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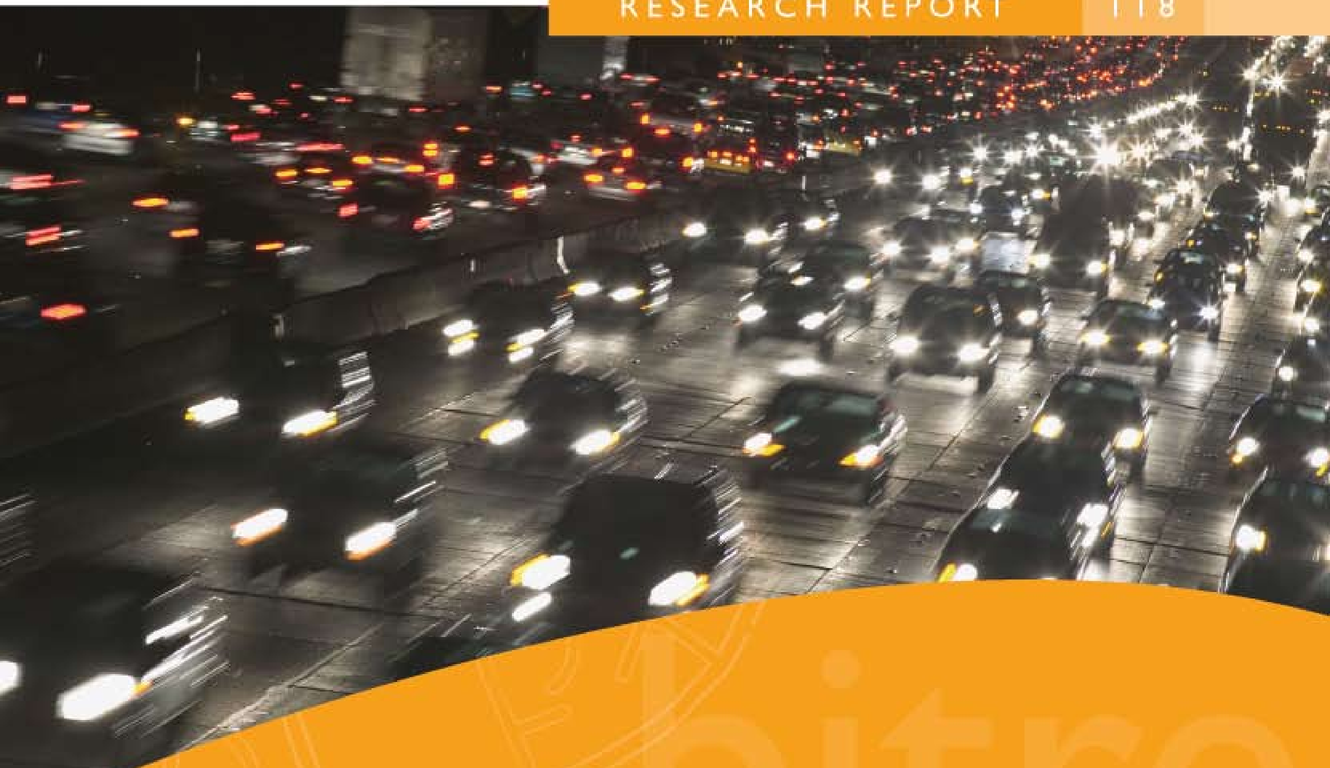

Road

Cost of road crashes in Australia 2006

Bureau of Infrastructure, Transport and Regional Economics

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Report 118

Department of Infrastructure, Transport,
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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 to the safety debate in Australia, and the unit values—particularly for a fatality, injury or cost of a fatal crash—are key inputs into policy development and cost-benefit analysis for safety programs and infrastructure projects.

This report presents new estimates of the cost of road crashes for 2006, updating previous estimates (Bureau of Transport Economics (BTE) *Road crash costs in Australia*, Report 102).

A key objective of this project was to make these estimates more useful to policymakers and the wider community.

The project team was Tim Risbey (Team Leader), Dr Hema De Silva, Mark Cregan, Joel Mallet, and Justin McEvoy. Alicia Tong, Amy Wagner and Winston Lu also contributed to the report. Robert Stewart and Dr Mark Harvey provided comments on the draft report.

BITRE greatly appreciated the assistance of states and territories with information and comments.

BITRE is also grateful for the assistance of Joe Motha and John Goldsworthy, of the Infrastructure and Surface Transport Policy Division of the Department of Infrastructure, Transport, Regional Development and Local Government.

Gary Dolman
Acting Executive Director
Bureau of Infrastructure, Transport and Regional Economics
December 2009

At a glance

- The social cost of road crashes was an estimated $17.85 billion in 2006 (1.7 per cent of GDP). This was a real decrease of 7.5 per cent compared to 1996 (Bureau of Transport Economics 2000).
- Fatal crashes cost an estimated $3.87 billion, injury crashes an estimated $9.61 billion and property damage crashes an estimated $4.36 billion.
- Human losses and related costs were 61.5 per cent of the cost of crashes.
- There were an estimated 653 853 road crashes in 2006 involving approximately 1.16 million vehicles, compared with an estimated 618 600 crashes involving approximately 1.13 million vehicles in 1996.
- 1602 people died as a result of road crashes in 2006, down from 1970 people in 1996.
- 31 204 people injured in road crashes were admitted to hospital in 2005–06. Of these, 20 958 people stayed one night or more (down from 21 189 in 1996).
- BITRE estimated that there were 4619 people who suffered a disability as a result of road crashes in 2006, up from an estimated 3997 in 1996.
- BITRE estimated that there were an additional 216 500 people treated for road crash injuries in 2006 who were not admitted to hospital.
- Estimated human losses were approximately $2.4 million per fatality, losses for a hospitalised injury were approximately $214 000 per injury (including disability-related costs), and losses for non-hospitalised injury were approximately $2200 per injury.
- Estimated losses from a person suffering a profound impairment were $3.82 million and losses due to a severe impairment were $1.78 million. Losses due to a moderate impairment were $542 000 and mild impairment were $126 000.
- The estimated cost of a fatal crash was $2.67 million in 2006. The cost of a hospitalised injury crash was approximately $266 000 and the cost of a non-hospitalised injury crash was approximately $14 700. The average cost of a property damage-only crash was approximately $9950.
- Costs that significantly decreased compared to 1996 (in 2006 dollars) were travel delay costs ($1.02 billion); vehicle repair costs ($832 million); legal costs ($779 million); disability-related costs ($699 million); and non-pecuniary losses ($510 million). Non-pecuniary or intangible losses include the quality of life a person would have enjoyed had they not died prematurely, and (for 2006 only) pain, grief and suffering of relatives and friends.
- Costs that significantly increased compared to 1996 (in 2006 dollars) were workplace and household losses ($1.7 billion); insurance administration ($498 million); and medical costs ($399 million).

- A number of costs not estimated in 1996 added approximately 1 per cent to total 2006 costs.
- The cost of human losses of a road fatality are derived using BITRE's hybrid human capital approach. If a willingness-to-pay based value of $6.2 million had been used to value the human costs of road crashes, then the estimated cost of road crashes would have been 52 per cent higher.

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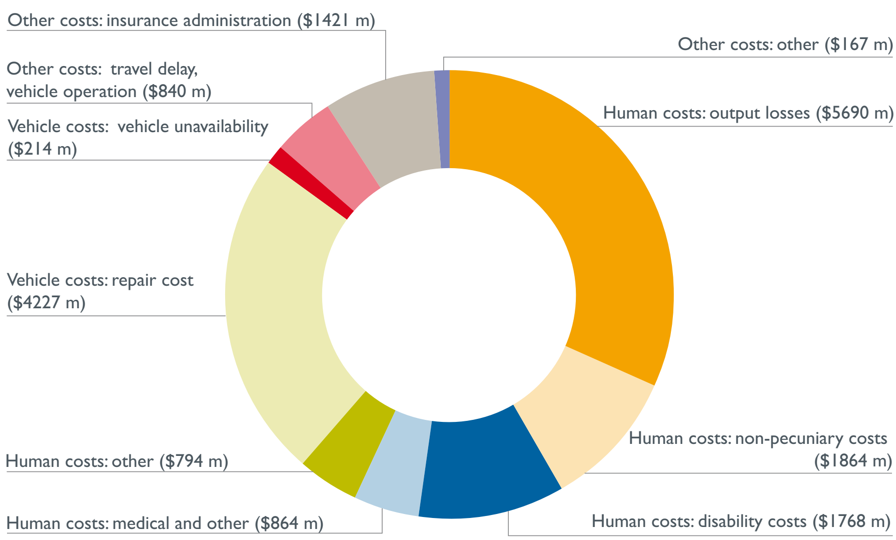
The social cost of road crashes was an estimated $17.85 billion in 2006 (1.7 per cent of GDP). This was a real decrease of 7.5 per cent compared to 1996 estimates (Bureau of Transport Economics 2000).

Fatal crashes cost an estimated $3.87 billion, injury crashes an estimated $9.61 billion and property damage crashes an estimated $4.36 billion.

Human losses—workplace and household losses, non-pecuniary[1] losses and disability-related costs—were 61.5 per cent of the cost of crashes (Figure E1).

FES.1 Social cost of road crashes by component, 2006



Source BITRE estimates.

There were an estimated 653 853 road crashes in 2006 involving approximately 1.16 million vehicles, compared with an estimated 618 600 crashes involving approximately 1.13 million vehicles in 1996.

In 2006, 1602 people died as a result of crashes, down from 1970 people in 1996.

1 Non-pecuniary or intangible losses 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.

In 2005–06, 31 204 people[2] were admitted to hospital, of which 20 958 stayed one night or more—down from 21 189 who stayed one night or more in 1996. BITRE estimates that a further 216 500 people injured in road crashes saw a general practitioner or were treated but not admitted to hospital.

Major costs were workplace and household losses ($5.69 billion), vehicle repair costs ($4.23 billion) and disability-related costs ($1.86 billion). The latter includes specialised equipment and care costs for people with a permanent disability.

TES.1 Major components of the social cost of road crashes, 2006

Cost element	Human related costs ($ millions)	Property damage and general costs ($ millions)	Total crash cost ($ millions)	Proportion (per cent)
Workplace and household losses	5 690.0	na	5 690.0	31.9
Repair costs	0	4 227.5	4 227.5	23.7
Disability-related costs	1 863.9	na	1 863.9	10.4
Non-pecuniary costs a	1 768.0	na	1 768.0	9.9
Insurance administration	269.7	1 421.3	1 691.0	9.5
Medical and related costs	864.2	na	864.2	4.8
Travel delay and additional vehicle operating costs	na	839.7	839.7	4.7
Legal costs	267.9	nse	258.2	1.5
Vehicle unavailability costs	na	214.1	214.1	1.2
Other	256.5	166.5	423.0	2.4
Total	10 980.2	6 869.1	17 849.3	100

Note: Components may not add to totals due to rounding.
na not applicable.
nse not separately estimated.
a Non-pecuniary or intangible losses for 2006 include the quality of life a person would have enjoyed had they not died prematurely and the pain, grief and suffering of relatives and friends.
Source BITRE estimates.

The estimated human losses from a road fatality were $2.4 million. Losses from a hospitalised injury were approximately $214 000 (including disability-related costs) and a non-hospitalised injury cost an estimated $2100.

BITRE estimates that 4619 (14.8 per cent) of the 31 204 people hospitalised due to road crash injuries suffered a disability, of which 1270 people (4.1 per cent of people hospitalised) had severe or profound limitation.

Estimated losses from a person suffering a profound impairment were $3.82 million and losses due to a severe impairment were $1.78 million. Losses due to a moderate impairment were $542 000 and mild impairment were $126 000.

The estimated cost of a fatal crash was $2.67 million per crash (Table E.2). Hospitalised injury crashes cost approximately $266 000 per crash and non-hospitalised injury crashes cost approximately $14 700 per crash. A property damage–only crash cost approximately $9950 per crash.

2 The latest available hospital data was for 2005–06 (Berry and Harrison 2008) and BITRE assumed for costing purposes that 31 204 persons were admitted to hospital due to road crashes in 2006.

TES.2 Estimated average costs of road crashes by crash outcome and jurisdiction, dollars, 2006

Jurisdiction	Fatal crash	Hospitalised injury crash	Non-hospitalised injury crash	Property damage only crash
New South Wales	2 667 484	265 670	14 723	9 979
Victoria	2 670 591	265 430	14 709	10 075
Queensland	2 664 622	266 016	14 740	9 867
South Australia	2 667 755	265 619	14 722	9 988
Western Australia	2 660 398	266 815	14 784	9 632
Tasmania	2 663 817	266 000	14 747	9 831
Northern Territory	2 658 492	267 157	14 818	9 506
Australian Capital Territory	2 693 284	264 677	14 667	10 433
Australia	2 666 511	265 770	14 728	9 942

Source BITRE estimates.

Factors contributing to the change in crash costs include:

- reduced numbers of road fatalities due to effective safety and infrastructure programs, and better vehicle technology
- changes to the 1996 disability costing methodology
- increases in the real cost of hospital and emergency services
- improvements to the estimation of travel time delays which significantly decreased the estimates
- increased insurance administration costs for vehicle damage, largely due to increasing numbers of registered vehicles
- a decrease in legal costs since 1996.

Four additional costs were estimated for 2006: health costs of additional local air pollution; higher vehicle operating costs for vehicles in crash-induced congestion; workplace and household losses due to imprisonment of persons found guilty of culpable driving causing death; and the non-pecuniary value for pain, grief and suffering of family and friends. These costs contributed approximately 1 per cent to total 2006 costs.

Crash cost estimates are sensitive to the following factors:

- the approach to valuing losses due to death or injury (such as human capital approach or willingness-to-pay approach)
- the availability and quality of data
- the values assumed for key parameters such as the social discount rate. BITRE has used a risk-free real discount rate of 3 per cent in this study, consistent with its previous transport safety costing studies (BTRE 2006).

An analysis of 2006 crash costs suggests that:

- The unit cost of human and related losses of a road fatality—derived using BITRE's hybrid human capital approach—is estimated to be $2.40 million. If a willingness-to-pay approach had been used to value fatality, injury and disability costs, then the estimated cost of road crashes would have been 52 per cent per cent higher.

- A lower social discount rate of 2 per cent would have increased total crash costs by approximately $1.5 billion (8.4 per cent).
- A higher social discount rate of 5 per cent rate would have decreased total crash costs by approximately $2 billion (11.2 per cent).
- There is significant uncertainty with respect to the cost of travel delays. BITRE modelling indicates delay costs could be $294 million lower (a 1.6 per cent decrease in total costs) or $968 million higher (a 5.4 per cent increase in total crash costs).
- Estimated travel delay costs are likely to be conservative as the bottleneck model used to estimate travel delays does not capture the network congestion that occurs where a crash disrupts a major road or intersection during peak periods.

Costs that significantly decreased compared to 1996 (in 2006 dollars) were travel delay costs ($1.02 billion), vehicle repair costs ($832 million), legal costs ($779 million), disability-related costs ($699 million), and non-pecuniary losses ($510 million).

Non-pecuniary or intangible losses include the quality of life a person would have enjoyed had they not died prematurely and (for 2006 only) the pain, grief and suffering of relatives and friends.

BITRE modelled uncertainty with respect to delay costs using risk management software and expected distribution of key parameters (response times and traffic flow restriction following emergency services attendance). This indicated delay costs range between $500 million and $1.76 billion at the 95 per cent confidence interval. BITRE has used the mid-point estimate of $791.7 million.

The change in disability costs reflects a more detailed methodology, the removal of welfare transfer payments to avoid the possibility of double counting, and the addition of the cost of carers for people suffering a road crash-related disability for profound, severe and moderate levels of impairment.

Reduced repair costs reflect lower average claims and repair values for passenger vehicles.

Injury-related legal costs have decreased substantially since 1996. Many jurisdictions have changed compulsory third party schemes to simplify claims processes. This has reduced the number of disputed claims and lessened reliance on court processes. In addition, civil legal costs for property damage cases have not been estimated for 2006 as there was insufficient data to exclude these costs from insurance administration costs.

Costs that significantly increased compared to 1996 (in 2006 dollars) were workplace and household losses ($1.7 billion), insurance administration ($498 million), and medical costs ($399 million).

Vehicle-related insurance administration costs increased in real terms by 41.8 per cent between 1996 and 2006, largely reflecting a larger vehicle fleet.

CHAPTER 1
Introduction

1.1 The social cost of road crashes

The cost of road crashes is an important input to the safety debate in Australia, and the unit values (value of a fatality, serious injury or cost of a fatal crash) are key inputs into policy development and cost-benefit analysis for safety programs and infrastructure projects.

BITRE's last estimate (BTE 2000) of the losses to society and economy due to road crashes was nearly $15 billion a year in 1996 (1996 dollars).

This report updates estimates of the annual cost of road crashes for 2006, and has sought to make these estimates more useful to policymakers and the wider community.

1.2 Road crash and injury definitions

The definition of a road crash is essential to costing the economic impact of road crashes and comparing changes over time. Not all accidents on a road are considered by authorities to be road crashes, and not all crashes occur on public roads.

BITRE has used the Australian Transport Safety Bureau (ATSB) guidelines for defining and classifying road crashes in this report.

ATSB (2004) defines a road crash as a crash involving a road vehicle on a public road. Road vehicles include motor vehicles, pedal cycles, towed devices, machines and ridden animals, but exclude skateboards, carts, prams and non-motorised wheelchairs.

A public road incorporates the area immediately adjacent to the carriageway including median strips and footpaths. Crashes that occurred outside this area are excluded except where the vehicle left the road in an out-of-control manner.

This definition of a road crash includes road vehicles sliding into the road reserve and hitting an object; pedal cyclists injuring themselves or pedestrians on a roadway; a runaway driverless vehicle colliding with an object or pedestrian; and a load falling from a moving vehicle.

Equally important is that this definition of road crash excludes suicides and homicides; events indirectly related to a road crash; off-road crashes (that is, crashes in car parks; on private property or on roads temporarily closed to the public) and collisions involving only non-road vehicles.

The terms 'accident' and 'crash' are often used interchangeably to describe vehicle collisions on public roads. BITRE uses the term crash to illustrate that collisions are generally avoidable and not the result of chance events.

In the safety literature, people involved in road crashes are usually classified according to the degree of injury severity—fatal injuries, serious injuries, minor injuries or no injuries—yet there is no common definition across all Australian states and territories of serious and minor injury groupings.

For costing purposes, people injured in road crashes are grouped into different groups.

A fatal injury (road fatality) is defined as a death resulting from a road crash occurring on a public road, with unintentional death occurring within 30 days from injuries sustained in the crash (Infrastructure 2009b).[3]

Non-fatal casualties are classified as either hospitalised or non-hospitalised injuries.

Hospital admission data has become the primary source of information about seriously-injured crash casualties in Australia. This has the advantage that casualties admitted to hospital are classified medically. These data are also more likely to record pedestrian, cyclist and motorcyclist casualties. However, hospital data comes with its own limitations. These include no direct link between a hospital admission and a crash.[4]

Hospitalised casualties include persons who were admitted to hospital regardless of their length of stay.

Non-hospitalised casualties include persons who attended hospital but were not admitted, and those who received treatment from a general practitioner. This excludes people who did not seek medical treatment.

This classification of injuries into hospitalised and non-hospitalised categories differs from BTE (2000) and BTCE (1988). Casualties in these reports were subclassified as either serious injuries (persons who were admitted to hospital for one day or more) or minor injuries (persons who were treated at hospital for less than one day plus casualties who received treatment from a general practitioner or did not seek medical assistance for their injuries).

1.3 How has BITRE costed road crashes?

Valuation of road crash costs involves estimating the total number of crashes and injuries, then quantifying the cost of specific crash components. The estimation of crash costs comprises human costs: loss of life; treatment of injuries and ongoing care of persons with disabilities; property costs and general costs.

3 This definition encompasses the 'underlying or contributory' causes of death as given in ICD-10 coding. ICD refers to International Classification of Diseases. Further details of ICD coding are in Chapter 4. It also has the following qualifications to it: (a) if a driver has a non-fatal heart attack that leads to a crash — which in turn causes death — then according to this definition, it can be treated as a road fatality; (b) if a heart attack causes death prior to a crash, then it is not a road fatality; and (c) a suicide occurring on a public road involving a vehicle is not regarded as a road fatality (see Routley et al 2003).

4 There are differences in injury definitions between jurisdictions. Privacy restrictions prevented BITRE matching patient data to crash data.

The estimation of crash costs is an inexact science (BTE 2000). The magnitude of estimates depends on the approach used as well as the quality and availability of data. BITRE has refined the crash cost methodology used in its previous work (BTCE 1988, BTCE 1992, BTE 1999 and BTE 2000).

The notional value of a life in this report is measured using a modified 'human capital' approach (BTE 2000, BTCE 1988). This approach involves estimating the sum of a person's future earnings as a proxy of their human capital—the stock of skills and knowledge that determine a person's potential earnings. BITRE notes that the:

- human capital approach is recognised as understating the human costs of road crashes
- willingness-to-pay approach is the theoretically superior approach in welfare economics; however, willingness-to-pay values for a road transport context in Australia are still under development (Abelson 2008, p.2).

BITRE has retained a modified human capital approach in this report to provide consistency with previous estimates and undertaken sensitivity testing to indicate the effect of using indicative willingness-to-pay values.

BITRE has made a number of significant changes to the methodology used by BTE (2000):

- the methodology for estimating injury costs has been extended to consider impairment and disability costs related to the type of injury; the cost of carers for those with profound, serious and moderate core disabilities; and the premature death of people with profound disabilities
- the methodology for estimating travel delays has been extended to a wider selection of crashes and to model uncertainty of key parameters
- BITRE has estimated the health costs of additional local air pollution and the additional vehicle operating costs resulting from the delays caused by road crashes

1.4 How is this report structured?

This report comprises seven chapters.

Chapter 2 presents statistics on the estimated number of crashes, casualties and vehicles involved in road crashes in Australia.

Chapter 3 discusses the method used to estimate the losses to society from road fatalities, including BITRE's approach to valuing loss of life.

Chapter 4 discusses the method used to value losses to society due to road crash-related injury and permanent disability.

Chapter 5 presents estimates of vehicle-related costs (damage to vehicles and vehicle unavailability), while Chapter 6 give estimates of other costs related to road crashes, including the cost of crash-related travel delay.

Chapter 7 summarises the estimated cost of crashes in 2006 and reports the results of sensitivity testing.

Appendix A gives the detailed methodology used to estimate both the numbers of road crashes and vehicles involved in crashes.

CHAPTER 2

Overview of road crash statistics

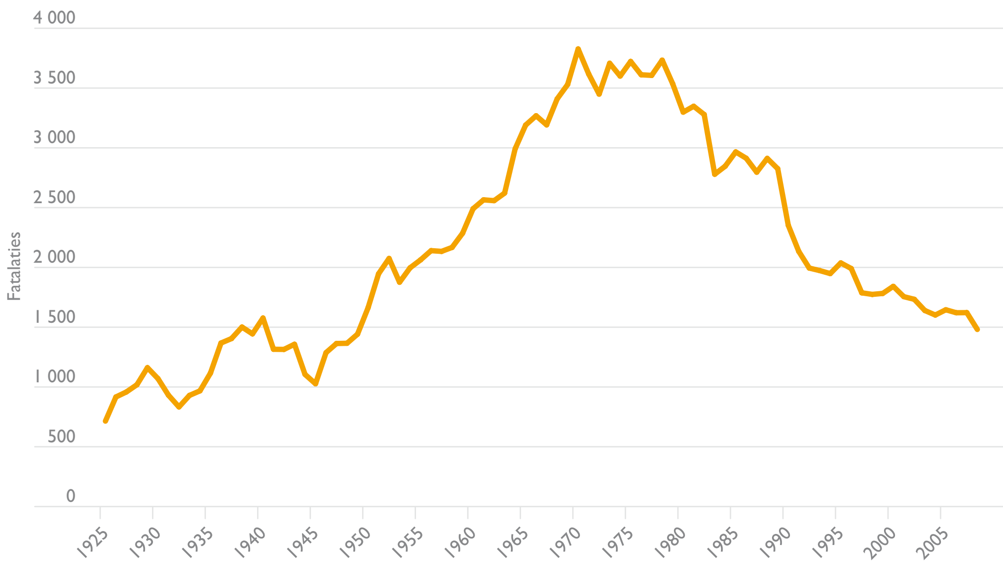
This chapter discusses trends in the number of road fatalities, and the estimated number of injuries, road crashes and vehicles involved in road crashes in 2006.

2.1 What are the trends in road fatalities?

Changes in the annual number of road deaths since 1925 is shown in Figure 2.1. Road crash fatalities have fallen from the peak of 3798 deaths in 1970.

Many factors have contributed to reductions in the number of fatalities. These include investments in road infrastructure and road safety programs, regulated changes in vehicle safety standards (for example, mandatory seat belts), and better vehicle design and safety equipment such as airbags.

F2.1 Road crash fatalities, historical trend 1925–2008



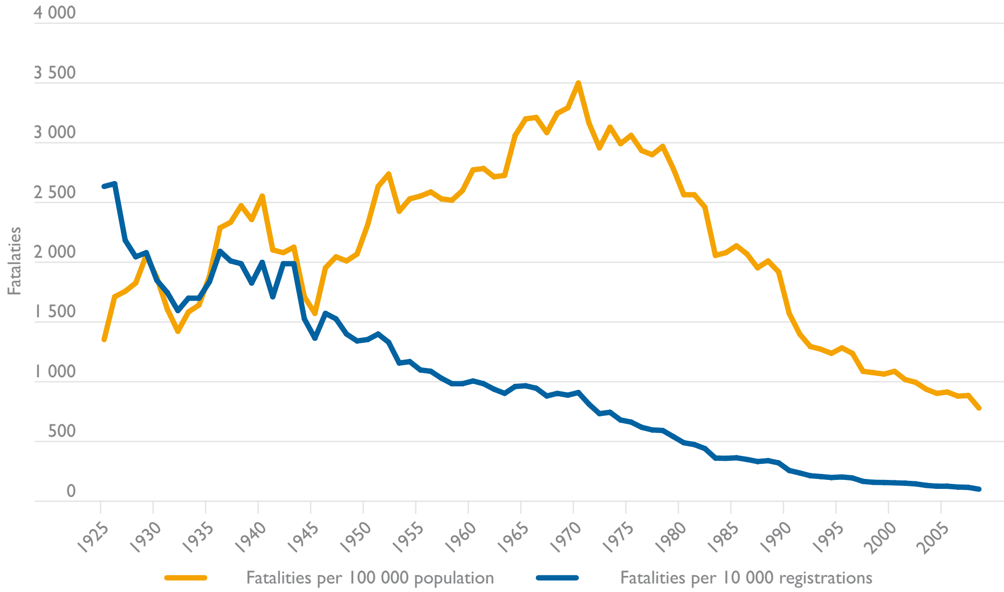
Source: ATSB (2007), Infrastructure Australian Road Deaths Database.

In 2006, there were 1602 road fatalities in 1455 crashes. On average, a fatal crash resulted in 1.1 deaths involving 1.3 vehicles. As in 1996, most fatal crashes in 2006 involved a single death and a single vehicle.

There were 368 fewer road fatalities and 313 fewer fatal crashes in 2006 than in 1996, when Australia recorded 1970 deaths in 1768 fatal crashes.

This downward trend in road fatalities is more evident when the trend is considered against the growth in population, vehicle usage and levels of car ownership. Standardised fatality rates are presented in Figure 2.2.

F2.2 Trend in standardised crash fatalities, 1925–2008



Source: ATSB (2007), Infrastructure Australian Road Deaths Database.

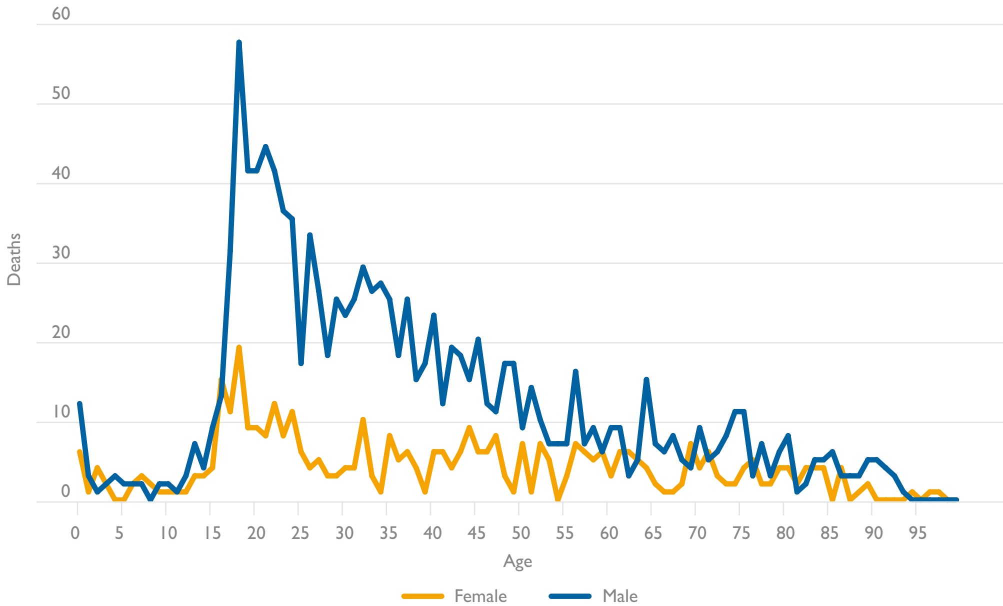
Standardised fatality measures remove population differences, vehicle usage and ownership levels to enable comparisons between jurisdictions and show trends over time. Between 1996 and 2006, standardised fatality rates:

- Fell from 10.8 fatalities per 100 000 persons to 7.7 per 100 000 persons (29 per cent)
- Fell from 1.8 fatalities per 10 000 registered vehicles to 1.1 per 10 000 registered vehicles (37 per cent)
- Fell from 1.1 fatalities per 100 million vehicle kilometres travelled to 0.8 per 100 million vehicle kilometres travelled (32 per cent)

The number of fatalities differs significantly by age and gender. Figure 2.3 shows that males accounted for most road fatalities in 2006, particularly males aged between 17 and 24-years-old where there were more than 30 deaths for each age group within this range.

Crash fatalities also differ significantly by jurisdiction (Table 2.1). The number of fatalities in 2006 ranged from 496 in New South Wales to 13 in the Australian Capital Territory.

F2.3 Fatalities by gender and age, 2006



Source: Infrastructure Australian Road Deaths Database.

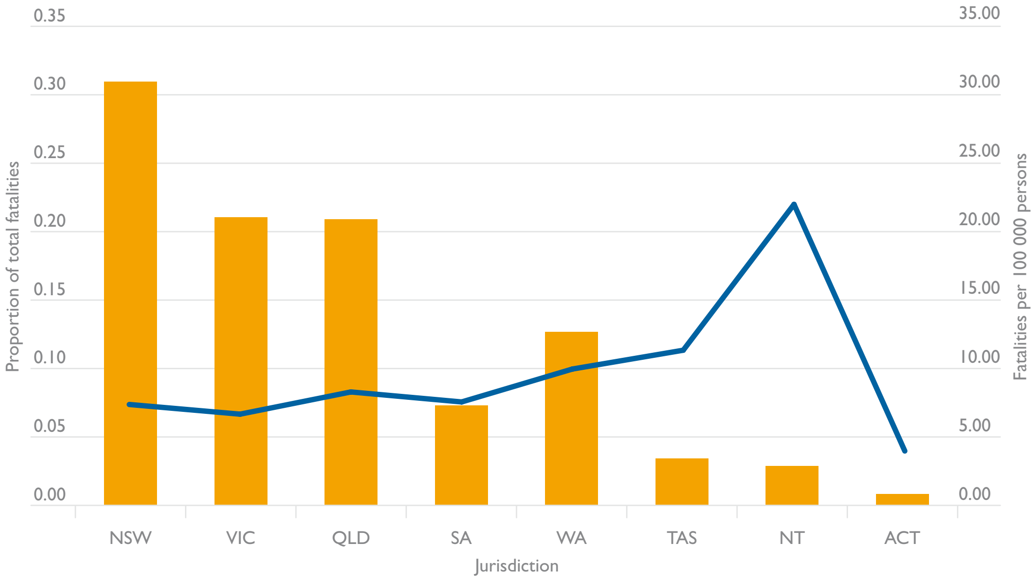
T2.1 Fatalities by jurisdiction, 2006

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	TOTAL
Fatalities	496	337	335	117	203	55	46	13	1602
Per cent	31.0	21.0	20.9	7.3	12.7	3.4	2.9	0.8	100.0
Rate per 100 000 people	7.28	6.57	8.19	7.46	9.86	11.23	21.84	3.89	7.74

Source: Infrastructure 2008a; ABS 2008c; BITRE Road Crash Database.

Figure 2.4 presents the proportion of fatalities by jurisdiction and the fatality rate per 100 000 population for all states and territories. When the fatality rate per 100 000 people is considered, the Northern Territory recorded over 20 fatalities per 100 000 population; this was more than twice the rate recorded in all states except Tasmania.

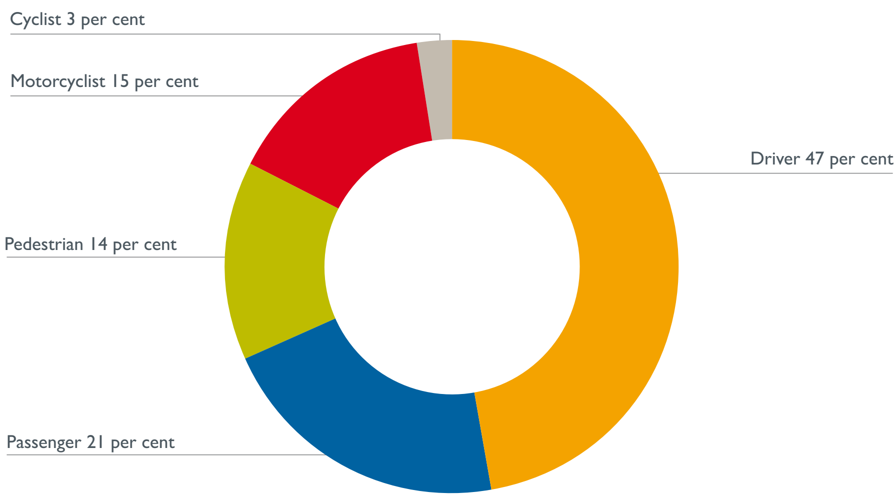
F2.4 Fatalities by jurisdiction, 2006



Source: Infrastructure 2008a; ABS 2008c: BITRE road crash database.

More than two-thirds of people killed in road crashes in 2006 were vehicle drivers or passengers (Figure 2.5).

F2.5 Fatalities by road user, 2006



Source: Infrastructure Australian Road Deaths Database.

More cars were involved in fatal crashes than any other vehicle type, however, the rates of involvement for motorcyclists and articulated trucks in fatal crashes per billion kilometres travelled were significantly higher than other vehicle types (Table 2.2).

T2.2 Fatal crashes by vehicle type involved, 2006a, b

Vehicle	Vehicles involved in fatal crashes c	Billion vehicle kilometres travelled	Vehicle involvement in fatal crashes per billion vehicle kilometres travelled d
Cars and light commercial vehicles	1415	201.5	7.0
Motorcycles	219	1.9	116.6
Buses	15	2.3	6.6
Rigid trucks	61	8.4	7.3
Articulated trucks	136	6.5	21.0

a Vehicle involvement in a crash does not mean that the vehicle's operator is at fault.

b Heavy vehicle numbers may underestimate actual vehicle involvement in fatal crashes due to data limitations. These limitations include jurisdictional differences in vehicle definitions.

c Vehicle involvement is not the same as the number of fatal crashes, as more than one vehicle can be involved in a single crash event.

d Rates calculated using BITRE's estimates of vehicle kilometres travelled by vehicle class.

Source: BITRE road crash database; BITRE estimates of vehicle kilometers travelled.

The Department of Infrastructure, Transport, Regional Development and Local Government (Infrastructure) (2008a) compared fatality rates among Organisation for Economic Cooperation and Development (OECD) nations standardised for country population, number of registered vehicles and kilometres travelled.

In 2006, Australia ranked:

- 18th out of 30 OECD nations with 7.7 road fatalities per 100 000 persons. In 1995,[5] Australia ranked 20th out of the same 30 countries with 11.2 fatalities per 100 000 persons. The OECD average road fatality rate per 100 000 people declined from 12.3 fatalities to 8.8 fatalities over that time (DITRDLG 2008a).
- 9th out of 26 OECD nations with 1.1 road fatalities per 10 000 registered vehicles. In 1995, Australia ranked 6th in the list of the same countries with 1.8 fatalities per 10 000 registered vehicles. The average OECD road fatality rate fell from 2.5 to 1.4 per 10 000 registered vehicles over that time (DITRDLG 2008a).
- 7th out of 17 OECD nations with 0.8 fatalities per 100 million vehicle kilometres travelled. In 1995, Australia ranked 5th in the list of the same countries with 1.2 fatalities per 100 million vehicle kilometres travelled. The average OECD road fatality fell from 1.4 to 0.9 fatalities per 100 million vehicle kilometres travelled over that time (DITRDLG 2008a).

2.2 How many people were injured in crashes?

People injured in road crashes may or may not receive medical treatment. Where medical treatment is received, it may be provided by emergency services at the scene, by medical staff at a hospital, by a general practitioner or by other health care providers.

Unlike fatalities, data on the number of people injured in road crashes is not systematically collected and studies have identified substantial underreporting of injuries in official crash data. Only 22 per cent of all reported crashes in Western Australia involved attendance by police (Chapman and Rosman 2008). Less than 65 per cent of hospital casualty records are in

5 No comparison data was available on road fatalities in OECD countries for 1996.

police records, although reporting levels increase with casualty severity (Rosman and Knuiman 1994, Rosman 2001). Injured pedestrians, pedal cyclists and motorcyclists are known to be underrepresented in state crash datasets with only 29 per cent of injured motorcyclists involved in single vehicle crashes also present in state crash records (Rosman and Knuiman 1994).

BITRE has classified injured persons for costing purposes as either hospitalised or not hospitalised (see Chapter 1). This categorisation into hospitalised and non-hospitalisation injuries reflects current reporting practice by including people discharged the same day (Berry and Harrison 2008), but differs from the definition of 'serious injury' in BTE (2000) which excluded same day discharges. Approximately 30 per cent of patients admitted to hospital are discharged the same day.

In 2006 approximately 249 306 people were killed or medically treated for injuries received in road crashes (Table 2.3). In deriving this estimate, BITRE has assumed that the same number of people were admitted to hospital in 2006 as 2005–06, the latest available hospital data (Berry and Harrison 2008).

BITRE estimates that there were approximately 31 204 people who were admitted to hospital and 216 500 people who received medical treatment who were not admitted to hospital.

T2.3 Road crash casualties by injury type

Injury severity	Estimated persons
Fatal a	1 602
Hospitalised, stayed 1 night or more b	20 958
Hospitalised, discharged the same day b	10 246
Not hospitalised estimate c, d	216 500
All casualties	249 306

a BITRE's road crash database records a total of 1598 fatalities. DITRDLG (2009a) has subsequently revised the number of road fatalities to 1602.

b Hospital admissions data is for 2005–06 (Berry and Harrison 2008).

c The estimated number of injured people who were not hospitalised includes an estimated 110 200 people who attended hospital but were not admitted, and 106 300 people treated by general practitioners (range between 91 425 and 121 165 people). It excludes people who did not seek medical treatment for road crash injuries.

d Various studies have assumed there are between 0.83 and 1.10 minor injuries for every hospital attendance. O'Connor & KPMG Peat Marwick (1993) found a ratio of one hospital admission to 3.53 hospital attendances for persons injured in road crashes. MUARC (1999) found a ratio of crash casualties presenting to hospitals (1) to general practitioners (0.83) in regional Victoria. BTE (2000) used a higher ratio of hospital presentations (1) to general practitioners (1.1).

Source: BITRE estimates.

This estimate excludes an unknown number of people who did not seek medical care, and is towards the upper bound of the range indicated by ATSB's 2006 Community Attitudes to Road Safety (CARS) survey for people involved in a crash. BITRE has not used the CARS data to estimate injuries as the survey as the survey: defines 'involvement' to include people in a vehicle who were not injured; relies on respondents to recall crash experiences and injuries of all parties; only records the most serious crash of each respondent; and does not include persons under 15 years of age; has a large sample error.[6]

The ABS National Health Survey 2001 (ABS 2003) found that 3 in 1000 persons reported experiencing an injury as a result of a vehicle accident, of which 63 per cent occurred on a

6 The 2006 CARS gives a midpoint estimate of 187 661 people involved in injury crashes. However, the survey data has wide error bounds, a 95 per cent confidence interval of between 49 675 and 325 647 people.

street or highway. BITRE has not used this data to estimate road crash injuries due to large sample errors.[7]

In 2005–06, the number of people hospitalised following road crashes ranged from 10 196 in New South Wales to 467 in the Northern Territory (Table 2.4). Hospitalisation rates range from 124 per 100 000 people in Western Australia to 230 per 100 000 people in the Northern Territory (Figure 2.6).

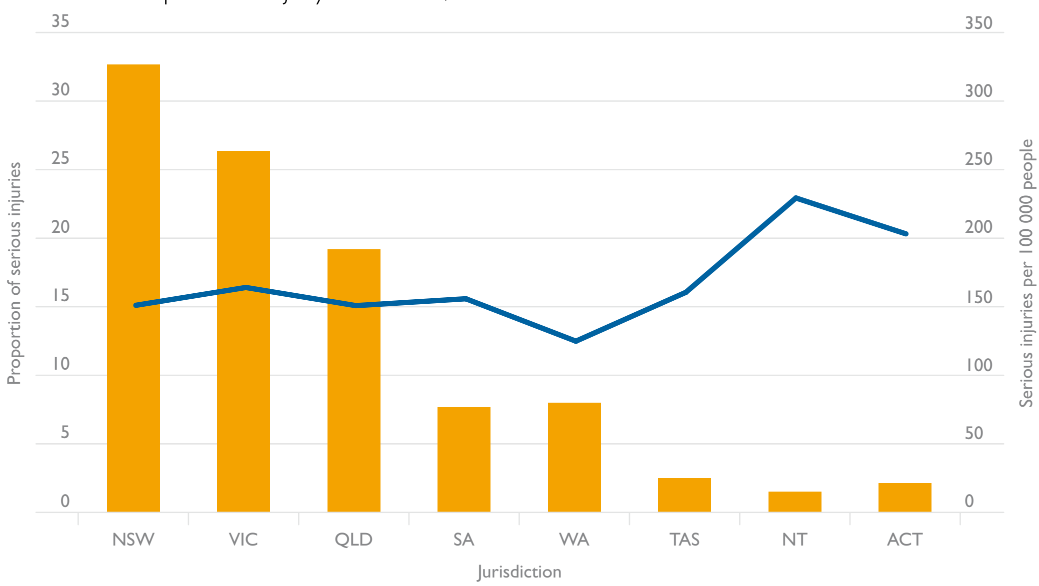
T2.4 Hospitalised injuries by jurisdiction, 2005–06

	Injured persons								
	NSW	VIC	QLD	SA	WA	TAS	NT	ACT a	Australia
Hospitalised injuries	10 196	8 225	5 981	2 397	2 498	778	467	662	31 204
Per cent of total	32.7	26.4	19.2	7.7	8.0	2.5	1.5	2.1	100.0
Per 100 000 people	150.6	163.7	150.4	155.4	124.2	160	230	203	167.2

a Approximately 30 per cent of ACT hospital cases were New South Wales residents.

Source: Berry and Harrison (2008); ABS (2008c).

F2.6 Hospitalised injury measures, 2005–06



Source: Berry and Harrison (2008); ABS (2008c).

7 Initial analysis using the ABS (2003) survey data suggested that approximately 12 000 people attended hospital following an accident on a road or highway in 2006, or less than 40 per cent of the 31 204 people hospitalised due to a crash in 2005–06 (Berry and Harrison 2008).

Australian Transport Council (2008) reports a 2.5 per cent annual increase in the numbers of people admitted to hospital between 2000 and 2006.[8] Berry and Harrison (2008) observed significant variability in the count of hospitalised persons, noting changes in admission practices and policies, but found less variability in 'high threat to life' admission rates. Admissions in the high threat to life group are increasing with growing numbers of injured male motorcyclists and pedal cyclists (Berry and Harrison 2008).

The proportion of people in the CARS reporting involvement in road crashes declined from 18 per cent in 2003 to 16 per cent in 2006 (ATSB 2006).[9] However, the number of injured motorcyclists and pedal cyclists increased over the same period (Berry and Harrison 2008). The decline reported in the CARS may therefore reflect the fact that these road user groups are involved in more single vehicle crashes and are less likely to carry passengers.

How many crashes were there?

BITRE estimates there were approximately 653 853 crashes in 2006 (Table 2.5), of which 59.2 per cent of crashes occurred in capital cities.

Only 157 616 (24 per cent) of these crashes were reported to road authorities.[10] These reported crashes involved approximately 281 500 vehicles and 83 500 casualties. On average, a reported crash involved 1.78 vehicles (including single vehicle crashes) and 0.44 casualties per reported crash.

BITRE's national road crash database for 2006 comprises data on reported crashes provided by state and territory authorities. This road crash database contains details of crashes, vehicles and casualties disaggregated by state or territory, metropolitan or non-metropolitan area, and vehicle types.

Crash severity is determined by the most severe casualty outcome. A crash categorised as 'fatal' will have resulted in at least one fatality, but may also have resulted in one or more hospitalised and/or non-hospitalised injuries.

BITRE estimated the number of unreported crashes in Table 2.5 using estimated vehicle numbers involved in crashes, crash ratios from reported crashes, and vehicle kilometres travelled (Appendix A). This approach differs from BTE (2000), which estimated the number of cars involved in crashes based on data for comprehensively insured vehicles, and used the average number of vehicles in reported crashes to estimate the total number of crashes.[11]

8 Connolly and Supangan (2006) observed that the number of persons hospitalised from road crashes had increased substantially.

9 CARS has produced consistent and stable estimates of the number of persons reporting being involved in road crashes over the past decade.

10 For 2006, 157 616 reported crashes excludes property damage only (PDO) crashes for Victoria. Data provided by Victoria did not include PDO crashes and BITRE estimated Victoria PDO crashes by applying the proportion of PDO to non-PDO crashes for all other states. At the time of BITRE's data request, Queensland was unable to supply data for non-fatal crashes for calendar year 2006. BITRE has used non-fatal Queensland crash data for 1 June 2005 to 30 June 2006.

11 BITRE obtained industry insurance data on claims made. It was not possible to directly estimate crash numbers or calculate ratios of vehicles per crash.

T2.5 Number of road crashes by location, Australia, 2006a

Severity b	Capital city	Other urban area	Rural	Total
Fatal crashes	471	246	738	1 455 c
Hospitalised injury crashes estimate c	15 038	5 314	5 146	25 498
Non-hospitalised injury crashes estimate d	111 000	39 200	38 000	188 200
Property damage only crashes estimate	260 700	102 700	75 300	438 700
Total crashes	387 209	147 460	119 184	653 853 c

a Capital city, urban and rural categories are based on the ABS Urban/Locality coding for the 2006 Census. Darwin includes crashes in Darwin and Palmerston. BITRE has defined non-capital city urban areas as areas generally having a population of 1000 or more based on the ABS definition of urban area, whereas rural areas include localities of 200-999 people.

b Crashes are classified according to the most severe injury outcome. There is no direct relationship between the number of crash casualties and crash type as several casualties—whether fatalities, hospitalised injuries or non-hospitalised injuries—can result from a single crash.

c Totals include two additional crashes, reflecting Infrastructure's (2009a) revised total of 1455 fatal crashes of in 2006. BITRE's database records a total of 1453 fatal crashes.

d Hospitalised and non-hospitalised crash numbers have been estimated using reported crashes in jurisdictional crash data, the number of hospitalised injuries per reported crash, the proportion of same day discharges reported by Berry and Harrison (2008), and Queensland's ratio of hospitalised to injury casualties.

Source: State and territory road crash data; BITRE estimates.

The higher the ratio of vehicles per crash the lower the estimated number of road crashes. The averge number of vehicles per crash (including single vehicle crashes) was 1.81 in 2006. Vehicle per crash ratios were lowest for fatal crashes (1.36), increasing for injury crashes (1.78) and property damage only crashes (1.82). In 1996, these ratios ranged from 1.6 to 1.96 vehicles per crash (BTE 2000).

Taking into account BITRE estimates of unreported crashes and non-hospitalised injuries, casualties occurred in approximately 33 per cent of all road crashes.

BITRE estimates approximately 1.16 million vehicles were involved in crashes in 2006 (Table 2.6).

T2.6 Vehicles involved in crashes by crash severity, Australia 2006[a]

Vehicles involved in	Australia
Fatal crash	
Cars and light commercial vehicles	1 415
Motorcycles	219
Buses	15
Trucks	197
Bicycles	43
Injury crash estimates (excluding fatal crashes)	
Cars and light commercial vehicles	406 600
Motorcycles	12 800
Buses	3 400
Trucks	16 000
Bicycles	4 243 b
Property damage crash estimates	
Cars and light commercial vehicles	671 700
Motorcycles	11 500
Buses	5 500
Trucks	26 500
Bicycles	662 b
Total vehicles all crash types	1 160 794

a Heavy vehicle numbers may underestimate actual vehicle involvement in fatal crashes due to data limitations. These limitations include jurisdictional differences in vehicle definitions.

b Actual bicycles involved in reported crashes. BITRE did not estimate bicycle involvement in road crashes due to a lack of data on bicycle numbers, vehicle kilometers travelled and insurance information.

Source: State and territory road crash database, BITRE estimates.

2.5 How many people were injured in each crash?

BITRE's estimates of casualties and casualty crash numbers for 2006 are summarised in Table 2.7. It is important to note that the crash classification (fatal, injury, or property damage only) is the most severe crash outcome for a specific individual. A fatal crash may also result in injuries of varying severity to other individuals.

T2.7 Casualty and crash numbers by jurisdiction, 2006

	Casualties		Crashes	
	Fatalities	Hospitalised injuries a	Fatal crashes	Hospitalised injury crashes b
New South Wales	496	10 196	449	8 332
Victoria	337	8 225	309	6 721
Queensland	335	5 981	313	4 887
South Australia	117	2 397	104	1 959
Western Australia	203	2 498	184	2 041
Tasmania	55	778	43	636
Northern Territory	46	467	41	382
Australian Capital Territory	13	662	12	541
Australia	**1602**	**31 204**	**1455**	**25 498**

a Include hospitalised injury casualties from both hospitalised injury crashes and fatal crashes.

b BITRE estimated hospitalised and non-hospitalised crash numbers based on reported crash data, the number of hospitalised injuries per reported crash, the proportion of same day hospital discharges (Berry and Harrison 2008) and ratio of hospitalised to injury casualties in Queensland.

Source: Infrastructure (2009a); Berry and Harrison (2008); BITRE national road crash database; BITRE estimates.

Each jurisdiction reported different categorisations of crash and casualty outcomes. Table 2.8 presents estimates of injury outcomes for Australia based on reported crash outcomes in Queensland.[12]

T2.8 Casualty ratios by crash type, Australia 2006

	Fatalities	Hospitalisation	Medical treatment	Other Injury	All casualties
Fatal crash	1.10	0.45	0.21	0.06	1.82
Injury crash a					
Hospitalisation	na	1.20	0.12	0.07	1.38
Medical treatment	na	na	1.19	0.08	1.27
Other injury	na	na	na	1.15	1.15

Note: Injury categories in this table are reported on a different basis to other data in this report. Crash ratios are calculated for reported crashes only.

a Queensland reported crash and injury classifications provide the most appropriate breakdown and have therefore been used to disaggregate injury crashes outcomes.

Source: State and territory road crash database, BITRE estimates.

2.5 How does 2006 compare with 1996?

Table 2.9 compares BITRE casualty estimates for 2006 with previous BTCE and BTE studies. There were 1031 fewer persons hospitalised for one day or more in 2005–06 than in 1996 (BTE 2000).

12 Queensland reported crash and injury classifications provide the most appropriate breakdown and have therefore been used to disaggregate injury crashes outcomes.

T2.9 Injured persons tally, selected crash costs reports

Source	Reference year	Fatalities	Serious a	Hospitalised (discharged the same day)	Minor injuries
Atkins (1981) a, b	1978	3 268	5 129	na	92 556
BTCE (1988) b	1985	2 942	11 790	na	216 895
BTCE (1992) a	1988	2 875	25 187	na	71 760
BTE (2000)	1996	1 970	21 989 c	na	213 322
BITRE (2009)	2006 e	1 602	20 958 d	10 246 d	216 500 d

na not available.

a Categorisation of 'serious injury' casualties has changed over time. BTCE (1992) regarded serious injuries as those that required hospitalisation for 48 hours or more, while BTE (2000) excluded persons discharged from hospital on the same day.

b Atkins (1981) and BTCE (1992) used tallies of injured persons taken directly from police records.

c Atkins (1981) and BTCE (1988) distributed casualties across six Abbreviated Injury Scale (AIS) categories for costing purposes. In this table, AIS class 6 casualties were assigned to fatalities, AIS class 3, 4 and 5 casualties were assigned to serious and AIS class 1 and 2 casualties were assigned to minor injuries.

d This table splits people admitted to a hospital but discharged the same day to allow direct comparison with the definition of serious injury used by BTE (2000). For comparison purposes minor injury estimates for 2006 should include people who are hospitalised and discharged the same day (216 500 + 10 246 = 226 746 minor injuries, compared with 213 322 in 1996).

e Fatalities for 2006. BITRE has estimated injuries for 2006 using the latest available hospital data for 2005–06.

Source: BITRE estimates.

While the number of people treated at hospital for road crash injuries appears to have been relatively stable over the past decade, changes in estimation methodology and changes in hospital admission practices mean it is not possible to identify clear trends.

BITRE estimates that there were 653 853 road crashes in 2006 involving an estimated 1.16 million vehicles, compared to 618 600 involving 1.13 million vehicles (Table 2.10).

T2.10 Estimated number of road crashes, Australia, 1996 and 2006

Category of crash a	1996	2006
Fatal crashes	1 768	1 455 d
Hospitalised injury crashes estimate (excludes same day discharges)	17 512	17 126 b
Other injury crashes estimate (includes same day discharges)	ne	196 600
Property damage only crashes estimate c	599 320	438 700
Total crashes	618 600	653 853

ne not estimated.

a Crashes are classified by the most severe injury outcome (fatality, injury and property damage only). There is no direct relationship between the number of casualties and crash type as several casualties—fatalities, hospitalised or non-hospitalised injuries—can result from a single crash.

b BITRE has estimated 17 126 'serious injury' crashes—injuries hospitalised for one or more nights—using the same definition as BTE (2000).

c Includes reported PDO crashes and BITRE estimates. BITRE estimates there were at least nine PDO crashes to each casualty crash in 2006. This estimate is comparable with previous studies which have used estimates of the number of property damage only crashes ranging from one casualty crash to seven PDO crashes up to one casualty crash to forty PDO crashes (BTE 2000).

d BITRE's 1453 fatal crashes differs from Infrastructure's (2009a) revised 1455 fatal crashes.

Source: BITRE road crash database; BTE (2000); BITRE estimates.

Table 2.11 summarises the numbers of vehicles involved in road crashes for 1996 and 2006. Different estimation methods are used and caution should be used in directly comparing the figures.

The ratio of passenger vehicles in road crashes per registered passenger vehicles has declined from 0.19 in 1978 to 0.08 in 2006 (Table 2.12). This decline was mainly driven by an increase in the numbers of registered passenger vehicles (up 48.6 per cent), although the estimated number of passenger vehicles involved in crashes was down 4.7 per cent.

T2.11 Estimated number of vehicles involved in crashes by vehicle type, 2006 and 1996

	Estimated number of vehicles	
Vehicle type	**1996**	**2006**
Passenger and light commercial vehicles	1 132 000	1 079 700
Motorcycles	18 220	24 500
Trucks b	44 580	42 700
Buses	9 550	8 900
Total vehicles	1 204 350	1 160 794 a

Note: Subtotals may not add due to rounding.

a 2006 total includes 4948 bicycles.

b Changes in truck involvement in crashes between 1996 and 2006 should be treated with caution due to possible differences in vehicle definitions.

Source: BITRE estimates; BTE (2000).

T2.12 Passenger vehicles involvement in crashes

Source	Base year	Passenger vehicles registrations (thousands)	Estimated damaged passenger vehicles (thousands)	Damaged vehicles per registration
Atkins (1981) a	1978	5 462	1 034	0.19
BTCE (1988)	1985	6 734	1 219 b	0.18
BTCE (1992) c	1988	7 158	1 068	0.15
BTE (2000)	1996	8 989	1 132	0.13
BITRE (2009)	2006	13 354	1 079	0.08

a Atkins tallies of injured persons were taken directly from police records.

b Revised data (ABS Motor Vehicle Census 1997).

c BTCE's (1992) estimate was also taken directly from police records.

Source: Atkins (1981); BTCE (1988); BTCE (1992); BTE (2000); BITRE (2009).

CHAPTER 3
Losses to society from road crash fatalities

'In Australia we spend about one-sixth of GDP to protect life and health in one way or another. This is a substantial diversion of resources away from other goods. Accordingly we would like to know whether this level of expenditure on health and safety is appropriate or whether it is too large or small. To assess such issues, quantitative measures of the value of life and health, and of safety, are needed.' (Abelson 2008, p.1)

BTE (2000) estimated that the cost of road crash fatalities in Australia in 1996 was approximately 20 per cent of the estimated total cost of road crashes in that year.

BTE (2000) used a hybrid human capital approach to estimate the human losses due to fatalities. Estimates such as the notional value of a statistical life—for unknown, or statistical, individual—and the cost of a fatal crash are important inputs to appraisal for road infrastructure and safety projects. It is important to distinguish between the cost of a fatality or death (the human losses only) and the cost of a fatal crash (comprising the human losses, vehicle-related costs and general costs). The cost of a fatal crash, on average, will be higher than the cost of a fatality as a fatal crash can involve more than one fatality (Department of Transport and Regional Services 2004).

This chapter outlines BITRE's methodology for estimating the human losses from a road crash, the empirical model used for costing, and presents revised estimates of road crash fatalities in Australia for 2006.

3.1 Approaches to costing fatalities

People generally value their own lives and the lives of family and friends very highly. Indeed, life can be argued to be priceless and there are many examples of where large amounts of money have been spent to save the life of an identified person. At the other end of the spectrum, much lower implicit values are placed on lives every day. Life is, in effect, given an implicit value each time a decision is made regarding the allocation of funding to health, emergency services, or occupational health and safety projects. When this value of life estimate is derived it is not any particular person's life that is valued but that of an unknown, or statistical, individual (BTE 2000).

The value of a statistical life—as used by road authorities and others to guide infrastructure, health and safety expenditure—reflects the average value for a large group of individuals of small risk reductions. Abelson (2008) observes that:

> '… we often spend money in both the public sphere and in markets to reduce the risk of an adverse event especially the risk of death. This introduces the valuation of probabilities into the equation. We often need estimates not only of the values of longevity and health but also of values of reductions in small risks of death.' (p. 2)

Transparent road infrastructure and safety funding decisions require an explicit value to be placed on losses due to death or injury to allow projects with a range of outcomes to be compared, including lives saved and injuries avoided.

The willingness-to-pay and human capital approaches are alternative approaches generally used for valuing the fatality and injury components of road crashes.

Willingness-to-pay approach

The willingness-to-pay approach estimates the value of life in terms of the amounts that individuals are prepared to pay to reduce risks to their lives (this is the value to the individual on an ex-ante basis, or before the fact). In other words, the willingness-to-pay approach attempts to capture trade-offs between wealth and small reductions in risk. This approach uses people's preferences (either stated or revealed) to ascertain the value they place on reducing risk to life, and reflects the value of intangible elements such as quality of life and joy of living (BTE 2000, pp. 20–21).

Conceptually, the willingness-to-pay approach is the superior approach as it tries to reflect people's preferences, consistent with economic welfare theory. The methods typically used to determine people's preferences are revealed preference (wage risk studies, studies of consumer behaviour) and stated preference surveys. Each of these approaches to determining preferences raises a number of methodological issues. In reviewing these methods, Abelson (2008) stated that:

> 'Revealed preference studies in labour or product markets are based on actual behaviour but are constrained by available data and have to make strong assumptions about understanding of probabilities. Stated preference studies can be custom-built and are flexible, but usually offer hypothetical choices and weak or non-existent budget constraints. These problems are generally well known. Good studies of any kind recognise the inherent problems of the method and attempt to deal with them.'

A number of issues remain:

1. The effectiveness of accurately capturing people's preferences. Stated preference surveys can result in non-market values that do not reflect trade offs in risk with incomes or wealth. Individuals may have difficulty understanding the small reductions in risk envisaged, and may therefore be unable to effectively rank alternatives.
2. There are ethical implications in the use of different 'values of life' for different contexts[13] and different people. A key argument for a willingness-to-pay approach is that the values should reflect the preferences of affected individuals, and may therefore be expected to change according to the income/wealth of the affected people, their risk preferences and levels of control of risk.

13 For the importance of context in valuing safety improvements see Loomes and Jones-Lee (1995).

3. The feasibility of allocating larger amounts of public resources to life and health based on individuals' preferences for marginal changes in safety. Abelson (2008) states '… in aggregate, groups of individuals cannot spend more than their total income on saving lives. Given the high proportion of GDP spent on health and safety, the aggregate budget implications and feasibility of basing all public policy for safety and health on individual marginal valuations may require consideration. As far as I am aware such a study has not been done.'
4. There are few willingness-to-pay studies for Australia in a road context (Hensher, Rose, de Ortúzar and Rizzi 2009). Overseas studies are unlikely to reflect local preferences and contexts, and translation to the local context is subject to large variation in exchange rates.

Human capital approach

The generic human capital approach estimates the expected value to society of forgone output on an ex-post basis (in other words, after the fact).

The output in this context refers to the forgone economic contribution to society from both workplace and household participation, from the age at which premature death occurs to the end of the expected natural life. Hence, implicit in the generic approach is the concept of 'productive life'.

The main criticisms of the generic human capital approach are:

- It is at odds with a basic tenet of welfare economics that the valuation of losses due to premature death should generally reflect the individuals' preferences. In other words, this approach measures earning capacity but it does not measure how much the deceased valued his or her own life (Feldman 1997).
- Equity issues arise because lifetime income profiles result in higher values for working-age people[14] than to older or younger people. This is because time is allocated, for most people, in a way that leisure is distributed more in the early and late stages of life, and most labour in the middle (Australian Safety and Compensation Council 2008). Unless adjustments are made, the human capital approach is perceived to undervalue the contribution of both the young and the old.[15]
- Unless adjusted for, human capital-based estimates of the losses ignore difficult to measure non-pecuniary (intangible) costs the quality of life that a person would have enjoyed had the person not died prematurely, and the pain, grief and suffering of family and friends.
- Human capital-based estimates are sensitive to the real discount rate chosen.

The advantages of the human capital approach are that it:

- provides a transparent, verifiable value that is relatively straightforward to estimate
- can reflect age and gender differences in output losses to society
- can provide a lower bound estimate of the losses due to death and injury from road crashes.

14 Due to capital market imperfections, age-productivity curves generally take the form of an inverted 'U' (Viscusi 2005).
15 For young people the stream of earnings may be years in the future and the discounting of future values used in the human capital approach can substantially reduce the present value of economic losses. For older people with no earned money income, a strict 'human capital' approach would result in no economic value assigned to the loss of life.

The hybrid approach used by BITRE

Both the human capital and willingness-to-pay approaches are imperfect in estimating value of life: the human capital approach has theoretical problems in regard to its application to the economic valuation of life, while the willingness-to-pay approach involves a range of empirical difficulties.

Practitioners have explored various means to modify the generic human capital approach. Some have tried to directly incorporate the risk-wealth trade-off that forms the foundation of the willingness-to-pay approach, though not through eliciting individual preferences based on survey.[16] BITRE has not used a risk aversion factor in this study.[17]

Others—including BTE (2000)—have added elements to the expected human capital-based losses in the event of a premature death, bringing the estimates closer to social value of losses due to a premature death.

BITRE has used a hybrid human capital approach in this report that:

- incorporates a notional value for the quality of life that would be lost by the unknown individual in the event of their premature death
- adds a component to losses due to a premature death of a child to ensure negligible values are not assigned to this loss
- adjusts the loss attributed to the premature death of an elderly person, to ensure a zero value is not assigned to these losses
- adds the cost to an employer due to the premature death of an employee, including costs arising from disruption at workplace and recruitment and training of a replacement
- adds medical and hospital costs for fatally injured persons; emergency services costs and coroner investigation costs
- adds the cost of a premature funeral. This is the additional cost to society of 'bringing forward' funeral costs that would otherwise be incurred at the end of a person's natural life
- adds the costs of prosecuting people for culpable driving offences, the cost of imprisoning those convicted, and the workplace and household losses of those serving a custodial sentence
- includes an allowance for the family and relatives of the deceased for the pain, grief and suffering that they endure. Schwabe-Christe and Soguel (1996) undertook a study in Switzerland using a contingent valuation approach to place a value on this pain grief and suffering of relatives.

16 Landefeld and Seskin (1982) argued that a risk aversion approach suggested could be used to directly incorporate risks to life in costing fatalities. They argued that individuals are generally willing to pay amounts in excess of the expected value of losses and proposed applying a factor—greater than unity—derived it by dividing the monetary excess that the individuals are willing to pay by the expected value of losses to bridge the gap between the generic human capital approach and the willingness-to-pay approach. Steadman and Bryan (1988) estimated a risk aversion factor using insurance data and applied it to the standard discounting formula to derive the social losses arising from premature death.

17 The risk aversion approach needs estimates of the parameter for different age cohorts. Industry data is likely to be biased as the proportion of Australian households with life insurance is relatively low, peaking at less than 20 per cent for 50-year olds (Battellino 2006). Further, life insurance is provided as part of compulsory superannuation arrangements for many people in Australia, and the level of insurance is unlikely to reflect individual preferences. Finally, for those who do chose their own level of insurance, self-selection is likely to result in high values as this sub-group is likely to be more risk-averse than the general population.

BITRE considers that quality of life is an important addition to the human capital approach. While usually considered in terms of losses encompassing a casualty's current and future pain and suffering, and inability to return to their pre-injury way of life, there is no suffering after death (BTE 2000, p.32).[18]

Notional values such as the cost of a fatal road crash or value of a statistical life are used in social cost-benefit assessments to capture the value to society of preventing expected future premature deaths.[19]

BITRE considers it is appropriate to consider an individual's loss of quality of life for a fatality when considering investments or programs that reduce the risk of road fatalities. In this context, including a non-pecuniary (intangible) cost such as quality of life is a notional value assumed for the current and future enjoyment of life by the unknown individual(s) whose life may be saved.

With respect to children, BITRE has assigned a notional value to the losses due to the death of a child to reflect the child's enjoyment of consumption. This loss has been proxied by the parent's expenditure on raising a child. In adopting this approach, it is important to recognise that an 'economist is not testifying to the value of a child' (Ireland 1991, p.242).[20]

Implications of using a hybrid human capital approach

Since BTE (2000), BITRE has used a modified human capital approach that values household losses, adjusts the losses due to premature death of young and old people, and adds a proxy value for an individual's quality of life losses. Despite these adjustments, this hybrid approach produces values that are significantly lower in magnitude than suggested by most willingness-to-pay studies.

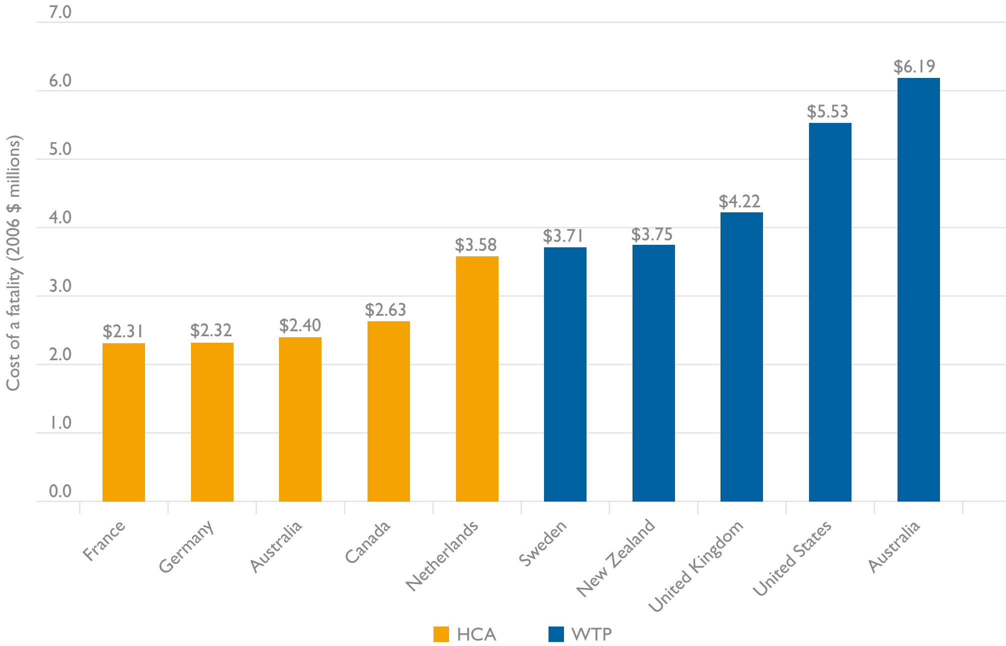
As shown in Figure 3.1, estimates of the cost of mortality based on the willingness-to-pay to avoid method are considerably higher than the corresponding estimates based on human capital approach to valuing the social losses due to death or injury (BTE 2000, p.21).

18 This has led Abelson (2003) to question the relevance of including quality of life for the deceased given an (ex-post) human capital approach to valuing losses.

19 There is an inherent inconsistency with using after the fact (ex-post) values for a statistical life when making (ex-ante) decisions that reduce the risk of future premature road crash deaths.

20 As Ireland (1991, p.241) notes, 'no economist could place a true value on the life of any individual from a social standpoint, let alone the value of a child whose life potential will not be realised because of the simple fact of his death'.

F3.1 Comparison of the cost of fatality estimates for developed countries



Note: All cost estimates are in 2006 Australian dollars. Estimates based on the human capital approach (HCA) are highly sensitive to the discount rate used to estimate the present value of output forgone due to premature fatality and the average age of fatalities. A discount rate of 3 per cent has been used in the estimate shown above for Australia.

Source: International Road Assessment Program (2004); Hensher, Rose, de Ortúzar and Rizzi (2009); Szabat and Knapp (2009); BITRE estimates.

Kenkel (2001) notes that 'Compared with the willingness-to-pay-based estimates such as those reviewed by the EPA (1997), the hybrid human capital/willingness-to-pay approach generally yields lower estimates of the [value of a statistical life], so this approach is sometimes seen as a more conservative approach to estimating the value of life-saving benefits.'

Critics of this hybrid human capital approach contend that it does not reflect individual preferences. In practice, governments choose to apply willingness-to-pay values 'averaged' across society—values that are unlikely to reflect the preferences of specific individuals or groups.

Ultimately, as Abelson (2008) states, willingness-to-pay values 'are sometimes described as efficiency values. If society so wishes, it may replace these individual values with socially determined higher or lower values that reflect different ethical views.'

The Office of Best Practice Regulation—part of the Australian Department of Finance and Deregulation—has issued guidance on how to treat the benefits of regulations designed to reduce the risk of physical harm in Regulatory Impact Statements. The Office of Best Practice Regulation (2008) found that willingness to pay is the appropriate way to estimate the value of reductions in the risk of physical harm (known as the value of statistical life) and that based on international and Australian research a credible estimate of the value of statistical life was $3.5 million and the value of statistical life year was $151 000. Due to complicating assumptions used to derive these estimates, it recommended that a sensitivity analysis should be undertaken as part of the cost-benefit analysis (Office of Best Practice Regulation 2008).

BITRE has addressed the effect of using higher willingness-to-pay values through sensitivity testing (see Chapter 7). The Office of Best Practice Regulation's value of $3.5 million is of similar magnitude to New Zealand (Figure 3.1 and Table 7.10).

3.2 Empirical modelling of fatality costs

This section outlines BITRE's empirical modelling of the cost to society of all road crash fatalities that—more often than not—shorten the individual's natural life. In this report, the term 'premature death' is used interchangeably with 'road fatality'. Losses due to a fatality are considered from a social point of view in terms of the cost components in BITRE's hybrid human capital approach.

Table 3.1 shows various direct and indirect costs used by BITRE to estimate the cost to society due to a premature death in a road crash. The largest costs are output losses (estimated using a human capital approach) and 'quality of life losses' (the current and future enjoyment of life by the unknown individual whose life may be saved by potential investments or programs that reduce the risk of road fatalities).

T3.1 BITRE hybrid human capital approach to valuing human losses

Cost component	Cost type	Method of assessment
1. Workplace & household losses	Economic cost	Human capital-based. Includes workplace and household losses for individuals who serve a custodial sentence.
2. Quality of life	Non-economic cost	Proxy equivalent to statutory limits on damages paid to an injured person for 100 per cent disability
3. Pain, grief and suffering	Non-economic cost	Proxy equivalent to statutory limits awarded to families of affected people
4. Ambulance, police and other emergency services	Economic cost	Other
5. Hospital and medical	Economic cost	
6. Coronial costs	Economic cost	
7. Premature funeral	Economic cost	
8. Workplace disruption and replacement	Economic cost	
9. Insurance administration	Economic cost	
10. Correctional services	Economic cost	
11. Legal costs	Economic cost	Includes the costs of prosecuting individuals charged with criminal offences following road crashes and civil (compensation) legal costs.

Source: BITRE.

Discount rate

Farber (2008) notes that there are two alternate approaches commonly used to determine the present value of an uncertain stream of benefits or losses: firstly, discounting the expected stream of output using a risk-adjusted discount rate or secondly, discounting the risk-adjusted expected stream of output using a risk-free[21] discount rate.

BITRE uses the latter approach to account directly for uncertainty in future benefits and cost streams. Streams of future benefits and losses have been adjusted for risks and uncertainties prior to discounting by taking expected values[22] noted below:

- life expectancy (because all persons of a similar age do not live a similar length of life)
- labour market participation rates (due to various socioeconomic and socio demographic reasons, all people of similar ages are not equally employable)
- workplace earnings and household contribution (the earning capacity of the workforce and the household contribution are relatively volatile).

The choice of an appropriate level for the discount rate is controversial (Burkhead and Miner 1971). Whilst the use of a higher social discount rate results in a lower estimate of the present value of the human losses, a lower social discount rate results in a higher present value.

In this report, BITRE uses a risk-free real discount rate of 3 per cent consistent with its previous transport safety costing studies (BTRE 2006). Such a rate falls well within the range of discount rates used by other practitioners to estimate human costs (Murray, Lopez and Jamison 1994; Vos and Begg 1999; BTRE 2006; Abelson 2008; Potter Forbes, Abelson, and Driscoll 2006).

Income growth rate

BITRE has used an expected real income growth per capita of 1.6 per cent per annum to estimate future losses due to forgone income earnings. This is the rate of real GDP per person for the 2010 decade (Treasury 2007, Table 2.3).

Cost components

Workplace and household losses

Workplace and household output losses are the principal basis of measuring what society forgoes due to premature death. The magnitude of output losses depends directly on the age at which the premature death occurs. These losses can be estimated by summing up:

- losses[23] due to premature death of a child (area A in Figure 3.2)
- loss of contribution to the workforce as measured by the potential losses in income from employment (area B)

21 According to Arrow and Lind (1970), public projects should be discounted at the risk-free rate of return as the government is able to pool risks widely.

22 The expected value is the probability weighted average of a set of observations—that is, it recognises explicitly the probabilities of occurrence of events.

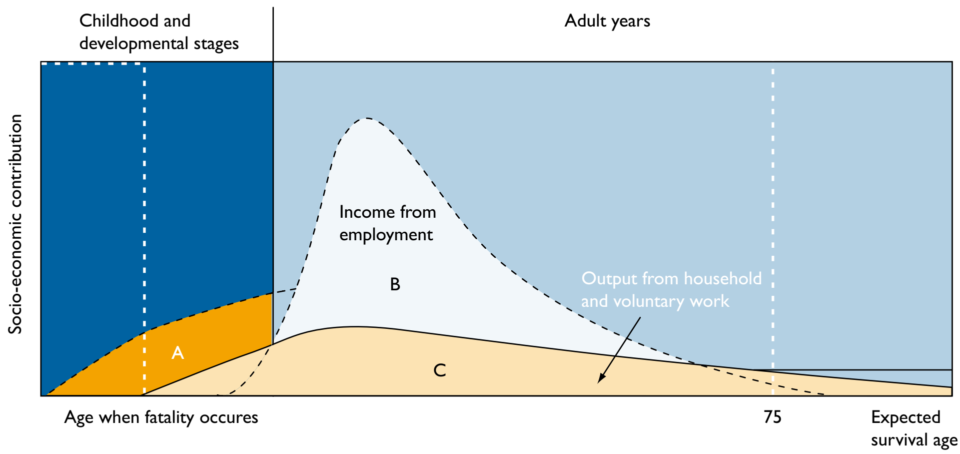
23 BITRE has assigned a notional value to the losses due to the death of a child to reflect the child's enjoyment of consumption. This has been proxied by the parent's expenditure on raising a child.

- losses in other types of contribution as a result of forgone opportunities to contribute in voluntary and household work; these two elements constitute non-wage contributions forgone by society due to premature death (area C in Figure 3.2).

As noted, BITRE has assigned a notional value to losses due to the death of a child to reflect the child's enjoyment of consumption. In keeping with arguments put forward in recent literature (Ward 1990; Folbre 2008), parental expenditure on raising a child up to the age of 15 years was considered as a proxy of their losses. Based on Department of Families, Community Services and Indigenous Affairs (2007), the average annual cost of raising a child from birth to 17 years of age is $10 406 per annum (2006 prices). This is different to BTE (2000), which estimated these losses by interpolating the adult income function to encompass the early developmental period.

Workplace and household losses due to a fatality are estimated for the period between the age of premature death up until the expected survival age (see Figure 3.2). Expected survival age is the age at which the natural death occurs. It is also termed the life expectancy of a person. As life expectancy is subject to considerable natural variability and all persons of a similar age are not expected to have a similar natural life span, the 'expected' value of life expectancy was used in the estimation of forgone workplace and household losses.

F3.2 Contributions to society across the normal lifespan of an individual



Source: BITRE.

As noted in the discussion of hybrid human capital approach, the term 'output' in the present context encompasses:

- forgone income for those participating in the workforce (more correctly the gross income)
- non-wage contributions from household and voluntary work.

Beyond the age of 75 the average household and voluntary work contribution declines to negligible values. BITRE has assumed that the average household and voluntary work contribution is constant after the age of 75.

The losses due to premature deaths of children and the output forgone due to premature deaths of others (areas A, B and C) in 2006 were estimated by aggregating discounted streams of income and output losses.

The discounting formula is shown in equation 3.1 (below):

$$PV = \sum_{t=0}^{t=T} \left(\frac{A_t + B_t + C_t}{(1+r)^t} \right)$$

$$PV = \sum_{t=0}^{t=T} \left(\frac{A_t + B_t + C_t}{(1+r)^t} \right) \quad (3.1)$$

Where,

PV is the present value of the forgone investment or output.

A_t is the loss due to the death of a child proxied by the annual cost of raising a child.

B_t is the value of lost annual employment contributions during adult years (that is, the gross income from salaries and/or wages).

C_t is the value of lost household and volunteer contributions.

T is the remaining expected lifetime had the casualty lived.

r is the social discount rate to account for the fact that the value of the losses in the present is higher than the value of future losses.

Non-pecuniary losses

Non-pecuniary, or intangible, costs include the quality of life losses for the unknown individual, and the pain, grief and suffering for family and friends. A value for quality of life is not directly observable. BITRE has used the approach taken by BTE (2000) of using a statutory value placed on total disability for a non-fatal road crash casualty as a proxy for the 'quality of life' of an unknown individual. The value for lost quality of life is $387 900 per fatality.[24] This is equivalent to the award for 100 per cent impairment, and is consistent with the approach used in Chapter 4 to value losses due to disability.

A premature death of a loved one affects the family and relatives—both immediately and over the years. Pain, grief and suffering may include distress, anxiety, traumatisation, anguish and various forms of post-traumatic stress disorders. BITRE has used statutorily-determined lump sum compensation awarded to families and dependents of a deceased person. BITRE has assigned $57 421 for a premature death.[25]

Ambulance, police and other emergency costs

Ambulance costs were estimated by aggregating the cost of transporting casualties from crash sites to hospitals and the cost of providing medical and respite care where needed. In 2006, these services cost on average $2154 per road fatality (see Chapter 4 for a discussion of ambulance service costing).[26]

24 This is the 2005 value used in Victoria.
25 Based on the maximum award of $50 000 in 2002 specified by the NSW Victim Support and Rehabilitation Act 1996 (PNSW 1997). See also a review of the payments to relatives in various Australian jurisdictions (Standing Committee on Legal Affairs 2004).
26 Excludes the cost of ambulance services for people injured in fatal crashes (see Chapter 4).

The cost of police services were estimated by estimating the total time costs of on-site interviews, inspection, measurements at the crash site, writing notes, management and other on-site activities and off-site activities, and adding an hourly cost for the equipment used by police (Howard, Young and Ellis 1977). The estimated average cost of police services in 2006 was $1879 per road fatality.

Fire crews are assumed to respond to fatal crashes. The cost of such services were estimated by taking the number of crashes requiring fire and rescue services and the unit cost of providing such services. In 2006, these services cost an average of $2873 per fatality.

Hospital and medical costs

The cost of hospital and medical treatment is only estimated for casualties who survived and were admitted to hospital, then died within 30 days from injuries sustained in the road crash.

In 2006 there were 334 fatalities due to fatal injuries (Berry and Harrison 2008). Assuming the mean length of hospital stay was 6.2 days and a cost of hospital and medical services averaging $1626 per day, the average hospital and medical cost amounted to $10 081 per fatality.

Coronial costs

Coronial investigations are required when a death is unexpected, violent, unnatural or suspicious, when the cause of death or the identity of the deceased is unknown, and when the death occurs whilst the person is under anaesthetic or in custody (National Coroners Information System 2008).

Deaths due to road crashes are always investigated by a coroner as they are considered to have an unnatural cause. Costs of coronial investigations include:

- administrative costs
- autopsies/examination by a pathologist to help explain the cause of death
- a hearing in open court known as a coronial inquest.[27]

Except for administrative costs, all others[28] are specific to the situation in which the death occurs. Approximately 80 per cent of deaths proceed to post mortem examination or autopsy (NSW Health 2007) and inquests are held for about 2 per cent of deaths (Magistrates Court Tasmania 2007).

BITRE estimated that the cost of a coronial investigation amounted to an average of $1965 per road fatality.

27 Such inquests are largely required to establish where, when and how the death occurred and to identify the deceased person if the identity is not known.

28 According to the SCRGSP (2008 p.6.57) 2007 Report on Government Services, 'all coronial investigations were considered to be lodgements not just those that required an inquest. Coronial investigations consist of all reportable deaths and fires'.

Cost of premature funerals

The premature funeral cost for a deceased person at a certain age is the difference between estimated cost of a funeral at the time of premature death and the discounted future value of a funeral at the end of a person's normal expected life.

Funeral costs arising from premature death were estimated allowing for the number of premature deaths at each age; jurisdictional variability in the costs of burials and cremations; and the relative split of funerals into burials and cremations.

Based on cost data collected from jurisdictions, the total cost of premature funerals for 2006 was estimated at $7 million.

Cost of workplace disruption and replacement

The period that lapses before a deceased worker can be replaced has been estimated to be about 9.6 weeks (Australian Safety and Compensation Council 2008). The cost to the employer of workplace disruption during this period is estimated by calculating the gross earnings of the employee during this period. The total workplace disruption cost was estimated taking into account the expected workplace participation rate, age and gender of road fatality.

The cost of replacing a deceased worker may include recruitment and training costs or the costs of training a current employee. These costs have been estimated accounting for the average recruitment cost per person and the percentages of persons who belong to each of the above categories.

An average recruitment cost was estimated using published recruitment costs for audited agencies in Victoria (Victorian Auditor General's Office 2005). A re-training cost was estimated based on data published for Western Australia (Department of the Premier and Cabinet Western Australia 2005). The average cost of recruitment/retraining was estimated at $6422 per person.

Insurance administration

Costs associated with the processing of claims for fatalities are included in the cost of administering statutory insurance schemes. BITRE estimated these costs using data and information published by various jurisdictions—particularly those published by the Auditor General's Office and the Transport Accident Commission of Victoria.

Most available data related to the average administration cost for all types of claims. The administration cost per fatality claim was estimated by scaling up the average cost to account for additional costs involved in the processing of fatality claims. The scaling factor used was estimated by dividing the average size of a fatality claim by the average size of claim for all types of claims.

The estimated average insurance cost in 2006 was $8247 per fatality.

Criminal legal costs

Criminal legal costs are the costs of prosecuting individuals charged with criminal offences following road crashes. These range from homicide related charges to negligent or reckless driving charges.

Offences vary across jurisdictions and can cover a different range of behaviour, harm and or fault.[29] There is therefore a lack of consistent data on crash–related offences, particularly for offences causing injury or property damage. BITRE has therefore only estimated criminal legal costs related to fatalities.

Where road fatalities are considered to be the consequence of culpable acts of a road user, criminal charges may be laid (for example, culpable driving causing death). BITRE estimates that 207 persons were prosecuted for culpable driving offences in Australia in 2006.

This estimate of 207 prosecutions is based an estimated 228 persons being killed by culpable driving in 2006, which was calculated using ABS (2006b) data of 1.1 victims per 100,000 for the offence of driving causing death for 2005.[30] This was adjusted for the fact that some people may face multiple charges from a single crash using an average of 1.1 charges per person for the offence of culpable driving causing death (Victorian Sentencing Advisory Council 2007b).

The indicative cost for a case that goes for a week in the Victorian Supreme Court is estimated to cost an average $47 572 in 2007 dollars (Victorian Bar 2008, p.25).

Adjusting this indicative cost to 2006 dollars, BITRE estimates that the total cost of criminal prosecutions as $9.62 million or approximately $6000 per fatality.

Costs of imprisonment

The costs of imprisonment include the costs of correctional services and workplace and household losses for individuals who serve a custodial sentence.

Correctional services costs comprise expenditure on provision of correctional services to those who are convicted of a criminal offence in relation to a road crash (BTE 2000).

Of the estimated 207 people prosecuted for culpable driving offences in Australia in 2006, BITRE has assumed 8 per cent of people charged with this offence were acquitted (Victorian Sentencing Advisory Council 2007c). Of those convicted, 81 per cent were sentenced to varying periods of imprisonment—approximately 60 per cent were sentenced to an average of 5 years and the remaining 40 per cent to an average of 3.4 years (Victorian Sentencing Advisory Council 2007a).[31]

The cost of imprisoning persons in Australia for culpable driving in 2006 was based on the daily cost of imprisonment for New South Wales (General Purpose Standing Committee 2001).

BITRE estimates that the cost to society of providing correctional services was $15 million in 2006, or an average of $9382 per road fatality.

29 The Victorian Sentencing Advisory Council (2007) provides a discussion of injury related offences and sentences across Australian jurisdictions

30 ABS data for 2006 and subsequent years is unavailable.

31 The estimates assume that the same sentencing regimes and outcomes apply in all jurisdictions.

Serving a custodial sentence also results in workplace and household losses during the period of imprisonment. BITRE has estimated these losses taking into account the age and gender-specific wage and workforce participation rates and the age profile of those imprisoned. BTE (2000) did not estimate this lost productive potential of inmates for 1996.

BITRE estimates that the workplace and household losses due to imprisonment of persons found guilty of culpable driving or driving causing death amounted to $33.0 million in 2006, or approximately $20 600 per fatality.

Civil legal costs

Civil legal costs are costs related to claims for compensation related to fatal road crashes. Based on Transport Accident Commission of Victoria data and relevant literature (Latham and Playford, 2002), the civil legal costs per fatality have been estimated at $16 800. This estimate takes into account the lower and upper bounds of claims made for compensation, total number of claims made, percentage of claims in dispute—thus requiring legal services—and the proportion of legal expenses born by the plaintiff (see also Chapter 4).

Empirical analysis

The cost to society of a premature death is sensitive to the average age of fatalities (BTRE 2006). BTRE (2006) showed that if the average age of a fatality increased from 35 to 42 years then this would have reduced the estimated social cost per fatality by 15 per cent.

De Silva, Risbey, McEvoy and Mallett (2008) showed that forgone losses per fatality can be sensitive to the use of single year data because of variability in:

- age-specific distribution of fatalities
- gender composition of fatalities (that is, the ratio of male to female fatalities) and the proportion of males in the total fatality mix
- the average age of fatalities.

Table 3.2 shows how the male-to-female composition of fatalities has fluctuated over a time span of five years. As shown, the standard deviation of the age-specific gender proportions of fatalities was higher in 2006 than in 2002. It also shows that there is no notable trend (increasing or decreasing) in the gender proportions in any age group.

T3.2 Ratio of male-to-female fatalities by age group, 2002–2006

Age group	2002	2003	2004	2005	2006
0–14	2.07	1.23	1.23	1.55	1.53
15–29	3.27	3.43	3.19	3.49	3.68
30–44	3.64	3.49	3.43	3.71	4.13
45–59	2.28	2.29	2.23	3.08	2.38
60–74	1.88	1.78	1.70	1.58	2.04
75+	1.29	1.14	1.48	1.15	1.85
Standard deviation	0.15	0.44	0.44	0.39	0.48

Notes: The change in male to female composition of fatalities has been measured using the standard deviation of the number of male fatalities per female fatality in each age group.

Source: BITRE estimates based on ATSB data.

Due to the stochastic nature of the annual fatality data noted here, the empirical analysis estimated fatality costs using fatality data for multiple years (i.e. data for not only for the 2006 reference year). An empirical procedure was used to trace inherent probabilities of occurrence for the observed gender split and age-specific distribution of fatalities. The analysis uses both incident data (see Chapter 2) and market data from a variety of sources.

3.3 Results

The estimated human and related losses from road fatalities was $3.84 billion, or $2.40 million per road fatality.

This compares to BTE's (2000) 1996 estimate of $4.30 billion and $2.17 million per fatality (in 2006 dollars). BITRE has re-estimated these values using a comparable approach and parameters to its 2006 estimates (including a 3 per cent discount rate). These differences are largely due to differences in the number, age and gender of road fatalities in the two reference years.

The cost per road fatality is relatively high for younger age groups. Table 3.3 shows that 15 to 29-year-olds accounted for 37.1 per cent of road fatalities and 45.5 per cent of the human losses to society.

T3.3 Road fatality cost by age cohort, 2006

Age group	Proportion of road fatalities	Proportion of human losses
0–14	4.8	3.4
15–29	37.1	45.5
30–44	24.7	31.3
45–59	15.0	13.1
60–74	10.3	4.6
75+	8.2	2.1
All age groups	100.0	100.0

Note: Components may not add to totals due to rounding.

Source: BITRE estimates.

Comparison between 1996 and 2006

Table 3.4 presents BITRE's estimates of the total costs to society due to crash fatalities in 2006.

T3.4 Comparison of road crash cost components for fatalities—1996 and 2006, millions (2006 dollars)

Cost component	Estimates for 1996 (2006 dollars, millions)	Estimates for 2006 (2006 dollars, millions)
Workplace and household losses	2 629	3 007 d
Non-pecuniary costs a	810	728
Legal costs	34	37 c
Work place disruption and replacement	20	17
Correctional services	22	15
Insurance administration cost	30	13
Premature funerals	4	7
Fire services	0	5
Ambulance	1	4
Hospital and medical costs	6	3
Police	16	3
Coronial costs	1	3
Other	189	Na
Total	3 763	3 842

Note: Components may not add to totals due to rounding.

ne Not estimated.

nse Not separately estimated.

a BTE (2000) estimate of non-pecuniary, or intangible, losses for 1996 was the quality of life a person would have enjoyed had they not died prematurely. BITRE's estimate for 2006 includes both the quality of life of the individual and the pain, grief and suffering of relatives and friends.

b BTE (2000) combined ambulance and medical costs in its 1996 road crash costing model.

c Legal costs include criminal prosecution and civil legal costs.

d Includes workplace and household losses due to imprisonment.

Source: BITRE estimates.

Table 3.5 shows BITRE's estimated average cost to society due to a road fatality in 2006 was $2.40 million (a real increase of 32.2 per cent on 1996). The estimates for 2006 have been stabilised against any significant annual variability in the gender proportion of fatalities and the number of fatalities in the most vulnerable group of road users: males aged between 15 to 24 years. Estimated losses to society presented in this table for both years utilise a 3 per cent discount rate and are expressed in 2006 dollars.

Despite a 19 per cent reduction in the number of fatalities, total workplace and household losses due to fatalities have increased by approximately 13 per cent in real terms.

This increase can be attributed to a combination of labour market factors (including higher participation rates) and changes in the demographic of the most vulnerable group of road users—young male road users:

- The average age of male fatalities increased from 36.5 years in 1996 to 37.6 years in 2006; the average age of female fatalities decreased from 42.5 years to 41.3 years; and the average age of all fatalities increased marginally from 38.2 years in 1996 to 38.5 in 2006.
- The male to female fatality ratio increased from 2.47 males to one female in 1996 to 2.95 males to one female in 2006.

T3.5 Road fatality costs per fatality for 1996 and 2006 (2006 dollars)

Cost component	1996 (thousand dollars)	2006 (thousand dollars)
Workplace and household losses	1 334.7	1 877.2
Non-pecuniary costs a	411.1	454.6
Legal costs	17.4	22.8
Workplace disruption and replacement	10.4	10.6
Correctional services	11.0	9.4
Insurance administration	15.5	8.1
Premature funeral	2.2	4.5
Fire and emergency response	0.0	2.9
Ambulance	0.5	2.2
Hospital and medical	3.1	2.1
Police	7.9	1.9
Coronial costs	0.7	2.0
Total b	1 814.5	2 398.2

Note: Components may not add to totals due to rounding.

a BTE's (2000) estimate of non-pecuniary, or intangible, losses for 1996 was the quality of life a person would have enjoyed had they not died prematurely. BITRE's estimate for 2006 includes both the quality of life of the individual and a notional amount ($57 421 per fatality in 2006 dollars) for the pain, grief and suffering of relatives and friends.

b Total for 1996 has been adjusted to exclude $95 800 per fatality of incorrectly attributed costs.

Source: BITRE estimates.

Table 3.6 compares the losses to society, the number of fatalities and male-to-female composition of fatalities in the two reference years and Table 3.7 compares their average ages.

T3.6 Road crash fatalities 1996 and 2006

	1996	Gender proportions 1996 (percentage)	2006	Gender proportions 2006 (percentage)
Number of male fatalities	1402	71.2	1197	74.7
Number of female fatalities	568	28.8	405	25.3
Total fatalities	1970	100.0	1602	100.0

Note: Components may not add to totals due to rounding.

Source: BTE (2000); BITRE estimates.

T3.7 Road crash fatalities by gender and average age of a fatality, 1996 and 2006

	1996	Average age of a fatality in 1996	2006	Average age of a fatality in 2006
Number of male fatalities	1402	36.5	1197	37.6
Number of female fatalities	568	42.5	405	41.3
Total fatalities	1970	38.3	1602	38.6

Source: BTE (2000); BITRE estimates.

Table 3.8 shows the workplace and household losses per capita for 1996 and 2006 in 2006 dollars. The same social discount rate, income growth rate, and labour market conditions have been used to estimate costs for 1996 and 2006.

T3.8 Per capita workplace and household losses by gender under constant financial and market conditions, 1996 and 2006 (2006 dollars)[a]

	1996 (thousand dollars)	2006 (thousand dollars)	Change (per cent)
Male fatalities	1 508.4	1 349.7	–10.5
Female fatalities	610.2	506.9	–16.9
Total workplace and household losses	2 118.6	1 856.6	–12.4

Note: Components may not add to totals due to rounding.

a The present value of forgone output was estimated using a 3 per cent discount rate. The rate of future income growth was assumed to be 1.6 per cent in real terms (see Section 3.2 above). Labour market conditions (salaries/wages and participation rates) were assumed to be same in 1996 and 2006.

Source: BITRE estimates.

Factors that have significantly increased the cost of fataltics in 2006 include higher labour force participation rates and increases in real incomes.The female participation rate increased from 55.0 to 66.3 per cent and the male participation rate increased from 73.2 per cent in 1996 to 77.4 per cent in 2006.

Sensitivity analyses

The discount rate used significantly affects the estimated losses due to a fatality using the human capital approach (Table 3.9). Sensitivity to parameters such as the average age of fatalities, the gender composition, the annual income or the workforce participation rates was not conducted as the empirical analysis adopted in this report took measures to stabilise the unit cost of a fatality for variability in these parameters.

T3.9 Sensitivity of discount rate on fatality costs in 2006

Discount rate	2 per cent	3 per cent	5 per cent	6 per cent	7 per cent
Total cost of fatalities (billion dollars)	4.56	3.84	2.91	2.62	2.40
Losses per fatality (million dollars)	2.85	2.40	1.82	1.64	1.50

Source: BITRE estimates.

3.4 Concluding observations

This study retains a hybrid human capital approach to valuing human losses (BTE 2000), presenting a conservative estimate of the losses to society from road fatalities.

In principle, willingness-to-pay studies of Australians are the ideal way to determine the value of specific safety improvements in Australia. Such studies need to be context specific, allowing those who will be affected by certain proposals to express their own view on how much safety they wish to buy. In practice, willingness-to-pay values are usually 'averaged' across society—values that are unlikely to reflect the preferences of specific individuals or groups. A human capital approach is appropriate where there are doubts about the reliability of values revealed by individuals in willingness-to-pay studies.

CHAPTER 4
Losses to society from road crash injuries

Road crashes trigger a stream of short- and long-term costs to the injured individuals and their families, as well as to society and governments.

The Australian Institute of Health and Welfare (AIHW) ranked transport injuries as the second biggest external cause of death in Australia after suicide (AIHW 2004). A major share of transport injuries is due to road crashes. Recent injury studies in Australia show that people injured in road crashes are largely those aged between 17 and 44 years (Berry and Harrison, 2008).

This chapter provides the methodology and estimates of the cost of road crash injuries for 2006.

BITRE's injury cost estimates for 2006 are estimated using a bottom-up approach to costing road crash injuries.[32]

4.1 Road crash injury profile

As outline in Chapter 1, injuries resulting from road crashes were categorised according to whether the person was hospitalised or not (see Infrastructure 2008a; Berry and Harrison 2008). This differs from the classification of injuries by BTE (2000) (see Chapter 1).

BITRE has further subdivided hospitalised and non-hospitalised injuries according to the injury outcomes that correspond to the level of severity.

Data on hospitalised injuries are compiled by hospital authorities in various jurisdictions in accordance with the International Classification of Diseases Australian Modification version 10 (ICD-10 AM). This classification separately identifies injuries due to road vehicle traffic crashes—those involving a motor vehicle, pedal cycle, ridden animal or animal-drawn vehicle on a public road—from injuries due to other external causes.

Table 4.1 profiles road crash injuries based ATSB and Infrastructure data, hospital data and BITRE's estimate of the number of non-hospitalised injuries.

Hospital data provides information on: injury by body region; demographic characteristics of the injured people; length of hospitalisation and the nature of separations (for example, died in the hospital due to injuries). Hospital data for the reference year is based on data for 2005–06 (Berry and Harrison 2008). This was supplemented by detailed data obtained from AIHW for 2003 and 2004.

32 See Hendrie et al (2001) for a marginal cost approach to estimate the cost of injury.

In 2006, road crashes resulted in 1602 road crash fatalities, 31 204 hospitalised injuries and approximately 216 500 non-hospitalised injuries.

The number of road crash-related injuries admitted to hospital in 2005–06—the latest year of available data—was 31 204 (Table 4.1).

Of these 31 204 hospitalised injuries, 10 246 (32.8 per cent) were discharged the same day they were admitted and 9381 (30 per cent) were classified as high threat to life injuries. The latter may include cases discharged the same day (Berry and Harrison 2008, p.14; 26).

The number of non-hospitalised injuries includes BITRE estimates of people treated by general practitioners and of people who attended hospital but were not admitted (Table 2.3).

T4.1 Fatalities and injuries in the two reference years—1996 and 2006

Road crash consequence	1996 a	2006 b
Fatalities	1 970	1 602
Hospitalised injuries—admitted, one or more bed nights c	21 989	20 958
Hospitalised injuries—admitted, discharged the same day c	na	10 246
Non-hospitalised injuries	na	216 500 d
Minor injuries	213 322	na
Total number of affected persons	237 281	249 306

a Fatalities and injuries for 1996 are as reported in BTE (2000). The number of minor injuries for 1996 includes injuries admitted to hospital and discharged the same day (BTE 2000).

b Hospitalised injuries for 2006 based on 2005–06 (Berry and Harrison 2008). BITRE has estimated the number of non-hospitalised injuries for 2006.

c Excludes 324 and 334 hospitalised injuries resulting in death in 1996 and 2006 respectively.

d BITRE's estimate of the number of non-hospitalised injuries in 2006 includes an estimated 110 200 people who attended hospital but were not admitted, and a mid-point estimate of 106 300 people treated by general practitioners (range between 91 425 and 121 165 people). It excludes people who did not seek medical treatment for road crash injuries.

Source: BITRE estimates.

As some hospitalised injuries result in death, the injury numbers are adjusted for deaths resulting from injuries within 30 days of initial hospitalisation. The number of fatalities for 2006 (1602) in Table 4.1 includes 334 people who died within 30 days due to injuries.

According to the ATSB definition of a fatality, injuries that result in death within 30 days of a road crash are fatal injuries. Consequently, deaths after 30 days would be classified as serious injuries.

According to the ATSB definition of a fatality, injuries that result in death within 30 days of a road crash are fatal injuries. While this differs from Berry and Harrison (2008)—who exclude all deaths from the definition[33] of 'seriously injured'—the difference is likely to be small (p.47).

The injury costs presented in this chapter do not include the cost of fatal injuries to avoid double counting.

33 A serious injury is defined by Berry and Harrison (2008) as an injury which results in the injured person being admitted to hospital, and subsequently discharged alive either on the same day or after one or more nights stay in a hospital bed (that is, deaths are excluded).

Injury outcomes

Injuries can result in two main adverse outcomes—impairments and disabilities.

Reddan (2007, p.24) notes that 'impairment is an objective construct defined as a loss, loss of use, or derangement of any body part, organ system or organ function'. Disability on the other hand 'is evaluated by non-medical means and is defined as an alteration of an individual's capacity to meet personal, social or occupational demands because of an impairment' (Reddan 2007, p.24).

To simplify data analysis and methodology of injury costing, this chapter considers that impairment and disability are sequential outcomes of injury. These two concepts are outlined in more detail in the following sections.

Injuries causing impairment

Impairments are a result of alteration in health status due to injury or disease. The degree of impairment is assessed medically to determine current and future treatment as well as to aid in lodging claims for compensation to cover medical and other costs (see Transport Accident Commission of Victoria 2008; Motor Accident Authority 2007; Ministry of Transport, 2008).

A quantitative measure of impairment is generally adopted by the medical profession to rate the functional outcomes of injuries. It ranges from zero to 100 where zero is no impairment. For example, an injury which is rated severe on the Abbreviated Injury Scale (AIS) may not necessarily result in a high level of impairment as the level of impairment also depends on age, gender and the body region affected. Accordingly, an identical injury to an older person may result in a relatively greater impairment than in a younger person.

The number of people with impairments was estimated using claims data provided by Transport Accident Commission of Victoria for persons who made a claim due to injuries received in a road crash in Victoria[34] and data obtained from AIHW for Australia. The following process was used:

First, BITRE determined the severity of a road crash injury using AIHW data. People hospitalised between one and 30 days were classified as having mild to moderate injuries, whereas people hospitalised for 30 to 60 days were classified as having moderate to severe injuries. People hospitalised for 61 to 211 days were regarded as having severe to catastrophic injuries.

Second, Transport Accident Commission of Victoria claims data was cross-tabulated according to injury severity levels and levels of impairment. BITRE used these data and disability weights—interpolated by BITRE according to body region and severity of impairment—to subdivide each of the groups according to the level of injury-induced impairment. This approach was used to estimate the proportion of road crash injury casualties that (for example) spent 61 to 211 days in hospital who subsequently became 90 to 100 per cent intellectually impaired due to traumatic brain injuries.

BITRE has interpolated disability weights from published weights (AIHW 2003b, Victorian Department of Human Services 1999). These range from zero to one to reflect the level of disability resulting from an injury to a certain body region. Higher disability weights are generally assigned to regions of relatively high sensitivity requiring longer hospitalisation. Apart

34 The claims data was available for males and females by six cost types, eight levels of impairment, and six injury types.

from sensitivity of the affected body region, the length of hospitalisation appears to depend on the age and gender of the person. These factors also affect the time taken to recover.

Table 4.2 shows BITRE estimates of the varying levels of impairments due to road crash injuries and the percentage of injury casualties with different levels of impairment.

T4.2 Persons injured in road crashes by impairment and injury severity, 2006

Severity scale	Level of impairment (per cent)	Number impaired	Percentage impaired
Injury severity less than minor	None to <1	10 246	32.8
1. Minor	1–10	3 086	9.9
2. Minor to Moderate	11–19	5 824	18.7
3. Moderate	20–49	8 969	28.7
4. Moderate to Serious	50–59	981	3.1
5. Serious	60–79	828	2.7
6. Serious to Severe	80–89	584	1.9
7. Severe	90–100	686	2.2
Total hospitalised injuries		31 204	100.0

Note: Components may not add to totals due to rounding.

Source: BITRE estimates based on Transport Accident Commission of Victoria categorisation of impairment.

Injuries causing disability

ABS (2004) defines a disability as any limitation, restriction or impairment, which has lasted, or is likely to last, for at least six months and restricts everyday activities. Disabilities are long-term outcomes of road crashes for which information is not available from police and hospital data. BITRE has assumed that the consequences of a particular disability are the same irrespective of the external cause of the disability (for example, a profound brain injury caused by a road crash gives rise to virtually the same consequences as a profound brain injury from a fall).

ABS (2004) provides estimates of the population of persons aged 15 to 64 with core disabilities where the main cause of the disability was an accident or injury that occurred on the road.[35] This subpopulation with a disability increased by 1.5 per cent per annum between 1998 and 2003, and the proportion of this sub population with a severe or profound limitation increased from 25.4 per cent in 1998 to 27.6 per cent in 2003 (ABS 2000; ABS 2004). This implies an average of 1270 new cases per year of people with severe or profound limitation over this five year period.

BITRE used these data, in conjunction with Fildes et al (1993) data on disability on discharge, to estimate the number of people injured in a road crash in 2006 who suffered an impairment resulting in a disability.

BITRE estimates that 4619 (14.8 per cent) of the 31 204 people hospitalised in 2006 due to road crash injuries suffered a disability, of which 1270 people (4.1 per cent of people hospitalised) had severe or profound limitation.

This estimate of 4619 new disability cases represents 22.0 per cent of the 20 958 persons hospitalised for one night or more in 2006. This compares to 3997 new disability cases

35 BITRE used spreadsheets based on the ABS's most recent 'Survey of Disability, Ageing and Carers' (ABS 2004). Survey standard errors in most age/gender subgroups are 25 per cent, but are 25–50 per cent (notably 0–4 and 85+ age groups) and greater than 50 per cent for a few subgroups.

(18.2 per cent) of the 21 989 persons hospitalised one night or more in 1996 (BTE 2000). BTE (2000) used unpublished ABS survey data to estimate that 3997 people would suffer a disability.

Of these, 26 per cent (1039 persons) suffered a severe or profound disability, with the remainder having some degree of moderate to minor core disability that restricted employment or schooling for some individuals (BTE 2000, p.48).

T4.3 Breakdown of hospitalised injuries by level of disability, 2006

Level of disability	Number affected	Percentage affected	Outcome/assumptions
Profound limitations	686	2.2	Few people with profound levels of core activity limitations successfully return to full regular activities. a
Severe limitations	584	1.9	A small proportion of people with severe levels of core activity limitations are able to undertake normal activities at reduced capacity or at a considerably reduced rate of participation.
Moderate limitations	1809	5.8	Many people with moderate limitations in core activities return to work at a lesser capacity or with some reduction in the average level of participation.
Mild limitations	1540	5.0	Mild limitations hinder capacity to resume normal activities or activity levels, and some people may not be able to resume all previous activities.
Injuries not resulting in a permanent impairment	26585	85.2	Affected persons return to work at full after 3 weeks of absence. They may require some care after leaving the hospital.
Total	31 204	100.0	

Note: Components may not add to totals due to rounding.

a Core activities include self care, mobility and communication. Limitations in these restrict schooling and/or employment and invariably require carer assistance (ABS 2004).

Source: BITRE estimates based on the ABS Survey of Disability, Ageing and Carers (ABS 2004).

Table 4.4 shows the estimated number of people with profound disabilities by age, gender and injury type. People with more than 90 per cent impairment are classified as having a profound impairment to core life activities (see Table 4.2 and the preceding discussion on the method of derivation).

T4.4 Breakdown of injuries causing profound disabilities, by age and injury type, 2006

Age group	Head	Neck	Thorax	Abdomen, lower back, lumber spine, pelvis	Shoulder and upper limb	Hip and thigh	Lower limb	Others not specified by region	Total
0–4 years	2	1	2	1	1	0	1	0	9
5–14 years	15	9	10	8	8	2	6	1	58
15–24 years	45	24	28	22	37	7	25	3	191
25–44 years	55	29	34	27	45	9	31	4	234
45–64 years	30	16	19	15	25	5	17	2	129
65+ years	15	9	10	8	11	2	9	1	65
Total	162	88	103	82	126	25	88	11	686

Source: BITRE estimates based on ABS (2004), AIHW and Transport Accident Commission of Victoria data.

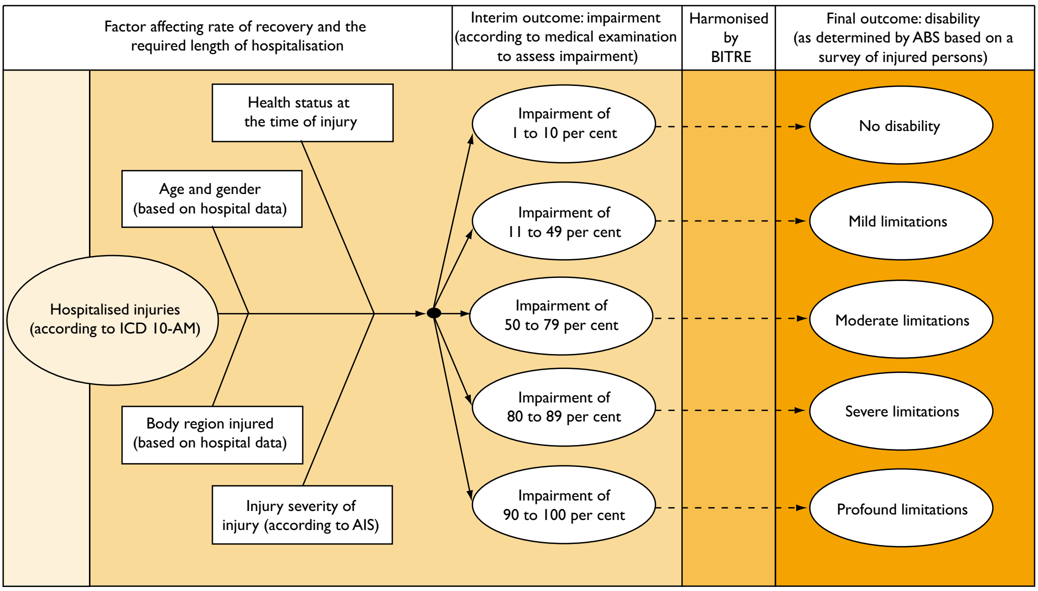
Consequences of impairments and disabilities

Impairments and disabilities impose costs on the injured individual, their families, community and the economy. Impairments and disabilities reduce the productive capacity of injured individuals and diminish the skill base of society.

Figure 4.1 shows the relationship between injuries as shown by hospital data, impairments as shown by Transport Accident Commission of Victoria data, and disabilities as shown by ABS survey data.

Cross tabulation and simple statistical techniques were used[36] to estimate the number of people affected by impairment and disability, their ages, gender, affected body regions, injury severity and the length of hospital stay.

F4.1 Outcomes of hospitalised injuries



Source: BITRE

Some impacts of crashes are short lived because the injured people regain their pre-crash physical and/or functional capacity and quality of life. Unfortunately, the lives of many injured people are altered for many years and, in the worst circumstances, permanently. The next section presents the methodology used to quantify the costs of impairments, disabilities and their interactions.

36 Due to sensitivity and privacy issues, probabilistic and other statistical techniques were not used for matching data from different sources.

4.2 Methodology of injury costing

Injury costing aims to capture all human costs and other costs[37] that directly relate to injury casualties, their families, society and governments.

Costs that immediately arise due to an injury include the cost of ambulance transport, Emergency Department costs, treatment costs—both medical and non-medical—either as a hospital inpatient and/or as an out-patient, the cost of rehabilitation services where required, and the cost of aids, equipment and other associated needs essential for the treatment. These costs attributable to the individual, family and the health systems are generally regarded as direct costs of injury.

Injuries also trigger a stream of flow-on post-incident costs as a result of physical and other impairments and disabilities that they cause. The main costs are losses in socioeconomic contribution to the economy, costs incurred in restoring lost output by replacing affected people who do not return to work or need re-training in order to return to work, and those who return to work—but work reduced hours.

Apart from direct and indirect costs, injuries give rise to intangible or non-pecuniary costs through pain and suffering and lost quality of life.

BITRE identified 10 different cost components made up of direct, indirect and non-pecuniary costs for its 'bottom-up' approach to injury costing.[38]

1. Workplace and household output losses
2. Medical and other related costs
3. Ambulance costs
4. Emergency services costs
5. Long-term care cost
6. Insurance administration cost
7. Legal costs
8. Work place disruption costs (temporary costs borne by employers as a result of injury to an employee that may include output forgone and/or costs associated with hiring temporary staff)
9. Recruitment and re-training cost
10. Non-pecuniary costs (that is, the pain and suffering of people injured in crashes).

These costs are not common to all types of road crash injuries. The cost of a certain type of crash injury depends on factors such as injury severity, age and gender of the affected person, length of hospitalisation, and whether the injury effects are of short- or long-term duration.

37 Risbey, de Silva and Tong (2007) provide a breakdown of human costs, vehicle costs and general costs associated with an injury crash.

38 In the 'bottom-up' approach all cost elements within a cost component are assigned a cost and aggregated to determine the actual injury cost to the nation. The 'top-down' approach on the other hand require assembling all costs incurred at the organisational levels and are then apportioning them subjectively to various services provided to those injured.

Using a single age, Figure 4.2 has been drawn (based on Kopjar 2003) to depict the short- and long-term output losses for different categories of injury and disability. Areas 'A', 'B' and 'C' represent workplace losses and household losses due to forgone voluntary contributions (as the capacity to contribute at pre-crash levels is permanently curtailed).[39]

Disability weights are used in conjunction with age and body region in the estimation of workplace and household losses to estimate the degree of impairment for each casualty.[40] The duration of a disability for each casualty was estimated using a combination of the disability weight, the age group of the injured person, and the individual's life expectancy.

Panel 1 of Figure 4.2 depicts short-term output losses for injuries that do not result in disability. Short-term output losses (area A in panel 1) are the cost of output forgone due to the employee absence from work and any additional costs to the employer (for example, other staff may have to work overtime or the employment of temporary staff). The cost to society is estimated using weekly incomes, ages and gender of persons affected, and the number affected by injuries.

The effects of injuries that result in disabilities are shown in panels 2 and 3 of Figure 4.2.

Panel 2 of Figure 4.2 depicts injuries that result in disabilities with a mild to severe impairment. These reduce the level of an individual's contribution (area B) and shorten their life expectancy (area C).[41] At the same time, additional resources may be needed to re-train these individuals in new careers.

Panel 3 of Figure 4.2 depicts more severe injuries that result in disabilities with a profound impairment. These injuries significantly reduce the individual's normal life expectancy.

39 The size of area A in all panels of Figure 4.2 has been exaggerated. Area A represents losses over a period of less than a month in the productive life of a person.

40 The same disability weights for a notional individual are also used as appropriate in the estimation of hospital and medical costs, rehabilitation and carer costs, and non-pecuniary losses for the individual (representing their lost quality of life)

41 Life expectancy is shortened by between one and four years for a moderate to severe disability, compared to an uninjured person of the same age, gender and pre-existing health state. AIHW (1999, p.60) note for all-cause disability that approximately 8 per cent of total life expectancy at birth was lost due to disability for both males and females.

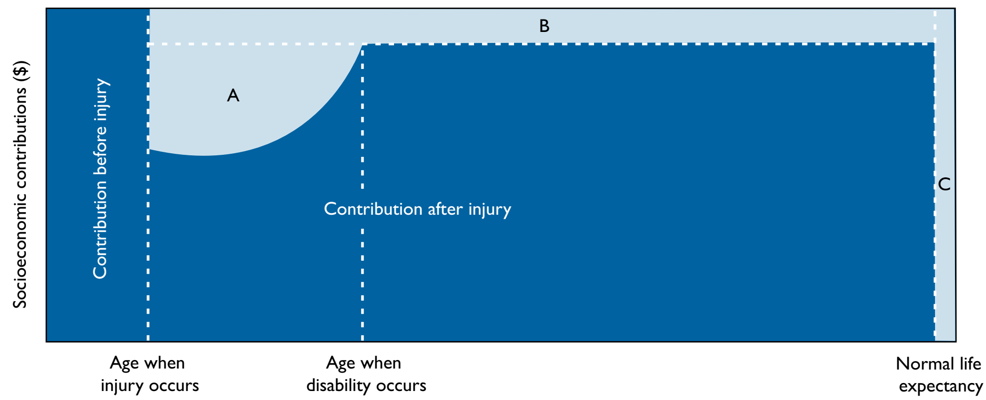
Workplace and household losses and workplace disruption losses

The workplace disruption costs and workplace and household losses due to injury and disability are illustrated in Figure 4.2.

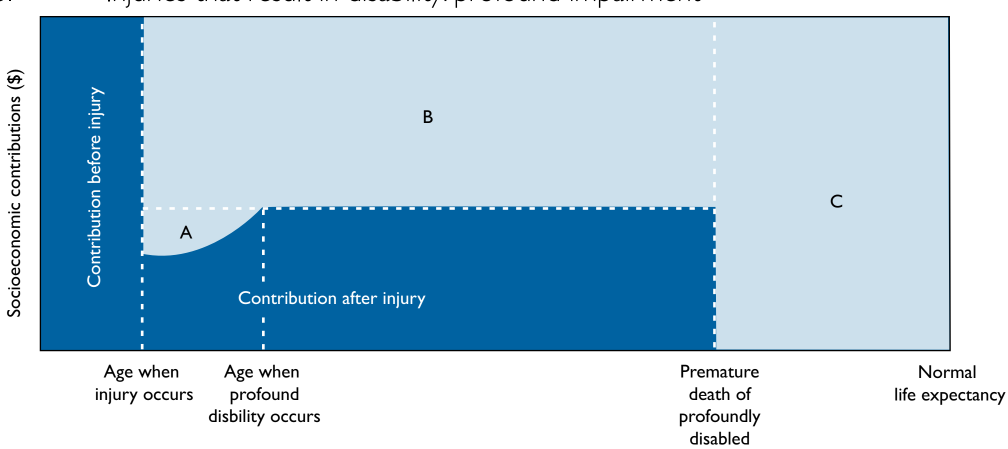
F4.2 Relationship between injury, disability and output losses

1. Injuries that do not result in disability

2. Injuries that result in disability: mild, moderate and severe impairment



3. Injuries that result in disability: profound impairment



Source: BITRE

Injuries commonly occurring in road crashes such as traumatic brain injury and spinal cord injury result in higher rates of mortality and morbidity, and reduce overall life expectancy for injured people compared with uninjured people (Cameron, Purdie, Kliewer, and McClure 2008; Strauss, De Vivo, Shavelle, Brooks and Paculdo 2008).

Most people suffering a road crash-related disability are still able to perform some core activities (Table 4.3). Core activities include self care, mobility and communication. Limitations in these core activity areas restrict schooling and/or employment and invariably require carer assistance (ABS 2004). The level of individual functioning and on-going contribution depends on the:

- age at which disability occurs
- severity of the injury leading to disability
- body region injured
- normal life expectancy of the age/gender cohort.

BITRE used information on injury-specific post-injury consequence, the gender, age and workforce participation rate, to estimate the number of persons in each category who would:

- withdraw from the workforce due to permanent incapacity
- return to work to perform duties at a reduced capacity
- return to full duties after a temporary absence
- return to full duties after a few days of absence.

ABS (2004) reports employment and participation levels for profoundly/severely disabled and all disabled persons. Using this data, BITRE made the following return to work assumptions:

- people with a profound disability do not return to work
- 3.0 per cent of people with a severe disability return to work
- 50.6 per cent of people with a moderate disability return to work
- 99.0 per cent of people with a mild disability return to work.

For each of these categories, workplace disruption costs borne by employers include output forgone and costs associated with hiring temporary employees. These were estimated by using the 'duration of the earnings forgone due to an affected person' as a proxy. Table 4.5 provides the proxies used for different disruption patterns and the disruption costs for 2006.

T4.5 Workplace disruption cost due to road crash injury, 2006

Category	Duration (weeks) of earnings forgone used as a proxy of disruption cost	Total cost (million dollars)
Permanent incapacity: no return to work	37.1	24.8
Temporary incapacity: reduced return	44.1	25.1
Temporary incapacity: return to full duties	4.6	8.2
Temporarily off work	0.7	19.7
Total		77.7

Note: The duration of earnings forgone due to absence from work was assumed to be the same as that given in Australian Safety and Compensation Council (2009) for work-related injury.

Source: BITRE estimates.

Disability losses (area B in panel 2 of Figure 4.2) are the costs to society due to an injured person suffering a disability. In this case a person is unable to contribute to society at the level prior to injury. In the work environment this may be a consequence of the affected person returning to work on reduced duties, at reduced level of participation, or both. The level of affected person's contribution depends on the degree of disability, a range of socioeconomic and demographic factors, and the return to work programs adopted.

Area C in panel 3 of Figure 4.2 represents an additional loss to society where a person dies prematurely as a result of the injury-related disability. This is more likely where disabilities result in profound limitations to core activities essential to living a normal life.

The workplace and household output losses to the economy due to output losses (including delay in returning to work) and reduced productive life are estimated by adding:

- a reduction in annual earnings and household contributions for persons with moderate, severe and profound limitations, and
- a reduction in the duration of the output contribution for those suffering profound limitations.

Disability-induced short-term output losses were estimated by taking the age, gender, workforce participation rate and the weekly wage rate that correspond to the affected person (Table 4.6). As in BTE's (2000) 1996 road crash costs study, and in other studies (e.g. Foreman, Murphy and Swerissen 2006), BITRE has assumed that the economy loses the equivalent of 25 work days for each person suffering an injury-related disability (Area A).

T4.6 Short-term workplace and household output losses, 2006

	Losses by males (million dollars)	Losses by females (million dollars)	Total (million dollars)
Workplace output losses	10.1	2.8	12.9
Household output losses	6.2	1.2	7.3
Total	16.3	4.0	20.2

Note: Components may not add to totals due to rounding.

Source: BITRE estimates.

Workplace output losses are estimated where an employee suffers moderate to severe disability (that is, for a period exceeding six months). These losses have been estimated by summing the discounted stream of annual losses from the onset of disability until the affected person's adjusted survival age.

Output losses occur in both the workplace and the household. Output losses at the workplace pertain only to injured persons who are currently employed and would potentially have been employed had they not suffered a disability. The latter group includes children between infancy to 16 years of age who were disabled in road crashes in 2006.

The loss of household contribution is estimated for both employed and unemployed persons.

Area B in Figure 4.2 represents the total output lost at the workplace and the household due to permanent disability. It is estimated by multiplying the annual earnings by the number of years lost due to disability (YLD). Equation 4.1 (below) has been widely used in literature to estimate YLD for a disabled person.

$$YLD = w \times [1 - \exp(-rt)]/r \qquad (4.1)$$

Where,

t is the average duration of the injury induced disability.

w is the disability weight and it ranges between 0 and 1—where 0 represents perfect health and 1 represents a health status equivalent to near death.

r appropriate real social discount rate (see Chapter 3) to account for the fact that losses in the present are valued more than future losses.

Equation 4.2 (below) shows the method of accounting for age, gender, YLD, average annual earnings, and age-specific participation rates when estimating workplace and household losses.

(4.2)

$$\text{Output losses} = \left(\begin{array}{l}\text{Number of}\\ \text{disabled persons}\\ \text{by age group}\\ \text{and body region}\\ \text{affected}\end{array} \times \begin{array}{l}\text{Years lost}\\ \text{due to disability}\\ \text{by age group}\\ \text{and body region}\\ \text{affected}\end{array} \times \begin{array}{l}\text{Average}\\ \text{annual earnings}\\ \text{by gender}\\ \text{by age group}\end{array} \times \begin{array}{l}\text{Average}\\ \text{participation}\\ \text{rate adjusted}\\ \text{for return to}\\ \text{work by}\\ \text{age group}\end{array} \right)$$

BITRE's estimate of workplace and household losses due to injury-related disability was $2.57 billion in 2006 (Table 4.7). These losses were estimated by adding short- and long-term workplace and household losses due to impaired productive capacity of $2.04 billion (areas A and B in Figure 4.2) to losses from premature death due to disability of $537.2 million (area C in Figure 4.2).

T4.7 Workplace and household losses due to disability, 2006[a]

	Losses by males (million dollars)	Losses by females (million dollars)	Losses by all persons (million dollars)
Workplace output losses from impaired productive capacity	1 517.4	483.5	2 000.9
Household losses from impaired productive capacity	24.1	11.7	35.8
Workplace and household losses from premature death b	438.9	98.3	537.2
Total	1980.4	593.5	2 573.9

Note: Components may not add to totals due to rounding.

a These losses relate to the sub-set of people who are hospitalised due to injury and then suffer a long term disability.

b Workplace and household losses due to the premature death of people suffering profound disabilities.

Source: BITRE estimates.

Medical and other related costs

As shown in Equation 4.3 (below), medical and other related costs consist of three cost elements: medical costs, hospital costs and paramedical costs.

(4.3)

$$\text{Medical and other related costs} = \left(\text{Number affected by degree of impairment} \times \text{Medical costs by degree of impairment}\right) + \left(\text{Total days spent in public and private hospitals—excluding same day separations} \times \text{Average cost per day of hospital stay}\right) + \left(\text{Number of affected by degree of impairment} \times \text{Paramedical costs by degree of impairment}\right)$$

Medical costs cover all costs related to a crash injury including consultations with general practitioners and specialists, surgery, hospital outpatient and paramedical costs, and medical excess payments.

Table 4.8 shows the medical costs by injury severity and the level of impairment.[42]

T4.8 People affected by road crash injuries and the medical costs by level of impairment, 2006

Level of impairment (per cent)	Number of people affected	Total cost (million dollars)
Less than <1	10 246	25.0
1. Minor (1–10)	3 086	10.5
2. Minor to moderate (11–19)	5 824	39.6
3. Moderate (20–49)	8 969	91.4
4. Moderate to serious (50–59)	981	13.3
5. Serious (60–79)	828	14.1
6. Serious to severe (80–89)	584	11.9
7. Severe (90–100)	686	16.3
All levels of impairment	31 204	222.0

Note: Components may not add to totals due to rounding.

Source: BITRE estimates based on Transport Accident Commission of Victoria data.

Hospital costs cover the cost of hospital stays for both public and private hospitals (the latter is considered as some injured patients are transferred to private hospitals). The exact numbers for the public/private split of hospital bed days for casualties of road crash were not available. Therefore, AIHW's published bed days by diagnosis related groups (DRG) for public and private patients for injuries were used as a proxy of the total public and private hospital days.

According to published AIHW data, only part of the public and private hospital costs are covered by State and Territory transport accident insurance bodies. Based on AIHW information (AIHW 2005b), BITRE assumed that about 39 per cent of bed days are spent in private hospitals. The estimated hospital costs are $155.6 million (Table 4.9).

42 BITRE adopted a direct method generally used for solving linear algebraic equations (see Collins II, 2003) to estimate the medical, paramedical and non-pecuniary costs per injury by level of impairment.

T4.9 Hospital costs arising from road crash injuries, 2006

	Total hospital days	Cost per patient day ($)	Total cost (million dollars)
Public hospitals	97 125	959	93.22
Private hospitals	61 874	1 008	62.4
All hospitals	158 999	–	155.6

Notes: Components may not add to totals due to rounding.

Cost per day for public hospitals is based on AIHW estimates of the cost per case-mix-adjusted separation for Australia (see AIHW 2005b). Comparable data for private hospitals were obtained from ABS (see ABS 2007a).

Source: BITRE estimates based on total hospital days published by Berry and Harrison (2008) and cost information in AIHW (2005b) and (ABS 2007a).

Paramedical costs encompass all public and private allied health costs.[43] BITRE estimated these costs using claims data provided by the Transport Accident Commission of Victoria for a three year period ending 2004. These data were adjusted for inflation and outliers.[44] The unit cost per claim by level of impairment was applied to the estimated number of claims in each impairment category for Australia to obtain the total paramedical costs reported in Table 4.10.

T4.10 People affected by road crash injuries and the associated paramedical costs by level of impairment, 2006

Level of impairment (per cent)	Number of people affected	Total cost (million dollars)
Less than <1	10 246	2.6
1. Minor (1–10)	3 086	7.0
2. Minor to Moderate (11–19)	5 824	26.3
3. Moderate (20–49)	8 969	60.9
4. Moderate to Serious (50–59)	981	8.9
5. Serious (60–79)	828	9.4
6. Serious to Severe (80–89)	584	7.9
7. Severe (90–100)	686	10.9
All levels of impairment	31 204	133.9

Note: Components may not add to totals due to rounding.

Source: BITRE estimates.

Ambulance costs for injury crashes

The main emergency services at a crash site are provided by ambulance services.

The ambulance costs for road crashes include the cost of:

- transporting the casualties from the crash site to a hospital
- providing medical and respite care to injured persons at the crash site and until being taken to a hospital
- transferring injured people between hospitals where required.

43 Paramedical costs encompass hospital-based rehabilitation, occupational therapy, vocational training, special equipments required in rehabilitation and care, home services required due to disability, and other associated services.

44 Claims data provided by the Victorian Transport Accident Commission was adjusted to within acceptable statistical bounds by plotting the total value of claims paid against each of the corresponding levels of impairment.

BITRE obtained the data and information from jurisdictions on the number of crashes attended by ambulance officers and the costs of road and air ambulance services that were provided. State and territory ambulance authorities attended approximately 22 822 road crashes in 2006. BITRE assumes that ambulances attended all 1455 fatal crashes and 83.8 per cent (21 367 crashes) of the 25 498 hospitalised injury crashes.[45] An average of 1.2 ambulances is required at each injury or fatal crash (Audit Office of New South Wales 2003).

BITRE estimates the average ambulance costs per crash were $2372. There is significant variability in costs and crash attendance across jurisdiction, with the reported costs of attendance per crash ranging from $1300 to $4100. Factors include the average number of injured people per crash, the level of air and helicopter ambulance use, and jurisdiction. The cost of a patient transfer was estimated at $1977 per person.

BITRE estimates the cost of ambulance attendance at 21 670 hospitalised injury crashes and of providing patient transfers[46] between hospitals was $59.9 million in 2006, an average of $1921 per hospitalised injury.

Emergency services costs for injury crashes

Apart from the ambulance services, road crashes may be attended by police services and fire and rescue services.

The investigations and crash recording services provided by police for road crashes were costed using the formula in Equation 4.4 (below).

(4.4)

$$\text{Police service costs} = \left(\text{Number of crashes attended by police} \times \text{Number of officers attending a crash} \times \text{Number of hours spent per crash} \times \text{Value of police services per hour}\right) + \left(\text{Number of crashes attended by police} \times \text{Number of hours spent per crash} \times \text{Equipment cost per crash}\right)$$

It has been assumed that all 25 498 crashes involving a hospitalised injury were attended by police. Cost elements include the time spent by police in performing on-site interviews, crash site inspection and measurements, writing notes, management, other on-site activities and off-site activities, plus the cost of equipment used by police (Howard, Young and Ellis 1977).

BITRE estimates that the cost of police services to attend hospitalised injury crashes in 2006 amounted to $35.29 million. This is an average of $1384 per hospitalised injury crash.

45 Not all patients arrive at hospital by ambulance. In 2005–06, 84.5 per cent of resuscitation and 47 per cent of emergency triage category patients arrived at emergency departments by ambulance, air ambulance or helicopter service (SCRGS 2009).

46 BITRE has assumed that 15 per cent of road crash patients require a transfer between hospitals. Fildes et al (1993) found that 15–20 per cent of road trauma patients required transfer between hospitals.

Fire and rescue services are only needed in road crashes where those present at the crash assess the need for such services. The cost of these services for injury crashes was estimated using the average number of road rescue extrications and the average unit cost of providing such services as shown in Equation 4.5 (below).

(4.5)

$$\text{Fire and rescue services costs} = \left(\begin{array}{c}\text{Number of crashes}\\ \text{requiring fire and}\\ \text{rescue services}\end{array} \times \begin{array}{c}\text{Unit cost of fire}\\ \text{and rescue services}\end{array} \right)$$

Emergency services across Australia reported attending 9914 road rescue extrications in 2005–06, increasing to 10 236 in 2006–07 (SCRGS 2009, Table 9A.20).

BITRE's estimates that the average cost where crashes were attended by fire and rescue services was $3166 (Chapter 6, section 6.5). The average number of road rescue extrications for 2006 was 10 075, of which 1455 are assumed to be fatal crashes and 8620 hospitalised injury crashes. The estimated cost of fire and rescue services at injury crashes in 2006 was $27.3 million (an average of $1070 per crash across all 25 498 injury crashes).

Disability-related costs

Disability-related costs include the estimated the costs of providing care for people who suffer a disability and the cost of disability services (workplace and household losses have estimated in the section above).

People with severe or profound disabilities affecting core activities (self care, mobility and/or communication) require help in activities of daily living. Using ABS survey data (ABS 2004), BITRE estimated that road crash injuries resulted in 4619 persons with a disability in 2006—this represents 14.8 per cent of the 31 204 hospitalised injuries (see Table 4.3).

Permanent disabilities result in a range of financial payments from government to the affected individual, families and wider society. The main financial costs from a social perspective[47] include disability pensions, payments to carers[48] and the cost of disability-related services. Disability pensions have been excluded as including both disability payments and lost earnings (the latter is estimated in the Workplace and Household Losses section) may result in double counting.

BTE (2000) estimated the cost of disability for 1996 using the annual average level of government support (including respite care) of $25 822 per person for all 3997 people with a road crash-related disability.

47 'Adopting a societal perspective assumes that all resources should be included regardless of who is responsible for bearing the cost. However, one needs to distinguish resource costs from transfer payments. The typical example of a transfer payment that does not need to be accounted for in the total sum of resource costs is an unemployment/disability benefit' (Gospodarevskaya and Harris 2000, p.20).

48 Carer Payment is a means tested form of income support for a person providing constant care for an adult or child with disability. The Carer Allowance is a non-means tested supplementary payment for people who provide daily care and attention at home to an adult or child with disability (Department of Families, Community Services and Indigenous Affairs, 2008).

BITRE has directly estimated the cost of providing care—informal and formal—to 3079 people with a profound, severe or moderate disability (that is, is it assumed that 1540 people with a mild disability do not require care). This care cost has been added to the estimated cost of disability services. Disability-related services may include specialist accommodation, the cost of aids and equipment, alterations to housing, therapy and specialist services, and day programs.

Cost of carers

Care for people with a disability may be provided by a mix of informal care, typically from family members, or care purchased from the market for formal care services. Care hours can be valued by self-valuation, opportunity cost or replacement cost methodologies. The cost is sensitive to the method used (Access Economics 2005).[49]

BITRE has used a replacement cost method to estimate future care costs where the cost of both informal and formal care is estimated using a market benchmark. This is consistent with the estimation of output losses whereby household contributions have been valued using an earnings benchmark.

Table 4.11 summarises the assumptions made to estimate the care hours per week by level of disability. The ABS 2003 Survey of Disability, Ageing and Carers (ABS 2005) indicates that 64 per cent of adult primary carers for a person with a profound limitation provide 40 hours or more of care per week, while 65.4 per cent of carers for a moderate or mild limitation provided less than 20 hours per week.[50] However, ABS (2005) does not provide average hours by limitation category, or care by secondary carers and formal providers.

BITRE has based its estimates on assumptions about a weekly care cycle (Table 4.11), with the average amount of care required per week increasing with the severity of a person's disability. Most working age people with a road crash-related disability living in a household have a physical disability (85 per cent), while only 5 per cent have an intellectual disability (ABS 2003).

The period for which people require care was estimated by taking the difference between the life expectancy at the time of injury and the years lost due to disability (compare the length of area B in Figure 4.2).

BITRE has estimated the number of years of care using normal life expectancies for age cohorts and long-term disability weights by body region, where available, with these weights assumed to decrease with reduced levels of impairment. For example, BITRE has used a disability weight of 0.725 for spinal cord injuries for a profound impairment due to a neck injury (AIHW 2003) and assumed weights of 0.54 for a serious impairment and 0.26 for a moderate impairment.[51]

The cost of each hour of care provided was valued at average hourly earnings for all persons. This hourly cost of care was weighted to reflect the fact that the majority of carers are female.

49 The opportunity cost measure reveals the resources that are diverted each year from production in the formal economy to informal care (this approach does not value leisure), while the replacement cost measure reveals the resources that would need to be diverted each year from the formal economy to replace the work done by informal carers, were their services no longer available. The self-valuation method is not commonly used and there are no reliable Australian studies (Access Economics 2005, p.16).

50 ABS (2003) provides data for persons aged 15–64 years living in households with a disability where the main cause of their condition was an accident or injury that occurred on a road.

51 Similarly, BITRE has used a Global Burden of Disease weight of 0.35 for a long-term skull injury for a serious impairment due to a traumatic brain injury, and assumed disability weights of 0.7 for a profound impairment and 0.175 for a moderate disability.

T4.11 Estimated hours per week of care by level of disability

	Profound limitations	Severe limitations	Moderate limitations
Days of care needed per week	7	3.8	3
Hours of care per day	15	7.5	3
Care hours per week	105	28.5	9

Note: Care hours are averages and may be informal or formal care, or a mix of both types of care. BITRE has assumed for costing purposes that people with a mild disability do not require care.

Source: BITRE estimates.

The following formula was applied to each age group by gender to estimate the costs of care due to road crash injuries (see Equation 4.6 below).

(4.6)

$$\text{Cost of care} = \left(\text{Number of persons with disability} \times \text{Average years for which care is received}\right) \times \left(\text{Hours of care needed per year} \times \text{Average hourly wage rate}\right)$$

The cost of future care needs due to road crash-related disability is estimated at $1.65 billion.

Other disability-related costs

In addition to the cost of care, people with a permanent disability incur a range of one-off and recurrent costs. These may include specialist accommodation, therapy and specialist services, day programs, specialist equipment and alterations to houses (see for example AIHW 2002).

Disability-related costs are likely to be considerably higher in the first year. BITRE estimates that the first year estimated cost of house modifications, aids and appliances is $39 522 for people with a profound and serious disability and $14 340 for a person with a moderate core disability.[52]

Recurrent annual disability-related costs were estimated by assuming average annual expenditure (excluding respite/in-home support) of $11 776 per user in 2005–06 on Commonwealth-State Disability Agreement programs; recurrent equipment-related costs of $925 per person (Price Waterhouse Coopers 2005); plus $5645 per person for medical and therapy costs.[53] This was estimated for the expected lifespan of individuals with a profound, serious or moderate disability.[54]

The total estimated cost of disability-related services, aids and appliances for people disabled in road crashes in 2006 was $209.9 million.

52 According to AIHW (2006b), cases of cerebral palsy and cerebral palsy like conditions with severe disability were consistently prescribed more expensive equipment than mild/moderate disability cases. On average, therapists listed equipment costing $3274 for mild/moderate disability case stories, compared to $26 905 for severe disability case stories. Age and 'additional needs' status did not appear to affect the cost of equipment prescribed. Expensive items contributing to the high cost of equipment in severe case stories included customised wheelchairs, modified vans, and sophisticated communication devices.

53 Therapy may include physiotherapy, occupational therapy, speech therapy, and social work. An average of 60 hours per person per annum is assumed.

54 Expected lifespan was estimated using the years of life lost (YLD) due to disability as detailed information was not available.

Insurance administration costs

Insurance administration costs with respect to injuries are the costs associated with administering compulsory third party (CTP) systems. Based on data provided by the Transport Accident Commission of Victoria, it was estimated that there are on average 2.3 claims made for each road crash resulting in an injury. The cost of administering injury claims has been estimated by applying an inflation adjustment to Transport Accident Commission of Victoria (2002) data.

The cost of administering injury claims in 2006 was estimated at $256.47 million. This amounted to $8219 per hospitalised injury.

Legal costs

Most road crash injury claims proceed to settlement without litigation. Nevertheless on average 20.5 per cent of claims are litigated (Suhood, 2006). The number of claims in dispute for 2006 was estimated by assuming that disputed claims are skewed towards the higher value claims and that the weighted average of all claims in dispute is about 21.5 per cent.

Taking the number of Transport Accident Commission of Victoria claims within claim bands ranging from $11 000 to $7 million, the average size of claims within each claim band was estimated. Using this information and the percentage claims in dispute, the total value of claims in dispute was estimated. The total legal cost of injury claims made in 2006 was estimated by applying the proportion of claimants' legal cost to the value of claims in dispute as given by Latham and Playford (2002).

Tables 4.12 shows that the total legal cost in 2006 amounted to $231.3 million, or $7413 per hospitalised injury.

T4.12 Number of insurance claims, percentage in dispute and legal cost, 2006

Upper band of claims	Total claims	Claims disputed	Average value per claim (million dollars)	Claimant's legal cost (per cent)	Legal cost (million dollars)
11 000	15 629	313	0.01	10	0.2
55 000	3 925	393	0.01	13	0.7
140 000	1 404	281	0.07	15	2.8
350 000	2 650	1 060	0.17	10	17.8
892 500	3 278	1 639	0.42	8	55.1
1 312 500	943	566	1.07	6	36.3
1 837 500	871	610	1.07	6	39.2
2 625 000	1 169	865	1.07	4	37.0
7 000 000	1 335	988	1.07	4	42.3
Total/average	31 204	6 713	na	na	231.3

Note: Components may not add to totals due to rounding.
na not applicable.
Source: Based on Latham and Playford (2002).

Recruitment and retraining costs

Recruitment cost has been estimated based on ABS (2004) survey data and the data obtained from the Transport Accident Commission of Victoria. These two data sources provide percentages of persons incurring core activity limitations and those suffering catastrophic injuries.

Based on the estimated number of persons and age-specific participation rates, BITRE estimated that employers needed to recruit 424 people to replace casualties with profound limitations. This estimation took into account the pre-crash gender and age-specific workforce participation rates applicable to the affected individuals. Given a recruitment cost of $3895 per person for replacement and training of the new recruit (OWD 2004),[55] the total cost of replacing and training injured people who could not return to work was estimated at $2.13 million in 2006.

A similar procedure was used to estimate the cost of re-training people with severe limitations (that is, severe disabilities) to take on alternate duties. BITRE estimated that, out of the 584 casualties with severe disabilities, about 361 could have returned to work with suitable re training. Accordingly, the estimated cost of re-training is $0.40 million.

Non-pecuniary costs of an injury

Non-pecuniary costs of an injury are the costs of pain and suffering of people injured in road crashes. Several approaches are adopted to quantify pain and suffering. These include court or jury awards,[56] values specified by legislation, and willingness-to-pay values.

BITRE has used the personal injury awards ascribed by the Transport Accident Commission of Victoria as a proxy for individual pain and suffering. The Victorian cap on general damages[57] for personal injury awards in 2004 was a maximum of $371 380 (CPI indexed). 'General damages' includes damages for pain and suffering, loss of amenities of life, and loss of enjoyment of life (Chu, 2004).

BITRE has estimated the number of people entitled to receive compensation for non-pecuniary losses and the average amounts that they received by considering the body region affected by an injury and its severity; the level of impairment; and the resulting type of limitation in day-to-day activities or level of disability caused by the impairment; and the age and gender of the casualties.

Data from the Transport Accident Commission of Victoria, the AIHW, Berry and Harrison (2008) and ABS (2004) were used to estimate the number of casualties affected by injury, how severely they were affected and the resulting level of impairment and disability.

Table 4.13 shows the number of casualties grouped according to the level of disability, the estimated average compensation payment to each group for the non-pecuniary losses incurred and the estimated total compensation in 2006.

55 This is in 2006 prices. Figures published by the Office of Workplace Development for 2004 were adjusted for inflation.

56 An advantage of court awards is that they are ex-post awards reflecting the value of harm 'after the fact' rather than the ex-ante assessment in willingness-to-pay figures.

57 These are payments covering general damages. These are also referred to in the literature as payments for non-economic losses.

T4.13 Compensation paid for non-pecuniary losses

Type of disability	Number affected	Average award per person	Total compensation paid (million dollars)
Profound limitations	686	382 037	262.0
Severe limitations	584	343 834	200.9
Moderate limitations	1 809	266 727	482.5
Mild limitations	1 540	61 222	94.3
Total	4 619		1 039.7

Notes: Components may not add to totals due to rounding.

The award for 100 per cent impairment was $387 900, based on the value used in Victoria. This was scaled down according to award payments published in impairment tables. In 1996, BTE (2000) estimated payments for non-pecuniary losses for all casualties with an impairment of 30 per cent or more.

Source: BITRE estimates.

Cost of non-hospitalised injuries

The cost of non-hospitalised injuries was estimated by assuming five days of lost output for each injured person (see Australian Safety and Compensation Council 2009). The medical costs of treating non-hospitalised injuries were assumed to be the same as treating persons with impairment ratings less than 10 per cent.

Transport Accident Commission of Victoria data provided medical costs[58] for impairments ranging from 10 to 100 per cent. These costs were interpolated to estimate the costs for those whose impairment is under 10 per cent—such as those suffering injuries that do not require hospitalisation. Assuming an average impairment of 5 per cent for people with non-hospitalised injuries, the medical cost was estimated at $1614 per person.

The total medical cost amounted to $349.5 million for 216 500 non-hospitalised injuries.

The output losses due to non-hospitalised injuries were estimated using adjusted average annual earnings for males of $55 972 and females of $35 637, and respective gender participation rates.[59] An average of five days of output losses was assumed for each person 15 years or older with a non-hospitalised injury.

Estimated output losses due to non-hospitalised injuries totalled $108.8 million.

The total cost of non-hospitalised injuries in 2006 was estimated at $458.33 million, or $2117 per non-hospitalised injury.

58 As noted previously under medical cost of hospitalised injuries, these costs include consultation, paramedical costs and any medical excess payments.

59 ABS catalogue numbers 6202.0 and 6302.0.

4.3 Results

Table 4.14 summarises the total number of injuries by category of injury. The estimated number of persons injured in road crashes increased 5.1 per cent between 1996 and 2006.

T4.14 Breakdown of road crash injuries, 1996 and 2006

Type of injury	1996	2006
Hospitalised—one night or more a	21 989	20 958
Hospitalised—discharged the same day	ns b	10 246
Non-hospitalised injuries	ne b	216 500
Minor injuries	213 322	ne
Total all injuries (excluding fatalities)	235 635	247 704

Note: Components may not add to totals due to rounding.

ne not estimated.

ns not separately identified.

a This figure excludes injured people admitted to hospital who subsequently died in the hospital.

b Included in estimate of minor injuries.

Source: BITRE estimates.

The total cost of injuries in 2006 was an estimated $7.14 billion compared to an inflation adjusted corresponding estimate for 1996 of $8.43 billion.[60] (Table 4.15) The main cost driver for 2006 was workplace and household losses (disability-related costs in 1996).

T4.15 Comparison of road crash cost components for injuries, 1996 and 2006, millions (2006 dollars)

Cost component	Estimates for 1996 (2006 dollars, millions)	Estimates for 2006 (2006 dollars, millions)
Workplace and household losses (hospitalised and non-hospitalised injuries)	1 474.8	2 682.7
Disability-related costs a	2 956.8	1 863.9
Non-pecuniary costs	1 960.6	1 039.7
Medical and related costs (hospitalised and non-hospitalised injuries)	407.5 b	860.9
Insurance administration cost	339.9	256.5
Legal costs	953.4	231.3
Work place disruption	235.1	77.7
Ambulance	nse b	59.9
Police	23.1	35.3
Fire and rescue services	80.1	27.3
Recruitment and re-training cost	0.4	2.5
Total	8 431.6	7 137.7

nse Not separately estimated.

a Disability-related costs include the costs of future care, specialist accommodation, therapy and specialist services, day programs, specialist equipment and alterations to houses.

b BTE (2000) combined ambulance and medical costs in its 1996 road crash costing model.

Source: BITRE estimates.

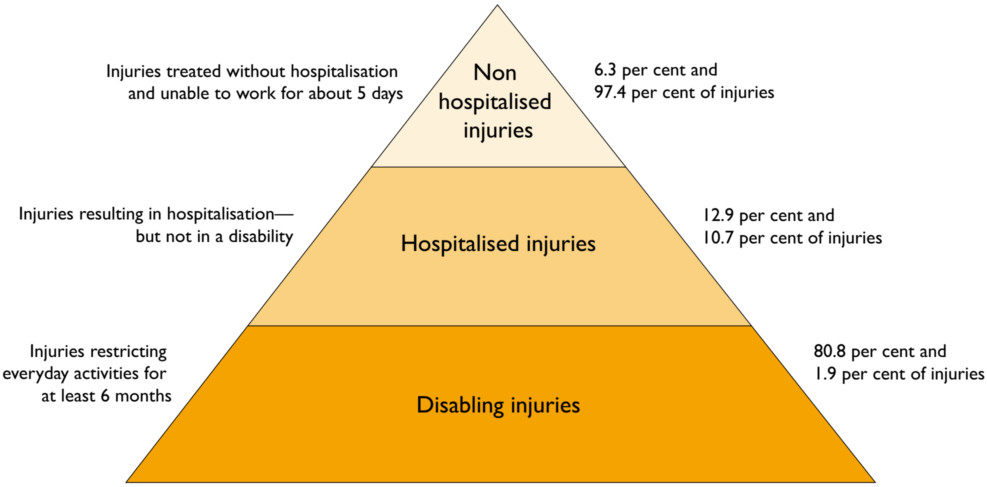
60 In 1996, the stream of long-term care costs were discounted at 4 per cent discount rate and the YLLs were estimated using a discount rate of 3 per cent. The 1996 total given here was estimated using a discount rate of 3 percent to discount long-term care costs.

While workplace and household losses and medical costs have significantly increased, there were substantial decreases in disability-related costs, non-pecuniary losses, legal costs and workplace disruption costs.

Injury-related legal costs decreased significantly between 1996 and 2006. Many jurisdictions including New South Wales and Queensland have changed compulsory third party schemes to simplify claims processes, reducing the number of disputed claims and lessening reliance on court processes.[61, 62]

Figure 4.3 compares the relative proportions of different types of injuries and the resulting injury costs to society.

F4.3 The relative proportions of injuries and costs, 2006



Source: BITRE.

Losses for a hospitalised injury were approximately $214 000 per injury (including disability-related costs), and losses for non-hospitalised injury were approximately $2100 per injury. These unit costs are not comparable to BTE's (2000) estimated costs of serious and minor injuries 1996 due to the change in injury definitions.

BITRE estimates that 4619 (14.8 per cent) of the 31 204 people hospitalised in 2006 due to road crash injuries suffered a disability, of which 1270 people (4.1 per cent of people hospitalised) had severe or profound limitation. Table 4.16 summarises the estimated losses to society from crash-related disability for 2006.

61 The New South Wales Motor Accidents Compensation Act 1999 reduced the proportion of claims made with legal assistance from 68 per cent to 50 per cent, with a 25 per cent real reduction in legal costs paid per claim (Motor Accident Authority 2007).

62 The Queensland Motor Accident Insurance Amendment Act 2000 reduced the proportion of claims with legal representation from 90 per cent prior to 75 per cent. The number of litigated claims fell from 28.1 per cent prior to the Amendment, to 4.2 per cent in the following year, subsequently declining to 0.5 per cent in 2005–06 (Motor Accident Insurance Commission 2008).

T4.16 Losses to society from crash related disability by level of impairment, 2006

Level of impairment	Per person
Profound	3 822 447
Severe	1 780 681
Moderate	541 717
Mild	125 513

Source: BITRE estimates.

BITRE has made a number of changes to the 1996 model used by BTE (2000):

1. The replacement cost of care for people with disabilities has been estimated using a market value approach. The average years of care are estimated using a person's age and BITRE's interpolation of disability weights based on body region and severity of impairment. BTE (2000) used average government payments per person as a proxy for disability-related costs.
2. Future workplace and household losses have been estimated using disability weights, taking into account return to work rates by severity of impairment. BTE (2000) assumed no future workplace and household contributions from people with a profound or severe disability, with minimal losses for people with a moderate or mild disability. Consequently, while the estimated numbers of people with a profound or severe disability increased in 2006 compared with 1996, the losses per person reduced substantially.
3. Future losses are assumed to vary by body area injured, age and gender of the injured person, and the cohort life expectancy. BTE (2000) assumed that the age of all persons with a disability was 35 for costing purposes.

4.4 Concluding observations

The cost of injuries in 2006 was $7.14 billion, a decrease of 15.3 per cent in real terms compared with 1996. However, caution needs to be exercised when directly comparing 2006 injury cost estimates with the 1996 estimates as the model used in 1996 resulted in significantly lower estimates for disability-related costs.

The injury costs for 2006 excludes compensation payments for economic losses, income support payments and carer payments. Instead, BITRE has included the losses to the economy due to absence from paid and household work, estimated the replacement cost of carers (including family members) for persons with a permanent disability, and estimated the costs of meeting the needs of people with a disability (for example, house modifications and wheelchairs).

The estimates in this chapter do not take account of the fixed cost to the hospital system of providing base capacity needed to respond to road trauma.

CHAPTER 5
Vehicle-related costs of road crashes

This chapter costs the associated vehicle costs arising from the damage caused to the vehicles involved in road crashes. These costs include the repair costs to fix the damage, the towing cost and the costs incurred due to the unavailability of the vehicle while being repaired or assessed.

5.1 Repairing vehicles involved in road crashes

Vehicles involved in road crashes inevitably end up damaged. BITRE have estimated the cost to repair the damage caused to the vehicles involved in road crashes within Australia in 2006.

Insurance information was used to estimate average claim values for collisions for cars, rigid trucks and articulated trucks. These average values for claims paid include write-offs.[63] An excess was applied to the average repair cost values.[64]

Bus repair costs were estimated due to a lack of insurance data for buses. Motorcycle repair cost estimates were obtained from Swann Motorcycle Insurance average repair cost data (IAG 2008).

The repair cost values utilised in the estimation are presented in Table 5.1.

T5.1 Estimated average repair costs by vehicle type Australia (2006 dollars)

Vehicle type	Repair cost per vehicle
Cars	2 989
Motorcycles	3 233
Bus a	9 523
Rigid Truck	12 000
Articulated Truck	31 400

a A weighted average repair cost for buses was calculated using the rigid truck repair cost and an assumed repair cost of $2000 for untowed buses.

Source: NRMA (2007); IAG (2008); ISA (personal communications 2008); BITRE estimates.

63 These values were lower than the costs of repairing new small and medium size vehicles following a 10 kilometre an hour crash test—the most common type of road crash (NRMA 2007; 2008). The NRMA Insurance low speed crash test program tested nine of Australia's top selling small vehicles, resulting in repair costs ranging from around $1000 to more than $7000 (NRMA 2008).

64 An average excess of $500 per crash for cars and light commercial vehicles was assumed (see for example, http://www.racq.com.au/motoring_advice/about_your_car/vehicle_running_costs2. BITRE assumed an excess of $1000 per crash for rigid trucks and $2000 for articulated trucks.

These average repair values and BITRE estimates of vehicles involved in road crashes (Table 2.11) were used to estimate total repair costs in Australia of approximately $4.2 billion for 2006 (Table 5.2).

T5.2 Repair costs for vehicles involved in road crashes, Australia 2006 (million dollars)

Vehicle type	Fatal crash	Injury crash (excluding fatal crashes)	Property damage only crashes	All crashes
Cars including light commercial vehicles	4.2	1 215.2	2 007.6	3 227.1
Motorcycles	0.7	61.1	17.4	79.2
Buses	0.1	8.6	75.8	84.6
Rigid Trucks	0.7	23.9	285.5	310.1
Articulated Trucks	4.3	48.1	471.9	524.3
All vehicles	10.1	1 357.0	2 858.1	4 225.2

Note: Components may not add to totals due to rounding.

Source: BITRE estimates.

5.2 Towing vehicles involved in road crashes

The cost of towing a disabled vehicle from a road site is an additional cost.

In estimating the vehicle repair costs (Section 5.1), cost of insurance claims information was utilised for light passenger vehicles and motorcycles which would generally include towing costs. Therefore, to avoid double counting only towing costs for heavy vehicles have been estimated.

The NSW Roads and Traffic Authority (2008) gives the first hour accident applicable fee for an 18 to 25 tonne tow as $202. This rate was assumed to be the total cost of a tow for all heavy vehicles (bus, rigid truck, articulated truck) reported towed from the crash scene.

Table 5.3 presents BITRE's estimate of the costs for 2006 of towing heavy vehicles involved in crashes.

T5.3 Towing costs for heavy vehicle involved in reported road crashes, Australia, 2006 (million dollars)

Heavy vehicle type	Estimated cost of towing
Bus	0.4
Rigid truck	1.0
Articulated truck	0.7
Total	2.1

Source: BITRE estimates.

5.3 Cost of vehicle unavailability

When a road crash occurs the vehicles involved suffer damage. The vehicles involved may be unavailable for a period of time while damage is assessed and the vehicle is repaired or replaced (or even impounded by police).

The vehicle is unavailable to the owner during this period and this also has a cost. To an owner of a commercial vehicle this period of unavailability may mean lost business, employee time wasted or delayed and cancelled work. A private owner may experience significant cost and inconvenience due to changing to public transport, hiring a replacement car, borrowing a vehicle or even cancelling trips. BITRE has estimated the costs of unavailability using vehicle replacement costs, generally the market value vehicle hire rates including full insurance costs.

The estimates of unavailable vehicles are based on the number of vehicles involved in reported crashes for 2006.[65] Vehicles involved in unreported crashes are assumed to be drivable and vehicle unavailability costs have not been estimated for these vehicles.

BITRE's road crash data identifies whether a vehicle was towed from the crash scene (260 000 vehicles) or not (50 000 vehicles). Information on whether a vehicle was towed or not was used to determine the period of time a vehicle was unavailable following a crash. BITRE has assumed that towed vehicles are unavailable for seven days and untowed vehicles for two days.

Rates used to cost the period of unavailability came from surveyed vehicle hire services, including Hertz, Budget, Europcar and Avis. Articulated truck rates were obtained from a commercial costing model. Table 5.4 shows the rates used for both towed and untowed vehicle types. BITRE estimates that vehicle unavailability cost was $214.1 million in 2006 (Table 5.5).

T5.4 Unavailable vehicle replacement costs, Australia, 2006

Vehicle Type	Towed vehicles		Untowed vehicles	
	Days unavailable	Rate per day (dollars)	Days unavailable	Rate per day (dollars)
Cars	7	100	2	120 a
Motorcycles b	7	100	2	120 a
Bus	7	221	2	221
Rigid truck	7	207	2	207
Articulated truck	7	429	2	429

a Car and motorcycle rates per day are assumed 20 per cent higher than the weekly rate.
b Motorcycle rates are the same as light passenger vehicle (car) rates.
Source: Industry sources; BITRE estimates (2009).

65 Total vehicle numbers include an estimated 30 000 vehicles where the driver was killed or hospitalised following a crash.

T5.5 Estimated vehicle unavailability costs, Australia, 2006

Vehicle type	Towed (million dollars)	Untowed (million dollars)	Total (million dollars)
Fatal crash			
Car (including LCVs)	0.9	0.0	0.9
Motorcycle	0.1	0.0	0.1
Bus	0.0	0.0	0.0
Rigid truck	0.1	0.0	0.1
Articulated truck	0.4	0.0	0.4
Total fatal crash	1.5	0.1	1.6
Injury crash (excluding fatal crashes)			
Car (including LCVs)	91.6	5.8	97.5
Motorcycle	4.3	0.4	4.7
Bus	1.6	0.2	1.8
Rigid truck	3.7	0.4	4.1
Articulated truck	5.3	1.7	7.0
Total injury crash	106.6	8.6	115.1
Property damage only			
Car (including LCVs)	81.4	4.5	86.0
Motorcycle	0.6	0.0	0.7
Bus	1.4	0.1	1.5
Rigid truck	3.6	0.3	3.9
Articulated truck	3.9	1.4	5.3
Total PDO	91.0	6.4	97.4
Total unavailability costs	199.1	15.0	214.1

Note: Components may not add to totals due to rounding.
Source: BITRE estimates.

5.4 How do vehicle-related costs in 2006 compare to 1996?

The estimated vehicle costs add up to approximately $4.44 billion, with vehicle repairs accounting for 95 per cent. Table 5.6 compares estimated vehicle-related costs for 2006 with 1996 (BTE 2000).

The 2006 estimate is 20 per cent less in real terms than 1996 for a similar number of vehicles involved in road crashes (BTE 2000). The lower estimate principally reflects changes in the estimation methodology, particularly the use of average repair cost values.

T5.6 Vehicle-related costs of crashes 1996 and 2006 (2006, million dollars)

Cost component	1996	2006	Change (per cent)
Vehicle repairs	5 004	4 225	–15.6
Towing	55	nse a	na
Vehicle unavailability	234	214	–8.5
Total vehicle costs	5 294	4 441 b	–16.1

Note Components may not add to totals due to rounding.

nse Not separately estimated.

a Towing results are not directly comparable because BITRE (2009) has car and motorcycle towing costs are included in vehicle repair costs for this category, whereas BTE (2000) has separately estimated towing costs of passenger vehicles.

b Total includes $2.3 million for towing of heavy vehicles.

Source: BITRE estimates, BTE (2000).

Table 5.6 indicates that estimated vehicle-related costs have decreased in real terms by 16.1 per cent.

The estimated number of vehicles involved in crashes decreased from approximately 1.20 million in 1996 to approximately 1.16 million in 2006. Adjusting for the change in estimated vehicle numbers, the real decrease between 1996 and 2006 in vehicle-related costs per vehicle involved in a crash is 12.6 per cent.

This reduction in vehicle repair costs partly reflects changes in methodology. Insurance data was only available for an average claim cost or repair cost. Consequently, an average cost per vehicle damaged was used, rather than differential costs for towed and un-towed vehicles as used by BTE (2000).

CHAPTER 6
Other costs of road crashes

Costs estimated in this chapter are travel delay costs, insurance overhead costs related to property, crash-related damage to street furniture, and police and emergency services response costs. The estimates cover cost elements that are not directly related to either human costs (Chapter 3 and Chapter 4) or property damage (Chapter 5).

6.1 Costs of travel delay

Crashes cause delays which impose non-recurrent congestion costs[66] on other road users. These include time lost due to queuing in traffic or from reduced travel speeds, increased fuel costs, and social costs such as increased health costs resulting from additional local air pollution.[67]

Estimates of travel time losses

Evidence from the literature indicates that crashes make a significant contribution to the costs of congestion, however, the magnitude depends on the general level of recurrent congestion. Cohen and Southworth (1999) state:

> 'Empirical evidence confirms that a major cause of day-to-day variability in trip times is the occurrence of traffic incidents, including major accidents ... and many minor incidents.'

Some 25–30 per cent of delays are estimated to be a consequence of crashes (Schrage 2006, p.4). Skabardonis et al (2003) examine peak periods on Californian freeways with significant recurrent congestion:

> 'Non-recurrent congestion delay is found to be between 13 to 30 percent of the total delay, which is lower than commonly quoted values of 40 to 60 percent of total delay. The portion of non-recurrent congestion delay depends on the study section characteristics, frequency and type of incidents, and the presence of recurrent congestion. Most importantly, the percentage of non-recurrent delay depends on the extent of recurrent delay. Clearly, if there is no recurrent delay, non-recurrent delay will account for 100 percent of total delay.' (Skabardonis et al 2003, p. 9)

However, Skabardonis et al (2003) note that the probability distribution for a delay has a high standard deviation and large 'tail', consequently, a single number can be very misleading.

66 Congestion can be either recurrent or non-recurrent, occurring at bottlenecks caused by conditions such as the reduction in the number of lanes and lane width. Causes include roadway maintenance, reconstruction or incidents (Chien and Chowdhury, 2000).

67 These costs are not considered by the road user when making their decision to travel.

With respect to freight, McKinnon et al (2008) state that much of the research has been confined to the effects of traffic congestion on direct, on-the-road costs and relied heavily on estimates of average increases in journey time and that:

> 'It is now quite common to measure congestion by the number of seconds lost per vehicle-km and to convert this figure into monetary values using standard costs for driver and vehicle time. Such calculations are deficient in two respects: 1. They take no account of the variability of transit times on congested road networks. 2. They ignore the consequential, 'off-the-road' costs incurred at collection and delivery points when deliveries arrive late.'

McKinnon et al (2008) found:

1. 'The average length of the delay caused by traffic congestion in the United Kingdom was relatively short, averaging 24 minutes, by comparison with an unweighted average delay time for all causes of 41 minutes.'
2. When the frequency and duration of delays are combined and the results weighted by the number of journey legs surveyed in each of the sectors, traffic congestion comes third, being responsible for 23 per cent of total delay time.
3. There was unanimous agreement across 2008 interviewees that most congestion is regular and predictable.
4. There was evidence that the frequency of 'major congestion incidents', which are much more disruptive to the supply chain, had increased significantly in recent years (pp.23–26).

Recent developments in the theory underpinning the external cost of crashes have investigated the relationship between traffic density and accident risk (Hensher 2006), the role of defensive driving behaviour (Steimetz 2008), and the use of optimal tolls in the case of crashes (Schrage 2006).

Schrage (2006) notes that, empirically, there are no clear cut answers to the questions of whether individual accident risk and accident severity change with traffic flow (density). While accident risk on interurban roads seems not to increase with the traffic volume, for urban traffic the elasticity of risk with respect to flow is found to be strictly positive (Schrage 2006 p.4–5).

Steimetz (2008) shows that accident risk may not increase with traffic density, however, defensive driving results in additional time losses.

BITRE's delay modelling indirectly takes into account traffic density by modelling flows, but does not account for losses due to defensive driving.

Framework for modelling traffic delays

Cumulative count bottleneck models are commonly used to predict queues caused by recurrent events like scheduled maintenance or non-recurrent events like accidents (Lindsey and Verhoef 1999, pp.5–6).

These simplified models assume that traffic flow through a bottleneck is uncongested up to a maximum flow or capacity. If incoming flow exceeds this capacity, or the maximum capacity is reduced below the incoming flow as in the case of an incident, then the excess flow accumulates in the form of an upstream queue. These deterministic queuing models are well known and widely utilised (Chien and Chowdhury, 2000).

Shock-wave models are another method for estimating delay. These models assume that the flow of traffic is analogous to fluid flow and the shock wave speed propagates linearly. For the determination of queuing delay, the shock wave speed is estimated based on traffic density (Chien and Chowdhury, 2000).

BTE (2000, p.91) used a deterministic queuing model adapted from Mannering and Kilareski (1998) to estimate crash delays to other road users. This queuing model assumes uniform arrivals and departures, with one departure channel.

BITRE has used a simple queuing model (BTE 2000) with refinements with respect to:

- Selection of road crashes that are likely to cause delay (including crash severity determined by the most severe casualty outcome).
- Estimating delays according to the time of day for both metropolitan and non-metropolitan areas.
- Limitations of this simple queuing modelling include likely under-estimation of delay costs by not considering increased costs:
- To drivers taking alternative routes or delaying their departure to avoid the crash site.
- To road users on other parts of the network where the queues caused by a crash block preceding intersections, causing delays.
- To road users on alternate routes that are imposed by drivers switching to these routes.
- To road users experiencing an 'extreme event' where a critical road or junction is shut down due to a road crash, causing widespread and lengthy delays to the entire network.

Despite these limitations, the simple queuing model is the best approach given the available data. These estimates would be enhanced by network modelling of accident delays using real time data. However, modelling of the associated congestion within the metropolitan (or non-metropolitan) road networks is beyond the scope of this study.[68]

The simple queuing model used in this study is a linear model providing an average order of magnitude estimate of delay costs to road users directly affected by road crashes. The delay costs in this model represent non-recurrent congestion costs that are in addition to normal levels of recurrent congestion experienced by road users.

Data sources and issues

The main variables are the demand volume (or traffic flow), the 'normal' capacity of the road, the restricted capacity of the road after the road crash incident and the total duration of the incident. To cost the estimated traffic delay BITRE has assumed:

1. Values for the 'time' of the people/traffic involved in the delay within the metropolitan and non-metropolitan areas.
2. A certain mix of the vehicles involved within the metropolitan and non-metropolitan areas of Australia.
3. Values of the flow of traffic for the road networks in the metropolitan areas and the freeway network in non-metropolitan areas.

68 This includes modelling the congestion from 'extreme events' like a multi-vehicle fatality closing the Sydney Harbour bridge during peak hour traffic, which would cause lengthy delays throughout most of the Sydney metropolitan area.

Further, it is assumed that crashes cause significant disruption and delay where they have been reported to police.[69]

Value of time and vehicle mix

Different vehicle types have different values of time; a fully laden articulated truck is allocated a different value of time than a car.

The traffic flow is disaggregated into a vehicle mix for both metropolitan and non-metropolitan areas, with each different vehicle type having separate 'values of time' applied.

The vehicle mix and the associated dollars per hour value of time are given in Table 6.1. Vehicle mix values are derived from BITRE estimates of vehicle kilometres travelled (VKT). The travel time estimates are based on AustRoads (2008), updated[70] road user values of travel time.

- Car travel is split between private and business car travel, depending on time of day and motorbikes are assumed to have the same cost value as private cars.
- Light commercial vehicles, rigid and articulated truck values are considered to be business travel.
- Bus passengers are assumed to be private users with the same average value of personal travel time as car users. Buses are assumed to have an average load that varies across time of day.

T6.1 Vehicle mix and time value during business hours

Vehicle type	Traffic mix (proportion)		Delay cost (dollars/hour/vehicle)	
	Metro	Non-metro	Metro	Non-metro
Private cars and motorcycles	62.2	56.0	30.0	31.9
Business cars	20.1	13.5	84.0	78.0
Light commercial vehicles	12.4	19.6	49.8	48.8
Bus	0.5	1.0	184.4	184.4
Rigid truck	3.7	4.4	55.1	47.4
Articulated truck	1.1	5.5	87.0	63.3

Source: BITRE estimates.

Traffic flow

For metropolitan areas traffic flows were estimated by disaggregating flows by road type and then applying an average flow to the model.

Crash data was available for the capital cities and metropolitan/non-metropolitan areas. For non-metropolitan areas, only delays due to freeway crashes have been estimated due to data limitations. Freeway crashes were selected by taking a subset of crashes where the posted speed limit was 110 kilometres per hour.

69 However, only 22 per cent of all reported crashes in Western Australia involved attendance by police (Chapman and Rosman 2008).

70 Values were deflated using CPI to June 2006 values, then averaged.

Crash data by road type and posted speed limit was supplied by some jurisdictions. The road types for metropolitan areas were disaggregated into the road types presented in Table 6.2, together with the average flow rate applied to the model.

Road type flow rates were based on the road capacity, number of lanes and vehicle lane flow as indicated in Table 6.3.

T6.2 Business hours flow rate by road type

Road type	Normal business hours flow rate (Vehicle/minute)
Freeway	72
Highway	45
Other road	16
Road	18
Street	18
Average	33.8

Source: BITRE estimates.

T6.3 Road type capacities, flow rates and average number of lanes

Road type	Normal capacity (vehicles per hour)	Normal capacity (vehicles per minute)	Vehicle flow per lane per minute	Number of lanes
Freeway	6000	100	18	4
Highway	4500	75	15	3
Other road	3000	50	8	2
Road	4000	66.67	9	2
Street	4000	66.67	9	2
Average		64.58	10.25	2.25

Source: BITRE estimates; BTE (2000); VicRoads Traffic System Performance Monitoring Information Bulletin 2005–2006.

Crash selection

The time of day a crash occurs affects the average flow rate of the traffic flow in the following manner:

- Peak hour traffic flows for freeways are 30 per cent higher than traffic flows in business hours
- Overnight traffic volumes are approximately 30 per cent of business hours volumes
- Saturday traffic volumes during the day are 10 per cent below normal weekday volumes
- Sunday traffic flows during the day are approximately 25 per cent below normal weekday volumes (VicRoads Traffic System Performance Monitoring Information Bulletin 2005–2006).

BITRE disaggregated metropolitan and non-metropolitan crashes into the 'crash time' categories in Table 6.4.

T6.4 Crash time of day and week

Crash time	Name	Description
1	Weekday peak	Weekday between 06:30–09:30 and 15:30–18:30
2	Weekday business hours	Weekday between 09:30–15:30
3	Weekday off-peak	Weekday between 18:30–06:30
4	Weekend day	Weekend between 06:30–18:30
5	Weekend night	Weekend between 18:30–06:30

Source: BITRE estimates.

Using the crash time categories in Table 6.4 and the data on the traffic flow, the multiplier factors were applied to the average flow rate in Table 6.2 to get a flow rate over a twenty-four hour period. The multipliers for the 'weekday business hours' base case are given in Table 6.5.

T6.5 Base case traffic flow rate multipliers

Crash time	Name	Multiplier
1	Weekday peak	1.25
2	Weekday business hours	1.0
3	Weekday off-peak	0.3
4	Weekend day	0.8
5	Weekend night	0.2

Source: BITRE estimates.

Crash severity

Crashes were disaggregated into fatal, injury and property damage only severity categories. The crash severity is assumed to affect the delay time of the emergency services attending the crash scene and hence, the time taken to return to 'normal' traffic flow levels.

Delay time multiples were assigned to each of the crash severity types. Due to a lack of Australian data on actual delay times, BITRE has used the US Federal Highway Administration (2005) hours-of-delay ratio of 49:86:233 for Property Damage Only: Injury: Fatal crashes derived from a survey of a number of US Police Departments.

Applying this ratio to the crash types by crash severity category produces the crash severity multiples in Table 6.6. These multiples are used to adjust the expected delay time for each crash category.

T6.6 Crash severity delay time multipliers

Crash severity	Description	Multiplier
1	Fatal	2.7
2	Injury	1.0
3	Property Damage Only	0.6

Source: BITRE estimates.

Response time

An important parameter used in the delay model is the time between the actual crash and the arrival of the emergency services.

Information on police response times to crashes were not available. BITRE has therefore used ambulance response times to life threatening incidents as a proxy. Ambulance services report the average time in minutes that 50 per cent and 90 per cent of ambulances arrive at the scene for a Code 1 (life threatening) emergency. For major urban areas in Australia reported response times are between 8 and 10 minutes (50th percentile) and 16 to 20 minutes (90th percentile).

The skewed nature of the distribution (50 per cent of responses take less than 9 minutes) suggests an average ambulance response time to casualty crashes of approximately 12 minutes in metropolitan areas.

While ambulances do not generally respond to property damage crashes, the average response time of other emergency services to property damage crashes is likely to be longer than casualty crashes, reflecting the lower relative priority.

Non-metropolitan casualty response times are slightly longer than metropolitan areas. Values for ambulance response times for injury crashes reported by McDermott, Cooper, Hogan, Cordner and Tremayne (2005) for Victoria are 7.8 minutes for metropolitan areas and 12.1 minutes for non-metropolitan areas.

The average emergency service response time in metropolitan areas is 12 minutes for casualty crashes and 18 minutes for property damage only crashes. Responses in non-metropolitan areas are assumed to take an additional four minutes in all categories. Responses to property damage crashes are assumed to take an additional five minutes in all categories, reflecting a non-emergency response.

Time at crash scene

The time that police and/or emergency services spend at the crash scene is based on the average reported time spent at the scene by the ambulance services as reported in McDermott et al (2005).

For metropolitan areas this was 25.2 minutes and non-metropolitan areas was 35.6 minutes. The delay time parameter varies with metropolitan/non-metropolitan crashes and with the severity of the crash, but does not vary with the time of day.

Restricted flow factor

After a road crash, some level of reduction in normal traffic flows is assumed after emergency services attend the crash scene. This relates to the amount of road capacity that is available after emergency services arrive and direct traffic.

BITRE has used a fixed value of 0.7, the same value as BTE (2000). While this value does not vary, it should be noted that often the road would be fully closed, particularly for a fatal accident where the road is closed until the coroner is finished at the scene.

The restricted flow factor is a representation only and may represent an alternate route, or detour, as opposed to the actual crash site.

Single vehicle crashes

All non-fatal injury and fatal crashes have been included in the subset of crashes irrespective of the number of vehicles involved.

There may be a case for excluding some property damage-only single vehicle crashes (see BTE 2000). For example, if a car runs off the road and hits a tree and there are no injuries, there is a likelihood that this crash would result in no significant delay to other road users. However, a vehicle colliding with a traffic light at a major intersection during peak hour traffic resulting in property damage and no injuries would cause significant delay.

BITRE did not have the detailed crash data to determine the likely delay on a case by case basis, and has used crash time and road type as indicators of expected delay.

Table 6.7 shows the number and proportion of single vehicle crashes drawn from crashes recorded in state databases. In metropolitan areas the highest share of reported single vehicle crashes in state crash databases were classified as fatal crashes, followed by the injury crashes.

Non-metropolitan areas have a higher percentage of single vehicle crashes; however, BITRE limited crash selection in non-metropolitan areas to freeways (proxied by a posted speed limit equal to or greater than 110 kilometres per hour).

Only a small proportion of reported single vehicle crashes in each of the three crash sets resulted in property damage only. It would appear reasonable to assume that most reported single vehicle property damage only crashes result in some delay to other road users.

Accordingly, single vehicle crashes have been included in the estimation of the costs of delays, with the proviso that results may overestimate delay caused by property damage only crashes.

T6.7 Single vehicle crash numbers and share of total crashes

Delay model	Number of crashes	Number of single vehicle crashes	Proportion of single vehicle crashes
Melbourne and Sydney metropolitan crashes			
Fatal	258	132	51.2
Injury	20 199	5 604	27.7
Property damage only	23 273	3 832	16.5
Subtotal	43 730	9 568	21.9
Other metropolitan crashes			
Fatal	277	123	44.4
Injury	21 723	4 016	18.5
Property damage only	49 309	6 994	14.2
Subtotal	71 309	11 133	15.6
Non-metropolitan freeway crashes			
Fatal	257	155	60.3
Injury	3 219	2 316	71.9
Property damage only	3 664	2 718	74.2
Subtotal	7 140	5 189	72.7
All region models			
Fatal	792	410	51.8
Injury	45 141	11 936	26.4
Property damage only	76 246	13 544	17.8
Total	122 179	25 890	21.2

Note: Components may not add to totals due to rounding.
Source: BITRE National Crash Database, BITRE estimates.

Estimated cost of lost time

The total travel delay cost is estimated at approximately $792 million in 2006 for the 122 000 reported crashes considered likely to have caused significant delays, or approximately $6 500 per crash (Table 6.8).

This is significantly less than BTE's (2000) estimate due in part to changes in methodology and greater disaggregation of the delay model. However, there is significant uncertainty with respect to key model parameters. BITRE modelled this uncertainty using risk management software and expected distribution of key parameters including emergency service response times and traffic flow restrictions. This indicates that delay costs range between $500 million to $1.76 billion at the 95 per cent confidence interval.

Fatal crashes have a delay cost ranging from $19 000 per crash to $21 400 per crash, whereas property damage-only crashes have a delay cost ranging from $5 400 per crash to $7 100 per crash.

Delay costs vary significantly by time of day and day of week. For a fatal crash in Melbourne or Sydney during weekday peak hours, over 4000 vehicles may be affected with an average delay of about fifteen minutes and the longest delay approaching thirty minutes. At the other end of the spectrum, a property damage only crash at the weekend at night is expected to affect only 150 vehicles with an average delay of just eight minutes. This variance is largely due to the variation in traffic flow over time, rather than the total length of time the road is blocked following a crash. Hence, expected duration of delays varies mainly due to the length of the queue. It is assumed that emergency service response times and the time taken to clear the crash site do not vary significantly by time of day.

Estimated travel delay costs are likely to be conservative as the bottleneck model used to estimate travel delays does not capture the network congestion that occurs where a crash disrupts a major road or intersection during peak periods.

T6.8 Travel delay cost estimates, 2006

	Number of crashes	Total travel delay cost (million dollars)	Cost per crash (dollars)
Melbourne and Sydney metropolitan areas			
Fatal crashes	258	5.2	20 000
Injury crashes	20 199	150.2	7 400
Property damage only crashes	23 273	165.7	7 100
Subtotal	43 730	321.0	7 300
Other capital city metropolitan areas			
Fatal crashes	277	5.3	19 000
Injury crashes	21 723	151.5	7 000
Property damage only crashes	49 309	266.6	5 400
Subtotal	71 309	423.3	5 900
Non-metropolitan areas			
Fatal crashes	257	5.5	21 400
Injury crashes	3 219	21.3	6 600
Property damage only crashes	3 664	20.5	5 600
Subtotal	7 140	47.3	6 600
Metropolitan and non-metropolitan areas			
Fatal crashes	792	15.93	20 100
Injury crashes	45 141	323.0	7 200
Property damage only crashes	76 246	452.8	5 900
Total	122 179	791.7	6 500

Note: Components may not add to totals due to rounding.

Source: BITRE National Crash Database; BITRE estimates.

6.2 Health costs of additional local air pollution

Delay caused by a road crash can result in additional time queuing in traffic with the engine running. This results in additional exhaust emissions to the atmosphere, contributing to local air pollution and imposing additional health costs on society (BTRE 2005).

BTRE (2007) estimated increased air pollution costs due to traffic congestion in Australian metropolitan cities. Based on these estimates, BITRE has used an average value of $0.03 per minute to estimate the additional health costs of the local air pollution emissions due to road crash induced traffic delays.

The health costs from increased local air pollution due to travel delay caused by road crashes in Australia for 2006 are presented in Table 6.9. The additional health costs amount to $53.3 million for 2006, or nearly 7 per cent of crash delay costs (Table 6.8).

T6.9 Estimated health costs of additional local air pollution, 2006

	Number of reported crashes likely to have resulted in delay	Estimated total additional health cost (million dollars)	Cost per crash (dollars)
Melbourne and Sydney metropolitan areas			
Fatal crashes	258	0.4	1 350
Injury crashes	20 199	10.1	500
Property damage only crashes	23 273	11.1	480
Subtotal	43 730	21.6	490
Other capital city metropolitan areas			
Fatal crashes	277	0.4	1 290
Injury crashes	21 723	10.2	470
Property damage only crashes	49 309	18.1	370
Subtotal	71 309	28.7	400
Non-metropolitan freeways			
Fatal crashes	257	0.4	1 410
Injury crashes	3 219	1.4	440
Property damage only crashes	3 664	1.4	370
Subtotal	7 140	3.2	440
Metropolitan and non-metropolitan areas			
Fatal crashes	792	1.1	1 350
Injury crashes	45 141	21.7	480
Property damage only crashes	76 246	30.6	400
Total	122 179	53.3	440

Note: Components may not add to totals due to rounding.

Source: BTRE (2007), BITRE National Crash Database; BITRE estimates.

6.3 Additional vehicle operating costs

The extra time spent in congested traffic caused by road crashes results in an increase in vehicle operating costs, including additional petrol use (BTRE 2005).

BITRE has used an average value of just under $0.03 per minute of delay to estimate the extra vehicle operating costs arising from crash-related travel delay, based on the estimated costs of traffic congestion in Australian metropolitan cities in BTRE (2007).

Table 6.10 presents BITRE estimates of the additional vehicle operating costs due to the travel delay caused by road crashes in Australia for 2006 of $48 million. These additional vehicle operating costs amount to 6 per cent of crash delay costs (Table 6.8).

T6.10 Estimated additional vehicle operating costs due to road crash induced travel delay, Australia, 2006

	Number of crashes	Total additional vehicle operating cost (million dollars)	Cost per crash (dollars)
Melbourne and Sydney metropolitan areas			
Fatal crashes	258	0.31	1 220
Injury crashes	20 199	9.06	450
Property damage only crashes	23 273	10.01	430
Subtotal	43 730	19.38	440
Other capital city metropolitan areas			
Fatal crashes	277	0.32	1 160
Injury crashes	21 723	9.19	420
Property damage only crashes	49 309	16.31	330
Subtotal	71 309	25.82	360
Non-metropolitan areas			
Fatal crashes	257	0.33	1 270
Injury crashes	3 219	1.26	390
Property damage only crashes	3 664	1.21	330
Subtotal	7 140	2.80	390
Metropolitan and non-metropolitan areas			
Fatal crashes	792	0.96	1 210
Injury crashes	45 141	19.51	430
Property damage only crashes	76 246	27.53	360
Total	122 179	48.01	390

Note: Components may not add to totals due to rounding.

Source: BTRE (2007), BITRE National Crash Database; BITRE estimates.

6.3 Costs of vehicle insurance administration

Motor vehicle-related insurance claims can arise from vehicle damage incurred in a road crash or elsewhere, the theft of the motor vehicle, specific cases of damage (for example, windscreen replacement or hail damage), and personal injury. This section estimates the costs of administering the motor vehicle property damage insurance system (costs associated with personal injuries are estimated in Chapters 3 and 4).

Insurance organisations providing insurance cover for motor vehicles incur expenses associated with administering the system and processing claims, including underwriting costs and general administration costs. BITRE has estimated the insurance overhead costs associated with motor vehicle damage using a top down approach based on the limited data available.

Australian Prudential Regulatory Authority (APRA) data for 2006 showed that gross claims expenses for commercial and domestic motor vehicle insurance were approximately $5.8 billion (excluding compulsory third party motor insurance), and that underwriting expenses and administration costs comprise on average 32 per cent of total expenses across all classes of insurer. Total expenses for motor vehicle claims were therefore estimated at $7.67 billion, of which underwriting and administration costs for motor vehicle property damage claims were approximately $1.8 billion (including costs such as legal costs and fire levies). BITRE adjusted this total to reflect ISA data that collision claims comprise 90 per cent of all the motor vehicle claims, and exclude fire levies.

BITRE estimates that the cost of vehicle-related insurance administration for 2006 was $1421.3 million. For all 1.16 million vehicles damaged in 2006 this amounts to approximately $1230 per motor vehicle property damage claim, or approximately $99 for every registered vehicle in Australia.

6.4 Cost of repairing street furniture

The cost of damage to non-vehicle property (often referred to as road furniture) due to road crashes is the estimated cost of repairs or replacement of crash damaged items. Non-vehicle objects were involved in approximately 3 per cent of reported crashes in 2006. These objects include light or telephone poles, sign or signal poles, buildings or structures, kerbs or guard rails, signs, guide posts and other items including trash bins.

BITRE estimated the cost of road furniture damage based on the number and type of items reported damaged by type of crash in the ACT, and various data on repair and replacement costs published by state and territory governments. BITRE assumed that the cost of damage to long-lived, relatively high value assets such as structures was 8 per cent of the replacement value of the asset. Low value items such as street signs were assumed to require replacement.

BITRE estimates that the cost of crash-related street furniture damage in 2006 was $40.2 million.

6.5 Costs of the emergency services response

Police, ambulance services and fire services all participate in responding to a road traffic accident. In some jurisdictions, services like the Rural Fire Service, Country Fire Authority and the State Emergency Service can also have roles in responding to road crashes. BITRE has assumed that police respond to 22 per cent of reported property damage-only crashes, ambulance services do not respond to property damage-only crashes, and fire services only respond to a portion of reported property damage only crashes.

This section presents estimation methodologies and the resulting estimated costs for property damage only crashes (emergency services costs related to fatalities and injuries are estimated in Chapters 3 and 4 respectively).

Fire Services

BITRE estimated the cost of fire emergency responses for metropolitan areas using data provided by the Victorian Metropolitan Fire and Emergency Services Board. BITRE estimated the cost for metropolitan Melbourne to be, on average, $3004. Similar data from the Victorian Country Fire Authority showed that non-metropolitan responses to be approximately 10 per cent above the equivalent metropolitan response. Data from South Australia, the NSW Rural Fire Service and the Steering Committee for the Review of Government Service Provision (SCRGSP) (2009) resulted in similar estimated values.

An average Australian wide value of $3166 dollars per road crash incident was used by weighting the average metropolitan and non-metropolitan values.

The SCRGSP (2009) showed that road rescues make up close to 5 per cent of the incidents attended by fire and emergency services. The SCRGSP (2009) also presented data by state for road rescue incidents attended and road rescue extrications. BITRE assumed all extrications involved either a fatal or injury crash, and that fire services responded to every fatal crash. The difference between road crash extrications and road rescue incidents attended is assumed to be the number of non-casualty crashes (or property damage only crashes) attended by fire services.

While fire and emergency services are unlikely to be required for most property damage-only crashes, cases where this is essential includes fires at road crash sites and cases where hazardous materials need to be contained and 'cleaned up'.

BITRE estimates that the total cost of fire and emergency services attending road crashes in 2006 was $66.7 million.

Police Services

Police services spend hours on crash investigation and recording services. Hours were estimated by aggregating the total time of on-site interviews, inspection, measurements at the crash site, writing notes, management and other on-site activities and off-site activities as well as the hourly cost of equipment used by police (Howard, Young and Ellis 1977). The costs per hour for police services are based on costs quoted in the NT Government Budget Papers (NT, 2004).

In 2006, the estimated average cost of police services per property damage-only crash was $1374 and BITRE has assumed that police attended 22 per cent of reported property damage-only crashes. The estimated cost of police services for property damage-only road crashes is $38.1 million.

6.6 How do other costs in 2006 compare to 1996?

Insurance overhead costs for vehicle property damage dominate the other cost components at an estimated $1 421 million in 2006. This is significantly more than 1996 ($880 million in 2006 dollars). The main reasons for this increase are:

- 29 per cent growth in the pool of insured vehicles between 1996 and 2006 (an increase of at least $255 million).
- BITRE did not have data needed to separate property damage-only legal costs from general insurance administration costs. These were excluded from legal costs estimates to avoid double counting. BTE (2000) included estimates of property damage legal costs in total legal costs.

The estimated travel delay related costs for 2006 totalled $890 million, comprising $792 million in delay costs, $52 million in the health costs of additional local air pollution, and $48 million from increased vehicle operating costs.

These results need to be treated with caution; risk modelling of uncertainty surrounding travel delays suggests that the estimated delay cost is conservative, and that the delay cost is between $500 million to $1.76 billion (95 per cent confidence interval).

CHAPTER 7
The economic and social costs of road crashes

This final chapter brings together road crash costs estimated in Chapters 3 to 6, presenting estimates by cost component, crash severity, jurisdiction, and how they impact different stakeholders.

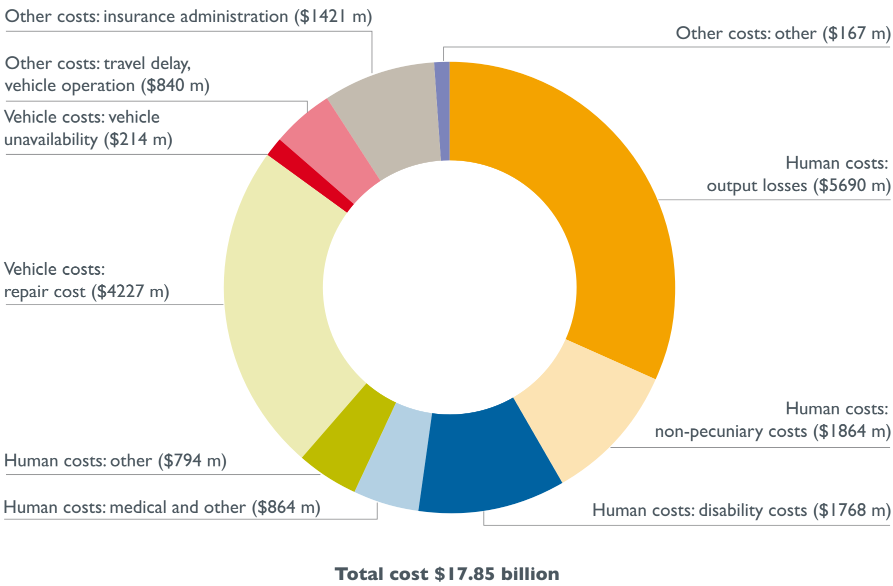
This chapter also compares road crash costs for 2006 with 1996 and suggests future work to improve the quality of cost estimates.

7.1 Social costs of road crashes in 2006

The estimated cost of road crashes was $17.85 billion or 1.7 per cent of GDP in 2006. A breakdown by major cost component is shown in Figure 7.1.

Human losses (workplace and household losses, non-pecuniary and disability costs) and related costs (compulsory third party insurance, ambulance and medical costs) represented 61.5 per cent of the total cost of road crashes in 2006.

F7.1 Social cost of road crashes by component, 2006



Source: BITRE estimates.

Workplace and household losses were the largest cost component in 2006 (Table 7.1), vehicle repair costs ranked second and disability-related costs ranked third.

Four costs were estimated that were not estimated for 1996 (BTE 2000). These were the health costs of additional local air pollution, higher vehicle operating costs for vehicles due to crash-induced congestion, workplace and household losses due to imprisonment for culpable driving causing death, and a (non-pecuniary) value for pain, grief and suffering for friends and relatives. These additional costs added approximately 1 per cent to the cost of crashes in 2006.

T7.1 Estimated social costs of road crashes in Australia by cost element, 2006

Cost element	Human related costs					
	Fatalities ($millions)	Hospitalised injuries ($millions)	Non-hospitalised injuries ($millions)	Property damage and general costs ($millions)	Total crash cost ($millions)	Proportion (per cent)
Workplace and household losses	3007.2	2 573.9	108.9	na	5 690.0	31.9
Repair costs	na	na	na	4 227.5	4 227.5	23.7
Disability-related costs a	na	1 863.9	na	na	1 863.9	10.4
Non-economic or non-pecuniary costs	728.3	1 039.7	na	na	1 768.0	9.9
Insurance administration	13.2	256.5	na	1 421.3	1 691.0	9.5
Medical and related costs	3.4	511.4	349.5	na	864.2	4.8
Travel delay and vehicle operating costs	na	na	na	839.7	839.7	4.7
Legal costs	36.5	231.3	na	na	267.9	1.5
Vehicle unavailability costs	na	na	na	214.1	214.1	1.2
Emergency and police services cost	7.6	62.6	na	72.9	143.1	0.8
Work place disruption	10.3	77.7	na	na	88.0	0.5
Ambulance	3.6	59.9	na	na	63.5	0.4
Health cost of crash-induced pollution	na	na	na	53.4	53.4	0.3
Street furniture damage cost	na	na	na	40.2	40.2	0.2
Correctional services	15.3	na	na	na	15.3	0.1
Recruitment and re-training	6.6	2.5	na	na	9.2	0.1
Premature funeral cost	7.2	na	na	na	7.2	0.0
Coronial costs	3.1	na	na	na	3.1	0.0
Total	3 842.4	6 679.5	458.3	6 869.1	17 849.3	100.00

Note: Components may not add to totals due to rounding.

na not applicable.

a Disability-related costs include the costs of future care, specialist accommodation, therapy and specialist services, day programs, specialist equipment and alterations to houses.

Source: BITRE estimates.

Road crash costs vary across jurisdictions due to both variability in the number of crashes and the cost of services/materials (Table 7.2).

T7.2 Estimated social cost of road crashes by cost type and jurisdiction, million dollars, 2006

Cost component	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Australia
Human cost of:									
fatalities	1187.4	817.1	827.7	275.0	481.3	113.7	108.4	31.7	3842.4
hospitalised injuries	2182.6	1760.6	1280.2	513.2	534.6	166.6	100.1	141.7	6679.5
non-hospitalised injuries	149.8	120.8	87.8	35.2	36.7	11.4	6.9	9.7	458.3
Vehicle and general costs	2216.3	1731.1	1353.0	519.4	621.9	178.4	123.3	125.6	6869.1
Total	5736.0	4429.7	3548.7	1342.8	1674.5	470.2	338.7	308.8	17849.3

Note: Components may not add to totals due to rounding.
Source: BITRE estimates.

Table 7.3 presents estimated crash costs for capital cities, other urban areas and rural areas.[71] In 2006, 53.2 per cent of 2006 road crash costs were attributable to crashes in capital cities, with a further 20.5 per cent for crashes in other urban areas. Rural crashes accounted for 26.2 per cent of total crash costs. However, rural areas accounted for over half (50.8 per cent) of fatal crash costs.

T7.3 Estimated social cost of road crashes in Australia by crash outcome, jurisdiction and region, million dollars, 2006[a]

Crash type	Region	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Total
Fatal	Capital city	365.2	325.0	232.1	114.6	165.6	18.7	18.7	10.6	1250.5
	Other urban	202.6	125.2	186.7	18.7	77.5	21.3	24.1	0.0	656.0
	Rural	629.1	373.0	416.1	143.9	243.1	74.7	66.8	21.3	1967.9
	Subtotal	1196.8	823.2	834.9	277.2	486.1	114.7	109.6	31.9	3874.4
Hospitalised injury	Capital city	1313.6	1218.6	602.1	349.5	398.3	28.5	50.1	90.4	4051.2
	Other urban	514.1	262.0	459.3	41.9	66.1	36.0	22.7	0.0	1402.1
	Rural	407.5	321.3	250.4	134.0	84.2	106.2	30.0	54.4	1388.0
	Subtotal	2235.1	1801.9	1311.8	525.5	548.7	170.8	102.8	144.7	6841.3
Non-hospitalised injury	Capital city	532.2	493.8	244.0	141.6	161.4	11.6	20.3	36.6	1641.4
	Other urban	208.3	106.1	186.1	17.0	26.8	14.6	9.2	0.0	568.1
	Rural	165.1	130.2	101.5	54.3	34.1	43.0	12.1	22.0	562.4
	Subtotal	905.6	730.1	531.6	212.9	222.3	69.2	41.6	58.6	2771.8
Property damage only	Capital city	871.3	660.1	361.5	218.4	314.9	32.0	41.1	58.7	2557.9
	Other urban	310.3	230.8	359.8	25.9	60.1	30.0	17.0	0.0	1033.8
	Rural	217.0	183.6	149.2	83.0	42.4	53.6	26.7	14.8	770.1
	Subtotal	1398.5	1074.4	870.4	327.2	417.4	115.5	84.7	73.5	4361.8
All crashes	All regions	5736.0	4429.7	3548.7	1342.8	1674.5	470.2	338.7	308.8	17849.3

Note: Components may not add to totals due to rounding.
a Region categories are based on the ABS Urban/Locality coding for the 2006 Census. Darwin includes crashes in both Darwin and Palmerston urban centres. BITRE has defined non-capital city urban areas as centres having a population of 1000 or more, and rural areas to include localities of 200–999 people.
Source: BITRE estimates.

The estimated cost of a fatal crash in 2006 was $2.67 million (Table 7.4). Hospitalised injury crashes cost approximately $266 000 per crash and non-hospitalised injury crashes cost approximately $14 700 per crash. A property damage-only crash cost approximately $9950 per crash.

71 Other urban areas have been defined as non-capital city urban areas with a population of 1000 people or more. Rural areas include population centres of less than 1000 people.

T7.4 Estimated average costs of road crashes by crash outcome and jurisdiction, dollars, 2006

Jurisdiction	Fatal crash	Hospitalised injury crash	Non-hospitalised injury crash	Property damage only crash
New South Wales	2 667 484	265 670	14 723	9 979
Victoria	2 670 591	265 430	14 709	10 075
Queensland	2 664 622	266 016	14 740	9 867
South Australia	2 667 755	265 619	14 722	9 988
Western Australia	2 660 398	266 815	14 784	9 632
Tasmania	2 663 817	266 000	14 747	9 831
Northern Territory	2 658 492	267 157	14 818	9 506
Australian Capital Territory	2 693 284	264 677	14 667	10 433
Australia	2 666 511	265 770	14 728	9 942

Note: Components may not add to totals due to rounding.
Incident data used in these estimates are primarily based on estimates in Table 2.9 of Chapter 2 for fatalities and injuries, and Tables 2.7 and 2.11 for property damage crashes.

Source: BITRE estimates.

BITRE estimates that crashes resulted in an estimated 4619 new cases of people suffering a disability in 2006. Table 7.5 presents costs by level of impairment.

T7.5 Estimated losses from crash-related disability by impairment level, 2006

Level of impairment	Per person
Profound	3 822 447
Severe	1 780 681
Moderate	541 717
Mild	125 513

Source: BITRE estimates.

Table 7.6 gives estimated crash costs by jurisdiction on a vehicle kilometre travelled basis. Costs per kilometre travelled were substantially higher for motorcycles. This reflects both the level of motorcycle involvement in crashes and the fatality and injury outcomes for this vulnerable road user group.

T7.6 Estimated social cost of road crash costs by vehicle type, cents per vehicle kilometre travelled, 2006

Vehicle type	Australia
Cars (including light commercial vehicles)	8.3
Motorcycles	20.2
Buses	6.1
Rigid trucks	4.8
Articulated trucks	4.0
All vehicles	8.1

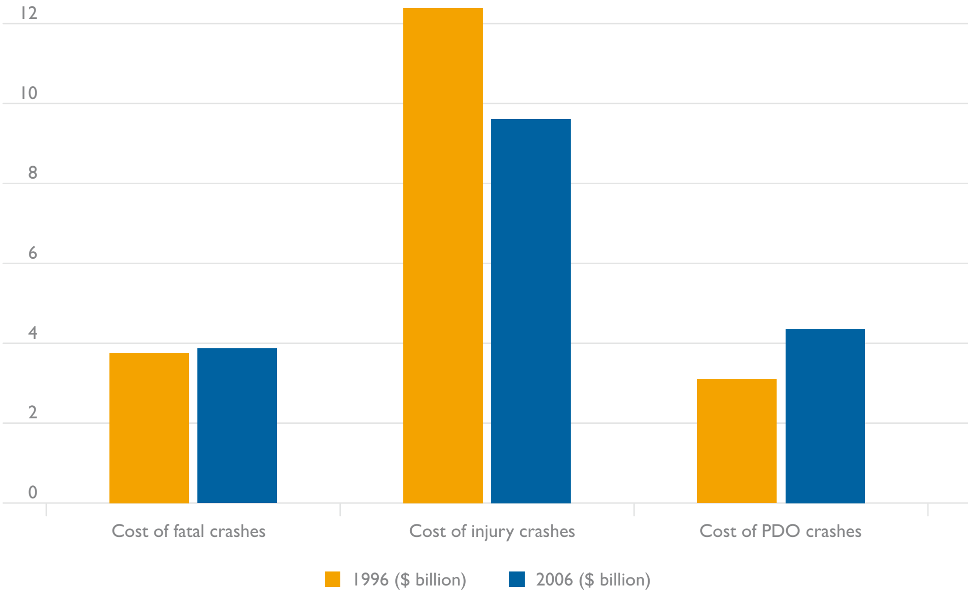
Source: BITRE estimates.

7.2 Changes in crash costs between 1996 and 2006

The social cost of road crashes was estimated to be $17.85 billion in 2006, a real decrease of 7.5 per cent compared to 1996 (2006 dollars). The reduction in fatalities was offset by increasing value of workplace and household losses.

Figure 7.2 compares the costs of fatal crashes, injury crashes and property damage crashes for 2006 and 1996 (2006 prices).

F7.2 Social cost of road crashes by crash outcome, 1996 and 2006 (billions, 2006 dollars)



Source: BITRE estimates.

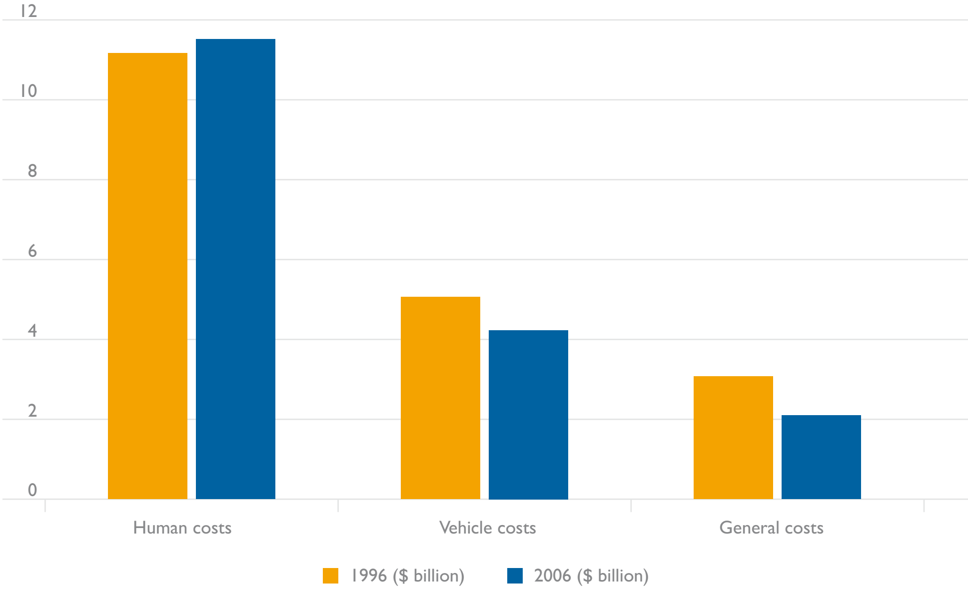
Factors contributing to the change in crash costs include:

- reduced numbers of road fatalities due to effective safety and infrastructure programs, and better vehicle technology
- changes to the 1996 disability costing methodology to exclude double counting
- increases in the real cost of hospital and emergency services
- improvements to the estimation of travel time delays, reducing the cost of travel delays resulting from road crashes
- increased insurance administration costs for vehicle damage, largely due to increasing numbers of registered vehicles
- a decrease in legal costs since 1996.

Many jurisdictions have changed compulsory third party schemes to simplify claims processes, reduce the number of disputed compensation claims and lessen reliance on court processes. In addition, legal costs for property damage-only crashes have not been estimated as there was insufficient data to exclude these costs from insurance administration costs.

Figure 7.3 compares 2006 estimates of the human, vehicle-related and general cost categories with 1996 (BTE 2000).

F7.3 Social costs of road crashes by cost group, 1996 and 2006 (billions, 2006 dollars)



Source: BITRE estimates.

The cost of fatal crashes was $3.87 billion, injury crashes $9.61 billion and property damage crashes $4.36 billion (Table 7.7). Injury crashes accounted for 53.9 per cent of total crash costs in 2006 compared with 64.1 per cent in 1996.

T7.7 Social cost of road crashes by cost group, Australia, 1996 and 2006

Road crash consequence	1996 crash costs (billion dollars, 2006 prices)	Proportion of costs in 1996 (per cent)	2006 crash costs (billion dollars, 2006 prices)	Proportion of costs in 2006 (per cent)
Fatalities	3.81	19.7	3.87	21.7
Injuries	12.36	64.1	9.61	53.9
Vehicle and other costs	3.13	16.2	4.36	24.4
Total	19.29	100.0	17.85	100.0

Note: Components may not add to totals due to rounding.

Source: BITRE estimates.

Table 7.8 gives a detailed breakdown of crash cost estimates for 1996 and 2006.

Costs that significantly decreased compared to 1996 (in 2006 dollars) were travel delay costs ($1.02 billion), vehicle repair costs ($832 million), legal costs ($779 million), disability-related costs ($699 million), and non-pecuniary losses ($510 million). Non-pecuniary or intangible losses include the quality of life a person would have enjoyed had they not died prematurely, and (for 2006 only) the pain, grief and suffering of relatives and friends.

The change in disability costs reflects both a more detailed methodology, the removal of welfare transfer payments to avoid possible double counting, and the addition of the cost of carers for people with a disability (for profound, severe and moderate impairments). Reduced repair costs reflect lower average claims and repair values for passenger vehicles.

Legal costs have decreased substantially since 1996. Many jurisdictions have changed compulsory third party schemes to simplify compensation claims processes, reduce the number of disputed claims and lessen reliance on court processes. In addition, legal costs for property damage cases have not been estimated for 2006 as there was insufficient data to exclude these from insurance administration costs.

Costs that significantly increased compared to 1996 (in 2006 dollars) were workplace and household losses ($1.7 billion), insurance administration ($498 million), and medical costs ($399 million). Vehicle-related insurance administration costs increased in real terms by 41.8 per cent between 1996 and 2006, largely reflecting a larger vehicle fleet.

T7.8 Social cost of road crashes by component, Australia, 1996 and 2006, million dollars

	1996 crash costs (2006 dollars)	Proportion of costs in 1996 (per cent)	2006 crash costs (2006 dollars)	Proportion of costs in 2006 (per cent)
Output losses	4015.9	20.8	5690.0	31.9
Repair costs	5059.2	26.2	4227.5	23.7
Disability cost	2563.1	13.3	1863.9	10.4
Non-pecuniary costs	2278.4	11.8	1768.0	9.9
Insurance administration	1192.7	6.2	1691.0	9.5
Medical and other related costs	465.0	2.4	864.2	4.8
Travel delay and VOC	1861.1	9.7	839.7	4.7
Legal costs	1047.1	5.4	267.9	1.5
Vehicle unavailability costs	234.4	1.2	214.1	1.2
Emergency and police services cost	108.2	0.6	143.1	0.8
Work place disruption	403.1	2.1	88.0	0.5
Ambulance	nse	0.0	63.5	0.4
Health cost of additional local air pollution	ne	0.0	53.4	0.3
Street furniture damage cost	38.6	0.2	40.2	0.2
Correctional services	21.9	0.1	15.3	0.1
Recruitment and re-training	0.0	0.0	9.2	0.1
Premature funeral cost	3.9	0.02	7.2	0.04
Coronial costs	1.3	0.01	3.1	0.02
Total	19293.9	100.0	17849.31	100.0

ne not estimated.

nse not separately estimated.

Notes: In 1996, disability costs included certain disability payments that have been excluded in the 2006 estimates. In 1996 ambulance costs were included with medical and other related costs. 2006 repair costs include light vehicle towing costs.

Components may not add to totals due to rounding.

Source: BITRE estimates.

7.3 Sensitivity of 2006 estimates

The total cost of road crashes is sensitive to factors that change the estimated cost of vehicle repairs and workplace and household losses. These include the number of damaged vehicles, the social discount rate, and the choice of a willingness-to-pay approach or human capital approach to value human losses.

Other factors include the availability and quality of data—of particular importance to estimated insurance overhead costs and costs of travel delay.

The sensitivity of crash costs was tested with respect to changes in repair costs by varying the number of cars and light vehicle damaged in injury crashes by +/–10 per cent. Total costs increased/decreased by less than 0.5 per cent.

Human capital–based estimates of the losses to society are sensitive to factors such as the discount rate, the average age of fatalities and gender proportion in the fatality mix, and average earnings. However, previous research (de Silva et al, 2008) and preliminary analysis using road fatality data for five years up to 2006 showed that the latter three variables did not significantly influence the cost of road crashes in 2006.

BITRE estimated workplace and household losses for 2006 using a discount rate of 3 per cent. Table 7.9 shows the sensitivity of crash costs to discounting workplace and household losses at different discount rates.

A discount rate of 2 per cent would increase total crash costs by approximately $1.5 billion (8.4 per cent), whereas a discount rate of 5 per cent rate would decrease total crash costs by approximately $2 billion (11.2 per cent).

T7.9 Sensitivity of 2006 road crash cost estimates to changes in the real discount rate

Cost component	Alternate discount rate of 2 per cent		2006 crash costs at a 3 per cent discount rate		Alternate discount rate of 5 per cent	
	($ billion)	(per cent)	($ billion)	(per cent)	($ billion)	(per cent)
Fatal crashes	4.6	23.6	3.9	21.7	2.9	18.4
Injury crashes	10.4	53.8	9.6	53.9	8.5	53.8
Property damage only crashes	4.4	22.5	4.4	24.4	4.4	27.8
Total	19.3	100.0	17.8	100.0	15.8	100

Note: Components may not add to totals due to rounding.

Source: BITRE estimates.

BITRE estimated the losses to society of premature death, injuries and disability using a modified human capital approach. If a willingness-to-pay to valuing approach had been used to value the human losses from road crashes, then this could have increased the total cost of road crashes by between approximately 17 and 52 per cent (Table 7.10).

T7.10 Sensitivity of 2006 road crash cost estimates to the use of willingness-to-pay approach to value human losses, 2006 Australian dollars

Approach to valuing premature death	Cost of fatalities (billions)	Cost of injury and disability (billions)	Cost of property damage and other costs (billions)	Total road crash cost, billions (2006 prices)	Change in 2006 Australian road crash cost if using willingness-to-pay value (per cent)
BITRE human capital based estimate 2006	3.84	7.14	6.87	17.85	–
Willingness-to-pay (New Zealand)	6.00	7.94	6.87	20.81	16.6
Willingness-to-pay (United Kingdom)	6.77	9.47	6.87	23.11	29.5
Willingness-to-pay (United States)	8.86	8.63	6.87	24.35	36.4
Willingness-to-pay (Australia a)	9.91	10.34	6.87	27.12	52.0

a Based on a Hensher, Rose, de Ortúzar and Rizzi (2009) estimate for 2007.

Source: International Road Assessment Program (2004); Hensher et al (2009); BITRE estimates.

The costs of injury and disability in Table 7.10 are estimated using a value for quality adjusted life years calculated by dividing the willingness-to-pay value of life by the years lost for a premature fatality (Abelson 2007).

7.4 Concluding observations

BITRE's assumptions in the analysis of road crash costs in this report are generally conservative and therefore tend to underestimate the cost to society of road crashes in Australia in 2006.

The report provides information essential to evaluate safety programs. The average crash values are important values used to assess the benefits of safety programs from avoiding road crash trauma.

Important areas for research include better data on:

- the incidence of unreported road crashes
- the incidence of non-hospitalised injuries resulting from crashes
- the incidence of property damage only road crashes
- the level of disability resulting from crash-related injury and impairment.

Although road crash costs vary by road type (Maunsell Australia Pty Ltd 2003, Cameron 2003), there was limited data on crash severity by road type. This is an area for future research.

APPENDIX A

Estimating the numbers of crashes and vehicles involved

The number of road crashes is an important parameter needed to estimate the cost to society of road crashes.

There is a large difference between the number of crashes and vehicles reported involved in police crash records, and the number of collision claims paid by insurers (and implied number of crashes).

As crash severity decreases, police are far less likely to be involved. Further, reporting of property damage-only crashes is not compulsory. Some jurisdictions do not require drivers to report crashes where there is no injury, whilst in other jurisdictions property damage-only crashes only need to be reported if damage exceeds a set threshold.

Previous estimates of the number of crashes have used a variety of data sources and methods (Table A1).

TA.1 Comparison of crash estimation methodologies

Report	Base year	Estimated cost	Number of casualty crashes	Non-fatal casualties	Method for estimating non-fatal casualty crashes	Total number of crashes	Method used to estimate crashes
Atkins	1978	1 591 (unadjusted)	71 334	97 685	Crash data (ABS)	556 823	Casualty(1) to PDO (6.8)
BTCE	1985	5 000 (unadjusted)	165 684 52 333 a	228 864	Crash data x 2.39 based on data from the predecessor of the Transport Accident Commission of Victoria	671 976	Casualty(1) to PDO (7)
BTCE	1988	6 131 (unadjusted)	21 984 b	96 947	Crash data (ABS)	590 852	As per Atkins
BTE	1996	14 980 (unadjusted)	19 280 c	235 311	Crash data (FORS) Minor estimated using ratio of 1:3.53:3.88	618 600	Used vehicle estimates from insurance data.
BITRE	2006	17 849	18 581 d	247 704	Hospitalised injury (Berry & Harrison 2008); Non-hospitalised injury (BITRE estimates)	653 800	–

PPO Property damage only.
a Adjusted to the definition used by BTE (2000).
b Fatal and hospital admission crashes.
c BTE (2000) count of fatal and serious crashes, where a serious injury crash resulted in at least one person being hospitalised for one or more nights.
d Includes 1455 fatal crashes and 17 126 crashes resulting in an injury requiring hospitalisation for one or more nights.
Source: Atkins (1981); BTCE (1988); BTCE (1992); BTE (2000); BITRE (2009).

BITRE has used a different approach to BTE (2000), which estimated the numbers of road crashes using insurance data.

Insurance Statistics Australia[72] provided valuable data on the number of comprehensive insurance 'collision' claims for passenger vehicles in 2006. These data excluded claims for windscreen damage and theft, but included claims for hail and fire damage. A separate industry source provided data on the costs of truck repairs. Insurance information for most other vehicle types was lacking.

However, it was not possible to exclude 'off road' crashes, such as low speed car park collisions. There was also an unknown level of double counting due to the fact that a claim for one vehicle may be recorded by more than one insurer, where an amount has been recovered from the insurer of the at fault party.

72 Insurance Statistics Australia Limited (ISA) is a collaboration of several large most 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.

Further, comprehensive insurance claims data has an underlying bias towards collisions involving more expensive vehicles and persons with protected no claim bonuses. The frequency of crashes for low value and uninsured vehicles is believed to be significantly higher than for high value, comprehensively insured vehicles.

Finally, the distribution of claims across jurisdictions differed significantly from the distribution of registered vehicles. This may reflect different propensities to make insurance claims and/or reflect a lack of coverage among insurance companies in some jurisdictions.

BITRE has used insurance data and jurisdictional crash data to estimate the total numbers of road crashes and vehicles involved in crashes. BITRE's national crash database for 2006 includes detailed records for all severity and standardised vehicle type crashes. Crashes were classified into fatal, injury and property damage only categories. Vehicle types were cars (including light commercial vehicles); motorcycles; buses; rigid trucks and articulated trucks.

BITRE has estimated an additional number of property damage-only crashes and vehicle involvement using a variety of crash ratios, data sets and assumptions using the following steps:

1. Property damage-only were estimated for Victoria based upon average crash ratios for all other jurisdictions.
2. The higher property damage-only ratio for Western Australia was combined with vehicle kilometres travelled (VKT) by jurisdiction to estimate additional property damage-only crashes for all other jurisdictions. Western Australia had a relatively high rate of property damage-only crashes in 2006. This appeared to be the result of Western Australia having the lowest reporting threshold ($1000) for property damage-only crashes.
3. A further estimate of additional unreported crashes was made using insurance claims data. Firstly, the number of car insurance claims was adjusted to include only cars involved in crashes on public roads. This was adjusted down using data from Berry and Harrison (2008) that 67.1 per cent of injuries presenting at the hospital due to vehicle collisions in 2005–06 occurred on public roads. Secondly, the number of cars in reported crashes was removed and the residual number of cars assumed to be involved in property damage-only crashes. Thirdly, this residual number of cars was converted to unreported property damage-only crashes using the ratio of cars in reported property damage-only 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.
4. The number of motorcycle property damage-only crashes was also adjusted to reflect De Rome and Brandon's (2007) finding that only 55 per cent of motorcycle riders involved in a serious crash reported the crash.

Abbreviations

AIHW	Australian Institute of Health and Welfare
AIS	Abbreviated Injury Scale
ABS	Australian Bureau of Statistics
ATSB	Australian Transport Safety Bureau
BITRE	Bureau of Infrastructure, Transport and Regional Economics (formerly the Bureau of Transport and Regional Economics)
BTCE	Bureau of Transport and Communications Economics
BTE	Bureau of Transport Economics
BTRE	Bureau of Transport and Regional Economics
CARS	Community Attitudes to Road Safety
c/ntk	cents per net tonne kilometre
GDP	Gross domestic product
HCA	Human capital approach
Infrastructure	Department of Infrastructure, Transport, Regional Development and Local Government (formerly the Department of Transport and Regional Services)
ntk	Net tonne kilometre
OECD	Organisation for Economic Cooperation and Development
TAC	Transport Accident Commission (Victoria)
VKT	Vehicle kilometres travelled
WTP	Willingness-to-pay
YLD	Years lost due to disability

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