table 4.1 https://www.abs.gov.au/statistics/labour/earnings-and-working-conditions/personal-income-australia/latest-release

[63] ABS Life Tables, 2018-2020 Table 1.9 https://www.abs.gov.au/statistics/people/population/life-tables/latest-release. The use of the life tables is most relevant for the oldest age group to determine the number of years lost. For simplicity, we assumed that any casualties would have lived beyond 75 years of age.

[64] Based on the World Development Indicators from the World Bank, https://data.worldbank.org/indicator/NY.GDP.PCAP.KD.ZG?end=2020&locations=AU&start=2000&view=chart

[65] Australian Bureau of Statistics, Gender Indicators, Australia, December 2020 Tables 1.14 and 1.17 https://www.abs.gov.au/statistics/people/people-and-communities/gender-indicators-australia/latest-release#economic-security.

[66] For people aged under 16 and over 65 years, we assumed no labour participation since for those age groups the income equivalent is derived based on other factors than wages.

[67] Unpaid work includes domestic activities, childcare, purchasing goods and services and voluntary work and care.

[68] ABS Gender Indicators, Australia, December 2020 Table 10.1 for people aged 15 and older. As the ABS does not report the 2011 Census version of this data on the website, we used the newest available data from the OECD cross country statistics https://stats.oecd.org/index.aspx?queryid=54757#, which should be from the 2011 Census.

The average income tax rate for an individual in Australia is 24.1[69] and is explicitly taken out for the calculation of household and other unpaid output losses.

Table 2.15 Time spent on paid and unpaid work by gender

	Time spent (minutes per day)	
Type of work	**Male**	**Female**
Time spent in paid work	304	172
Time spent in unpaid work	172	311
Time spent in paid and unpaid work	476	483
Ratio of unpaid to paid work	0.56	1.81

The hybrid approach makes adjustments for those who are economically inactive (children and older people) and not part of the labour market by using the average cost of raising a child for an average household as a proxy for those children aged 0 to 17 years.[70] Older people who have left the labour market would similarly be associated with a very low human capital loss. However, wage income is not the primary source of income after the age of 65 years, payments like pensions and retirement savings income (e.g., superannuation) are thought to be the main source. To get a better idea of the income of the older age cohorts, we used the income data from the 2016 Census, in which people report their weekly total personal income.[71] We found that the earnings for 65- to 74-year-olds drop to 55 per cent of the average pre-retirement income and further to 41 per cent for the age categories of 75 to 84 and 85+. We used these same relative wage drops as input for the Hybrid Human Capital estimations. These adjustments to the standard Human Capital Approach helped prevent the elderly and children from being valued close to 0. The following **Table 2.16** presents the present value of total lifetime loss from workplace and household outputs that is associated with a fatality of a certain age and gender. When considering the combined workplace and household losses, females have a slightly higher output loss than males. There are three reasons for this. Compared with males, females work slightly more hours, have a higher life expectancy of approximately two years, and for those who are in the labour market, they work in higher paid roles.[72]

[69] OECD Taxing Wages Australia: https://www.oecd.org/ctp/tax-policy/taxing-wages-australia.pdf.

[70] The cost of bringing up children was taken from research conducted by the University of Canberra for AMP financial services. This report found the lifetime costs of a child from birth until they finish their education for a middle-income family to be $406,021. The costs used for the costing model utilised these figures and assumed a weekly spending of $406.

[71] To estimate the income of elderly people, we used population wide Australian Bureau of Statistics (ABS) 2016 census data on total personal income Table B17, which details income for three age categories over the age of 65.

[72] An alternative approach would be to recognise that females, especially those with younger children, are more likely to work in higher paid jobs in order to be able to compensate for childcare and other unpaid work they would perform should they not be employed in the labour market.

Table 2.16: Present value of workplace and household output loss (in 2020 dollars)

	Expected life span		Present value of lifetime productivity		Labour force utilisation rate	
Age category (years)	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
0–4	80	85	$2,537,636	$2,632,849	-	-
5–16	70	75	$2,883,935	$3,009,183	-	-
17–25	62	66	$3,273,674	$3,370,407	0.72	0.71
26–39	52	56	$3,361,572	$3,349,883	0.86	0.74
40–54	37	40	$2,587,429	$2,591,492	0.87	0.78
55–64	26	29	$1,639,801	$1,739,714	0.78	0.66
65–74	18	20	$983,608	$1,138,354	-	-
75+	10	12	$506,713	$641,554	-	-

Short-term and long-term workplace and household output losses following injuries

For injuries we estimated the number of days they are off work and used the same forgone workplace and household productivity loss method described in the previous section. We derived estimates from a population-based study by Gray and Collie (2019) which analyses the entire population of people who are absent from work for at least 5 days due to road crashes.[73] They present numbers by length of hospital stay, which can be seen as a proxy for severity of the injury. We used the presented numbers and matched them with the groups of injury we distinguish by attributing the worst cases to the most injured group and taking in more from the next worst group until the proportions are equivalent to those injury groups in the entire population. The estimated average numbers of weeks a person is off work by injury severity can be found in the following table (**Table 2.17**).

Table 2.17: Short-term workplace losses by level of severity (calculation based on Gray and Collie 2019)

Level of severity	Weeks of forgone earnings
Hospitalised serious injury resulting in profound disability	152.0
Hospitalised serious injury with moderate/mild disability	30.0
Hospitalised less severe injuries	2.0
Non-hospitalised	0.7

For the most severely injured people, we used ABS data of the Disability, Ageing and Carers Survey 2018 to get an estimate of their labour participation.[74] The table below (**Table 2.18**) reports the utilisation by injury as an average across all age groups. Note we assumed that all disabilities occur following severe injuries and the numbers for MAIS 1 or 2 and non-hospitalised in the table below equate to those for the population without disability as reported by the ABS.

[73] Gray and Collie (2019) use workers' compensation and road traffic compensation data to look at the most complete universe of cases.

[74] We use unemployment and labour force participation rates for each age group to derive the utilisation rate of the proportion who has work given the injury sustained in the road crash.

Table 2.18: Long-term workplace losses by level of severity

	Per cent in employment	
Level of severity	**Male**	**Female**
Hospitalised serious injury resulting in profound disability	25.9	21.1
Hospitalised serious injury with moderate/mild disability	52.5	47.9
Hospitalised less severe injuries or non-hospitalised	84.8	75.8

Profound disability can also lead to an earlier death later in life and we estimated this in line with the BITRE (2009) report by assuming 2.5 years are lost for a profound or severe disability. Calculations of the long-term workplace losses are then akin to 2.5-year earlier fatality.

2.5.3. Pain, grief, and suffering (Hybrid Human Capital approach)

In addition to short-term and long-term workplace and household losses, the hybrid approach included a statutorily determined lump sum compensation awarded to families and dependents of a deceased person for a premature death to value intangible loss from pain, grief, and suffering. The loss in quality of life from impairment or fatality was valued at the level of insurance compensation for injuries. These compensation payments were scaled according to level of impairment, with 100 per cent of the compensation being paid for a fatality. The statutory payment of $366,900 for lost quality of life per fatality paid by TAC in 2020[75] was used as a value for a premature death in the cost calculation of a fatality. We note that the statutory TAC lump sum payment for fatality are in absolute terms lower in 2020 compared to the 2005 value of $387,900 use in BITRE (2009). This is unexpected and was noticed by a number of stakeholders. We therefore include a case in the sensitivity analysis where we used the inflated TAC values from 2005 instead of the 2020 statutory value. In this case the cost for a fatality would be 45 per cent higher at $542,500.

An additional $7,500 is a maximum statutory amount awarded to the family of victims for their pain and grief.[76] For pain, grief and suffering of injured road crash casualties, disabilities are only assumed to be present among the most severe injured. We assumed a profound or severe disability with an impairment of on average 90 per cent for which the TAC statutory lump sum payment is $241,800 and for the moderate disability we assumed an average impairment of 50 per cent, for which the TAC compensation of $88,900 is used.[77]

2.5.4. Willingness to pay approach

The WTP approach is used internationally to estimate the Value of a Prevented Fatality (VPF) (HM Treasury, 2018), which, as noted above, is also referred to as the Value of a Statistical Life (VSL). The WTP approach is a method to value—in monetary terms—goods or services and often non-market goods. The value of a road safety improvement is measured as the amount that those affected would individually be willing to pay for (small) improvements in their safety, most typically measured as the value of small reductions in risk to life (Jones-Lee, 1976). These amounts are then aggregated across individuals to arrive at an overall value for the safety improvements. This aggregation provides the monetary value attributed by society to prevent a fatality of an anonymous ('statistical') person as a result of a traffic accident. The VPF used in UK public policy accounts for human costs (pure WTP component minus discounted lost consumption), lost gross output and medical and ambulance costs (HM Treasury, 2018; Maria Rivera Castiñeira, 2016).

[75] https://www.tac.vic.gov.au/clients/how-we-can-help/compensation/impairment-benefits?tab=4&drop=1.

[76] https://www.victimsservices.justice.nsw.gov.au/victims-services/how-can-we-help-you/victims-support-scheme/recognition-payment.html.

[77] These numbers are in alignment with BITRE (2009) estimations and within the rough definitions of moderate and severe/profound disability impairments. For the details on how we define a severe injury see **Section 2.4.2** above.

A key consideration in estimating the human cost of road crashes is the use of road safety specific WTP values compared to the use of standardised values of life such as the VSL. The current study used the Office of Best Practice Regulation recommended standard VSL (Office of Best Practice Regulation, 2021).

A road specific willingness to pay study run by the Australian Transport Assessment and Planning (ATAP) is under way and once the results are available, they will be used to quantify road-specific intangible costs and will replace the WTP values currently used in this report. That study is valuing improvements to road safety for drivers and passengers of privately-owned motor vehicles, including estimates of the:

- Value of fatality risk reductions (mortality)
- WTP to avoid minor, major, and incapacitating injuries (morbidity)
- WTP to avoid property damage
- Value of travel time savings
- Value of reliability

The present study estimated the indirect cost of road crashes using the Hybrid Human Capital approach in the main section of the report. The WTP approach is then used in a separate chapter where we replaced the relevant cost categories from the Hybrid Human Capital approach with willingness to pay values. It was important to avoid double counting and to this end **Appendix A** includes a description and a table that details which cost component is captured and measured under the Hybrid Human Capital and which are replaced by the WTP values. To summarise the table, the two main cost categories replaced by WTP measures were the indirect cost and pain, grief and suffering cost, as well as a few smaller proportions of some direct cost which are thought to be borne by the individual involved in the car crash.

The VSL used in this current report is sourced from Office of Best Practice Regulation (OBPR, 2021) which specifies the VSL to be $5.0 million dollars and the value of a statistical life year (VSLY) to be $217,000. Calculating the cost of a fatality using the VSLY was straight forward. We took the $217,000 as a flow of benefit over the expected lifetime of the deceased and calculated the resulting discounted present value. This is equivalent to how we calculated the workplace and household losses based on the flow of earnings.

However, calculating for the loss from injury was more complicated from a single measure of VSL, as we needed to make assumptions about the proportion of a full loss of life, which were attributed to each severity type of injury (disability weights). Small changes in these assumptions have large effects on total costs.

We present VSL cost calculations based on the weights reported in AAA (2017). These are derived as disability-adjusted life years lost (a weighted average over all road crash injuries resulting in disability). The weighted average disability weight across all levels of disability (profound, severe, moderate and mild) is stated to be 0.182[78] We apply this weight to all MAIS3+ injuries[79] to calculate an alternative WTP based cost measure in the WTP Chapter.

As a second approach, while waiting for the forthcoming ATAP WTP study result, we attempted to use the road specific willingness to pay values from the NSW Roads and Traffic Authority study from 2008 undertaken by PricewaterhouseCoopers (PWC) in conjunction with the Hensher Group.[80] That study involved a stated preference survey of road users with the aim of estimating WTP values for reducing the risk of death and of various levels of injury severity. We report the value associated with a fatality but could not find a way of applying these NSW numbers in a rigorous way.

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[78] This average is taken from the AAA (2017) which cited Gabbe et al (2016). The specific average weight cited is not explicitly reported in the 2016 paper and must have involved further calculation to derive.

[79] Based on the sample description in Gabbe (2016) we know that the type of injuries which are included in the questionnaire sample have for example an ISS of >15, this is roughly comparable to a MAIS3+ categorisation. As such we applied the disability weight to all MAIS3+ injuries for this alternative but not to more minor injuries which get a weight of zero.

[80] The values are reported in NSW (2016)

2.6. Data sources

The unit medical and long-term care costs of fatal and non-fatal injuries were estimated based on insurance claims from TAC data. Vehicle repair cost were estimated based on insurance industry data. Workplace and household loss estimates use a combination of sources from the ABS. Estimates of short-term work absences were supplemented by information from the study by Grey and Collie (2019). In addition to the available data held by BITRE for this study which were made available to the ANU team, an overview of data sources used is presented in **Table 2.19**.

Table 2.19: Data source

Dimension	Source	Cost component
Crash incidence (disaggregation by age, gender, crash severity, road user category, remoteness area, type of crash, vehicles type)	National Crash Database (NCD)	Used for all costs
Long-term care cost and disability incidence	Transport Accident Commission (TAC) ABS (2019) Disability, Aging and Carers Survey 2018 (For incidence - Australia New Zealand Trauma Registry (ATR))	Specialised care, Long-Term Care, Adaptation to incapacity (home or physical aids), unpaid carer time
Human capital cost by age, gender	Australian Bureau of Statistics ABS (2018) and ABS (2021) Incidence of short-term losses Literature (Gray et al.,2019)	Long-term and short-term workplace and household output losses
Recruitment and training cost	Literature (Manipis et al.,2021)	Friction in the labour market
Loss of quality of life	TAC	Pain grief and suffering
Estimation life years lost	Life tables (ABS, 2020)	Burial costs and income/ household loss
Value of a statistical life	Office of Best Practice Regulation (OBPR, 2021),	Indirect cost
Acute and emergency care cost	TAC (For incidence - Australian Institute of Health and Welfare (AIHW))	Medical and hospital cost
Non-hospitalised costs	TAC	Medical and hospital cost
Ambulance cost	Report on Government Services 2021	Ambulance services
Fire crew cost	Report on Government Services 2021(Productivity Commission, 2021)	Fire and emergency response
Insurance administration cost	TAC, Insurance Industry	Other costs

Dimension	Source	Cost component
Vehicle repair and towing	NTI data	Vehicles related cost
Vehicle operating costs	ATAP guidelines	Other cost
Coronial costs	Queensland delivering coronial services report	Fatality
Early burial cost	Literature (Van Der Laan et al. 2017)	Fatality
Street furniture damage	BITRE (2009)	Vehicles related cost
Vehicle unavailability costs	Market rates	Vehicles related cost
Time costs of travel delay	ATAP guidelines, Chin et al (2004)	Other cost
Air pollution	ATAP guidelines	Other cost
Culpable driving (number of and cost of court case)	Sentencing Advisory Council Victoria	Fatality
Cost of imprisonment (per cent acquitted, for how long and cost of imprisonment)	Australian Institute of Criminology (Anthony Morgan, 2015)	Fatality

2.7. Cost inflation

All costs values were adjusted into one common year real term dollar value. That is, if costs came from different sources which have different base years or occur years in the future, we inflated or deflated the cost using the Consumer Price Index to bring them to a common base year, the end of 2020.

2.8. Discounting

In Australia, there is a range of discount rates recommended by government agencies. As agreed with BITRE, the discount rate used in the base case was 3 per cent, with rates of 2 per cent, 4 per cent, 5 per cent and 7 per cent used in the sensitivity analysis.

These rates were informed by the current Australian government bond rate (2 to 3 per cent), an Australian specific social discount rate (1.75 per cent), the ATAP guidelines (4 per cent, 7 per cent, 10 per cent p.a.) (Australian Transport Assessment and Planning, 2019), the Office of Best Practice Regulation (OBPR 2016) (3 per cent, 7 per cent and 10 per cent per annum). The very high discount rates recommended by national infrastructure guidelines of 7 per cent (in real terms) have been strongly criticised by Terrill and Batrouney (2018) which suggest a 3.5 per cent rate for low systematic risk projects instead. Further information on discounting is provided in **Appendix B**.

2.9. Sensitivity analysis

Sensitivity analysis was undertaken to account for uncertainties in parameter estimates used in the model (e.g., around congestion valuation and statutory values used for pain, grief and suffering) and methodological uncertainties (e.g. top-down vs bottom-up estimation of unreported crashes). Several methods to conduct sensitivity analysis, including univariate sensitivity analysis were undertaken in the respective chapters and multivariate sensitivity analysis was conducted in Chapter 9.

In the road safety context, it was essential to identify the most important contributions to cost and improve the estimation. An overview of tested assumption IS given in **Table 2.20**.

We consulted BITRE and key stakeholders to further identify the variables that make a material difference to the estimates in the cost model. Key assumptions were varied based on the degree of uncertainty, alternative methods were used and alternatives to the best sources of data were used to help account for uncertainties that were identified by the team and stakeholders.

Table 2.20: Sensitivity analysis inputs and assumptions

Inputs and assumptions	Base case	Variation
Discount rate	3 per cent	2, 4, 5, and 7 per cent
WTP methodology	OBPR recommended VSL value	ATAP transport WTP results (forthcoming)
Statutory value used for the valuation of pain, grief and suffering	2020 statutory values from TAC	2009 statutory values from TAC inflated to 2020 dollars
Opportunity cost of time spend in congestion (travel delay cost)	Valued at 40 per cent of paid work equivalent (ATAP leisure time valuation)	Valued at 30 per cent of paid work equivalent (Gwilliam et al. 1997)
Incidence of unreported hospitalised road crash injuries	AIHW data	AIHW data restricting by place of occurrence
Incidence of unreported non-hospitalised road crash injuries	Inferred road specific GP visits based on Day, Valuri and Ozanne-Smith (1999)	Reported GP visits across all causes of injury from Day, Valuri and Ozanne-Smith (1999)
Incidence of PDO crashes	Top-down estimation based on APRA and ISA data	Bottom-up estimation base on ACT reported crashes
Long-term care cost not covered by insurance, in form of unpaid work caring for family living at home	All profound disability cases are in special care homes and the remainder of 46 per cent are taken care at home	Either all or none of the disabilities are associated with extra carers cost
Street furniture cost	Inflated BITRE (2009) estimates by CPI and increase in crashes	Tripling of the inflated BITRE (2009) values
GDP per capita as growth of real income rate	Average GDP per capita over the last 10 years (0.8 per cent)	Average GDP per capita over the last 20 years (1.2 per cent)
Insurance administration	10 per cent	15 per cent

In addition, we tested the impact of alternative approaches to valuation of non-direct costs using the hybrid human capital and WTP approaches.

2.10. Rapid review

The research team was asked to extend the economic analysis to aid in addressing three important policy questions posed by BITRE:

1. Which type of crash has the highest social cost?
2. Does the cost of crashes warrant more being spent on crash prevention?
3. How do the benefits of road safety investments compare to benefits derived from other health investments?

The costing study provides essential information to address the first key policy question.

Given information on cost alone does not allow policy makers to answer Policy Questions 2 and 3, we have undertaken a rapid review of the literature focusing on empirical studies which have been designed to address these questions. Based on the review, we synthesised existing empirical evidence to inform a benchmarking exercise of interventions and to highlight the remaining gaps. In addition, we outlined below a methodological approach that would be needed to undertake future empirical analysis to address these policy questions robustly within an Australian context.

The rapid review was conducted in accordance with the Cochrane Rapid Reviews Methods Group reporting guidelines. We also worked with stakeholders to identify further relevant literature. Following the identification of relevant literature, one reviewer screened all abstracts and a second reviewer screened 20 per cent of the abstracts. A third reviewer was involved to resolve any conflict on inclusion of papers. The data extraction template was piloted with approximately 10 to 15 articles. The evidence was synthesised.

Chapter 3. Losses to society from road crash fatalities

3.1. Key point summary

- Between 2016 and 2020, there were 1,187 annual fatalities from road crashes. *
- The lifetime economic cost to society for each road crash fatality was $3.0 million and the estimated total annual cost of fatality was $3.5 billion.
- Drivers comprised almost half of the fatality cost at $1.7 billion, as they make up 48 per cent of all fatalities.
- About two-thirds of the fatalities occur outside major cities with a total of $2.3 billion.
- Run-off-road crashes are the type of crash that constitute the majority of fatalities and the highest cost, at $1.6 billion.
- The cost of productivity losses accounted for 81 per cent of total costs.

*The average number of fatalities, and all other incidences, was estimated as an average over the last five years of data available (2016–2020). A five-year average is more robust to random fluctuations over the years, particularly, in specific sub-categories (e.g., younger ages females).

Box 3.2: Key point summary for Chapter 3

3.2. Incidence of road crash fatalities

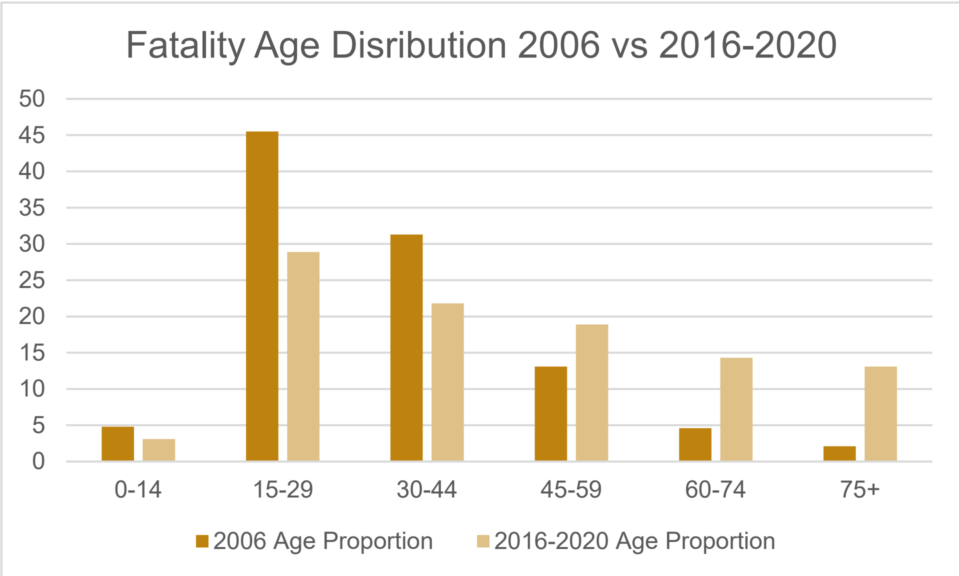
The NCD defines a fatality as a crash that occurred on a public road and that results in death within 30 days of the crash. The incidence of road crash fatalities was derived from the NCD. There was a total of 1,187 road crash fatalities and of the total fatalities, the highest proportion of road crash fatalities was in the age category of 26 to 39 years (23%, or 267) and the lowest proportion of road crash fatalities was in the age category of 0 to 4 years (1%, or 13). Fatalities are nearly 3-1 for males to females. **Table 3.21** presents the incidence of road crash fatalities by age category and gender. The data below reflect the five-year annual averages over 2016 to 2020.

Table 3.21: Incidence of road crash fatalities by age category and gender

Age category (years)	Female	Male	Total
0–4	6	7	13 (1%)
5–16	13	26	39 (3%)
17–25	53	184	237 (20%)
26–39	59	208	267 (23%)
40–54	50	186	236 (20%)
55–64	34	102	136 (11%)
65–74	33	71	104 (9%)
75+	57	98	155 (13%)
Total	**305**	**882**	**1,187 (100%)**

The age distribution of fatalities has shifted dramatically since the last BITRE report (BITRE 2009). The average age over the years 20016 to 2020 is 44.9 years, an increase of more than 6 years from the 38.6 in 2006. As the **Figure 3.2** shows the entire distribution has shifted dramatically to the right.[81]

Figure 3.2: Age distribution of fatalities, comparing 2016-2020 and 2006 (in per cent)



3.3. Cost results

The estimated total cost of road crash fatalities using a human capital methodology was $3.5 billion, equating to $2.9 million per road crash fatality. The previously estimated total cost of road crash fatalities (BITRE, 2009) was $5.2 billion, equating to $3.3 million per road crash fatality (inflated to 2020 dollars). The main difference in the estimated cost across the two cost reports can be attributed to a lower statutory value for pain, grief and suffering which is about 50 per cent lower. We include an alternative assumption of a higher per person lump sum value in the sensitivity analysis.

3.3.1. Total cost of road crash fatalities by age cohort and gender

The total cost of road crash fatalities was relatively high for individuals in the middle-age category, in particular, males. Individuals in the age category of 26 to 29 years accounted for 30 per cent of the total cost of road crash fatalities. Individuals in this age category not only had the highest cost per road crash fatality ($3.9 million per road crash fatality) but also the highest incidence of fatalities (23%). **Table 3.22** presents the total cost of road crash fatalities by age category and gender, and **Table 3.23** presents the average cost per road crash fatality by age category and gender.

[81] The age groupings for the comparison follow the grouping reported in BITRE (2009) which differs from the updated more detailed age grouping used throughout this report.

Table 3.22: Total cost of road crash fatalities by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$19	$21	$40
5–16	$46	$89	$134
17–25	$206	$697	$904
26–39	$228	$808	$1,036
40–54	$156	$578	$734
55–64	$77	$221	$298
65–74	$54	$107	$162
75+	$66	$101	$168
Total	**$852**	**$2,622**	**$3,474**

Table 3.23: Average cost per road crash fatality by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male
0–4	$3.15	$3.05
5–16	$3.53	$3.40
17–25	$3.89	$3.79
26–39	$3.86	$3.88
40–54	$3.12	$3.11
55–64	$2.25	$2.17
65–74	$1.65	$1.51
75+	$1.16	$1.03

3.3.2. Total cost of road crash fatalities by cost components

The total cost of road crash fatalities was estimated to be $3.5 billion. Workplace and household output losses constituted the largest proportional cost of road crash fatalities ($2.9 billion) and cost of street furniture constituted the smallest cost of road crash fatalities ($0.1 million). Costs for pain, grief, and suffering were relatively high, accounting for $444 million of the total cost. Medical and related costs were relatively low accounting for $19.4 million of the total cost. The per-person medical and related costs from the TAC ranged from $14 to $1.5 million. Evidently, some road crash fatalities involved very little medical costs (for example, if the person had died on crash impact) while others have large medical and paramedical cost. All costs reported are in 2020 dollars. **Table 3.24** presents the average annual cost between the years 2016-2020 of all road crash fatalities listed by cost component

Table 3.24: Total cost of road crash fatalities by cost component (in million 2020 dollars)

Cost component	Value
Workplace and household output losses	$2,856.4
Pain, grief and suffering	$444.4
Correctional services	$62.2
Insurance administration	$30.4
Medical and related costs	$19.4
Travel delay and operating costs	$19.0
Repair costs	$12.9
Premature funeral	$8.6
Legal costs	$7.9
Ambulance	$5.9
Emergency and police services	$4.0
Recruitment and re-training costs	$3.0
Coronial costs	$2.4
Vehicle unavailability	$1.4
Externality cost of crash-induced pollution	$0.8
Street furniture	$0.1
Total	**$3,479**

3.3.3. Hospital and medical costs

The total hospital and medical costs were estimated to be $19.4 million, with the cost per road crash fatality estimated to be $13,992. **Table 3.25** presents the hospital and medical costs by age category and gender.

Table 3.25: Hospital and medical costs by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$0.1	$0.1	$0.1
5–16	$0.3	$0.4	$0.7
17–25	$0.8	$1.6	$2.4
26–39	$0.3	$3.1	$3.4
40–54	$1.1	$2.8	$3.9
55–64	$0.3	$2.3	$2.6
65–74	$0.3	$1.9	$2.2
75+	$1.3	$2.9	$4.2
Total	**$4.4**	**$15.0**	**$19.4**

3.3.4. Ambulance, police and fire/emergency services and administration costs

Fire services was assumed to respond to all fatal road crashes at a total cost of $1.9 million and an average cost of $1,600 per incident. Ambulance was also assumed to attend all fatal crashes and account for a cost of $5.9 million and on average $5,000 per fatality. Police also attend every fatal crash at an overall cost of $2.0 million and $1,700 per fatality. Administrative costs associated with the transport accidence insurance is $24,500 per fatality and accounts for $29 million of total costs. Insurance administrative cost for vehicle repairs for crashes with fatalities account for another $1.3 million. A disaggregation of these costs by road type and remoteness can be found in the section on other costs of road crashes.

3.3.5. Funeral costs

The total funeral cost was estimated to be $8.6 million, with the cost per road crash fatality estimated to be $7,200. **Table 3.26** presents the funeral costs by age category and gender.

Table 3.26: Funeral costs by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$0.1	$0.1	$0.1
5–16	$0.1	$0.3	$0.4
17–25	$0.5	$1.7	$2.2
26–39	$0.5	$1.8	$2.3
40–54	$0.4	$1.4	$1.8
55–64	$0.2	$0.6	$0.8
65–74	$0.2	$0.3	$0.5
75+	$0.2	$0.3	$0.5
Total	**$2.2**	**$6.4**	**$8.6**

3.3.6. Coronial costs

The total coronial cost was estimated to be $2.4 million, with the average cost per road crash fatality estimated to be $2,000. The total cost for males was estimated to be almost three times the cost for females, which is consistent with the observed higher incidence of road crash fatality in males and the highest costs associated with individuals in the age categories of 17 to 25 years and 26 to 39 years. **Table 3.27** presents the coronial costs by age category and gender.

Table 3.27: Coronial costs by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$0.0	$0.0	$0.0
5–16	$0.0	$0.1	$0.1
17–25	$0.1	$0.4	$0.5
26–39	$0.1	$0.4	$0.6
40–54	$0.1	$0.4	$0.5
55–64	$0.1	$0.2	$0.3
65–74	$0.1	$0.1	$0.2
75+	$0.1	$0.2	$0.3
Total	**$0.6**	**$1.8**	**$2.4**

3.3.7. Legal and correctional costs

Legal and correctional costs do not vary by age or gender. Hence, we observed that individuals in the age category of 26 to 39 years with the highest incidence of road crash fatality, have statistically the highest overall legal cost associated with culpable driving ($0.7 million). Total legal costs of fatal road crashes are $3.2 million, accounting for $2,700 per road fatality **Table 3.28** presents the legal costs by age category and gender.

Table 3.28: Legal by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$0.02	$0.02	$0.04
5–16	$0.04	$0.07	$0.11
17–25	$0.14	$0.50	$0.64
26–39	$0.16	$0.57	$0.73
40–54	$0.14	$0.51	$0.64
55–64	$0.09	$0.28	$0.37
65–74	$0.09	$0.19	$0.28
75+	$0.15	$0.27	$0.42
Total	**$0.83**	**$2.40**	**$3.23**

The correctional cost for fatal road crashes is $62 million, accounting for $52,000 per road fatality, is presented in

Table 3.29.

The costs for common law litigations in connection with fatalities is estimated to be $4.7 million.

Table 3.29: Correctional costs by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$0	$0	$1
5–16	$1	$1	$2
17–25	$3	$10	$12
26–39	$3	$11	$14
40–54	$3	$10	$12
55–64	$2	$5	$7
65–74	$2	$4	$5
75+	$3	$5	$8
Total	**$16**	**$46**	**$62**

3.3.8. Workplace and household output losses

Productivity losses following a road crash fatality represent the value of goods and services that is not produced due to premature death. We estimated this cost by calculating the present value of expected lifetime earnings by age group and gender. This resulted in a total cost of $2.9 billion, with the average cost of $2.4 million per road crash fatality. Workplace and household output losses are the single biggest contributor to cost of fatalities. Within this cost category workplace losses account for 62.2 per cent of the cost and the remainder is household and voluntary output losses. **Table 3.30** presents the cost of workplace and household output losses by age category and gender.

Table 3.30: Cost of workplace and household output losses by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$16	$18	$34
5–16	$39	$75	$114
17–25	$179	$602	$781
26–39	$198	$699	$897
40–54	$130	$481	$611
55–64	$59	$167	$226
65–74	$38	$70	$107
75+	$37	$50	$86
Total	**$694**	**$2,162**	**$2,856**

3.3.9. Workplace disruption and replacement

In addition to the workplace and household output losses, a premature fatality can cause workplace disruption. The cost of workplace disruption and replacement was estimated by calculating the cost of replacing a deceased worker as the unit cost of recruitment and training (weighted by management or non-management roles). The unit cost for recruitment and training amounted to $4,115, and the unit cost was slightly higher for females than for males as females are more often in management/professional roles[82]. Not every person in the population is in employment so the cost of workplace disruption and replacement applies only to people who actively participate in the labour market. To account for people who are out of the workforce or are unemployed, we weighted the incidence of road crash fatalities in each age category by the proportion of people who participate in the labour market. This meant that the cost of workplace disruption and replacement would not be applied to children until they are 15 years or older, and similarly, the cost of workplace disruption and replacement would be very low for people in the oldest age category. The total cost of workplace disruption and replacement was estimated to be $3.0 million. Broken down by age category, we observed the highest cost for males in the age category of 26 to 39 years, due to the number of road crash fatalities and a large proportion of individuals in this age category participating in the labour market. **Table 3.31** presents the cost of workplace disruption and replacement by age category and gender.

Table 3.31: Cost of workplace disruption and replacement by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$-	$-	$-
5–16	$0.00	$0.01	$0.01
17–25	$0.16	$0.54	$0.69
26–39	$0.18	$0.73	$0.91
40–54	$0.16	$0.65	$0.82
55–64	$0.09	$0.32	$0.42
65–74	$0.03	$0.10	$0.13
75+	$0.01	$0.02	$0.03
Total	**$0.64**	**$2.37**	**$3.01**

3.3.10. Pain, grief, and suffering

We derived the total human costs of pain, grief and suffering from the TAC value of lump sum payments to families of road crash fatalities of $366,900 and a statutory payment to the family of a victim for the grief of up to $7,500. The total human cost was estimated to be $444 million. We observed differences in human costs and these were driven by the differences in incidence across age and gender. We observed the highest cost for males in the age category of 26 to 39 years, as they represent the largest number of road crash fatalities. **Table 3.32** presents the human cost by age category and gender. We include an alternative assumption with a higher per person lump sum value in the sensitivity analysis.

[82] Australian Bureau of Statistics, Jobs in Australia 2014-15 to 2018-19: https://www.abs.gov.au/statistics/labour/jobs/jobs-australia/latest-release.

Table 3.32: Pain, grief and suffering cost by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$2	$3	$5
5–16	$5	$10	$15
17–25	$20	$69	$89
26–39	$22	$78	$100
40–54	$19	$69	$88
55–64	$13	$38	$51
65–74	$12	$27	$39
75+	$21	$37	$58
Total	**$114**	**$330**	**$444**

3.4. Cost of road crash fatalities by road user and remoteness

We observed that drivers, who make up the largest number of road crash fatalities (48 per cent) also bear the largest proportion of cost of road crash fatalities. While pedestrians and cyclists have the highest per-person hospital and medical costs, they represented a small proportion of the total costs. **Table 3.33** presents the average cost of road crash fatalities by road user and remoteness.

Table 3.33: Average cost of road crash fatalities by road user category and remoteness area (in million 2020 dollars)

Road user category	Major cities	Outside major cities	Total
Driver	$389	$1,268	$1,657
Motorcyclist	$313	$359	$672
Passenger	$164	$463	$627
Pedestrian	$267	$154	$421
Pedal cyclist	$59	$41	$100
Total	**$1,192**	**$2,284**	**$3,476**

3.5. Cost of road crash fatalities by age category and remoteness

We observed that the largest proportion of cost of road crash fatalities occur outside of major cities, in rural and remote areas ($2.3 billion or 66%). **Table 3.34** presents the average cost of road crash fatalities by age category and remoteness.

Table 3.34: Average cost of road crash fatalities by age category and remoteness (in million 2020 dollars)

Age category (years)	Major cities	Outside major cities	Total
0–4	$13	$27	$40
5–16	$43	$92	$134
17–25	$321	$583	$904
26–39	$373	$663	$1,036
40–54	$224	$511	$734
55–64	$88	$210	$298
65–74	$54	$108	$162
75+	$78	$90	$168
Total	**$1,192**	**$2,284**	**$3,476**

3.6. Cost of road crash fatalities by crash type and remoteness

The largest contributor to the cost of road crash fatalities was run-off-the-road crashes. This crash type is often fatal in nature. The differences in the cost between crash types can be accounted for by the distribution of age and incidence for the different crash types. Hospital and medical cost differ considerably between the different crash types, with the costs associated with pedestrians in major cities being three times as high as for a run-off-the-road fatality outside major cities. The medical costs only make up a small proportion of the overall cost associated with a road crash fatality. **Table 3.35** presents the average cost of road crash fatalities by crash type and remoteness.

Table 3.35: Average cost of road crash fatalities by crash type and remoteness (in million 2020 dollars)

Crash type	Major city	Outside major cities	Total
Run off road	$382	$1,233	$1,615
Head on	$221	$515	$736
Pedestrian struck	$251	$147	$398
Same direction	$129	$87	$215
Intersection adjacent	$94	$115	$209
Other	$114	$188	$302
Total	$1,192	$2,284	$3,476

3.7. Sensitivity analysis—Univariate

For the estimation of the most important cost component for fatal crashes, the workplace and household output losses, we assumed that the average real wage increase over 40 years would equal the per capita GDP growth over the most recent 10-year horizon. If we change this to a 20-year horizon the assumed annual real earnings in our model would increase from 0.81 per cent to 1.22 per cent.

Table 3.36 shows the new cost estimates with the 20-year based real income growth assumption in place and compared the results to the base case. This approach raises the cost for workplace and household output losses for fatalities by 8 per cent. Overall, the total cost for road crash fatalities increases by $234 million to $3.8 billion which is a 7 per cent increase.

Table 3.36: Average cost of road crash fatalities by cost component (in million 2020 dollars)

Cost component	Real wage increase (20-year base)	Cost base case (10-year base)	Change (per cent)
Workplace and household output losses	$3,087	$2,854	8
Total fatality costs	$3,752	$3,518	7

Another alternative assumption we wanted to test is around the value of pain, grief and suffering for a loss of life which is based on statutory TAC values. If we don't use current values but derive inflated values from the statutory values used in BITRE (2009), we get a 48 per cent higher value per fatality, resulting in a total cost for pain, grief and suffering from road crash fatalities of $653 million.

Chapter 4. Losses to society from road crash injuries

4.1. Key point summary

- The average number of injuries per year between the years 2016-2020 was estimated to be 135,000; 29 per cent of these were hospitalised injuries, the remainder were emergency department and general practitioner visits.
- The average cost to society of each road crash injury was $87,900 although this varied substantially by injury severity. It ranged from $4.2m for the most severe injuries resulting in permanent profound disability (1 per cent of all injuries) to $25,900 for minor injuries which are not hospitalised (71 per cent of all injuries). The total annual cost of all injuries was estimated to be $11.8 billion.
- Hospitalised injuries make up 29 per cent of all incidences of injury from road crashes but account for 79 per cent of all injury crash related costs. The most severely injured (MAIS3+) road crash injuries account for less than 3 per cent of all road crash injuries but contribute 39 per cent of all injury crash costs.
- The average cost per road user was significantly higher for motorcyclists and pedestrians, and both road user types are over-represented in terms of cost proportions (15 and 7 per cent respectively).
- 61 per cent of road injuries occur in major cities, costing a total of $7.3 billion.
- The cost of workplace and household output losses accounted for 40 per cent of the total costs of $11.8 billion.

Box 4.3. Key point summary for Chapter 4

4.2. Incidence of road crash injuries

4.2.1. Incidence of hospitalised injuries

A severe injury (or hospitalised injury) is when a person involved in a road crash requires medical treatment for injuries sustained in the crash and has been admitted to the hospital irrespective of the length of stay but did not die from their injuries within 30 days. The incidence of hospitalised injuries that result from road crashes was derived from the NCD, in conjunction with data from the AIHW. There was an average of 38,794 hospitalised injuries annually on average in the years 2016 to 2020. Of these injuries, the highest proportion was in the age category of 26 to 39 years (24%, or 9,444) and the lowest proportion was in the age category of 0 to 4 years (< 1%, or 331). **Table 4.37** presents the incidence of hospitalised injury by age category and gender. The data below reflect the five-year annual averages over 2016 to 2020.

Table 4.37: Average annual incidence of hospitalised injuries by age category and gender

Age category (years)	Female	Male	Total
0–4	144	188	331 (1%)
5–16	784	1,170	1,954 (5%)
17–25	3,421	5,202	8,623 (22%)
26–39	3,575	5,868	9,444 (24%)
40–54	3,034	5,044	8,078 (21%)
55–64	1,800	2,742	4,541 (12%)
65–74	1,422	1,629	3,051 (8%)
75+	1,349	1,422	2,771 (7%)
Total	**15,529**	**23,265**	**38,794 (100%)**

4.2.2. Incidence of non-hospitalised injuries

A minor injury (or non-hospitalised injury) is when a person involved in a road crash requires medical treatment for injuries sustained in the crash but has not been admitted to hospital. The incidence of minor injury (or non-hospitalised injury) that results from road crashes was derived from the NCD, in conjunction with the measurement of the extent of under-reporting in police-recorded injuries from the literature. This will help to account for the incidence of patients who attend hospital but who are not admitted to hospital, and patients who sought medical attention from GPs.[83] We estimate a total of 95,989 non-hospitalised injuries. Of those, females accounted for 40 per cent of incidences (38,424) and males accounted for 60 per cent of incidences (57,565). **Table 4.38** presents the incidence of non-hospitalised injury by age category and gender. The data below reflect the five-year annual averages over 2016 to 2020.

Table 4.38: Incidence of non-hospitalised injuries by age category and gender (number of people)

Age category (years)	Female	Male	Total
0–4	355	464	820 (1%)
5–16	1,940	2,896	4,835 (5%)
17–25	8,464	12,872	21,336 (22%)
26–39	8,847	14,520	23,367 (24%)
40–54	7,508	12,480	19,988 (21%)
55–64	4,453	6,784	11,237 (12%)
65–74	3,520	4,030	7,549 (8%)
75+	3,337	3,520	6,857(7%)
Total	**38,424**	**57,565**	**95,989 (100%)**

4.2.3. Incidence of injuries by level of severity

The TAC data were used to derive the proportion of hospitalised injuries that are considered most severe (i.e., a MAIS3+ score).[84] The ATR data were used to estimate the number of hospitalised injuries that are considered

[83] For more details, refer to **Section 2.4.3** for the estimation of non-hospitalised injury crash incidence.

[84] For more information, please refer to **Footnote 7**.

the most severe and that resulted in a permanent long-term disability. An annual average of 1,098 people were categorised as severely injured, with a MAIS3+ score and were profoundly or severely disabled as a result of the road crash injury. An annual average of 2,721 people were categorised as severely injured, with a MAIS3+ score and were moderately disabled as a result of the road crash injury. People in this category had a road crash that resulted in a long time off work and a moderate to mild disability but will be able to return to work. The remaining people who were hospitalised amounted to 35,000 people per year, equating to 26 per cent of the total number of people injured in road crashes. **Table 4.39** presents the incidence of road crash injury by level of severity. The data below reflect the five-year annual averages over 2016 to 2020.

Table 4.39: Average incidence of road crash injuries by level of severity (2016 to 2020)

Level of severity	Female	Male	Total	Hospitalised (per cent)	Injured (per cent)
Hospitalised severe injury (MAIS3+) with profound disability	355	743	1,098	2.8	0.8
Hospitalised severe injury (MAIS3+) with moderate disability	880	1,841	2,721	7.0	2.0
Hospitalised injuries (MAIS 1 or 2)	14,294	20,681	34,975	90.2	25.9
Non-hospitalised	38,424	57,565	95,989	-	71.2
Total	**53,953**	**80,830**	**134,783**	**100.0**	**100.0**

People who were hospitalised with a severe injury (MAIS3+) accounted for 9.8% of all hospitalised injuries but accounted for 67 per cent of the overall cost of injuries. This reflects the high hospital and medical costs, workplace losses, and long-term care costs associated with these injuries. Relative to the age and gender distribution of the total hospitalised injuries, this group of people includes more males and people in older age categories; and comparatively, less females and people in the younger age categories.

Table 4.40 presents the incidence of hospitalised severe injury by age category and gender. The data below reflect the five-year annual averages over 2016 to 2020.

Table 4.40: Incidence of hospitalised serious injury by age category and gender

Age category (years)	Female	Male	Total
0–4	12	8	20 (1%)
5–16	35	63	98 (3%)
17–25	193	503	696 (18%)
26–39	204	582	787 (21%)
40–54	181	558	739 (19%)
55–64	165	358	523 (14%)
65–74	197	252	448 (12%)
75+	248	260	507 (13%)
Total	**1235**	**2584**	**3819 (100%)**

4.3. Cost results

The estimated average annual cost between the years 2016-2002 of road injury was $11.8 billion using a human capital methodology, compared with the inflated corresponding estimated cost from 2009 of $12.8 billion, an 8 per cent reduction. Losses per hospitalised injury were $241,000 and $25,900 for non-hospitalised injury. This compares to the inflated previous 2009 estimates of $299,100 and $16,200 respectively.[85] These differences are largely due to differences in the cost parameters for pain, grief and suffering, a different methodology for the estimation of long-term care costs and better data on the incidence of severe road injuries which are estimated to have long-term disabilities in the two reports. Legal costs were also estimated to be lower compared to the last report, yet most other cost components had higher estimates compared with estimates in the previous report (BITRE, 2009).

4.3.1. Total cost of road crash injuries by level of severity

Table 4.41 presents the cost of road crash injuries by level of severity and gender.

Table 4.41: Cost of road crash injuries by level of severity and gender (in million 2020 dollars)

Level of severity	Female	Male	Total	Hospitalised (%)	Injured (%)
Hospitalised severe injury (MAIS3+) with profound disability	$1,356	$3,231	$4,587	49	39
Hospitalised severe injury (MAIS3+) with moderate/mild disability	$877	$2,110	$2,987	41	25
Hospitalised injuries (MAIS 1 or 2)	$728	$1,049	$1,777	11	15
Non-hospitalised injury	$992	$1,499	$2,491		21
Total	**$3,953**	**$7,889**	**$11,842**		**100**

4.3.2. Total cost of road crash injuries by age cohort and gender

For hospitalised injuries, the total cost per road injury was relatively high for the middle age categories, in particular for males. Individuals with hospitalised injuries in the age category of 26 to 39 years accounted for 26 per cent of the cost of road injuries. Individuals in this age category had both the highest cost per injury and the highest incidence of hospitalised injury. The per-person cost differences are mainly driven by the differences in workplace output losses across life stages. The cost for a middle-aged male was highest due to having their prime of their productive life, with the highest labour market outcomes ahead of them. **Table 4.42** presents the hospitalised injury cost by age category.

[85] To make these numbers comparable between the two reports we have allocated the other cost proportionally across the different types of crash severity. See also the explanation in **Section 7.2.5**

Table 4.42: Hospitalised injury cost by age category (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$27	$21	$48
5–16	$147	$245	$392
17–25	$657	$1,588	$2,245
26–39	$675	$1,789	$2,463
40–54	$553	$1,474	$2,027
55–64	$360	$699	$1,059
65–74	$281	$332	$614
75+	$260	$243	$503
Total	**$2,961**	**$6,390**	**$9,351**

For non-hospitalised injuries, people in the age category of 40 to 54 years had the largest cost, mainly due to the increased hospital and medical costs associated with that age category. **Table 4.43** presents the non-hospitalised injury cost by age category.

Table 4.43: Non-hospitalised injury cost by age category (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$6	$9	$16
5–16	$37	$56	$93
17–25	$182	$280	$463
26–39	$235	$387	$621
40–54	$247	$384	$631
55–64	$131	$206	$337
65–74	$84	$99	$183
75+	$69	$78	$147
Total	**$992**	**$1,499**	**$2,491**

4.3.3. Total cost of road crash injuries by cost component

The total cost of road crash injury was estimated to be $11.8 billion. The workplace and household output losses constituted the largest cost component of $4.8 billion. Recruitment and training cost constituted the smallest cost component of $5 million. Generally, medical related costs were high ($2.3 billion) as were long-term care costs ($1,5 billion). Pain, grief and suffering were estimated to be $507 million. Some costs, such as pain, grief and suffering or recruitment and training, do not apply to minor, non-hospitalised injuries as we assumed that disabilities and significant impairments occur only for hospitalised injuries.[86]

Table 4.44 presents the cost of road crash injuries by cost component.

[86] This is a generalisation and while in practice this does not always follow strictly along hospitalised vs. non-hospitalised patients, this assumption does not affect our overall results.

Table 4.44: Cost of road crash injuries by cost component (in million 2020 dollars)

Cost component	Hospitalised	Non-hospitalised	Total
Workplace and household output losses	$4,662	$91	$4,753
Medical and related costs	$1,545	$755	$2,299
Long term care cost	$1,447	$89	$1,536
Repair costs	$350	$861	$1,211
Insurance administration	$406	$286	$692
Pain, grief and suffering	$507	$0	$507
Travel delay and operating costs	$97	$223	$320
Ambulance	$79	$92	$171
Emergency and police services	$120	$14	$134
Vehicle unavailability	$43	$64	$107
Legal costs	$84	$0	$84
Externality cost of crash-induced pollution	$5	$10	$15
Street furniture	2.59	6.42	$9
Recruitment and re-training costs	$5	$0	$5
Total	$9,351	$2,491	$11,842

4.3.4. Medical and related costs

The total hospital, medical and paramedical costs of injury were estimated to be $2.3 billion, of which 33 per cent were due to non-hospitalised injuries and 35 per cent to severe hospitalised injuries (MAIS3+). Medical and related costs were estimated to be $39,800 per hospitalised injury and $7,900 per non-hospitalised injury. Naturally, among the hospitalised injuries, MAIS3+ injuries with mild or moderate disability have higher cost ($53,200) and the highest cost for MAIS3+ injuries with profound or severe disability, where the medical related cost for these 2.8 per cent worst injured was on average $593,400. **Table 4.45** presents the hospital and medical costs for non-hospitalised injury by age category and gender.

Table 4.45: Medical and related costs for non-hospitalised injury by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$0.6	$1.4	$2
5–16	$4.9	$8.4	$13
17–25	$35.5	$60.6	$96
26–39	$68.7	$122.5	$191
40–54	$93.8	$144.6	$238
55–64	$45.5	$80.5	$126
65–74	$23.4	$30.9	$54
75+	$13.9	$19.5	$33
Total	**$286**	**$468**	**$755**

Hospitalised injury accounted for 26 per cent of all incidences of road crash injury but 67 per cent of all injury-related cost. **Table 4.46** presents the hospital and medical costs for hospitalised injury (all injury severities) by age category and gender.

Table 4.46: Medical and related costs for all hospitalised injury (MAIS 1, 2 and 3+) by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$2.9	$2.4	$5
5–16	$21.2	$25.7	$47
17–25	$93.9	$206.9	$301
26–39	$104.3	$271.0	$375
40–54	$115.1	$251.4	$367
55–64	$73.5	$134.8	$208
65–74	$57.7	$64.8	$123
75+	$62.0	$56.9	$119
Total	**$531**	**$1,014**	**$1,545**

Most severe road crash injuries accounted for less than 3 per cent of all road crash injuries but 35 per cent of hospital and medical costs. **Table 4.47** presents the hospital and medical costs for most severe hospitalised injury (MAIS3+) by age category and gender.

Table 4.47: Medical and related costs for severe hospitalised injury (MAIS3+) by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$2.2	$1.4	$4
5–16	$12.4	$16.0	$28
17–25	$46.6	$130.3	$177
26–39	$37.4	$138.5	$176
40–54	$34.8	$129.3	$164
55–64	$33.4	$67.8	$101
65–74	$32.9	$39.4	$72
75+	$38.3	$35.6	$74
Total	**$238**	**$558**	**$796**

4.3.5. Long-term care cost

We used TAC data and estimate unpaid family carer hours to account for all costs related to disability. Total cost for long-term care is $1.5 billion and hospitalised injury accounted for 94 per cent of all long-term care costs.

Table 4.48 presents the long-term care costs for hospitalised injury (all injury severities) by age category and gender.

Table 4.48: Medical and related costs for hospitalised injury (MAIS 1, 2 and 3+) by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$4	$3	$7
5–16	$49	$92	$141
17–25	$115	$347	$461
26–39	$77	$254	$330
40–54	$52	$192	$244
55–64	$39	$89	$129
65–74	$31	$46	$77
75+	$29	$29	$57
Total	**$396**	**$1,051**	**$1,447**

The most severe road crash injuries (MAIS3+) accounted for less than 3 per cent of all road crash injuries but 90 per cent of long-term care costs. **Table 4.49** presents the long-term care costs for the most severe hospitalised injuries (MAIS3+) by age category and gender.

Table 4.49: Medical and related costs for severe hospitalised injury (MAIS3+) by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$4	$3	$7
5–16	$47	$91	$139
17–25	$112	$343	$455
26–39	$71	$243	$314
40–54	$44	$182	$226
55–64	$36	$84	$120
65–74	$30	$42	$71
75+	$28	$28	$56
Total	**$373**	**$1,015**	**$1,388**

4.3.6. Ambulance, Police and Fire/Emergency services and Administration costs

These costs are discussed in more detail in the Other Cost Chapter below. Ambulance costs were estimated to be $134 million, with an average cost of $4,000 per severe injury (MAIS3+) and $1,800 per injury for all other hospitalised injuries. The difference in cost of road crash injuries is due to much costlier helicopter emergency services used for some of the most severely injured. Police services costs were estimated to be $75 million, with an average cost of $1,600 per hospitalised injury. The cost for non-hospitalised injury was much lower as we estimated that only 10 per cent of these injuries would be attended by police. Fire and emergency services were estimated to cost $58 million, with an average cost of $1,500 per injury. Fire and emergency services respond to all hospitalised road crashes but not minor injury crashes. A disaggregation of these costs by road type and remoteness can be found in the section on other costs of road crashes.

4.3.7. Legal costs

Legal costs for road crash injuries are due to common law litigations. In particular, legal costs apply for the plaintiffs and the defendants in states with at-fault legal systems for road crashes. We assumed that 10 per cent of all hospitalised claims are litigated.[87] Using data from the literature on typical cost and TAC data on claim size and distribution, we estimated the total cost of litigation following road crash injuries to be $84 million. Of which, 38 per cent (or $32 million) were due to serious injuries (MAIS3+) and 62 per cent (or $52 million) were due to other hospitalisations.[88]

4.3.8. Workplace and household output losses

Productivity losses following a road crash injury represent the value of goods and services that is not produced due to short-term absences from work or inability to help at home, inability to return to work or do household jobs due to a long-term disability, and premature death following a disability. We estimated these three costs separately. First, we calculated the earnings for the weeks off-work given the severity of the injury. Secondly, we calculated the present value of expected lifetime earnings by age category and gender for the proportion of injuries with permanent disabilities who cannot return to work. And lastly, we calculated the cost of the

[87] More details on the method and data used can be found in **Section 2.5** above.

[88] Legal costs do not vary by age or gender, hence there is no extra information gained by presenting this cost by age category and gender.

increased probability of premature death for severe road crash injuries. For all these costs we take both the workplace loss (paid work) and the output loss in the household (unpaid work) into account.[89]

This resulted in a total cost of $4.8 billion, with an average cost of $35,300 per road crash injury. This cost varies by the level of severity. For severe injuries, which often result in long-term permanent disability that precludes them from the labour force, the average per-injury cost was $1.1 million. For minor injuries, which never result in a hospital admission and are assumed to result in only a few days of work missed, the average per-injury cost was $945.

Table 4.50 presents the cost of short-term and long-term workplace and household output losses for hospitalised injuries with profound disability by age category and gender. **Table 4.51** presents the cost of short-term and long-term workplace and household output losses for hospitalised injuries with moderate/mild disability by age category and gender. **Table 4.52** presents the cost of short-term workplace and household output losses for less serious hospitalised injuries by age category and gender. **Table 4.53** presents the cost of short-term workplace and household output losses for non-hospitalised injuries by age category and gender.

Table 4.50: Cost of short-term and long-term workplace and household output losses for hospitalised injuries (MAIS3+) with profound disability by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$6.6	$4.0	$11
5–16	$22.6	$36.8	$59
17–25	$145.6	$348.8	$494
26–39	$162.5	$440.5	$603
40–54	$121.5	$360.9	$482
55–64	$79.0	$156.9	$236
65–74	$58.3	$61.8	$120
75+	$47.1	$36.1	$83
Total	**$643**	**$1,446**	**$2,089**

Table 4.51: Cost of short-term and long-term workplace and household output losses for hospitalised injuries (MAIS3+) with moderate disability by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$8.1	$5.4	$14
5–16	$27.9	$49.3	$77
17–25	$173.8	$454.5	$628
26–39	$187.3	$551.8	$739
40–54	$132.1	$422.7	$555
55–64	$81.8	$174.7	$257
65–74	$60.1	$69.8	$130
75+	$41.7	$36.0	$78
Total	**$713**	**$1,764**	**$2,477**

[89] More details can be found in **Section 2.5.2**

Table 4.52: Cost of short-term workplace and household output losses for hospitalised injuries (MAIS 1 or 2) with short-term wage loss only by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$-	$-	$-
5–16	$0.0	$0.1	$0
17–25	$6.9	$5.2	$12
26–39	$15.8	$13.5	$29
40–54	$21.7	$14.6	$36
55–64	$9.4	$6.2	$16
65–74	$1.4	$0.9	$2
75+	$0.1	$0.1	$0
Total	**$55**	**$41**	**$96**

Table 4.53: Cost of short-term workplace and household output losses for non-hospitalised injuries with short-term wage loss only by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$-	$-	$-
5–16	$0.0	$0.1	$0
17–25	$6.3	$5.0	$11
26–39	$14.5	$13.0	$28
40–54	$19.9	$14.2	$34
55–64	$9.0	$6.2	$15
65–74	$1.4	$0.9	$2
75+	$0.1	$0.1	$0
Total	**$51**	**$39**	**$91**

4.3.9. Recruitment and re-training cost

In addition to the workplace and household output losses, disability following a road crash injury can cause workplace disruption. The cost of workplace disruption and replacement was estimated by calculating the cost of replacing a disabled worker and the unit cost of recruitment and training (weighted by management or non-management roles). The unit cost for recruitment and training amounted to $4,115, and the unit cost was slightly higher for males than for females as males are more often in management roles. Not every person in the population is in employment so the cost of workplace disruption and replacement applies only to the reduction in the proportion of people who actively participate in the labour market. To account for people who are out of the workforce or are unemployed, we weighted the incidence of disability in each age category by the proportion of people who participate in the labour market before the disability.[90] Children will not have a workforce replacement cost until they are 15 years or older, and similarly, the cost of workplace disruption

[90] More details on the method and labour utilisation rates can be found in **Section 2.5**

and replacement was very low for people in the oldest age category, due to low workforce participation. The total cost of workplace disruption and replacement was estimated to be $4.6 million. Broken down by age category, we observed the highest cost for males in the age category of 26 to 39 years, due to the number of road crash injuries and a large proportion of individuals in this age category participating in the labour market before their disability. **Table 4.54** presents the cost of workplace disruption and replacement by age category and gender.

Table 4.54: Cost of workplace disruption and replacement by age category and gender (in *thousand* 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$-	$-	$-
5–16	$5	$9	$14
17–25	$267	$710	$977
26–39	$295	$988	$1,283
40–54	$276	$952	$1,228
55–64	$216	$546	$762
65–74	$92	$166	$258
75+	$10	$29	$39
Total	**$1,162**	**$3,399**	**$4,562**

4.3.10. Pain, grief and suffering

We derived the total human costs for serious injury crashes that result in profound/severe or moderate/mild disability. We used the TAC value of lump sum payments to families of road crash injuries multiplied by the level of impairment. The total human cost of pain, grief and suffering was estimated to be $507 million. The observed differences in human costs by age category and gender are driven by the differences in incidence across age categories and gender. The highest cost is born by males between the ages of 26 to 39 years, as they represent the largest number of serious road crash injuries. **Table 4.55** presents the human cost of pain grief and suffering for serious hospitalised road crash injuries by age category and gender.

Table 4.55: Human cost of pain, grief and suffering for serious hospitalised road crash injuries by age category and gender (in million 2020 dollars)

Age category (years)	Female	Male	Total
0–4	$1.6	$1.0	$3
5–16	$4.7	$8.4	$13
17–25	$25.6	$66.9	$92
26–39	$27.2	$77.3	$104
40–54	$24.0	$74.2	$98
55–64	$21.9	$47.5	$69
65–74	$26.1	$33.4	$60
75+	$32.9	$34.5	$67
Total	**$164**	**$343**	**$507**

4.4. Cost of road crash injuries by road user and remoteness

Drivers who make up the largest number of road crash injuries (60 per cent), have the highest cost of road crash injuries ($6.5 billion). For the most vulnerable road users, motorcyclists and pedestrians, the proportion of injured people fell to 10 per cent and 5 per cent respectively from the proportion of fatalities (18 per cent and 14 per cent respectively), but the proportion of pedal cyclists significantly increased to 5 per cent compared to their proportion among fatalities (3 per cent). The average hospital and medical cost per road user (and thus the severity of the injury and likelihood of disability) was significantly higher for motorcyclist and pedestrians, when compared with other road users. This was reflected in their over-representative cost proportions of 16 and 7 per cent respectively. **Table 4.56** presents the cost of road crash injuries by road user and remoteness.

Table 4.56: Cost of road crash injuries by road user category and remoteness area (in million 2020 dollars)

Road user category	Major cities	Outside major cities	Total
Driver	$3,974.92	$2,578.63	$6,554
Passenger	$1,033.45	$905.82	$1,939
Motorcyclist	$1,082.89	$751.95	$1,835
Pedestrian	$657.90	$171.90	$830
Pedal cyclist	$551.78	$132.56	$684
Total	**$7,301**	**$4,541**	**$11,842**

4.5. Cost of road crash injuries by age category and remoteness

Comparing the distribution of the cost of road crash fatalities between major cities and outside major cities, we observed that the pattern of distribution was reversed - 62 per cent of the cost was due to road crash injuries that occurred in major cities and 38 per cent was due to road crash injuries that occurred outside major cities. **Table 4.57** presents the cost of road crash injuries by age category and remoteness.

Table 4.57: Cost of road crash injuries by age category and remoteness area (in million 2020 dollars)

Age category (years)	Major cities	Outside major cities	Total
0–4	$35	$29	$64
5–16	$280	$205	$485
17–25	$1,572	$1,136	$2,708
26–39	$2,018	$1,067	$3,085
40–54	$1,673	$985	$2,658
55–64	$836	$560	$1,396
65–74	$481	$316	$797
75+	$407	$243	$650
Total	**$7,301**	**$4,541**	**$11,842**

4.6. Cost of road crash injuries by crash type and remoteness

The largest contributor to the cost of road crash injuries was same direction crashes, with an estimated cost of $3.6 billion. While same direction crashes represent only a small proportion of fatal injuries (7 per cent) their proportion of the cost increases to 37 per cent among non-hospitalised injury crashes. Same direction crashes are particularly common in major cities (44 per cent of all injury crashes).

The second largest cost was from run-off-the-road crashes, which accounted for $2.9 billion or 24 per cent of all costs. This type of road crash is not only often fatal but also results in more severe injuries for those who survive. Run-off-the-road crashes occur more often outside major cities, and while they represented a smaller proportion among all injuries (23 per cent), they constitute the biggest proportion of hospitalised injury crashes (34 per cent).

The next largest contributor to the cost of road crash injuries was intersection crashes, with an estimated cost of $1.8 billion. **Table 4.58** presents the cost of road crash injuries by crash type and remoteness area.

Table 4.58: Cost of road crash injuries by crash type and remoteness area (in million 2020 dollars)

Crash type	Major cities	Outside major cities	Total
Same direction	$2,895	$717	$3,612
Run off road	$976	$1,892	$2,868
Intersection adjacent	$1,178	$670	$1,848
Head on	$1,074	$566	$1,639
Pedestrian struck	$443	$152	$595
Other	$736	$544	$1,280
Total	**$7,301**	**$4,541**	**$11,842**

4.7. Sensitivity analysis—Univariate

An important part of the cost estimation with injury crashes is treatment of underreported incidence in the NCD. In Section 2.4.2 we described how we estimated underreporting of hospitalised injuries. We used data from the AIHW and derived a factor of 1.84 to estimate the actual incidence from NCD reported hospitalised injury crashes.

The AIHW reports hospitalisations separately by road vehicle traffic crashes and non-traffic crashes. This level of information is used in the base case estimation where we use the reported road vehicle crashes. The AIHW data also record the place of occurrence. If we use a more conservative approach and only use the road vehicle crashes that took place on streets and highways[91], we get a factor of 1.60 to estimate the hospitalisation incidence from the NCD reported hospitalised injury crashes.

Table 4.59 shows the new cost estimates with the low hospitalisation assumption in place and compares the results to the base case. Overall, the total cost for injuries drops by $1.6 billion to $10.3 billion which is a 13 per cent drop.

[91] This leaves out parking places, farm, forests, and where the place is unspecified. Hence, this is a most conservative approach, which will likely underestimate the number of hospitalisations from road crashes.

Table 4.59: Sensitivity to hospitalisation estimate by level of severity

Level of severity	Cost with low hospitalisation	Per cent of hospitalised	Cost base case	Per cent of hospitalised	Change in per cent
Hospitalised severe injury (MAIS3+) with profound disability	$3,982	39	$4,587	39	-13
Hospitalised severe injury (MAIS3+) with moderate disability	$2,591	25	$2,987	25	-13
Hospitalised injuries (MAIS 1 or 2)	$1,523	15	$1,777	15	-14
Non-hospitalised injury	$2,156	21	$2,491	21	-13
Total	**$10,253**		**$11,842**		**-13**

Another important assumption in the incidence estimation for non-hospitalised injury was that for every crash injured person which presents themselves at an emergency room, there is an additional 0.61 that go straight to a primary care provider such as a GP. An alternative assumption would be to use the reported 0.83 people derived across all types of injuries (not specific for transport). This measure has been used in the BITRE 2009. Non-hospitalised injury cost goes up by 14 per cent to a total of $2,842, an increase of $351 million or 3 per cent of the total cost of injury crashes if this assumption is changed.

We also wanted to test the assumption about the number of people with disabilities following a road crash injury which are cared for by family at home. The default case is to assume that all profound disabilities are being cared for at a care facility and the proportion of severe disabilities are being cared for by relatives at home. If we assume instead that all disabilities are cared for at home, and account for the unpaid carer work, we get a total estimate for long-term care cost of $2.8 billion, an increase of 85 per cent in this cost category, raising the total social cost of road crashes by $1.3 billion or almost 5 per cent. If we assume instead that all carer costs are covered by local transport insurance schemes, the total estimate for long-term care cost is $824 million. A reduction from the base case scenario of $712 million or 2.6 per cent of the total social cost of road crashes.

One last assumption we wanted to test is around the value of pain, grief and suffering for loss of quality of life due to a disability which are based on statutory TAC values. If we don't use current TAC values but derive inflated values from the statutory values used in BITRE (2009), we get a 48 per cent higher value per level of disability, resulting in a total cost for pain, grief and suffering from road crash injuries of $751 million.

Chapter 5. Vehicle-related costs of road crashes

5.1. Key point summary

- Between 2016 and 2020, there were annually an estimated 1.7 million vehicles involved in road crashes.
- The economic cost to society for all vehicle-related cost was estimated to be $12.1 billion and the cost per vehicle was estimated to be $7,100.
- The vast majority of vehicle-related cost (85 per cent) was due to repair cost.
- 69 per cent of the vehicle-related cost were due to crashes in major cities.
- The estimated costs are higher than those reported in the previous report, with a 84 per cent increase in the overall cost in this category. The increased estimate is completely driven by a 48 per cent increase in the estimated incidence, while unit costs have increased with inflation.
- The cost of vehicle insurance administrative costs per vehicle was $616.

Box 5.4: Key point summary for Chapter 5

5.2. Incidences of vehicles involved in road crashes

The largest group of vehicles involved in road crashes are those involved in property damage only (PDO) crashes. We estimated the incidence of these based on the police reported casualty crashes in the National Crash Database (NCD) and jurisdiction data on PDO crashes.[92]

A PDO crash is a collision on public roads where no party sustained any injuries. We estimated that there is a total of 1.5 million vehicles involved in PDO crashes. A large proportion of these crashes occurred in major cities (73 per cent) and involved cars or light commercial vehicles (84 per cent). The smallest incidence was observed for buses, which accounted for less than one per cent of all vehicles involved in crashes.

The incidence of all vehicles involved in road crashes includes the number of vehicles involved in casualty crashes, as these will cause property damage in addition to the cost related to the injury of people involved. In general, there are on average less cars involved in more severe road crashes. For fatal crashes the NCD reports on average 1.58 vehicles per crash. For hospitalised injury crashes this is 1.73 vehicles and in non-hospitalised crashes there are on average 1.92 vehicles involved. **Table 5.60** presents the incidences of vehicles involved in road crashes by vehicle type, remoteness, and level of severity. The figures reported in the table reflect averages over five years.

[92] For details see **Section 2.4.4**.

Table 5.60: Estimated vehicles involved in road crashes by vehicle type, remoteness and level of severity

	Fatal		Hospitalised injury		Non-hospitalised injury		PDO		
Vehicle type	**Major cities**	**Outside major cities**	**Major cities**	**Outside major cities**	**Major cities**	**Outside major cities**	**Major cities**	**Outside major cities**	**Total**
Cars and light commercial vehicles	454	725	29,664	13,769	73,400	34,069	958,251	323,742	1,434,074
Motorcyclist	95	128	3,928	2,777	9,720	6,870	67,534	44,355	135,408
Buses	13	6	296	107	733	264	8,139	1,941	11,498
Heavy rigid trucks	35	46	701	403	1,735	997	19,047	8,984	31,948
Articulated trucks	18	76	381	532	942	1,316	9,234	10,549	23,048
Pedal cyclist	23	18	1,960	504	4,849	1,247	48,643	11,050	68,294
Total		**1,637**		**55,022**		**136,142**		**1,511,468**	**1,704,269**

5.3. Cost results

5.3.1. Total vehicle-related cost of road crashes

The estimated cost of vehicle damage in road crashes was $12.2 billion, equating to $7,200 per vehicle. This estimated cost was higher than the previous estimated cost in BITRE (2009) of vehicle damage of $8.3 billion, equating to $7,200 per vehicle (inflated to 2020 dollars). The differences between the two estimated costs are simply due to a higher estimate of the number of vehicles involved in road crashes. Increased cost for repair, which grew by more than general inflation, are standing against similar size in admin cost reductions. **Table 5.61** presents the vehicle-related cost of road crashes by vehicle type and remoteness.

Table 5.61: Vehicle-related cost of road crashes by vehicle type and remoteness (in million 2020 dollars)

Vehicle type	Major cities	Outside major cities	Total
Cars and light commercial vehicles	$7,092	$2,462	$9,554
Motorcyclist	$723	$478	$1,200
Buses	$96	$24	$120
Heavy rigid trucks	$345	$169	$514
Articulated trucks	$355	$425	$780
Total	**$8,611**	**$3,558**	**$12,169**

5.3.2. Cost of vehicle repairs

The cost of vehicle repairs reflected the largest component of vehicle-related costs (85 per cent). The total cost of vehicle repairs was estimated to be $10.5 billion, equating to an average of $6,100 per vehicle. **Table 5.62** presents the cost of vehicle repairs by vehicle type and remoteness.

Table 5.62: Cost of vehicle repairs by vehicle type and remoteness (in million 2020 dollars)

Vehicle type	Major cities	Outside major cities	Total
Cars and light commercial vehicles	$6,085	$2,134	$8,219
Motorcyclist	$630	$419	$1,049
Buses	$83	$21	$104
Heavy rigid trucks	$303	$147	$449
Articulated trucks	$310	$366	$676
Total	**$7,411**	**$3,087**	**$10,497**

5.3.3. Cost of towing vehicles involved in road crashes

Additional towing costs were estimated for heavy vehicles involved in road crashes, based on the NSW maximum fee schedule for towing and the towing proportion by vehicle type. For cars and light commercial vehicles, the cost of towing was assumed to be included with the insurance claim costs. There was a total cost of $17.9 million for towing heavy vehicles following an accident. **Table 5.63** presents the vehicle towing costs by vehicle type and remoteness.

Table 5.63: Vehicle towing cost by vehicle type and remoteness (in million 2020 dollars)

Vehicle type	Major cities	Outside major cities	Total
Buses	$0.1	$0.2	$0.3
Heavy rigid trucks	$1.7	$2.6	$4.3
Articulated trucks	$3.3	$10.0	$13.3
Total	**$5.1**	**$12.8**	**$17.9**

5.3.4. Cost of vehicle unavailability

Vehicle unavailability costs were estimated, based on vehicle rental rates in major cities and in regional centres. We considered the proportion of towed vehicles and assumed that crashes with low damage cost and no towing have, on average, only one day of unavailability resulting from a crash. The overall cost of vehicle unavailability was estimated to be $523 million. **Table 5.64** presents the vehicle unavailability cost by vehicle type and remoteness.

Table 5.64: Vehicle unavailability cost by vehicle type and remoteness (in million 2020 dollars)

Vehicle type	Major cities	Outside major cities	Total
Cars and light commercial vehicles	$347	$96	$443
Motorcyclist	$26	$14	$39
Buses	$4	$1	$5
Heavy rigid trucks	$9	$5	$14
Articulated trucks	$10	$12	$22
Total	**$396**	**$127**	**$523**

5.3.5. Insurance administration cost

Insurance administration cost are estimated as a 10 per cent proportion of repair cost. As such we estimate a total cost of $1.1 billion in administration cost.

5.3.6. Street furniture

Due to a lack of data on the cost of street furniture we estimated these costs on the basis of the $40 million estimate from BITRE (2009). The cost was inflated by the increase in total crashes estimated compared to 2006 (an increase of 48 per cent) and inflated to 2020 dollar. The estimated total cost for street furniture was $80.4 million, which we distribute according to accident proportions across crash severity categories.

Given the feedback by stakeholders that these cost estimates are likely to low, we triple the cost in the sensitivity analysis.

5.4. Sensitivity analysis—Univariate

As discussed in **Section 2.4**, we used a top-down approach, where we used insurance industry data to estimate the PDO incidence as our baseline case for the estimations in this chapter. The alternative bottom-up approach, based on the strong reporting requirements of the ACT, led to a 20 per cent lower estimate of overall vehicles involved in crashes. With the alternative incidence estimation, which decreased the number of PDO vehicles involved in crashes by 28 per cent, the overall cost estimate for all vehicle-related cost goes down by $3.3 billion (27 per cent). **Table 5.65** outlines the overall vehicle-related cost estimates for the top-down incidence numbers.

Table 5.65: Sensitivity using the bottom up incidence estimation -- vehicle-related cost of road crashes by vehicle type and remoteness (in million 2020 dollars)

Vehicle type	Major city	Outside major cities	Total
Cars and light commercial vehicles	$5,154	$1,802	$6,956
Motorcyclist	$535	$355	$890
Buses	$70	$18	$88
Heavy rigid trucks	$253	$125	$377
Articulated trucks	$261	$316	$577
Total	**$6,273**	**$2,616**	**$8,888**

An alternative assumption for the calculation of the insurance administration cost is a 15 per cent proportion of the repair cost. In this case we estimate a total of $1.6 billion in administration cost which is, by assumption, 50 per cent higher than in the base case.

As an alternative for the cost of street furniture we triple cost, assuming that due to the lack of data we have starkly underestimated the true cost. This will bring the new total for this cost category to $241.2 million.

Chapter 6. Other costs of road crashes

6.1. Key point summary

- Congestion costs (travel delay costs, additional vehicle operating costs, and costs of adverse environmental impacts) were estimated to be $1.4 billion on average per year between 2016-2020).
- Travel delay costs made up the largest part of these other costs accounting for $910 million.
- Additional vehicle operating costs accounted for $400 million per year.
- Externality cost from crash-induced pollution accounted for $64 million per year.
- Police, ambulance, and fire and emergency response services were estimated to be $314 million.
- This was broken down into $77 million for police services, $177 million for ambulance services, and $60 million for fire and emergency response services.

Box 6.5: Key point summary for Chapter 6

Costs estimated in this chapter are travel delay costs, additional vehicle operating costs, air pollution costs, costs associated with damage to street furniture and vehicle insurance administration costs. This chapter gives also more details on the costs for police, ambulance, and emergency response services.

6.2. Cost results

6.2.1. Travel delay costs

The total travel delay cost was estimated at approximately $907 million. Fatal crashes have the highest travel delay cost per accident ranging from $26,000 per fatal crash on a highway in a major city to $6,700 per fatal crash on a local road outside of major cities. The difference in the unit cost per crash is largely due to the varying flow of traffic given the type of road and the likelihood of lane closures, which is higher in fatality crashes where coroners may close the crash site for examination (ACT Magistrates Court, 2000), as well as a longer crash duration for more severe crash types. Fatal crashes account with $13 million for only 1.5 per cent of the total travel delay cost.

The total cost of travel delays related to hospitalised injury crashes were estimated to be $67 million or approximately 7.5 per cent of the total cost of travel delays with a unit cost ranging from $4,500 to $1,200. The total travel delay costs related to non-hospitalised injury crashes were approximately $155 million or 17 per cent of the total cost of travel delay costs. The unit cost of each crash ranged from $4,200 for hospitalised injuries on a highway in a major city to $1,100 dollars on a local road outside of a major city.

Property damage only crashes have a delay cost ranging from $1,500 per crash to $340 per crash. They accounted for 74 per cent of the total cost of travel delay ($672 million) given the much higher incidence of this type of crash.

The estimated total travel delay cost is similar to BITRE's previous estimate, looking at the per crash unit cost it has decreased by 22 per cent. This is due in part to changes in methodology and due to different model parameters. The previous BITRE model considered vehicle-type specific delay cost for the cars affected by the congestion following a crash and weighting based on time-of-day of the crash. The Australian sources used in this report to estimate delay times suggest significantly lower crash durations compared to the previous report, which used US-based estimates. The current study is based on Queensland data and did not include the large metropolitan areas of Sydney or Melbourne, including any modelling of congestion from ‘extreme events’ like a multi-vehicle fatality resulting in the closure of the Sydney Harbour bridge during peak hour traffic, which would cause lengthy delays. A significant consideration in our model is that the model does not account for the number of people in the car, and thus, may underestimate the true cost of travel delays due to road crash incidences. **Table 6.66** presents the cost of travel delay due to road crashes by crash type and road type.

Table 6.66: Cost of travel delay by crash severity and road type

	Cost per road crash	Number of crashes	Total cost (in million 2020 dollars)
Highway—Major city			
Fatal	$26,003	73	$2
Hospitalised injury	$4,472	3371	$15
Non-hospitalised injury	$4,165	8341	$35
Property damage only	$1,550	96692	$150
Arterial—Major city			
Fatal	$10,402	162	$2
Hospitalised injury	$1,777	7831	$14
Non-hospitalised injury	$1,655	19377	$32
Property damage only	$774	236346	$183
Local roads—Major city			
Fatal	$10,165	158	$2
Hospitalised injury	$1,717	9088	$16
Non-hospitalised injury	$1,599	22486	$36
Property damage only	$791	244861	$194
Highway—Outside major city			
Fatal	$20,098	237	$5
Hospitalised injury	$3,470	3211	$11
Non-hospitalised injury	$3,232	7945	$26
Property damage only	$986	67472	$67
Arterial—Outside major city			
Fatal	$7,017	299	$2
Hospitalised injury	$1,212	5023	$6
Non-hospitalised injury	$1,128	12429	$14
Property damage only	$344	105645	$36
Local roads—Outside major city			
Fatal	$6,720	164	$1
Hospitalised injury	$1,202	4444	$5
Non-hospitalised injury	$1,120	10995	$12
Property damage only	$444	95033	$42
Total			$907

6.2.2. Additional vehicle operating costs

The total additional vehicle operating cost was estimated to be $402 million; these additional vehicle operating costs amount to 29 per cent of crash induced congestion costs. The highest additional vehicle operation costs associated with a crash were for fatality crashes on major city highways. This incurred a cost of $12,000 per crash but these cashes are only a small fraction of the total vehicle operating cost. All fatality crashes on all roads accounted for approximately 1.5 per cent of the total vehicle operating cost. The highest additional vehicle operating cost was observed in the property damage only categories. Property damage only crashes on major city highways were estimated to be 16 per cent ($67 million), and on arterial roads in major cities 20 per cent ($81 million), of the total costs. This pattern was consistent in other road types as the incidence of PDO crashes is eight times that of other crash types together. **Table 6.67** presents the additional vehicle operating costs due to road crash-induced travel delay by crash type and road type.

Table 6.67: Additional vehicle operating costs due to road crash-induced travel delay by crash severity and road type

	Cost per road crash (in dollars)	Number of crashes	Total cost (in million 2020 dollars)
Highway—Major city			
Fatal	$11,556	73	$1
Hospitalised injury	$1,987	3371	$7
Non-hospitalised injury	$1,851	8341	$15
Property damage only	$689	96692	$67
Arterial—Major city			
Fatal	$4,624	162	$1
Hospitalised injury	$790	7831	$6
Non-hospitalised injury	$736	19377	$14
Property damage only	$344	236346	$81
Local roads—Major city			
Fatal	$4,504	158	$1
Hospitalised injury	$761	9088	$7
Non-hospitalised injury	$708	22486	$16
Property damage only	$350	244861	$86
Highway—Outside major city			
Fatal	$8,852	237	$2
Hospitalised injury	$1,528	3211	$5
Non-hospitalised injury	$1,423	7945	$11
Property damage only	$434	67472	$29
Arterial—Outside major city			
Fatal	$3,091	299	$1
Hospitalised injury	$534	5023	$3
Non-hospitalised injury	$497	12429	$6
Property damage only	$152	105645	$16
Local roads—Outside major city			
Fatal	$2,987	164	$0
Hospitalised injury	$535	4444	$2
Non-hospitalised injury	$498	10995	$5
Property damage only	$197	95033	$19
Total			$402

6.2.3. Externality cost of crash-induced pollution

The air pollution cost associated with traffic congestion due to road crashes was estimated to be approximately $64.1 million. The unit cost of air pollution ranged from $14 per crash for a property damage only crash on an arterial road outside of major cities, where few cars are affected for a short time to $1,800 per crash on a highway in a major city, where many cars are affected for a much longer duration. Externality cost have gone down by 40 per cent on a per crash basis compared to BITRE (2009). This is due to a change in methodology. **Table 6.68** presents the air pollution costs by crash type and road type.

Table 6.68: Externality cost of crash-induced pollution costs by crash severity and road type

	Cost per road crash	Number of crashes	Total cost (in million 2020 dollars)
Highway—Major city			
Fatal	$1,845	73	$0.1
Hospitalised injury	$317	3371	$1.1
Non-hospitalised injury	$295	8341	$2.5
Property damage only	$110	96692	$10.6
Arterial—Major city			
Fatal	$845	162	$0.1
Hospitalised injury	$144	7831	$1.1
Non-hospitalised injury	$134	19377	$2.6
Property damage only	$63	236346	$14.9
Local roads—Major city			
Fatal	$846	158	$0.1
Hospitalised injury	$143	9088	$1.3
Non-hospitalised injury	$133	22486	$3.0
Property damage only	$66	244861	$16.1
Highway—Outside major city			
Fatal	$828	237	$0.2
Hospitalised injury	$143	3211	$0.5
Non-hospitalised injury	$133	7945	$1.1
Property damage only	$41	67472	$2.7
Arterial—Outside major city			
Fatal	$289	299	$0.1
Hospitalised injury	$50	5023	$0.3
Non-hospitalised injury	$46	12429	$0.6
Property damage only	$14	105645	$1.5
Local roads—Outside major city			
Fatal	$402	164	$0.1
Hospitalised injury	$72	4444	$0.3
Non-hospitalised injury	$67	10995	$0.7
Property damage only	$27	95033	$2.5
Total			$64.1

6.2.4. Police services cost

The total police services cost was estimated to be $77.3 million, and the police service unit cost was estimated to be $1,858. Police attended all fatal and hospitalised injury crashes and about 10 per cent of non-hospitalised injury crashes, but on average none of the property damage only crashes.[93] **Table 6.69** presents the police services cost by crash type and road type.

Table 6.69: Police services costs by crash severity and road type

	Cost per road crash	Number of crashes attended	Total cost (in million 2020 dollars)
Highway—Major city			
Fatal	$1,858	73	$0.1
Hospitalised injury	$1,858	3,371	$6.3
Non-hospitalised injury	$1,858	771	$1.4
Arterial—Major city			
Fatal	$1,858	162	$0.3
Hospitalised injury	$1,858	7,831	$14.5
Non-hospitalised injury	$1,858	1,792	$3.3
Local roads—Major city			
Fatal	$1,858	158	$0.3
Hospitalised injury	$1,858	9,088	$16.9
Non-hospitalised injury	$1,858	2,080	$3.9
Highway—Outside major city			
Fatal	$1,858	237	$0.4
Hospitalised injury	$1,858	3,211	$6.0
Non-hospitalised injury	$1,858	735	$1.4
Arterial—Outside major city			
Fatal	$1,858	299	$0.6
Hospitalised injury	$1,858	5,023	$9.3
Non-hospitalised injury	$1,858	1,150	$2.1
Local roads—Outside major city			
Fatal	$1,858	164	$0.3
Hospitalised injury	$1,858	4,444	$8.3
Non-hospitalised injury	$1,858	1,017	$1.9
Total			$77.3

[93] All details of the attendance and cost estimation can be found in **Section 2.5.1**

6.2.5. Ambulance services cost

The cost of ambulances was estimated based on the different ambulance types (Helicopter Emergency Medical Service [HEMS] or road ambulance), crash severity, number of casualties per crash and rural loading. The total costs of ambulance services were estimated to be $177 million. Ambulances attended all fatal and hospitalised injury crashes and about 60 per cent of non-hospitalised injury crashes, but on average none of the property damage only crashes.[94] **Table 6.70** presents the ambulance services cost by crash type and road type.

Table 6.70: Ambulance services costs by crash severity and road type

	Cost per road crash	Number of crashes attended	Total cost (in million 2020 dollars)
Highway—Major city			
Fatal (HEMS)	$11,611	20	$0.2
Fatal (road)	$2,311	53	$0.1
Hospitalised injury (HEMS)	$11,611	89	$1.0
Hospitalised injury (road)	$1,772	3,282	$5.8
Non-hospitalised injury (road)	$1,592	4,958	$7.9
Arterial—Major city			
Fatal (HEMS)	$11,611	44	$0.5
Fatal (road)	$2,311	118	$0.3
Hospitalised injury (HEMS)	$11,611	207	$2.4
Hospitalised injury (road)	$1,772	7,624	$13.5
Non-hospitalised injury (road)	$1,592	11,518	$18.3
Local roads—Major city			
Fatal (HEMS)	$11,611	43	$0.5
Fatal (road)	$2,311	115	$0.3
Hospitalised injury (HEMS)	$11,611	240	$2.8
Hospitalised injury (road)	$1,772	8,847	$15.7
Non-hospitalised injury (road)	$1,592	13,367	$21.3
Highway—Outside major city			
Fatal (HEMS)	$11,611	64	$0.7
Fatal (road)	$3,599	173	$0.6
Hospitalised injury (HEMS)	$11,611	85	$1.0
Hospitalised injury (road)	$2,727	3,126	$8.5
Non-hospitalised injury (road)	$2,386	4,723	$11.3
Arterial—Outside major city			$0.0
Fatal (HEMS)	$11,611	81	$0.9
Fatal (road)	$3,599	218	$0.8
Hospitalised injury (HEMS)	$11,611	133	$1.5
Hospitalised injury (road)	$2,727	4,890	$13.3
Non-hospitalised injury (road)	$2,386	7,388	$17.6
Local roads—Outside major city			
Fatal (HEMS)	$11,611	44	$0.5
Fatal (road)	$3,599	120	$0.4
Hospitalised injury (HEMS)	$11,611	118	$1.4
Hospitalised injury (road)	$2,727	4,326	$11.8
Non-hospitalised injury (road)	$2,386	6,536	$15.6
Total			**$177**

[94] All details of the attendance and cost estimation can be found in **Section 2.5.1**

6.2.6. Fire and emergency response services cost

The cost of fire and emergency response services was estimated using data from the Productivity Commission in form of the Australian Government services reports. The total cost was estimated to be approximately $60.4 million, and the unit cost was estimated to be $1,773. State and territory emergency services and fire services attended all fatal and hospitalised injury crashes, but none of the other crash severity categories. [95] **Table 6.71** presents the fire and emergency response services cost by crash severity and road type. Of these costs, the highest costs were for local roads in major cities, which was estimated to be $16.1 million (27 per cent of the costs).

Table 6.71: Fire and emergency response services costs by crash severity and road type

	Cost per road crash	Number of crashes attended	Total cost (in million 2020 dollars)
Highway—Major city			
Fatal	$1,773	73	$0.1
Hospitalised injury	$1,773	3,371	$6.0
Arterial—Major city			
Fatal	$1,773	162	$0.3
Hospitalised injury	$1,773	7,831	$13.9
Local roads—Major city			
Fatal	$1,773	158	$0.3
Hospitalised injury	$1,773	9,088	$16.1
Highway—Outside major city			
Fatal	$1,773	237	$0.4
Hospitalised injury	$1,773	3,211	$5.7
Arterial—Outside major city			
Fatal	$1,773	299	$0.5
Hospitalised injury	$1,773	5,023	$8.9
Local roads—Outside major city			
Fatal	$1,773	164	$0.3
Hospitalised injury	$1,773	4,444	$7.9
Total			**$60.4**

6.3. Sensitivity analysis—Univariate

The congestion cost or travel delay cost was calculated using inputs from the literature to determine the hourly wage to be used for work related and non-work trips. The ATAP guidelines[96] suggest taking 129.8 per cent of the average wage for business trips and 40 per cent of the average wage for non-work-related trips. This has been our base case assumption. Gwilliam et al. (1997) recommended, accounting for the extra cost to the employer, so that 133 per cent of wages are used for work or paid time lost due to traffic delays and 30 per cent of hourly income for commuting and personal travel. If we change the assumptions and use these Gwilliam et al. (1997) values instead, we get a total travel delay cost of $810 million dollars, which is 11 per cent or 97 million lower than the base case.

[95] All details of the attendance and cost estimation can be found in **Section 2.5.1**

[96] See ATAP guidelines - PV2 road parameter values, August 2016.

Chapter 7. The economic and social costs of road crashes

7.1. Key point summary

- The total annual cost of road crashes in Australia over the years 2016-2020 are estimated using a Hybrid Human Capital methodology as $27.1 billion (2020 dollars), reflecting a increase of 12 per cent in real terms compared with the total cost of road crashes in 2006 (BITRE 2009).
- Road crash fatalities decreased by 26 per cent since 2006 or 41 per cent per capita (from 7.8 per 100,000 people to 4.6 per 100,000 people).
- An estimated 38 800 people injured in road crashes were admitted to hospital, up from 31,204 in 2006.*
- We estimated less than half the number of non-hospitalised injuries compared with the estimates in BITRE 2009. However, we also estimate property damage only crashes to have doubled, or a 70 per cent increase on a per capita basis.
- Workplace and household output losses and repair cost remain the largest cost components, contributing to 67 per cent of the total cost.
- Compared with the previous cost estimates reported in BITRE (2009), estimated medical-related costs have significantly increased while long term care costs and the costs of pain, grief and suffering have decreased due changes in data and methodology.
- Head-on crashes represent a disproportionate share of the total cost, as do run-off-the-road crashes.
- Governments bear an estimated $3.9 billion (14 per cent) of the total social cost, with three-quarters born by the Commonwealth, 21 per cent by state and territories, and local governments bearing 2 per cent of the total cost.

*Although this is not directly comparable given changes in hospital reporting in Victoria in 2012 and NSW in 2017.

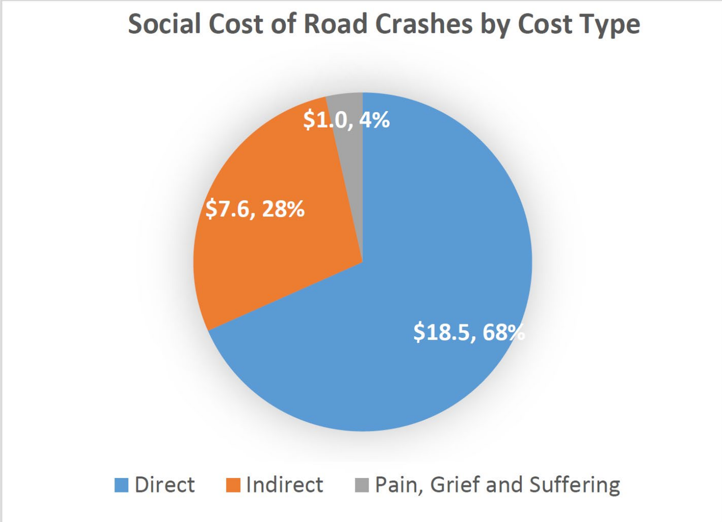
Box 7.6. Key summary for Chapter 7

7.2. Costs results

7.2.1. Social cost of road crashes overview

Figure 7.3 below provides an overview of the contribution of the three cost types—direct, indirect and pain, grief, and suffering—to the overall cost of road crashes in Australia. Direct costs represent 62 per cent ($13.7 billion) of the total cost, with indirect costs representing 34 per cent ($7.6 billion). The non-pecuniary cost of pain, grief and suffering represented 4 per cent ($1.0 billion) of the total cost.

Figure 7.3: Social cost of road crashes by cost type (in billion 2020 dollars)



7.2.2. Social cost by severity and cost component

The total annual cost of road crashes between the years 2016-2020 was estimated to be $27.1 billion (2020 dollars).

Looking at the cost of road crashes by severity, the biggest contributor to the total cost was hospitalised injury crashes with an estimated cost of $9.4 billion (36 per cent), followed by property damage only crashes with an estimated cost of $11.7 billion (43 per cent). While the incidence of road crash fatalities is low, the cost of road crash fatalities was estimated to be $3.5 billion (13 per cent). The cost of non-hospitalised injury was estimated to be $2.5 billion (9 per cent).

Table 7.72 presents the estimated social cost of road crashes in Australia by level of severity and remoteness and give the cost per incidence. The costs of crashes divided by the number of crashes in each severity level is listed in Column 5 and shows how much costlier high severity crashes are relative to low severity crashes.

Table 7.72: Estimated social cost of road crashes in Australia by level of crash severity and remoteness area, (in million 2020 dollars)

Level of crash severity	Major cities[97] (in million dollars)	Outside major cities (in million dollars)	Total (in million dollars)	Cost per crash (in dollars)
Fatal	$1,193	$2,286	$3,479	$3,174,687
Hospitalised injury	$5,579	$3,771	$9,351	$282,446
Non-hospitalised injury	$1,683	$807.46	$2,491	$30,404
Property damage only	$8,464	$3,260	$11,723	$13,799
Total	**$16,919**	**$10,125**	**$27,043**	**$28,122**

Looking at the cost of road crashes by cost component, the biggest contributor to the total cost was repair costs with an estimated cost of $10.5 billion (38 per cent), followed by workplace and household output losses with an estimated cost of $7.6 billion (28 per cent). Medical-related costs were high with an estimated cost of $2.3 billion (9 per cent). Other large costs components are insurance administration cost of $1.6 billion, Long-

[97] The ABS Remoteness Area category of "*Major cities of Australia*" includes all capital cities in Australia apart from Darwin and Hobart.

term care cost of $1.3 billion and pain, grief and suffering related cost ($1.0 billion). Coronial cost constituted the smallest cost component of $2 million. Some costs, such as long-term care costs or pain, grief, and suffering, do not apply to minor injury or property damage only crashes. **Table 7.73** presents the estimated social cost of road crashes in Australia by cost components.

Table 7.73: Estimated social cost of road crashes in Australia by cost component and crash severity, (in million 2020 dollars)

Cost Component	Fatality	Hospitalised injury	Non-hospitalised injury	Property damage only	All Injury
Repair cost	$13	$350	$861	$9,292	$10,515
Workplace and household losses	$2,856	$4,662	$91	na	$7,609
Medical related costs	$19	$1,545	$755	$0	$2,319
Insurance administration	$30	$406	$286	$928	$1,650
Long term care costs	na	$1,447	$89	na	$1,536
Travel delay and operating costs	$19	$97	$223	$969	$1,309
Pain, grief and suffering	$444	$507	na	na	$952
Vehicle unavailability	$1	$43	$64	$415	$523
Ambulance	$6	$79	$92	$0	$177
Emergency and police services	$4	$120	$14	$0	$138
Legal costs	$8	$84	na	na	$92
Externality cost of crash-induced pollution	$1	$5	$10	$48	$64
Correctional services	$62	na	na	na	$62
Street furniture	$0.1	$3	$6	$71	$80
Premature funeral	$9	na	na	na	$9
Recruitment and re-training	$3	$5	na	na	$8
Coronial cost	$2	na	na	na	$2
Total	**$3,479**	**$9,351**	**$2,491**	**$11,723**	**$27,043**

Table 7.74 presents the cost component as cost per crash incidence. That is the total cost of a component divided by the number of crashes in each severity level. We observe that workplace and household losses and pain grief and suffering are the biggest cost for fatalities, while for hospitalisations medical and long-term care cost become also large cost components.

Table 7.74: Estimated social cost *per crash incidence* by cost component and crash severity, (in 2020 dollars)

Cost Component	Fatality	Hospitalised injury	Non-hospitalised injury	Property damage only
Repair cost	$11,827	$10,619	$10,549	$10,983
Workplace and household losses	$2,613,335	$141,406	$1,111	na
Medical related costs	$17,785	$46,846	$9,251	na
Insurance administration	$27,798	$12,300	$3,504	$1,097
Long term care costs	na	$43,888	$1,088	na
Travel delay and operating costs	$17,355	$2,940	$2,738	$1,146
Pain, grief and suffering	$406,599	$15,387	na	na
Vehicle unavailability	$1,239	$1,313	$781	$490
Ambulance	$5,424	$2,391	$1,129	$0
Emergency and police services	$3,630	$3,630	$172	$0
Legal costs	$7,222	$2,538	na	na
Externality cost of crash-induced polution	$690	$137	$128	$57
Correctional services	$56,931	na	na	na
Street furniture	$70.6	$79	$79	$84
Premature funeral	$7,879	na	na	na
Recruitment and re-training	$2,757	$138	na	na
Coronial cost	$2,205	na	na	na
Total	**$3,182,747**	**$283,613**	**$30,530**	**$13,857**

7.2.3. Social cost by jurisdictions

In relation to the total cost of road crashes by state and territory, the cost burden for New South Wales is the biggest, followed by Victoria and Queensland. The variability in the cost burden across states and territories is due to differences in crash incidence and remoteness. **Table 7.75** presents the estimated social cost of road crashes by severity and state and territories.

Table 7.75: Estimated social cost of road crashes by crash severity and jurisdiction, (in million 2020 dollars)

Level of crash severity	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Australia
Fatal	$1,033	$760	$734	$271	$438	$107	$112	$25	$3,479
Hospitalised injury	$2,349	$2,603	$2,834	$324	$858	$122	$208	$52	$9,351
Non-hospitalised injury	$833	$517	$456	$265	$269	$105	$19	$25	$2,491
Property only	$3,938	$2,445	$2,120	$1,279	$1,315	$425	$77	$123	$11,723
Total	**$8,153**	**$6,325**	**$6,144**	**$2,139**	**$2,881**	**$760**	**$417**	**$225**	**$27,043**

7.2.4. Social cost by road user category and crash type

The cost of road crashes involving casualties represents two-thirds of the total social cost of road crashes (see **Table 7.76**).

In terms of the cost of road crashes by road user category, drivers, who make up the largest number of road crash casualties with 68 per cent, contribute the biggest overall cost share of 54 per cent ($8.2 billion). While motorcyclists make up 6 per cent of all casualties on roads, their proportion of the estimated cost is much higher at 16 per cent ($2.5 billion). Similarly, pedestrians and cyclists, who each represent 3 per cent of casualties, are over-represented in their cost contribution with 8 per cent ($1.3 billion) and 5 per cent ($0.8 billion), respectively.

Table 7.76: Estimated social cost of road crash casualties by road user category and remoteness, (in million 2020 dollars)

Road user category	Major cities	Outside major cities	Total
Driver	$4,365	$3,848	$8,212
Passenger	$1,198	$1,369	$2,567
Motorcyclist	$1,396	$1,111	$2,507
Pedestrian	$925	$326	$1,251
Cyclist	$611	$174	$784
Total	$8,494	$6,827	$15,321

In terms of the cost of road crashes by crash type group, the largest contributor was same direction crashes, with an estimated cost of $8.7 billion (32 per cent). Same direction crashes represented an estimated 36 per cent of all crashes and are much more common in major cities, but they often only lead to non-hospitalised injury or property damage. The second largest contributor to the cost of road crashes was run-off-the-road crashes, with the estimated cost of $6.2 billion (23 per cent). Run-off-the-road crashes represent 22 per cent of all crashes and are about 7 per cent costlier than the average crash and 18 per cent costlier than the average same direction crash. Run-off-the-road crashes occur more often outside major cities in more rural or remote area of Australia. Head on crashes are responsible for $4.3 billion (16 per cent) of the total social cost of road crashes. This type of road crash is over-represented in the total cost, as run-off-the-road crashes represent 11 per cent of all crashes. Such crashes are more likely to result in fatalities or severe injuries and the average cost of a head on crashes is 42 per cent higher than for the average crash. **Table 7.77** presents the social cost of road crashes by crash type and remoteness.

Table 7.77: Estimated social cost of road crashes by crash type group and remoteness, (in million 2020 dollars)

Crash type groups	Major city	Outside major cities	Total
Same direction	$7,097	$1,598	$8,695
Run off road	$2,085	$4,143	$6,228
Head on	$2,738	$1,524	$4,262
Intersection adjacent	$2,499	$1,308	$3,807
Pedestrian struck	$946	$378	$1,323
All other crash types	$1,594	$1,136	$2,729
Total	**$16,958**	**$10,087**	**$27,043**

7.2.5. Comparison to BITRE 2009 report

Table 7.79 on the next page presents the estimated cost of road crashes in Australia by cost component with comparisons to the estimates reported for 2006 in BITRE (2009).[98] Looking at Columns 2 and 4 we can compare the total cost for each cost component. To adjust for an increase in overall crash incidence from 2006 through 2020, Column 3 and 5 present costs per crash for the current report and the 2009 report respectively. Column 6 gives the differences in per crash cost between the two reports in percentage terms.

The overall estimated social cost of road crashes in Australia is approximately 12 per cent higher than the previous 2006 estimate (BITRE 2009). While workplace, household losses and travel delay costs are very similar to previous estimates, there are significant differences for other cost components. Repair costs have increased faster than CPI over the period since the last report and there are overall more crashes, which accounts for the increased repair costs. Medical-related costs were estimated to be double the previous estimate, which is due to a different data source and higher medical cost. Long-term care costs and cost for pain, grief and suffering have reduced by half. These changes are due to differences in the data sources used for the cost estimation. Lastly, insurance administration costs are estimated to be about half of the previous estimate, and this is due to a different estimation assumption of a lower per claim volume admin cost.

Table 7.78 give an overview over the cost components with the largest differences. Any cost which increased or decreased by more than $300 million is listed. We describe the size of the difference and name factors that lead to the big differences.

[98] All cost estimates from BITRE (2009) are inflated to 2020 dollar values to be directly comparable to the estimates in this report.

Table 7.78: Largest differences compared to BITRE 2009 report, by cost component

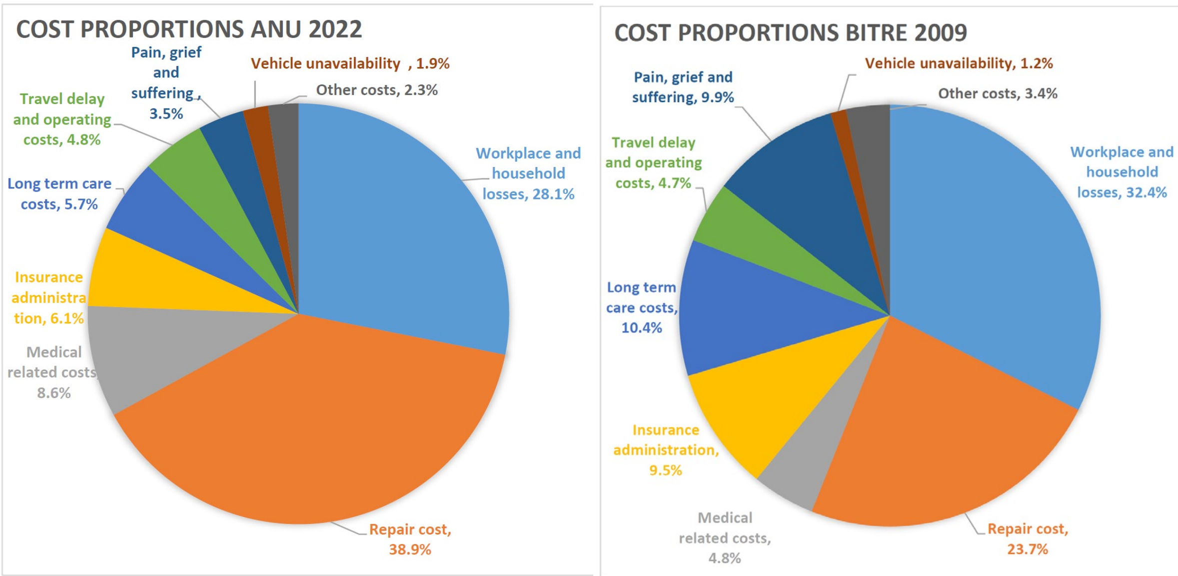
Cost component	Size of difference	Factors for difference
Repair cost	+$4,807 (+86%), unit cost: +25%	Repair costs have increased faster than CPI (+30% for cars and +61% for motorbikes) and more crashes (+48%)
Pain, grief and suffering	-$1,441 (-60%), unit cost: -73%	Differences in the statutory TAC value used (-48%) and decrease incidences of fatalities (-26%).
Medical related costs	+$1,149 (+98), unit cost: +35%	Improved data source with higher medical cost.
Long term care costs	-$987 (-39%), unit cost: -59%	Differences in methodology, strong dependence on assumptions. Improved cost data sources used..
Insurance administration	-$639 (-28%), unit cost: -51%	Different assumption of lower cost proportion of claim total (-30%)

Table 7.79: Estimated social cost of road crashes in Australia by cost component, comparison to 2009 Report (in million 2020 dollars)

	ANU 2022		BITRE 2009		
Cost Component	**Total Cost ($ million)**	**Cost over Crash ($)**	**Total Cost ($ million)**	**Cost over Crash ($)**	**Change in Cost over Crash (per cent)**
Repair cost	$10,515	$10,889	$5,718	$8,745	25
Workplace and household losses	$7,609	$7,880	$7,819	$11,959	-34
Medical related costs	$2,319	$2,401	$1,170	$1,789	34
Insurance administration	$1,650	$1,708	$2,288	$3,500	-51
Long term care costs	$1,536	$1,590	$2,522	$3,858	-59
Travel delay and operating costs	$1,309	$1,355	$1,136	$1,738	-22
Pain, grief and suffering	$952	$986	$2,393	$3,659	-73
Vehicle unavailability	$523	$542	$290	$443	22
Ambulance	$177	$183	$81	$123	49
Emergency and police services	$138	$143	$194	$296	-52
Legal costs	$92	$95	$362	$554	-83
Externality cost of crash-induced pollution	$64	$66	$72	$111	-40
Correctional services	$62	$64	$21	$32	103
Street furniture	$80	$83	$54	$83	0
Premature funeral	$9	$9	$10	$15	-40
Recruitment and re-training	$8	$8	$12	$19	-58
Coronial cost	$2	$2	$4	$6	-61
Total	**$27,043**	**$28,005**	**$24,147**	**$36,930**	**-24**

In **Figure 7.4** we observe the difference in the proportion of the total social cost the various cost components account for in this report (left chart) and in the BITRE 2009 report (right chart). The components are order according to their size in this report and we can see in the right chart the proportion changes significantly for a number of components. Relative to the new proportions repair cost and medical related cost were smaller in the 2009 analysis. On the other hand, insurance administration cost, pain grief and suffering and disability related cost were a larger component of social cost in the 2009 report.

Figure 7.4: Cost component proportions, comparison with BITRE 2009 Report



To gain a better understanding of the differences between the estimates in this report and the 2009 report, we present the changes in the estimated incidence and the changes in the unit cost per incident in **Table 7.80**.

Road crash fatalities fell by 26 per cent since 2006 and 38 per cent on a per capita basis (from 7.8 per 100,000 people to 4.6 per 100,000 people). Each road crash fatality costs society $2.9 million, which is 10 per cent less than the previous estimate. This is due to an older age distribution compared to the previous report. The average age of fatalities increased by over 6 years to 44.9 from 38.6 years in 2006. Younger fatalities are more costly as can be seen from the **Table 3.23**. We simulate what the cost of a fatalities would have been with an age distribution as it was in 2006 and found that cost would have been 20 per cent higher. Another factor is the lower statutory cost for pain, grief and suffering.

The incidence of road crash hospitalised injuries has increased by 24 per cent since 2006, which means it has grown proportional to the growth in population. Each hospitalised injury costs society $241,000, which is 19 per cent less than the previous estimate. This is due to a lower statutory cost for pain, grief and suffering and a lower estimate of long-term care costs. Our long-term care cost estimation method uses different data compared to BITRE (2009), in part as some data on the incidence is no longer available and we have much more detailed data on the cost side using transport accidence insurance data.

We estimated that the incidence of non-hospitalised injuries halved, but the cost per non-hospitalised injury was estimated to be much larger compared with the previous report. The difference in incidence rate was due to different parameters taken from the literature and newer data. Part of the difference in cost is due to the larger than zero estimates of ambulance, disability, and police cost for this group. However, the biggest difference comes from the increased medical-related cost which makes up a relatively large component in this crash class of 30 per cent (compared with 16 per cent in the 2009 report). The difference is due to more detailed health cost data from TAC, which allowed us to get a better estimate for non-hospital medical costs which are 5 times what was estimated in BITRE (2009).

Finally, we estimate that there were more than double the number of property damage only crashes. We estimate a 70 per cent increase on a per capita basis. This stark increase is due to better industry data and a different methodology to estimate the unreported property damage only crashes. The cost per property damage only crash is 8 per cent lower which is largely due to a lower insurance administration cost estimate.

Table 7.80: Incidences and per unit costs by crash severity, comparison to 2009 report

	ANU 2022 Report		BITRE 2009 Report[99]		Change	
Casualties/vehicles	**Incidence (#)**	**Unit cost ($1,000)**	**Incidence (#)**	**Unit cost ($1,000)**	**Incidence (%)**	**Unit cost (%)**
Fatal	1,187	$2,931	1,602	$3,271	-26%	-10%
Hospitalised injury	38,794	$241.0	31,204	$299.1	24%	-19%
Non-hospitalised injury	95,989	$25.9	216,500	$16.2	-56%	60%
Property damage only	1,511,454	$7.8	715,862	$8.5	111%	-8%
Road Crashes	**965,676**	**$28**	**653,853**	**$37**	**48%**	**-24%**

Table 7.81 gives an overview of the incidence per 100,000 people for the two reports. The trend that roads and cars are becoming safer leading to fewer and less severe road crashes on Australian roads has continued. While there were 25.5 fatalities per 100,000 people in 1976 there were only 7.8 per 100,000 in 2006. The annual average over the year 2016-2020 is down to 4.6 fatalities per 100,000 people. That means the number of road deaths per capita has dropped 40 per cent over the last 14 years. The group of PDO crashes has increased on a per capita basis by 70 per cent. Hence the overall number of crashes per capita of any severity has also increased by 19 per cent over this period.

Table 7.81: Incidences and incidence per 100,000 people by crash severity, comparison to 2009 report

	ANU 2022 Report		BITRE 2009 Report		Change	
Casualties/vehicles	**Incidence (#)**	**per 100,000 people**	**Incidence (#)**	**per 100,000 people**	**Incidence (%)**	**per 100,00 (%)**
Fatal	1,187	4.6	1,602	7.8	-26%	-40%
Hospitalised injury	38,794	151	31,204	151	24%	0%
Non-hospitalised injury	95,989	374	216,500	1,050	-56%	-64%
Property damage only	1,511,454	5,885	715,862	3,470	111%	70%
Road Crashes	**965,676**	**3,760**	**653,853**	**3,170**	**48%**	**19%**

[99] To make the cost by crash severity more comparable across the two reports, we proportionally distributed all costs of categories, which were previously summarised as '*Property damage and general cost*'.

7.2.6. Road crash cost burden

Table 7.82 shows the breakdown of the cost burden of road trauma by government and individuals for each cost component. The distribution is based on a AAA commissioned study by Economic Connections (2017) with some additional assumptions being made. Details can be found in **Appendix C**

Table 7.82: Burden of the social cost of road crashes

Cost category	Government				Non-government (individuals and families)
	Commonwealth	State & territory	Local	Total	
Productivity loss and suffering (fatalities and injuries)					
Workplace and household losses	$2,266	$188	$40	$2,494	$5,115
Pain, grief, and suffering				$0	$952
Health and Disability related					
Long term care costs	$313			$313	$1,223
Medical – hospitalised	$36	$42	$0	$78	$1,486
Medical – non-hospitalised	$347	$116	$0	$463	$291
Emergency services					
Ambulance		$120		$120	$56
Fire and Emergency		$20		$20	$41
Police		$77		$77	$0
Vehicle-related					
Repair costs	$11	$63	$11	$84	$10,431
Vehicle unavailability	$1	$3	$1	$4	$519
Travel delay and operating costs	$1	$8	$1	$10	$1,298
Externality cost of crash-induced pollution				$0	$64
Street furniture		$53	$27	$80	$0
Legal and other					
Legal costs		$92		$92	$0
Correctional services		$62	$0	$62	$0
Coronial costs		$2	$0	$2	$0
Premature funerals				$0	$9
Recruitment and re-training				$0	$0
Insurance administration				$0	$1,650
Total	**$2,975**	**$848**	**$79**	**$3,902**	**$23,134**

Table 7.82 indicates that individuals and their families bear most of the cost burden from road crashes (86 per cent). Most of the larger cost components, borne by individuals, are covered through insurance schemes

(such as vehicle third party and workers' compensation) and are thus distributed across all registered vehicle owners. However, some smaller components, like premature funeral costs or part of medical non-hospital costs, are borne by road crash casualties and their families.

Governments bear an estimated $3.9 billion (14 per cent) of the total social cost. Across different levels of government, we estimated that three-quarters of those $3.9 billion are covered by the Commonwealth and another 22 per cent by states and territories. Local governments cover only 2 per cent of the total government costs. The burden of road crashes to the government is almost identical in size and proportion to AAA (2017).

Chapter 8. Willingness to pay approach

8.1. Key point summary

- We used the current OBPR value of a statistical life to replace all costs borne by the individual.
- We valued loss due to disability using weights for disability-adjusted life years lost taken from AAA (2017).
- Total social cost increase by $590 million which is a 2 per cent increase in the overall social cost of road crashes, bringing the estimated overall social cost of road crashes to $27.6 billion.
- A road specific willingness to pay study run for the Australian Transport Assessment and Planning Guidelines is under way and once the results are available, they will be used to quantify road-specific intangible costs and will replace the WTP values currently used in this report.

Box 8.7. Key summary for Chapter 8

8.2. WTP estimates

In the main chapters of the report, we used a hybrid human capital approach to measure the indirect cost of road crashes. An alternative to valuing the human capital losses and losses for pain, grief and suffering is the use of a willingness to pay (WTP) measure that values the perceived cost of a loss of life or a disability - or in fact the WTP to avoid such loss or disability. As detailed in the methodology chapter of this report (**Chapter 2**), we used the OBPR WTP measure for a value of a statistical life. A transport-specific WTP measure would be the preferred measure should this become available in the future.

That the relative magnitude differs depending on whether WTP approach or hybrid human capital approach is used is not surprising - a point we return to in **Chapter 10**. .

Table 8.83 compares the estimated cost of road crash injuries, using the hybrid human capital cost estimates reported in Chapter 3 and 4, is compared with WTP estimates using weightings for disability-adjusted life years lost from AAA (2017) in conjunction with the current OBPR VSL . We note that disability adjusted life years and value of a statistical life have different underpinning theoretical bases - a point we return to in the discussion in **Chapter 10**.

If we are to use the WTP method instead of the hybrid human capital method, then a subset of the total social cost, which is presented in Column 2, is replaced with the values of Column 3. The cost categories replaced represent 32 per cent of the overall social cost of road crashes. These include workplace and household output losses, cost for unpaid home care of disabled, cost for pain, grief, and suffering, early funeral cost and individual proportions of repair, medical and ambulance cost. A detailed description of the cost replaced can be found in **Appendix A.** Substituting these costs with the users' WTP to avoid these adverse outcomes, lets us compare the results from these two different approaches and provides an alternative overall social cost estimates.

If we use the OBPR WTP measure together with the weightings for disability-adjusted life years lost from AAA (2017), the subset of costs replaced increased by 7 per cent and the overall social cost of road crashes increased by $590 million which is a 2 per cent increase (bringing the estimated overall cost to $27.6 billion).

Table 8.83: Cost to the individual (mostly indirect and pain, grief and suffering costs) of road crashes using Hybrid Human Capital and WTP approach by level of severity. (in million 2020 dollars)

Level of severity	Hybrid Human Capital Approach	OBPR VSL with disability weights from AAA (2017)	Change (%)
Fatality	$2,887	$5,935	106
Hospitalised severe injury (MAIS3+) with disability	$5,225	$3,410	-35
Hospitalised injuries (MAIS 1 or 2)	$264	$0	-100
Non-hospitalised	$379	$0	-100
Total	$8,755	$9,345	7

A road specific willingness to pay study run for the Australian Transport Assessment and Planning Guidelines is under way and once the results are available, they will be used by BITRE to quantify road-specific intangible costs and will replace the WTP values currently used in this report. In the meantime we attempted to use the road specific willingness to pay values from the NSW Roads and Traffic Authority study from 2008 undertaken by PricewaterhouseCoopers (PWC) in conjunction with the Hensher Group[100]. Similar to the forthcoming ATAP study, the 2008 study used a stated preference survey of road users with the aim of estimating WTP values for reducing the risk of death and of various levels of injury severity. We could not find a way of applying these NSW numbers in a rigorous and satisfactory way, in particular for the different levels of road injuries due to validity concerns.

Overall we find human costs related to road fatalities are between $3.0 billion and $6.5 billion higher (106 and 224 per cent higher)[101] when a willingness to pay (WTP) approach is used (compared to using the Hybrid Human Capital approach). This shows that WTP methods typically put a much higher value on a loss of life compared to the Hybrid Human Capital approach, which is what we would expect. Surprisingly we found the reverse to be true for severe injuries resulting in disabilities, for this group the WTP values were 35 to 63 per cent lower than the human costs derived in the Hybrid Human Capital approach.

[100] The values are reported in NSW (2016)

[101] The value associated with a fatality from the NSW (2016) WTP numbers is $7.9 million in 2020 dollars, which is 58 per cent higher than the non-road specific OBPR value for a fatality.

Chapter 9. Sensitivity of results

9.1. Key point summary

- Social cost estimates were modestly sensitive to a change in the discount rate, with the cost estimates ranging from 6 per cent higher to 13 per cent lower than the estimated total cost.
- A multivariate sensitivity analysis, changing the most important assumption gives a range of estimates from $22.2 billion (18 per cent lower) to $30.3 billion (12 per cent higher).
- With the willingness to pay approach we get range of estimates between $23.5 billion at the low and $29.1 billion at the upper end.

Box 9.7. Key summary for Chapter 9

9.2. Discounting

In the main chapters of the report, we used a discount rate of 3 per cent. This has a large effect on cost flows that occur far into the future, such as workplace losses and is particularly relevant for the estimates using the Hybrid Human Capital approach. **Table 9.84** presents these social cost estimates disaggregated by crash severity if the assumed discount rate is instead lower (2 per cent) or higher (4, 5 or 7 per cent).

As expected, the estimated cost of road crash fatalities and serious injuries is reduced when the discount rate is assumed to be higher (since future costs are valued less) and is increased when the discount rate is assumed to be lower (since future costs are valued more). This is because road crashes fatalities and serious injuries lead to some cost flows that occur far into the future. On the other hand, property damage only crashes and crashes with more non-hospitalised injuries do not have such cost flows at later points in time and are not affected by the discount rate change. The overall cost of road crashes reduces by 13 per cent to $23.6 billion if the largest discount rate of 7 per cent is applied and increases by 6 per cent to $28.8 billion if the discount rate of 2 per cent is applied.

Table 9.84: Sensitivity of road crash cost estimates to changes in the real discount rate (in billion 2020 dollars)

	2 per cent		**3 per cent (base)**		**4 per cent**		**5 per cent**		**7 per cent**	
Level of severity	**Cost**	**(%)**	**Cost**	**(%)**	**Cost**	**(%)**	**Cost**	**(%)**	**Cost**	**(%)**
Fatalities	$4.1	18	$3.5	13	$3.0	15	$2.7	13	$2.2	12
Hospitalised injuries	$10.4	40	$9.4	35	$8.6	38	$8.0	37	$7.2	35
Non-hospitalised injuries	$2.5	10	$2.5	9	$2.5	11	$2.5	12	$2.5	13
Property only crashes	$11.7	32	$11.7	43	$11.7	36	$11.7	38	$11.7	40
Total (% change from base)	**$28.8**	**(106)**	**$27.0**	**(100)**	**$25.8**	**(95)**	**$24.9**	**(92)**	**$23.6**	**(87)**

9.3. Multivariate sensitivity analysis

While the sensitivity analysis in **Section 6.3** looked at univariate parameter changes one at a time, this multivariate analysis brings all these changes together. Doing multivariate parameter changes help to explore how the different changes interact with each other. Multiplier effects are possible among the joint parameter changes (e.g. changing the GPD per capita value has a multiplier effect in the calculation of an increased number of disabled people in home care). The important parameters assumptions previously identified in Chapters 3 through 6 are separated into two groups, depending on if the parameter alternative was lowering or increasing the cost estimate relative to the base case. For each group of cost increasing assumption changes and cost decreasing assumption changes we re-estimate the social cost. One could think of these as most and the least conservative sets of assumptions. They provide us with a lowest cost and highest cost estimates, giving us a range for the total cost of road crashes, representing the underlying uncertainty with the most important model assumptions. These estimates are summarised in**Table 9.85**.

The lowest cost estimate adjusts the base case using: i) the bottom-up approach to estimate the total crash number, resulting in a 22 per cent reduction in the estimated PDO crash incidence; ii) conservative interpretation of AIHW's number of hospitalisations from on-road crashes, resulting in a 13 percent lower hospitalised injury rate; iii) alternative assumptions about the opportunity cost of time for non-business when stuck in congestions, resulting in a 11 per cent lower weighted average per hour travel delay cost; iv) assume that none of the disabilities from road injury lead to unpaid work by relatives caring for them at home, this resulted in 46 per cent reduction in total long-term care cost.[102]

The highest cost estimate adjusts the base case using: i) the inflated statutory payments for pain, grief and suffering from BITRE (2009), leading to an increase in these human cost of 48 per cent ii) triple the estimated street furniture repair cost in case these have increased much more than inflation since BITRE (2009); iii) a 20-year real per capita GDP growth average, resulting in a 50 per cent increase in the assumed wage growth; iv) a 15 per cent administration cost on repair cost, resulting in a 50 per cent increase in the overall insurance administration cost and v) using the a 1:0.83 ratio of GP to emergency department visits, resulting in an increased 14 per cent increase in non-hospital injury cost; vi) assume that all disability from road injury are cared for by relatives at home, putting in unpaid carer work, resulting in 85 per cent higher long-term care cost.[102]

Compared to the Hybrid Human Capital approach with base case assumptions, the lowest estimate reduces the total cost of road crashes by 18 per cent (or $4.8 billion), down to $22.2 billion. The highest cost estimate raises the total cost of road crashes by 12 per cent (or $3.2 billion), up to $30.2 billion.

Table 9.85: Cost of road crash injuries by level of severity and gender (in million 2020 dollars)

Level of severity	Base Case	Lowest cost estimate	Change (%)	Highest cost estimate	Change (%)
Fatalities	$3,479	$3,477	0	$3,922	13
Hospitalised injuries	$9,351	$7,495	-20	$11,426	22
Non-hospitalised injuries	$2,491	$2,154	-14	$2,874	15
Property only crashes	$11,723	$9,097	-22	$12,040	3
Total (% change from base)	**$27,043**	**$22,224**	**-18**	**$30,262**	**12**

If the same analysis is done using the WTP approach we get a lowest cost estimate of $23.5 billion and a highest cost estimate of $29.1 billion. The high-low interval shrinks slightly, as higher or lower values from the relevant cost subset calculated in the Hybrid Human Capital approach are replaced with the constant values from the WTP analysis, which are not affected by any of the changed assumptions above.

[102] More detail on all the assumption changes can also be found in the respective sensitivity analysis sections at the end of each chapter.

Chapter 10. Discussion

This report is the fourth in a series of reports by BITRE, which first commenced in 1980s (BITRE, 1988) and have aimed to provide a comprehensive examination of the cost of road crashes in Australia. The last report in this series reported 2006 costs and was published in 2009.

The current study replicates and extends the previous BITRE study. The study aimed to use current data, improved methods and include a wider scope of economic costs. This study builds a model to examine crash cost by crash type and resource burden. The study includes a wide range of sensitivity analyses.

The economic cost model in this study, which is consistent with the model from the previous BITRE report (Bureau of Infrastructure and Transport Research Economics, 2009), is summarised below.

First, we estimated and reported costs separately for:

- Fatal road crashes
- Road crash injuries, including post-incidence costs (cost following hospitalised and non-hospitalised injuries, and long-term care cost)
- Vehicle-related costs (repair, towing, cost of vehicle unavailability)
- Other costs (including travel delays, air pollution, insurance administration etc.)

Second, we explored further disaggregation of costs by crash type and remoteness area:

- Crash type (such as head-on and side-on crashes)
- Road user category (such as pedestrians, cyclists, and motorbikes)
- Major cities versus outside major cities

Finally, we identified the cost burden by stakeholder type:

- Commonwealth and State government
- Crash victims and their families or all road users

Results from the cost model (e.g., by type of crash, type of stakeholder etc.) will contribute to and provide additional functionality to BITRE's dashboards (e.g., serious injuries from road crashes dashboard) and enhance the usefulness of the data resources.

10.1. Interpretation of the results

The total annual cost of road crash fatalities was estimated to be $3.5 billion using a Hybrid Human Capital methodology, with an average cost of $2.9 million per road crash fatality. The total cost of road crash injuries was estimated to be $11.8 billion, with an average cost of $241,000 per hospitalised injury and $25,900 per non-hospitalised injury. The total cost of property damage only crashes was estimated to be $11.7 billion, with an average of $7,800 per property damage only crash.

Direct costs accounted for 64 per cent of the total cost of road crashes, with the majority of costs due to repairs. Indirect costs accounted for 28 per cent of the total cost of road crashes, and costs for pain, grief, and suffering accounted for 4 per cent.

The current study extended the previous 2009 BITRE report by including an analysis of the resource burden of road crashes. We estimated $3.9 billion (14 per cent of total cost) to be a resource burden to State and Federal governments, with three quarters (76 per cent) borne by the Commonwealth, 22 percent by states and territories, and 2 percent by local governments. $23.1 billion (86 per cent of total cost) is the resource burden to all road users and crash victims and their families.

The $27.0 billion estimate for annual costs of road crashes over the year 2016-2020 equates to 1.4 per cent of GDP. This estimate represents an increase of 12 per cent in real term costs compared with the estimates in the 2009 BITRE report. Factors contributing to the difference in the cost of road crashes across the two reports (i.e., the current report and the previous 2009 BITRE report) include:

- Changes to incidence: a 26 per cent drop in road crash fatalities and lower estimates of non-hospitalised injury.
- Changes to unit cost: A reduction in the unit cost of long-term care, pain, grief, and suffering and an increase in medical related cost for non-hospitalised injury.
- Changes to methods: We use detailed TAC data and data from the Australian Trauma Registry, which are more appropriate to determine unit cost and the number of injuries resulting in disability.
- Changes in assumptions: Information on the number of people showing up at the emergency room and visiting GPs has been updated, and a new assessment of ambulance and police attendance suggests that non-hospitalised injury crashes are partly attended.

It should also be noted that cost estimates can vary depending on:

- The approach taken to value losses due to fatality or injury (the differences in the two approaches are explained further in **Subsection 10.2**).
- The availability and quality of data (see **Subsection 10.3**).
- The values assumed for key parameters (such as the social discount rate of 3 per cent).

Throughout the empirical chapters (**Chapters 3** to **6**) and the summary chapter (**Chapter 7**), sensitivity analyses were conducted to assess the impact of uncertainties in: parameter estimates, assumptions made; and other methodological uncertainties. In summary, based on the sensitivity analyses, we observed that the results are most sensitive to:

- The assumptions made to estimate the under reported incidence of hospitalised injuries.
- The assumptions made to estimate the unreported property damage only crash incidence.
- The assumed real wage growth used for the calculation of foregone future earnings after fatalities and injury crashes.
- The discount rate used which changes the total estimate by about 5 per cent for each percentage point change.

The estimated cost of road crashes varies between $22.2 billion to $30.3 billion depending on the assumptions made.

10.2. Differences and benefits of methods used: Hybrid Human Capital approaches vs Willingness to Pay (WTP)

To estimate the cost of road crashes in Australia, two different methodologies were used to value indirect and human costs of road crashes: (i) the hybrid human capital method and (ii) the willingness to pay approach, which is used to derive a value of a statistical life (VSL). While the WTP/VSL approach is commonly used internationally, the methodology to value non-direct costs is not universally agreed upon in the Australian context. BITRE used both approaches in their 2009 cost of road crashes in Australia report. To be consistent with national and international approaches, and as requested by BITRE, we valued indirect and human costs using both a Hybrid Human Capital approach and WTP approaches.

The Human Capital method measures the productivity loss (value of forgone output) due to the road crash. We used the Hybrid Human Capital method that BITRE developed for their 2009 report, which modifies the generic Human Capital method to incorporate a notional cost for the value for quality of life and costs of premature death for the economically inactive (children and the elderly) to avoid negligible or zero values that would be assigned to such groups using standard human capital approach to valuing productivity loss. The Hybrid Human Capital method resulted in more conservative estimates. Based on the Hybrid Human Capital method, the total cost of road crashes was estimated to be $27.0 billion.

The WTP method measures the value attributed by society to prevent a fatality of a statistical life as a result of a road crash. This method is generally viewed to be the most appropriate method to estimate human costs (e.g., Freeman et al., 2014; Jones-Lee, 1976). Based on the WTP approach using the OBPR values and disability weighting estimate from AAA (2017), the total cost of road crashes was estimated to be $27.6 billion (with a range between $23.5 billion to $29.1 billion given by the uncertainty in assumptions) which is very close to the Hybrid Human Capital approach. As noted in Chapter 8, it is not surprising that the two approaches generate different results given their differing underlying methods and paradigms (i.e. market and non-market approaches), however, this study also encountered challenges in applying values for different levels of injury rigorously using existing WTP estimates.

We also note that forgone economic productivity (in the hybrid human capital approach) may not capture the full value of human life. Similarly, the proxies used to value children and older people in the hybrid human capital approach may not represent the full value - for example, the value of a child is arguably more than the cost of raising them. We also note in relation to combining the OBPR VSL and disability weights that disability adjusted life years and value of a statistical life are different constructs with different underpinning theoretical foundations – empirical VSLs are derived from individual values of risk reductions whereas DALYs involve disability weights determined by experts multiplied by year of life lost.

10.3. Gaps in current data

While the NCD covers all fatal crashes, there is uncertainty around the incidence of hospitalised and non-hospitalised injuries and property damage only crashes. Hence, there is a gap in current data on the national number of road crash casualties who end up not being admitted to hospital or who do not go to the emergency room in the first place. Similarly, we do not have a complete picture of the national number of on-road property damage only car crashes, as reporting is not mandatory in most jurisdictions. Furthermore, the available industry data does not distinguish between on-road crashes and other types of claims.

The TAC data, which are available to us, are outstanding in their detail. We have used them extensively in this report to cost medical, paramedical, hospital, and long-term care costs. However, it would be good to have similar transport accident insurance data from other jurisdictions to ensure that the derived per incidence cost is representative of Australia.

We are currently missing data on the cost of street furniture damage and had to rely on the numbers derived from the previous report, potentially underestimating this category's actual costs. Therefore, it would be beneficial to gain access to jurisdictional data on the cost of repairing street furniture. Alternatively, we would need a statistic on the number of crashes involving street furniture damage and the average repair cost per accident.

10.4. Addressing the three policy questions

As indicated in Chapter 1 in addition to the primary objective of quantifying the cost of road crashes in Australia, the current study also set out to extend the economic analysis to aid in addressing the three key policy questions posed by BITRE:

Policy Question 1	Policy Question 2	Policy Question 3
Which type of crash has the highest social cost?	Does the cost of crashes warrant more being spent on crash prevention?	How does the benefit of road safety investments compare with other health investments?

We addressed policy question 1 using the estimated economic cost model. Based on the cost model, we identified that head-on and run-off-road crash types have the highest social cost burden being more severe than the average crashe. The estimated cost of head-on type crashes was $4.3 billion accounting for 16 per cent of the total cost of road crashes, and each crash being more than 42 per cent costlier than the average. The estimated cost of run-off-road type crashes was $6.2 billion, accounting for 23 per cent of the total cost of road crashes, and each crash being more than 7 per cent costlier than the average. Same direction crashes have a 10 per cent lower per crash cost but due to their high incidence, particularly in major cities, they account for $8.7 billion or 32 per cent of costs. **Table 10.86** presents the social cost of road crashes by crash type and remoteness.

Table 10.86: Estimated social cost of road crashes by crash type group and remoteness, (in million 2020 dollars)

Crash type groups	Major city	Outside major cities	Total	Per Crash (in dollars)
Same direction	$7,097	$1,598	$8,695	$25,361
Run off road	$2,085	$4,143	$6,228	$29,892
Head on	$2,738	$1,524	$4,262	$39,844
Intersection adjacent	$2,499	$1,308	$3,807	$26,637
Pedestrian struck	$946	$378	$1,323	$24,458
All other crash types	$1,594	$1,136	$2,729	$24,684
Total	**$16,958**	**$10,087**	**$27,043**	$28,003

Given information on cost alone does not allow policy makers to answer Policy Questions 2 and 3, we have undertaken a rapid review of the literature focusing on empirical studies which have been designed to address these questions.

In addressing policy question 2, the rapid review found nearly all the road safety interventions to be cost-effective with positive net present values. This demonstrates that there are significant opportunities for efficient, beneficial further investments. Three observations were identified that could inform future road safety investments in Australia: 1) The value of consistent measurement of outcomes of potential interventions; 2) The selection of interventions using data-driven approaches; and 3) Equity consideration regarding private-borne costs. The review also identified the need for more information and data to properly assess the need for spending more on road traffic crash prevention.

In addressing policy question 3, the rapid review examined investments in road safety and suicide prevention as two distinct types of public health events amenable to behavioural change interventions. It is recognised, however, that there are also substantial differences between road safety and suicide prevention. The review considered investment and empirical research on suicide and road safety investments undertaken in Australia, USA, UK, and the Netherlands. The rapid review found positive benefit–cost ratio and net present values for all the suicide prevention interventions, and all but one (cycling collision warning) road safety interventions, with some interventions better than others. Rigorous cost-benefit analysis can provide decision-makers with information on whether the social benefits of a particular project or policy exceed its social costs. Whether or not more funds should be allocated towards investment in road crash prevention overall, however, would require information on the relative social value of potential projects and policies in other sectors, as well as relevant budgetary and legal constraints. Both road safety interventions and suicide prevention reduce costs associated with medical care, emergency services, lost productivity, and intangible costs. Road safety interventions, however, differed from suicide prevention studies by including costs averted from property damage, emissions, and travel time and regarding relative recurring and setup costs.

10.5. Future research

Future studies on the social cost of road crashes in Australia would benefit from:

- Improved data on the number of on-road property damage only crashes, the number of non-hospitalised injury crashes, and cost for repair and damage to freight of trucks. Data improvements align with the National Road Safety Strategy 2021–30 which promotes harnessing data for better road safety analysis.
- Empirical estimation of an Australian value of statistical life (and injury weightings) or WTP values by crash severity using best practice methods.
- Updating key inputs in the cost model as data improve and conditions change.

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Appendix A: Cost components and measurements included in the Hybrid Human Capital and WTP approaches

A WTP study was commissioned by ATAP (Australian Transport Assessment and Planning, 2018) to obtain estimates of the value of travel time savings, reliability improvements, and improvements to road safety for drivers and passengers of privately owned motor vehicles. The values will be published for use in cost–benefit analyses of transport initiatives.

The survey asks respondents to make hypothetical choices between pairs of alternative routes with differing cost, travel time, variability in times, reliability and safety attributes. Safety characteristics for the alternative routes are described in terms of numbers of crashes along the route per annum for five severity levels ranging from fatal to property damage only. Statistical modelling is employed to estimate the average WTP by survey respondents to avoid a single crash for each severity level.

It seems reasonable to assume that individuals completing the survey will make their decisions based on the costs they incur themselves, not the costs for society as a whole. The WTP values derived from the survey are therefore expected to cover only the costs incurred by crash victims and will exclude costs incurred by other members of society — governments, employers, other road users, and society in general. To obtain the full social WTP cost of a crash, the excluded costs have to be added to the WTP value obtained from the survey. Thus the WTP estimate only gives a substitute measure for a part of the hybrid human capital cost.

Table A.87 splits the human capital cost components into parts likely to be included in and not included in WTP measures. Governments bear part of medical-related and long-term care costs. Repair and insurance administration costs are spread of all insured road users, except for excesses in insurance policies and loss of no-claim bonuses. Costs of traffic delays are incurred by other road users while society in general bears pollution costs. Governments pay for much of the costs of emergency services and other direct costs, with the exception of premature funerals. Employers incur recruitment and training costs.

Table A.87: Cost components included and not included in WTP measures

Cost type	Hybrid Human Capital cost component	Included in WTP measure - will be <u>excluded moving to WTP</u>	Not included in WTP measure - <u>remain included moving to WTP</u>
Indirect	Workplace and household losses	all forgone after-tax earnings and all household and voluntary work losses (85 per cent of the total cost)	income and payroll taxes forgone by governments
Direct	Repair costs	vehicle insurance excesses (8 per cent of total cost)	rest of repair costs (imposed on all insured motorists)
Direct	Medical related costs	part incurred by individuals and families (14.7 per cent of total cost)[103]	part incurred by governments
Direct	Insurance administration	–	all (imposed on all insured motorists)
Direct	Travel delay and operating costs	–	all (imposed on other road users)
Indirect	Pain, grief and suffering	all	–
Direct	Long term care costs	part incurred by individuals and families (14.7 per cent of total cost)[103]	part incurred by governments
Direct	Externality cost of crash-induced pollution	–	all (imposed on general society)
Direct	Vehicle unavailability	all	–
Direct	Ambulance	part incurred by individuals and families (11 per cent of total cost)[104]	part incurred by governments and part by people with ambulance insurance
Direct	Fire and Emergency	–	incurred by governments or all vehicle operators
Direct	Police	–	all (incurred by governments)
Direct	Legal costs	–	all (incurred by governments)
Direct	Correctional services	–	all (incurred by governments)
Direct	Street furniture	part incurred by individuals and families where governments bill damage to identified at-fault motorists. (we assumed none)[105]	Part incurred by governments
Direct	Premature funerals	all	–
Indirect	Recruitment and re-training costs	–	all (incurred by employers)
Direct	Coronial costs	–	all (incurred by governments)

[103] AIHW 2021 states that of the total annual health spending in Australia 14.7 per cent is the proportion individuals spend on health. While the specific number for road related health spending might be lower, in the absence of a better estimate we assume this to be the proportion individual expect to be burdened with when answering the WTP question.

[104] The cost of ambulance services to hospital are not covered by Medicare. As a result, ambulance costs are different in each state and territory. In states and territories such as the ACT, VIC, QLD, WA and Tasmania, ambulance costs for people injured in road accidents are free. While in NSW, SA and NT these services incur a fee. In NSW, the callout fee is $415 plus an additional charge of $3.74 per kilometre. In SA, the callout fee is $1085 and the per km charge is $6.20. While in NT, the callout fee is $815 for the first 10 km and a $5.25 charge per km greater than 10km. We calculate an average of $234 across all states (assuming a 10km ride and that these are life-threatening).

[105] This will be a very small proportion, of an already small cost component and we have no basis to make an assumption. Will treat this zero. With more data this assumption can be revaluated.

Appendix B: Discounting

Discounting captures an individual's preference for gains such as income or consumption today rather than in the future. Discounting allows us to calculate the present value (PV) of income or consumption that occur in the future. It allows translation of future values into their current value. The PV of a specific amount received t periods in the future is calculated by:

$$PV = \frac{FV}{(1+r)^t}$$

where FV is the future value and represents a cost which occurs t periods in the future and r is the annual discount rate.

The choice of social discount rate is a perennially contentious issue. A standard approach to determine the appropriate interest rate is think of it as a representation of the opportunity cost. A risk-free long-term investment option is typically used to represent such opportunities cost. The 30-year Australian government bond rate is the investment rate closest associated with a long-term investment in the Australian context. This rate has come down from 3 per cent over the last few years to now around 2 per cent.

An alternative way to derive a social discount rate is given in the flowing formula by Ramsey (1928):

$$r = \rho + \theta g$$

where is the ρ pure time preference (this is typically thought to be close to zero and often set to be 0.1 per cent), θ is the elasticity of marginal utility of consumption (an estimate for Australia lies between 1.5 and 1.8)[106] and g is the projected long-run average growth rate (for Australia the real per capita growth rate has been 0.8 per cent over the last decade and 1.2 per cent over the last 20 years). Assuming values of $\rho = 0.1$ and $\theta = 1.65$ and $g = 1.0$ results in an social discount rate for Australia of $r = 1.75$ per cent.

The 'green book 'guidelines in the UK recommend a standard value discount rate of 3.5 per cent in real terms (HM Treasury, 2019). HM Treasury recommends reducing the standard value for long term outcomes, greater than 30 years due to uncertainty about future values of its components.

[106] See Evans (2005) page 211.

Appendix C: Cost burden of road crashes

Table D.88 shows the breakdown of the cost of road trauma by government funding shares for each cost category. These burden calculations are based on a AAA commissioned study by Economic Connections (2017) which estimate the financial costs to governments of road trauma for a subset of economic cost. In order to distribute all cost components derived in this study some additional assumptions are necessary and discussed in detail below.

Table D.88. Burden of the social cost of road crashes

Cost category	Government				Individuals and families
	Commonwealth	State & territory	Local	Total	
Productivity loss and suffering (fatalities and injuries)					
Workplace and household losses[107]	29.8%	2.5%	0.5%	32.8%	67.2%
Pain, grief and suffering				0.0%	100.0%
Health and Disability related					
Long term care costs	20.4%			20.4%	79.6%
Medical - hospitalised[108]	2.3%	2.7%		5.0%	95.0%
Medical - non-hospitalised[109]	46.0%	15.4%		61.4%	38.6%
Emergency services					
Ambulance		68.1%		68.1%	31.9%
Fire and Emergency		32.5%		32.5%	67.5%
Police		100.0%		100.0%	0.0%
Vehicle-related					
Repair costs	0.1%	0.6%	0.1%	0.8%	99.2%
Vehicle unavailability	0.1%	0.6%	0.1%	0.8%	99.2%
Travel delay and operating costs	0.1%	0.6%	0.1%	0.8%	99.2%
Externality cost of crash-induced pollution				0.0%	100.0%
Street furniture		66.4%	33.6%	100.0%	0.0%
Legal and other					

[107] The cost to government include lost taxes of 24.1 per cent of workplace income (of which 80 per cent are born by the commonwealth) and an approximate income support net increase of 28.6 per cent for workplace Income (born fully by the commonwealth). The workplace losses make up 62.2 per cent of the total in this cost category. The household and voluntary work losses are entirely borne by individuals.

[108] Cost recovery through the motor vehicle third party insurance system leads to a full discovery unless uninsured drivers are involved. We follow the assumption in AAA (2017) of 5 per cent. The split of these remaining cost between commonwealth and state and territory government are 47:53 according to AIHW (2021)

[109] We update the numbers using the AIHW (2021) report, which acknowledges that that the Commonwealth contributes a proportion of 3:1 relative to the states and territories in primary health care and referred medical services funding.

Cost category	Government				Individuals and families
	Commonwealth	State & territory	Local	Total	
Legal costs		100.0%		100.0%	0.0%
Correctional services		100.0%		100.0%	0.0%
Coronial costs		100.0%		100.0%	0.0%
Premature funeral				0.0%	100.0%
Recruitment and re-training				0.0%	0.0%
Insurance administration				0.0%	100.0%

Source: Based on Table 23 in AAA-commissioned study by Economic Connections (2017) and additional assumptions and calculations.

The AAA report (2017) sets out to distinguish between financial costs to government and costs to individuals and family. Financial costs to government include, for example the loss of taxation revenue, costs associated with disability care, health services, emergency services, legal services and other costs related to vehicles such as infrastructure damage. In order to allocate cost between government and individuals the authors of the AAA report take into account that costs are often insured, in which case they are born by the individual, that is they are distributed across all individuals who are insured. For example, health costs are assumed to be covered by workers' compensation or vehicle third party and therefore ultimately born by individual. Only the cost for uninsured drivers falls back onto government. We follow the arguments in the AAA report and adopt the cost burden allocation for equivalent categories.[110]

To be able to allocate all cost categories derived in this report we make additional assumptions. For smaller cost outside the hospital system, it is assumed that people often use Medicare for simplicity. Similarly, for long term care costs it is assumed that most is funded through insurance.[111] For the distribution of taxation losses, we take the burden going to government to be 24.1[112] per cent of workplace output losses, akin to the methodology for household losses described in **Section 2.5.2**. We use the estimates from AAA (2017) for the net increase in income support to be 28.6 per cent of workplace output loss, which is entirely born by the commonwealth government.[113] The remainder of workplace losses is born by individuals and their families and all road users via insurance schemes, as are all household output losses. Furthermore, we included in the table the costs associated with pain grief and suffering; insurance administration; externalities from crash induced pollution and funeral costs, which are born entirely by the individuals and families. Recruitment and re-training cost are assumed to neither be borne by individuals or government but industry. Excluded from the analysis remain the efficiency costs of additional government revenue-raising.

[110] The AAA report (2017) discusses the assumptions for each cost category in detail on pages 39-41.

[111] We assumed that 90 per cent of the cost estimate in this report are care cost with the remainder going to aids and appliances. We weight the cost distribution accordingly.

[112] OECD Taxing Wages Australia: https://www.oecd.org/ctp/tax-policy/taxing-wages-australia.pdf.

[113] This estimation is based on a simple proportional scaling of the taxation losses, see table C13 in AAA (2017). We did not account for transfer payments 'saved' due to fatalities. An alternative assumption would have been to argue that income support is not generally a government transfer but comes out of insurance claim payments, which is the case for moderate to severe injury road crash disabilities (more than 50 per cent impairment) insured through transport accident insurers.

Appendix D: Rapid Review to address two Policy Questions

D.1. Key point summary

Policy question 2: Does the cost of crashes warrant more being spent on crash prevention?

- The rapid review found nearly all of the road safety interventions to be cost-effective and had positive net present values.
- This demonstrates that there are significant opportunities for efficient, beneficial further investments.
- Three observations were identified that could inform future road safety investments in Australia:
    - The value of consistent measurement of outcomes of potential interventions
    - The selection of interventions using data-driven approaches
    - Equity consideration regarding private-borne costs.
- The review identified the need for more information and data to properly assess the need for spending more on road traffic crash prevention.

Policy question 3: How do the benefits of road safety investment compare with other health investments?

- The rapid review focussed on suicide prevention as one other health investment and empirical research on suicide and road safety investments undertaken in Australia, USA, UK and the Netherlands
- The rapid review found positive benefit–cost ratio and net present values for all of the suicide prevention interventions and all but one (cycling collision warning) road safety interventions, with some interventions better than others.
- Rigorous cost-benefit analysis can provide decision-makers with information on whether the social benefits of a particular project or policy exceed its social costs. Whether or not more funds should be allocated towards investment in road crash prevention overall, however, would require information on the relative social value of potential projects and policies in other sectors, as well as relevant budgetary and legal constraints.
- Both road safety interventions and suicide prevention reduce costs associated with medical care, emergency services, lost productivity, and intangible costs.
- Road safety interventions however differed from suicide prevention studies by including costs averted from property damage, emissions, and travel time and regarding relative recurring and setup costs.

Box D.8: Key summary points

D.2. Introduction

Road crash deaths and injuries are a major public health problem. The 2019 data shows that there were 1,195 road crash deaths, representing a 5.3% increase from the previous year (BITRE, 2020).

The rate of road crash deaths per population in Australia increases as remoteness increases. Approximately two thirds of road crash deaths occurred in regional and remote areas while one third occurred in major city areas. This disproportionate number of road crash deaths in regional and remote areas remained unchanged over the last decade (BITRE, 2019).

While the number of deaths has decreased since 2006, the number of serious injuries[114] due to road crashes since 2005 has increased significantly. Road crash serious injury data (latest data was 2018) shows an increase of 11.3% over the previous five years. The rate per 100,000 population for serious injuries for the same timeframe was 35 times higher than that for deaths (BITRE, 2020).

As part of the Social Cost of Road Crashes study, BITRE posed three policy questions:

- Policy question 1: 'Which type of crash has the highest social cost?'
- Policy question 2: 'Does the cost of crashes warrant more being spent on crash prevention?'
- Policy question 3: 'How do the benefits of road safety investments compare with other health investments?'

The first question is addressed by the results of the costing study. For policy questions two and three, we aimed to contribute to BITRE's understanding of these policy questions. To understand these questions require not only the consideration of costs, but also the consideration of benefits arising from road crash prevention. For this reason, we conducted a rapid review to identify evidence from the literature (Garritty et al., 2020; Hamel et al., 2021; Tricco et al., 2015) by drawing on empirical studies that have considered both costs and benefits of road crash prevention to address the remaining two policy questions. Though these policy questions are not answerable through a literature review, the rapid review may generate some useful findings, from the different methods used between road crashes and health investments.

Policy question 2 (Does the cost of crashes warrant more being spent on crash prevention?) was addressed through our first rapid review, which identified literature that has reported on the costs and benefits of investment in road crash prevention. More specifically, in consultation with BITRE, we searched for literature reporting cost-benefit analysis on road crash prevention that target either behavioural change or physical environmental change. The scope of road crash prevention interventions includes road and vehicle safety and was limited to the prevention of road crashes involving vehicles (i.e., cars, commercial vehicles, trains, buses, motorcycles, and bicycles) and road users (i.e., pedestrians).

Overall, our first rapid review found nearly all the road crash prevention to be cost-effective and had positive net present values.

Policy question 3 (How do the benefits of road safety investments compare with other health investments?) was addressed through our second rapid review. We realise that cost benefit analyses from road safety investment studies and health investment studies will not be comparable given the different methodological approaches used in economic evaluation applied in the two sectors. For example, health studies generally do not include indirect costs and benefits (i.e.: productivity losses, impact on carers etc.) whereas these costs are included in road safety studies. Discount rates also differ between these two areas.

One alternative in making a comparison would be to extract the direct costs and benefits alone when reviewing the road safety literature, however given the heterogeneity in the methodologies employed across the studies (e.g., perspectives, populations, intervention types, and primary outcome measure), a direct comparisons between the studies was not possible. Another alternative was to select a health area which cost benefit analysis include both direct and indirect costs and benefits, such as in suicide prevention. Although there are

[114] As described in **Chapter 1** of this report, a serious injury—defined as a hospitalised injury—is when a person involved in a road crash requires medical treatment for injuries sustained in the crash and is confirmed as being admitted to hospital, irrespective of the length of stay, who does not die from their injuries within 30 days.

obvious differences between the two events from a transport and economics as well as a medical point of view, in consultation with BITRE, we narrowed health investments to focus on suicide prevention due to the common elements in its research. We are aware of the possible inference readers may draw between the behaviour of drivers and that of people who attempt suicide. While 96% of road crashes may be attributed to poor driver behaviour, including disregard for road rules, such as BAC > 0.5, speeding in excess of the local limit (e.g., school zones); in this review however, we treat the two policy areas as separate topics. Given the limitations of comparable methodological approaches used in safety investment studies and health studies as mentioned above, we chose suicide prevention studies because its CBA methodology includes both direct and indirect costs and benefits Similarly, the prevention of suicide and the prevention of road crashes are both policy areas using interventions for diverse populations of all ages. Suicide is a major global health problem affecting the human lifespan and is a leading cause of death for young people and people of working age (Calear et al., 2016; Kinchin & Doran, 2017, 2018). Suicide and road crashes for Australia and the 12 selected countries also share a similar proportion of total disability-adjusted life years, both ranging between 1 to 3% (**Figure D.5** and **Figure D.6**).

Figure D.5: Disability-adjusted life years (DALY) of road injuries as percentage of total DALYs in the selected 12 countries

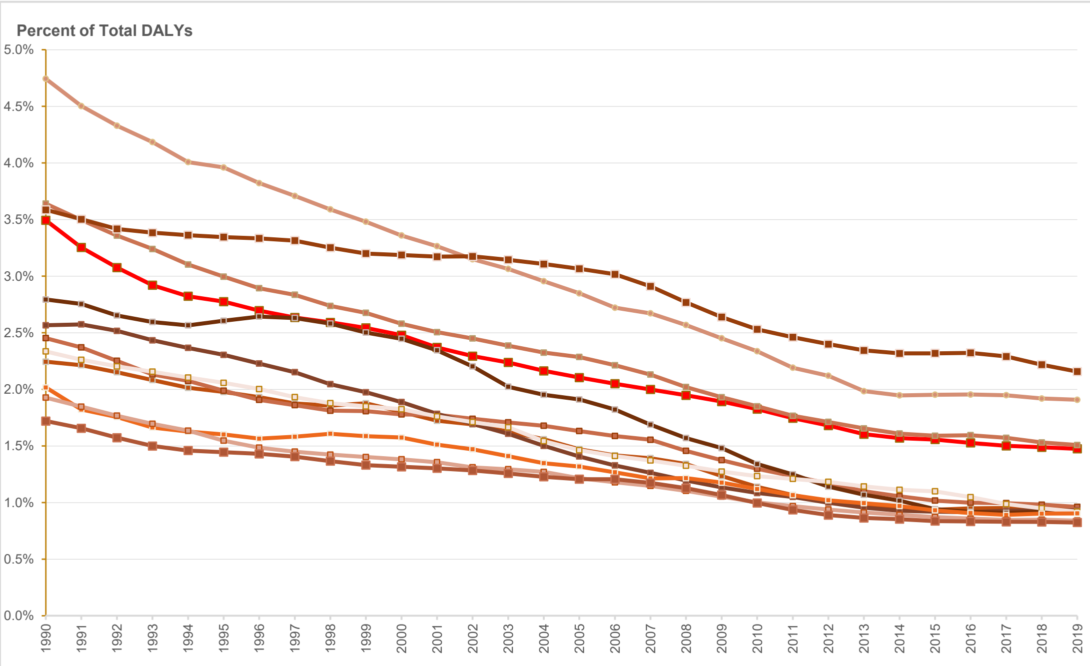
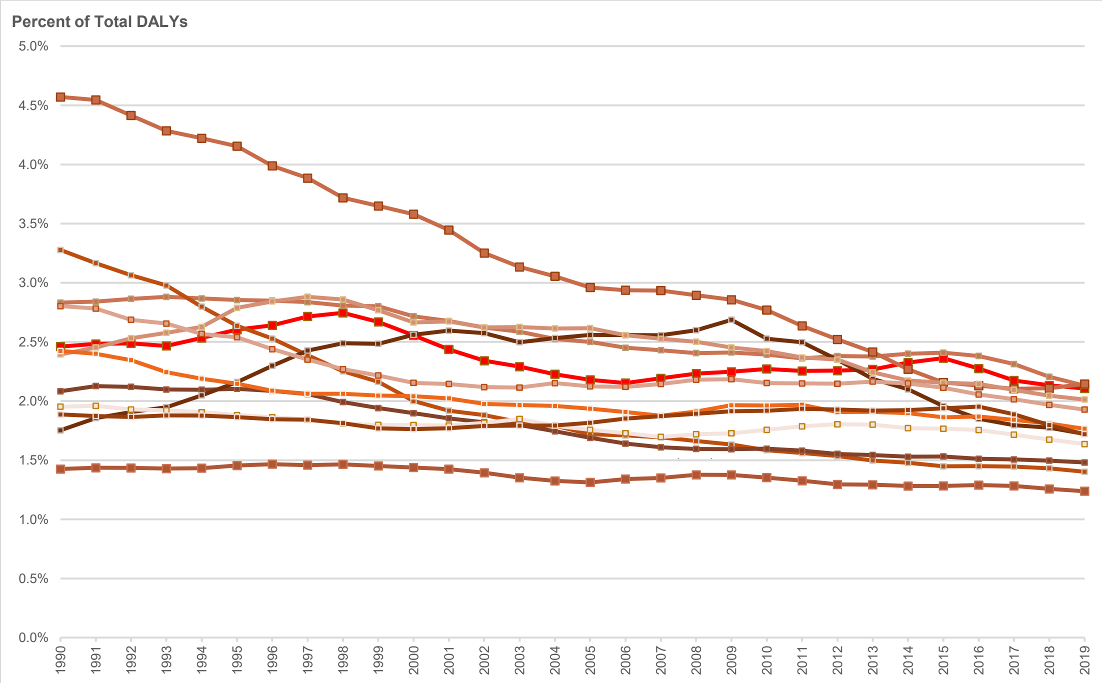


Figure D.6: Disability-adjusted life years (DALY) of suicide as percentage of total DALYs in the selected 12 countries



As with the first rapid review, to ensure comparability across sectors, cost-benefit analysis studies in road crash prevention and suicide prevention were both limited to interventions that target either behavioural change (education programs including alcohol reduction, restraint use, speeding interventions and road crash prevention aimed at specific groups; and hotline services and community based programs for suicide prevention) or physical environmental change (road way modifications use of barriers, speed bumps, and barriers on bridges, etc.). A parallel benchmarking exercise was undertaken to compare the relative costs and benefits of interventions to prevent road crashes and prevent suicide.

Overall, the review for policy question three consistently found positive benefit-cost ratio and NPVs for a range of interventions in suicide prevention and road crash prevention investments despite the heterogeneity in design among the included studies.

D.3. Methods

The methodology behind the two rapid reviews follows the recommendations of the Cochrane Rapid Reviews Methods Group (RRMG) (Garritty et al., 2020). Rapid reviews have emerged as an effective way to generate evidence in a timely, practical and relevant manner by streamlining the steps of systematic reviews (Hamel et al., 2021; Tricco et al., 2015). Given the overlap in the methodology, we discuss both reviews in this section jointly, highlighting key differences as appropriate.

D.4. Search strategy

The literature searches were performed (up to 29 November 2021) using the following search terms:

- (intervention OR program OR prevention) AND (crash OR collision OR accident) AND (transport OR road) AND (cost AND benefit OR "economic evaluation") for policy question 2;
- ("suicide prevention" OR "suicide intervention" OR "suicide program") AND (cost AND benefit OR "economic evaluation") for policy question 3.

Articles were sourced from the following databases and electronic journal collections: Pubmed, Web of Science, Cochrane review and Cochrane trials, EconLit, Science Direct, ProQuest, Suicide and Life Threatening

Behaviour, Applied health Economics and Health Policy and Journal of Behavioral and Experimental Economics. Key studies relevant to the two reviews were identified, and a manual search of their reference lists was performed to identify further articles of interest.

D.5. Eligibility criteria

The searches were limited to full-text studies in English published between 2011 and 2021. Eligible studies had to meet the following criteria:

- Use a cost-benefit analysis method on road crash prevention (policy question 2 and 3) or suicide prevention (policy question 3);
- Use interventions targeted at behavioural change and/or physical environmental change (for policy questions 2 and 3);
- Take place in Australia, New Zealand, the United States of America (USA), Canada, the United Kingdom (UK), Ireland, Norway, Sweden, Denmark, Finland, Germany and the Netherlands (NL)[115] (for policy questions 2 and 3);
- Itemise program costs and benefits, and have outcomes that were either benefit–cost ratio (BCR) or net present values (NPV) (for policy questions 2 and 3).

For both reviews, studies presenting multiple interventions and/or using multiple country settings were screened for individual interventions that fit the inclusion criteria.

Behavioural interventions were defined as those targeted to influence and reduce the risk of behavioural contributory factors such as speeding, use of seat belts, road transport drivers driving under the influence of drugs and/or alcohol and gatekeeper awareness and suicidal risk assessment for suicide prevention. Interventions where the road user's decision is overridden such as autonomous emergency brakes and ignition interlocks were not included under this category. Interventions were also included if they did not relate to driving behaviour, such as an in-person licence renewal policy. Physical environmental interventions were defined as changes to the physical environmental that would improve and reduce the risk of crashes, such as road signs, roundabouts and speed bumps, or suicide risk such as suicide barriers.

To ensure comparability across studies, costs were converted to purchasing power parity (PPP) adjusted to Australian dollars and inflated to 2019 using the Campbell and Cochrane Economics Methods Group and the Evidence for Policy and Practice Information and Coordinating Centre cost converter(CCEMG-EPPI-centre, 2020; van Mastrigt et al., 2016).

D.6. Data analysis

Two reviewers screened titles and abstracts and reviewed full texts using Covidence systematic review software. We resolved disagreements by consensus, involving a third reviewer. We extracted data into a predesigned Excel spreadsheet for study title, author, year, journal, objective, country, setting, intervention, comparator, outcomes, study design, perspective, time horizon, discounting rate, costs, incremental costs per benefits, sensitivity analysis, conclusion, and other important comments. Risk of bias was assessed by using a validated economic evaluation checklist Critical Appraisal Skills Programme (CASP, 2018) to ascertain (i) the validity of the economic evaluation; (ii) the assessment and comparability of costs and benefits; and (iii) usefulness of the results if adopted in Australia (**Table D.90**).

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[115] In agreement with BITRE, the review focused on eleven OECD-member countries in addition to Australia. New Zealand, United Kingdom, United States and Canada were selected based on their OECD and Commonwealth status and having an Anglosphere background. Germany, Ireland, the Netherlands, and Scandinavian countries (Finland, Denmark, Norway and Sweden) were included based on their high road safety ranking for road crash deaths per 100,000 population and to increase the possibility of finding papers in English.

Given the diversity of the interventions and the heterogeneity of the results, we performed a qualitative synthesis to descriptively synthesise the data.

D.7. Results

This section will discuss the results for both reviews jointly, highlighting key differences as appropriate. We retrieved 1,014 abstracts from the two literature searches (694 for policy question 2 and 3 and 320 for policy question 3). We screened 795 abstracts after removing 209 duplicates. We assessed 69 full-texts studies and 17 were retained and assess using CASP. Fourteen studies were identified suitable to address the two policy questions. Nine of the included studies were road crash prevention studies (i.e., addressing policy question 2 and 3); the remaining five were on suicide prevention (addressing policy question 3). From the nine studies on road crash prevention, 15 interventions were included in the review. The five suicide prevention studies included one intervention each, totalling five interventions. **Figure D.7** illustrates the screening process and **Table D.89** presents a summary of the included studies.

Figure D.7: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram showing how the 14 studies included in this review were identified.

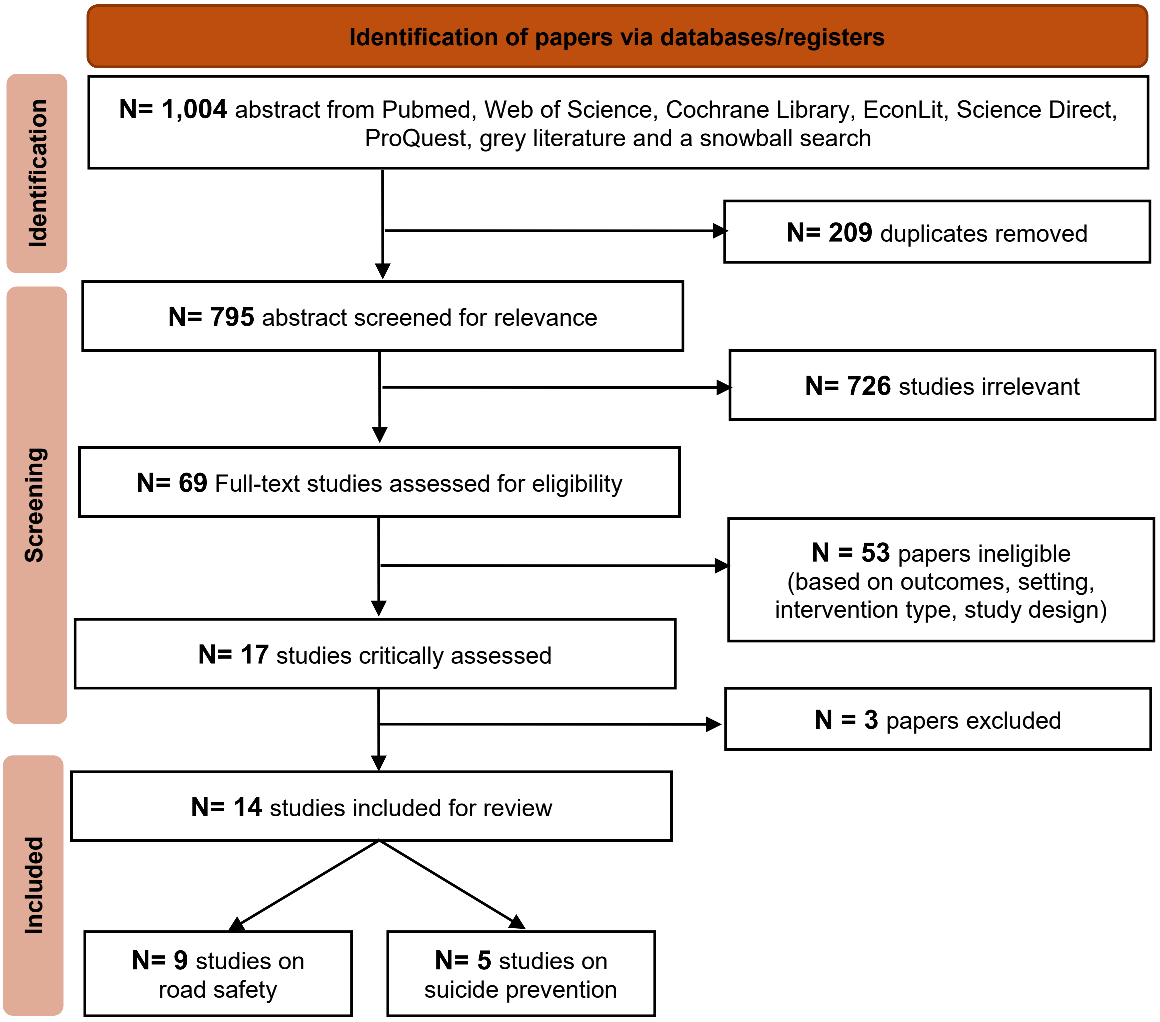

Table D.89. Summary of the 14 included studies

Road crash prevention studies
• *Behavioural interventions* (Camden et al., 2018): USA, lane departure warning (LDW) & video-based onboard safety monitoring (OSM) (Medina-Flintsch et al., 2017): USA, lane departure warning Singichetti, Naumann, Sauber-Schatz, Proescholdbell, and Marshall (2020): USA, behavioural road safety policies (increased seat belt fine, seat belt enforcement campaigns, license plate impoundment, saturation patrols, and speed cameras) • *Physical environmental interventions* (Beale et al., 2018): USA, safety signage program (Gross et al., 2021): USA, open-road tolling (Steinbach et al., 2013): UK, 20mph zones (Tripodi & Persia, 2015): NL, cyclist e-safety applications (”Lexguard” blind spot system & ”Light Lane” laser projection) (Peters & Anderson, 2012): UK, 20 mph zones • *Behavioural & Physical environmental interventions* (Weijermars & Wegman, 2011): NL, safe traffic system (infrastructure and enforcement)
Suicide prevention studies
• *Behavioural interventions* (Godoy Garraza et al., 2018): USA, suicide prevention program (Kinchin & Doran, 2017): Australia, awareness training (Doran & Ling, 2014): Australia, awareness training (Ashwood et al., 2015): USA, gatekeeper training • *Physical environmental interventions* (Whitmer & Woods, 2013): USA, suicide barrier

D.7.1. Study characteristics

Nine of the 14 studies focused on road crash prevention and they were conducted in the United States of America (USA) (n = 5), the United Kingdom (UK) (n = 2) and the Netherlands (NL) (n = 2). The remaining five studies focused on suicide prevention, and they were conducted in the USA (n = 3) and Australia (n = 2).

The studies covered a variety of settings and groups. The road crash prevention studies included highways, toll roads, and roads in urban areas, as well as commercial vehicles, cyclists, and other passenger vehicles. One paper observed a national traffic safety program. The suicide prevention studies covered the youth, workplace settings and communities as a whole.

D.7.2. Cost effectiveness

All but one of the fifteen interventions on road crash prevention were found to be cost-effective when compared to doing nothing/existing conditions. The incremental cost per benefit were reported as either a benefit–cost ratio (BCR) or in net present value (NPV), or both. The BCR ranged between 0.04 (Tripodi & Persia, 2015) to 62.6 (Beale et al., 2018), while reported NPVs ranged between -$62,246 (Peters & Anderson, 2012) and $388.5 million (Singichetti et al., 2020).

Furthermore, all of the suicide prevention studies demonstrated an overall benefit. The outcomes included: incremental benefit–cost ratios of 4.6 (Doran & Ling, 2014), 1.5 (Kinchin & Doran, 2017), 50 (sectoral) and 1,108 (societal) (Ashwood et al., 2015), 4.5 (Godoy Garraza et al., 2018) and 17.7 (Whitmer & Woods, 2013).

Direct and indirect costs were included in all 14 studies except for one road safety study (Weijermars & Wegman, 2011) and one suicide prevention study (Godoy Garraza et al., 2018).

In the road safety studies, though all but one paper used a societal perspective, the approach used to measure the benefits varied. Only five studies included a comprehensive societal cost of crashes covering monetised quality-adjusted life years (QALYs). These studies included value of a statistical life (VSL) estimates (measured in 2019 Australian dollars) of $3.2 million (Steinbach et al., 2013), $11 million (Medina-Flintsch et al., 2017) and $14.7 million (Beale et al., 2018; Camden et al., 2018).

D.7.3. Intervention types

Behavioural interventions

Behavioural interventions were used in three of the nine road safety studies, and in four of the five suicide prevention studies. Behavioural interventions in road safety involved onboard safety technology such as lane departure warnings and video-based onboard safety monitoring systems (OSM), as well as influencing behaviour through awareness (seat belt enforcement campaigns), consequential regulations (increased seat belt fines and license plate impoundment) and monitoring methods (saturation patrols). The road safety investments in behavioural change focused on driving behaviour as the modifiable determinant, by using warning and audio/visual assistance to drivers, and through building road user's awareness and setting consequences for violations.

Behavioural interventions in the suicide prevention studies involved more than changing the behaviour of people at risk of suicide, but rather they focused on changing the community and worksites to be supportive of people at risk of suicide. Primarily these interventions involved training either workplace employees or community members, or gatekeepers.

Physical environmental interventions

Physical environmental interventions were used in six road crash prevention studies and one suicide prevention study. These interventions in road crash prevention involved changes to road infrastructure such as road signs and toll designs, speed limits, cyclist safety devices to improve visibility of and for cyclists, and speed cameras. Physical interventions in suicide prevention involved a bridge barrier to prevent people attempting suicide off a bridge (**Table D.90**).

Behavioural & physical environmental interventions

Only one road safety paper used interventions that involved both behavioural and physical environmental interventions. The road safety paper discussed a national program using traffic calming and other infrastructure designs along with traffic enforcement as the modifiable determinant.

D.7.4. Risk factors and protective factors

The road safety intervention's modifiable determinants covered several risks factors associated with road crashes: speeding, drink and driving, seat belts, driver alertness, road conditions, and visibility. One paper Weijermars and Wegman (2011) featured a combination of road safety interventions using infrastructure as well as enforcement and education measures.

The only suicide risk factor covered in the reviewed studies was suicide by occupation type, where Kinchin and Doran (2017) looks at the Australian workforce as a whole with benefit–cost ratio of 1.5 (societal), while Doran and Ling (2014) focuses on the construction industry. Both interventions were cost effective with benefit–cost ratios of 1.5 (societal) and 4.6 (sectoral) respectively.

A number of protective factors for suicide were covered in the reviewed articles, including community support through gatekeeper training (Ashwood et al., 2015; Godoy Garraza et al., 2018), and support in the workplace (Doran & Ling, 2014). A physical protective factor using a suicide barrier was observed in (Whitmer & Woods, 2013) with a benefit–cost ratio of 17.7.

D.7.5. Parallel benchmarking

In **Table D.90**, the present value of the total costs and benefits of the different interventions, along with each intervention's incremental costs per benefits.

Table D.90: Parallel benchmarking of the 14 studies

Interventions	Costs[a]	Benefits[a]	Incremental cost per benefit (BCR or NPV) [a,b]
Road safety interventions			
• *Behavioural intervention*			
Video-based onboard safety monitoring (Camden et al., 2018)	$2,772 per truck (new trucks) $65,899 per truck (new & existing)	$9,647 (new trucks) $164,478 (new and existing)	3.5 (new trucks - societal) 2.5 (new & existing - societal)
Lane departure warning (Camden et al., 2018)	$786 per truck (new trucks) $21,659 per truck (new & existing)	$2,163 (new trucks) $36,866 (new and existing	2.8 (new trucks - societal) 1.7 (new & existing - societal)
Lane departure warning (Medina-Flintsch et al., 2017)	$1,722 per truck	$13,089 (industry) $7,319 (societal)	7.6 (industry) 4.3 (societal)
Increased seat belt fines (Singichetti et al., 2020)	-$9.4 million [c]	$397.8 million	NPV: $407.2 million (societal)
License plate impoundment (Singichetti et al., 2020)	- $13.2 million [c]	$50.9 million	NPV: $64.4 million (societal)
Seat belt enforcement campaigns (Singichetti et al., 2020)	$ 3.2 million [c]	$298.4 million	NPV: $295.1 million (societal)
Saturation patrols (Singichetti et al., 2020)	$8.3 million [c]	$218.2 million	NPV: 209.9 million (societal)
Speed cameras (Singichetti et al., 2020)	$8.9 million [c]	$246.3 million	NPV: $153.3 million (societal)
• *Physical environment*			
Safety signage program (Beale et al., 2018)	$0.8 million	$17,2 million (human capital) $50,2 million (societal)	21.5 (human capital) 62.6 (societal)
Open-road tolling (Gross et al., 2021)	$429 million	$416 million	~1 (societal)
20mph zones (Steinbach et al., 2013)	$0.2 million per km	$213,395 per km (5 years) $344,122 per km (10 years)	BCR (societal): 1.3 (5 years); 2.1 (10 years) NPV: $53,000 (5 years)

Interventions	Costs[a]	Benefits[a]	Incremental cost per benefit (BCR or NPV) [a,b]
			$183,727 (10 years)
Cyclists' safety application – laser projection (Tripodi & Persia, 2015)	$881 million	$1,273 million	1.4 (societal)
Cyclists' safety application- blind spot warning system (Tripodi & Persia, 2015)	$1,621 million	$144 million	0.1 (societal)
20 mph zones (Peters & Anderson, 2012)	$0.2 million (low casualty areas) $0.2 million (high casualty areas)	$121,796 (low casualty areas) $858,634 (high casualty areas)	BCR (societal) 0.7 (low casualty areas) 4.6 (high casualty areas) NPV: - $62,246 (low casualty areas) $672,877 (high casualty areas)
• *Behaviour & Physical environment*			
Safe traffic system (Weijermars & Wegman, 2011)	$1,395 million	$5,000 million	3.6 (sectoral)
Suicide prevention interventions			
• *Behaviour*			
Suicide prevention program for Gatekeepers/community members (Ashwood et al., 2015)	$0.6 million	$28 million (sectoral) $611,8 million (societal)	51 (sectoral) 1,108 (societal)
Suicide prevention program for worksites (NSW) (Doran & Ling, 2014)	$0.9 million (annual)	$4.2 million	4.6 (societal)
Suicide prevention program for youth (Godoy Garraza et al., 2018)	$83.4 million (5 years)	$ 375.1 million (5 years)	4.5 (sectoral)
Suicide prevention program for worksites (Australia) (Kinchin & Doran, 2017)	$ 44.4 million (annual)	$ 66.3 million (annual)	1.5 (societal)
• *Physical environment*			
Bridge barrier (Whitmer & Woods, 2013)	$ 88.2 million (20 years)	$1,563.9 million	17.7 (societal)

[a] adjusted for general trends where appropriate, converted using the CCEMEG cost converter to convert the costs to AUD and inflated to 2019 dollars
[b] benefit–cost ratio, unless otherwise indicated
[c] cost figures for interventions in Singichetti et al. (2020) are net costs which include revenues generated from fines and fees.

The interventions can be grouped into low-cost methods totalling less than $20 million, and high-cost methods, which cost over $20 million.

Low-cost methods in road safety were mostly behavioural interventions which ranged between -13.2 million (license plate impoundment) and $8.9 million (speed cameras). Only one physical environmental intervention, the safety signage program ($0.8 million) was a low-cost method. A low-cost method in suicide prevention was the gatekeeper/community program ($0.6 million).

High-cost interventions ranged between $83.4 million (suicide prevention program for youth) to $1,621 million (cyclists' blind spot warning).

Three studies presented used annual figures for its implementation costs, these were suicide prevention program for gatekeepers ($0.6 million), worksites in NSW ($0.9 million) and worksites in Australia ($ 44.4 million).

Average costs per vehicle were used for interventions involving lane departure warnings and video-based on-board monitoring systems (Camden et al., 2018; Medina-Flintsch et al., 2017); while average costs per km were used for 20mph speed zones (Peters & Anderson, 2012; Steinbach et al., 2013).

D.8. Discussion

The aim of the two rapid reviews was to provide a synthesis of studies reporting economic evaluation of road safety investments and suicide prevention programs to address two policy questions. The majority of the studies consistently found that interventions in suicide prevention and road safety investments were cost-effective, despite the heterogeneity in design among the included studies. However, there is a risk of publication bias as interventions with positive results are more likely to be published. Findings from the current review also highlight that there has been less research relating to cost-benefit analysis of suicide prevention compared to road safety investments.

D.8.1. Policy question 2 - Does the cost of crashes warrant more being spent on crash prevention?

Overall, the rapid review found nearly all the road safety interventions to be cost-effective and had positive net present values.

Cost-benefit analysis (CBA) is a widely accepted method in determining efficient resource allocation and priority setting (OBPR, 2020). Rooted in applied welfare economics, CBA assesses different policy or project alternatives by comparing their welfare effects on society(Mouter, 2021). Rigorous cost-benefit analysis can provide decision-makers with information on whether the social benefits of a particular project or policy exceed its social costs. Whether or not more funds should be allocated towards investment in road crash prevention overall, however, would require information on the relative social value of potential projects and policies in other sectors, as well as relevant budgetary and legal constraints. In the interventions included in the review, those that were cost-effective had benefits that outweighed its costs, indicating a social return that is higher than the level of funding spent on the intervention. This demonstrates that there are significant opportunities for efficient, beneficial further investments.

Australian Government's response to the Joint Select Committee on Road Safety Report (DITRDC, 2021) expressed their support for the first recommendation that "the Australian government commit more funding to road safety". Whether more funds should or should not be allocated towards investment in road crash prevention cannot be assessed using a cost-benefit analysis (CBA). The answer to this question, requires empirical research to properly assess the value of spending more on road crash prevention, which is beyond the scope of this review.

When considering policy question two, our first review identified three aspects that were consistent across the reviewed studies: 1. Components and measurements of outcomes; 2. Intervention selection and associated risks; and 3. Who bears the cost of the interventions.

Components and measurement of outcomes

In assessing whether to invest in road safety programs, the final benefit–cost ratio depends on the decisions regarding what is and is not included for the program costs and intervention benefits, and how these are measured. Estimating the societal impact from crashes can be measured using a human capital or willingness to pay approach. The choice of approach has different implications for avoided costs relating to deaths and injuries. A major disadvantage of the human capital approach is that human losses are valued on the basis of production losses, which significantly underestimates social losses (BITRE, 2014). Five of the nine studies (seven of the reported 15 interventions) in this rapid review used a VSL approach while 3 studies used a human capital approach (and one used both). Though the WTP is considered more superior, the techniques for determining WTP values vary and are quite complex (Australian Transport Council, 2011). This variation is reflected in the wide range of the value of a statistical life in the reviewed studies (between $3.2 million – $14.7 million).

Intervention selection and associated risk factors

Selecting an appropriate intervention and its implementation influences the impact and subsequently the potential cost savings of a road crash prevention program. The road crash interventions with the highest (Beale et al., 2018) and lowest (Tripodi & Persia, 2015) benefit–cost ratios suggest selecting interventions that directly influence the identified crash risk. The selection and prioritisation of road safety intervention in Australia would involve using the Australian National Risk Assessment Model with Australian parameters and cost-benefit analyses.

The five risk factors covered in the reviewed articles are in line with road safety policies in Australia and internationally (Australian Transport Council, 2011; ITF-OECD, 2008, 2017; WHO, 2021). The impact of road crash prevention to address these risk factors may also benefit from improvements caused by other interventions (Singichetti et al., 2020; Weijermars & Wegman, 2011). Examples of these mutual benefits include increased seat belt fines and seat belt enforcement campaigns, as well as road signage programs and safety rating programs such as ANCAP's 5-star ratings (Paine et al, 2015) and a vehicle's safety improvements. Identifying the risk factors in the road and transport system requires analysing the sequence of events leading to crashes and injuries.

Private-borne costs of road safety interventions

The distribution of road safety risks can be examined along several dimensions (Elvik, 2009), such between groups of road users, regions and communities, and with respect to who bears the cost and who benefits from it.

Four of the nine reviewed studies involved interventions in which investment costs were mainly borne by individuals and corporations, including on-board safety systems, cyclist safety devices, and helmet use. Though research shows advanced safety technology to be effective in preventing crashes involving commercial vehicles, corporations are hesitant to adopt costly technology and government agencies may be hesitant to create regulation mandating their use (Camden et al., 2018).

Furthermore, equity is also an important consideration in the development and implementation of road safety interventions. Though most of these interventions are found to be cost-effective, road safety policies may disproportionately affect lower socio-economic groups. Lower socio-economic group members are less likely to have vehicle technology that improve seat belt use (audible alerts) and disproportionately affected in paying fines (Elvik, 2009; Singichetti et al., 2020). Singichetti et al. (2020) highlights several equitable approaches, such as an alternative sentencing program for seat belt violations where violators receive a waiver or reduced fees if they attend a course on seat belt use. Another method that is applied in Finland sets the fine according to the violator's income.

D.8.2. Policy question 3 – The benefits of road safety investment relative to other health investments?

Focusing on suicide prevention as one other health investment, the rapid reviews found positive benefit–cost ratio and NPVs for a range of interventions (road crash and suicide prevention). Some interventions were found to be better than others. However, given the heterogeneity in the methodologies employed across the studies (e.g., perspectives, populations, intervention types, and primary outcome measure), it is not possible to make direct comparisons between the studies. With a limited budget, the best overall outcome would be to invest in the best (outcome per $) interventions first, ideally using consistent CBA methods to compare options. Three general observations can be made when comparing the benefits between road safety investments and suicide prevention programs based on their similarities and differences.

Similarities between the road safety and suicide prevention studies: Social costs averted

A societal perspective of investing in road safety and suicide prevention both include benefits from the following averted costs, with some differences. Both interventions include costs associated with medical care, emergency services, lost productivity and intangible costs. Savings from road safety investments however also included property damage, emissions, and travel time.

Differences between the road safety and suicide prevention studies: Modifiable determinants and recurring costs

A large difference in the two groups of reviewed studies on road safety investments and suicide prevention is that the reviewed road safety interventions were all aimed at modifiable determinants associated with the reduction in risk factors, whereas the suicide prevention reviewed studies enabled protective factors for people at risk.

Another difference between the road safety interventions and suicide prevention programs were maintenance or recurring costs. Most of the road safety interventions, for both behavioural and physical environmental types, involved initial setup costs that were followed by much lower recurring costs. Some examples are the safety signage programs, onboard safety monitoring devices and 20mph zones. The suicide prevention programs however, which were mostly community training programs required recurring costs that were the same or not much lower than its initial setup costs.

D.8.3. Limitations

There were several limitations to the review. The heterogeneity of the methods and settings used in the interventions limited the ability to synthesis the results, which affects the generalisability of the findings. Different studies included different populations; some studies used vehicles as the unit of observation while others included the road users. Furthermore, the heterogeneity of the studies based on the country in which the research was conducted reflects different health systems, which limits the ability to integrate study results and generalise the findings. The studies also differ in their coverage, as some focused on specific provinces and towns while others report on state and nation levels. Another limitation, from a policy perspective would be the comparison between road crashes and suicide prevention programs, given the apparent differences between the two events from a transport and economics as well as a medical point of view.

D.9. Conclusion

The rapid reviews evaluated and compared road crash prevention and suicide prevention interventions to answer two policy questions:

- Policy question 2: 'Does the cost of crashes warrant more being spent on crash prevention?'
- Policy question 3: 'How do the benefits of road safety investments compare with other health investments?'

In answering policy question 2, the review identified the need to have more information and data to properly assess the value of spending more on road crash prevention. Such data include empirical research identifying the priorities that inform Australian policymakers' decision-making, and implementation and outcome evaluation of previous road safety policies. The Australian Government has made an explicit objective to prevent deaths and injuries from road crashes, and cost-benefit analyses are an effective way in measuring the social benefit compared to the investments made.

Despite the heterogeneity and diverse methodological quality of the literature reviewed and the settings in which the studies occurred, we identified some areas of consistency that can provide the basis for potential future road safety investments in Australia. The first aspect is the components and measurements of outcomes, where the policy implications of using one method over the other can be significant. A second aspect is the selection of interventions used to improve road safety. Some methods including data-driven approaches can be considered to identify optimal countermeasures and modifiable determinants to target. The third aspect is equity consideration regarding private-borne costs.

In answering policy question 3, three main observations can be made based on the similarities, differences, and differentiating interventions by low and high implementation costs. The similarities included societal costs from both road safety interventions and suicide prevention associated with medical care, emergency services, lost productivity, and intangible costs.

Studies on road safety interventions however differed from suicide prevention studies by including costs averted from property damage, emissions, and travel time. Other differences were the modifiable determinants targeted by the groups of studies as well as the size of recurring costs relative to setup costs associated with the interventions.

Finally, while the review identified a range of behavioural and physical environmental interventions, there is a lack of published information in some areas. These include an understanding of the broader policy contexts such as: 1) reasoning behind governments' decision to spend public funds on preventing car accidents; and 2) the level of spending on preventing car accidents compared to other pervasive social and/or community issues.