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# Social Cost of Road Crashes

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## Abstract

Road crashes impose large human and financial costs on society. BITRE (2010) has estimated that the social cost of road crashes to Australia was $17.85 billion in 2006 (1.7 per cent of GDP).

Human losses—estimated using BITRE's hybrid human capital approach—were 61.5 per cent of the total cost of crashes. 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.

The unit values are key inputs into policy development and cost-benefit analysis for safety programs and infrastructure projects. BITRE's estimated human losses were $2.4 million per fatality, $214 000 per hospitalised injury (including disability-related costs), and $2100 per non-hospitalised injury.

A key objective was to make BITRE's estimates more useful to policymakers, road safety practitioners, and the wider community. This paper outlines changes and refinements to crash costing methods, data issues and limitations, and the implications for future updating of crash values.

## 1. Introduction

A road crash is a crash involving a road vehicle on a public road (ATSB 2004).[1] The term 'crash' rather than 'accident' is used as collisions are generally avoidable and not the result of chance. A road fatality is a death resulting from a crash on a public road where unintentional death occurs within 30 days from injuries sustained in the crash (DITRDLG 2009).

For non-fatal injuries there is no common definition across Australia of serious and minor injury. Hospital admission data has become the primary source of information about seriously-injured crash casualties. This has the advantage that casualties admitted to hospital are classified medically, and data are also more likely to record pedestrian, cyclist and motorcyclist casualties. However, hospital data gives no direct link between a hospital admission and a crash. While monthly fatality[2] data is available promptly, hospital data complexities mean that it takes years to produce estimates of annual hospitalised injuries, limiting its usefulness for monitoring trends in road safety.

BITRE (2010) has classified non-fatal casualties as either hospitalised—persons admitted to hospital regardless of their length of stay—or non-hospitalised. The latter group includes

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[1] This definition of a road crash excludes suicides and homicides; events indirectly related to a road crash; off-road crashes; and events involving only non-road vehicles.

[2] Preliminary data of fatalities is available in BITRE's (2010b) publication Road Deaths Australia, April 2010 (. The latest available hospitalised injuries data for 2006-07 was published in December 2009 (Henley and Harrison 2009).

people who attended hospital but were not admitted and people treated by a general practitioner, but excludes people who did not seek medical treatment.

This classification of injuries is different to the approach used in previous Bureau reports (BTE 2000 and BTCE 1988) and this has important implications for the average cost of injuries.

In 2006 there were an estimated 653 853 road crashes involving approximately 1.16 million vehicles. This compares with an estimated 618 600 crashes involving approximately 1.13 million vehicles in 1996 (BTE 2000).

Fatalities were significantly lower, with 1602 people dying as a result of crashes in 2006, compared with 1970 people in 1996.

While the number of people hospitalised one night or more was similar (31 204 people admitted to hospital in 2005-06, of which 20 958 stayed one night or more—down from 21 189 who stayed one night or more in 1996), the number of people with a disability increased by 15.6 per cent (4619 people in 2006—up from an estimated 3997 in 1996).

The number of people with profound and severe limitations increased by 22.2 per cent (1270 people in 2006, compared with BTE's (2000) estimate of 1039 for 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.

# 2. Methodology

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); vehicle damage costs; and general costs such as insurance administration and emergency services costs.

This is a partial analysis focussed on the economic and social costs of crashes. The general assumption is that resources 'saved' by investing in safety projects that prevent crashes are put to productive use elsewhere in the economy.

The estimation of crash costs is an inexact science (BTE 2000). The magnitude of estimates depends on the approach used—typically a 'willingness to pay' or a 'human capital' based approach—as well as the quality and availability of data.

## 2.1. BITRE's approach to costing human losses

The willingness-to-pay and human capital approaches are alternative approaches generally used for valuing the fatality and injury components of road crashes. BITRE (2010) used its modified human capital costing approach used in its previous work (BTCE 1988, BTCE 1992, BTE 1999 and BTE 2000), which is generally agreed to give a conservative estimate of costs.

BITRE (2010) modified human capital approach:

- included a notional amount for quality of life for the current and future enjoyment of life by the unknown individual(s) whose life may be saved.
- assigned a notional value to the losses due to the death of a child to reflect the child's enjoyment of consumption proxied by the parent's expenditure on raising a child. In doing so, an 'economist is not testifying to the value of a child' (Ireland 1991, p.242).

- added an allowance for the family and relatives of the deceased for the pain, grief and suffering that they endure.[3]

Despite these additions, this modified human capital approach still produces values that are significantly lower in magnitude than suggested by most willingness-to-pay studies.

In principle, Australian studies using the willingness to pay approach are preferred to determine the value of specific safety improvements in Australia. Such studies need to be context specific. In practice, willingness-to-pay values are often taken from studies in other countries, 'averaged' across society and unlikely to reflect the preferences of specific individuals or groups.

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 (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. It recommended sensitivity analysis be undertaken.

BITRE (2010) used sensitivity testing to show the effect of higher willingness-to-pay values.

## 2.2. Costing components

Costs are broadly grouped into human related costs (fatalities and injuries), property damage and general costs (Table 1).

**Table 1: Components of the cost of road crashes**

| *Fatality costing* | *Injury costing* | *Vehicle and other costs* |
|---|---|---|
| Workplace and household losses | Workplace and household output losses | Vehicle repairs and towing |
| Quality of life | Medical and other related costs | Vehicle unavailability |
| Pain, grief and suffering | Ambulance costs | Travel delay |
| Ambulance, police and other emergency | Emergency services costs | Health costs of local air pollution |
| Hospital and medical | Long-term care cost | Additional vehicle operating costs |
| Coronial costs | Insurance administration cost | Vehicle insurance administration |
| Premature funeral | Legal costs | Repairing street furniture |
| Workplace disruption and replacement | Work place disruption costs | Costs of emergency services response |
| Insurance administration | Recruitment and re-training costs | |
| Correctional services | Pain and suffering of people injured in crashes | |
| Legal costs | | |

Source: BITRE 2010

BITRE (2010) made a number of changes to the costing methodology used by BTE (2000):

- fatality costs now include workplace and household losses due to imprisonment of persons found guilty of culpable driving causing death, the resource costs of imprisoning these persons, and the non-pecuniary value for pain, grief and suffering of family and friends.

3 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.

- injury costs have been extended to consider impairment and disability costs related to the type of injury; the cost of carers for those with disabilities; and the premature death of people with profound disabilities.
- travel delay costs extended to more crashes and to model uncertainty of key parameters.
- Adding estimates of the health costs of additional local air pollution and the additional vehicle operating costs resulting from the delays caused by road crashes.

## 2.3. Key parameters

The present value of the uncertain stream of future benefits or losses has been calculated by discounting the risk-adjusted expected stream of output using a risk-free discount rate. Benefit and loss streams have been adjusted prior to discounting for the following factors:

- life expectancy (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).

BITRE (2010) used a risk-free real discount rate of 3 per cent consistent with its previous transport safety costing studies (BTRE 2006).[4]

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).

## 2.4. Casualty and crash data

Key data in the estimation of crash costs are the number of fatal and non-fatal casualties, the number of crashes, and the number of vehicles damaged.

There were 1602 road fatalities in 1455 crashes in 2006. A fatal crash resulted in an average of 1.1 deaths and involved on average 1.3 vehicles. Most fatal crashes involved a single death and a single vehicle.

Unlike fatalities, data on the number of people injured in crashes in Australia is not systematically collected and various studies have identified substantial underreporting in official crash data. BITRE (2010) estimates that there were approximately 249 306 people killed or medically treated for injuries received in road crashes in 2006 (Table 2).

**Table 2: Estimated 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 |

44 This discount rate falls within the range of 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).

| | |
|---|---|
| Not hospitalised[c,d] estimate | 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 (see Note (d) in Table 2.3, BITRE (2010).
Source: BITRE (2010)

Similarly, there was under-reporting of crash numbers. BITRE (2010) estimated vehicle numbers involved in crashes, then combined this estimate with crash ratios from reported crashes and estimates of vehicle kilometres travelled to estimate the number of crashes.[5] Only 24 per cent of the estimated 653 853 crashes in 2006 were reported to road authorities.

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

# 3. Fatality costing

The cost of fatalities in 2006 was approximately $3.8 billion, or 21.5 per cent of the social cost of road crashes.

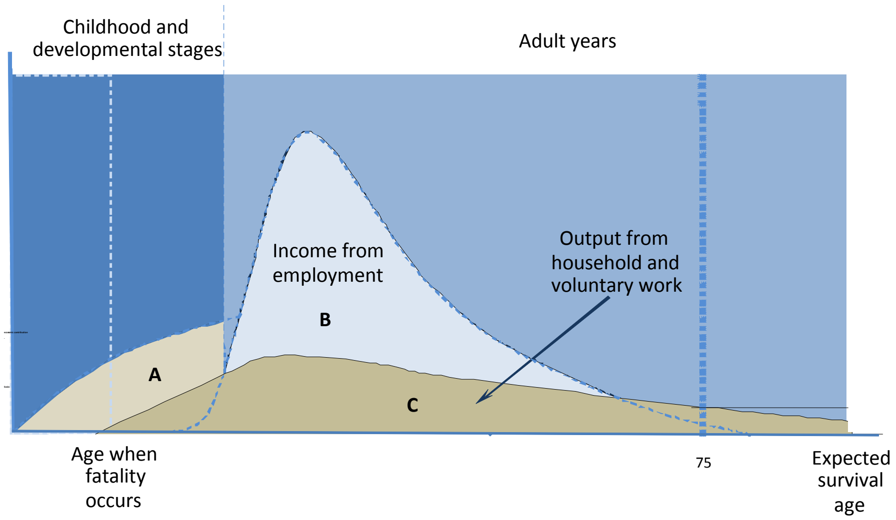
Workplace/household output losses and non-pecuniary losses comprised 97 per cent of the estimated cost of fatalities in 2006.

Output losses includes both forgone income for those participating in the workforce (gross income) and non-wage contributions from household and voluntary work. The magnitude of these losses depends on the age at which premature death occurs. BITRE (2010) estimated these losses by summing:

- losses due to premature death of a child (area A in Figure 1).
- lost contribution to the workforce as measured by the potential losses in income from employment (area B in Figure 1)
- losses in voluntary and household work; these two elements constitute non-wage contributions forgone by society due to premature death (area C in Figure 1).

**Figure 1: Contributions to society across the normal lifespan of an individual**

5 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.




Source BITRE (2010)

For older people with no earned money income, household and voluntary work contributions decline to negligible values beyond the age of 75. BITRE (2010) assumed that average household and voluntary work contributions are constant beyond the age of 75.

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 for the individual losses is not directly observable. BITRE (2010) used statutory values placed on total disability for a non-fatal road crash casualty as a proxy for the 'quality of life' of an unknown individual. This notional value was $387 900 per fatality, equivalent to the award for 100 per cent impairment. This is consistent with the approach used to value losses due to road crash related disability.

The premature death of a loved one affects family and relatives both immediately and over years. BITRE has used statutorily-determined lump sum compensation awarded to families and dependents of $57 421 for each premature death.

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 the:

- age distribution of fatalities
- ratio of males to females and the proportion of males in the total
- average age of fatalities.

BITRE analysis of the male/female ratios by age showed that the standard deviation of the age-specific gender proportions of fatalities was higher in 2006 than in 2002, but that there was no notable trend in the gender proportions in any age group. Given significant annual variability, BITRE stabilised its cost estimates by using incident data for 2002-2006.

The human and related losses from road fatalities in 2006 were estimated at $3.84 billion, or $2.40 million per fatality. This compares[6] to $4.30 billion or $2.17 million per fatality in 1996 (in 2006 dollars, using the same approach and assumptions).

Despite a 19 per cent reduction in fatalities between 1996 and 2006, workplace and household losses increased by 13 per cent in real terms. This increase is due to labour market factors (including higher participation rates) and changes in the demographic of the most vulnerable group of road users—young male road users.

# 4. Injury costing

The cost of injuries in 2006 was approximately $6.7 billion, or 40 per cent of the social cost of road crashes.

Hospitalised injuries are classified by the level of severity.[7] However, not all injuries result in impairment, and not all impairments cause a disability.[8]

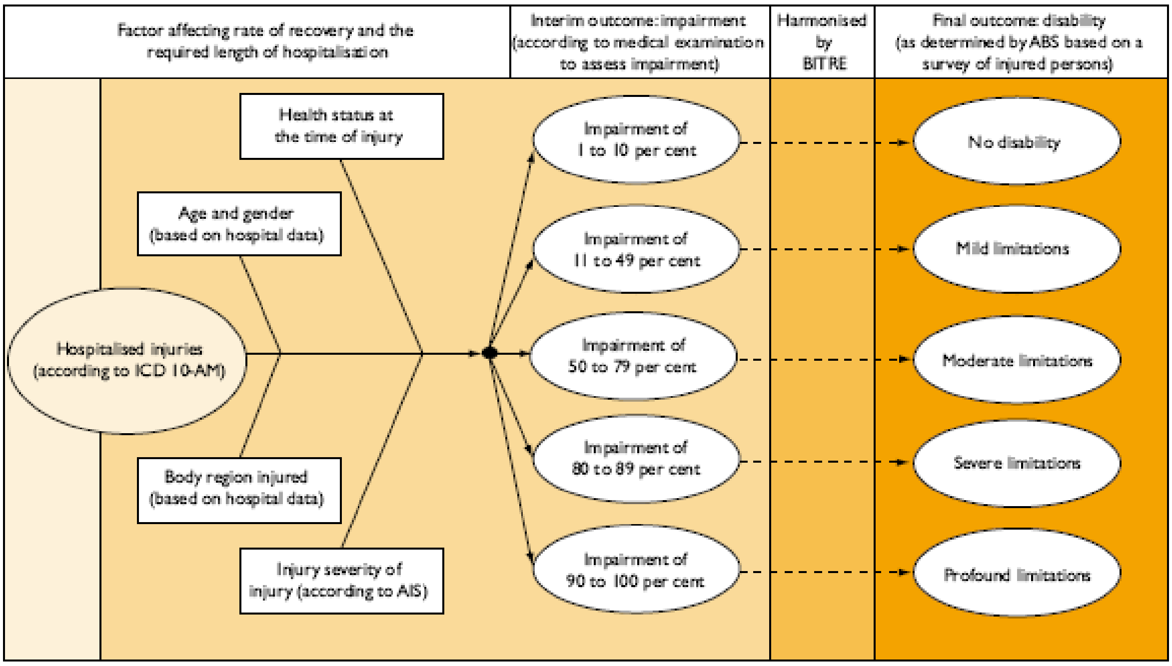
ABS (2004) defines a disability as any limitation, restriction or impairment, which has lasted, or is likely to last, for at least six months and restricts everyday activities. There is limited data linking crash injuries to disability outcomes. BITRE (2010) therefore estimated both the number people with injuries resulting in a disability and the degree of severity (see Figure 2).

**Figure 2: Outcomes of hospitalised injuries**

[6] BITRE (2010) re-estimated BTE (2000) values for 1996 using a comparable approach and parameters to its 2006 estimates (including a 3 per cent discount rate).

[7] Hospitalised injuries are classified by hospitals in accordance with the International Classification of Diseases Australian Modification version 10 (ICD-10 AM). Hospital data provides information on: body region; demographic characteristics; length of hospitalisation and the nature of separation (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.

[8] Not all injuries result in impairment, and not all impairments cause 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’ while disability ‘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’.




Source BITRE (2010)

Cross tabulation and simple[9] statistical techniques were used 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.

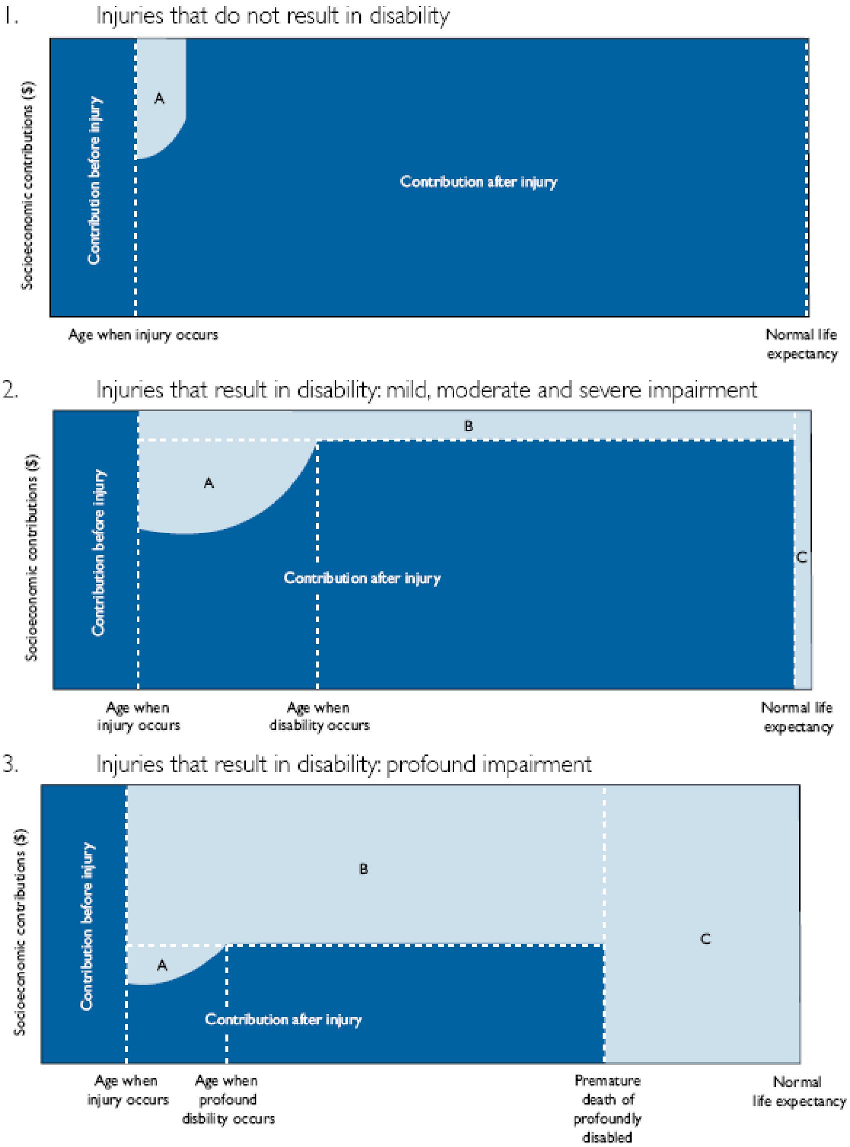
BITRE estimates that 4619 (14.8 per cent) of the 31 204 people hospitalised in 2006 due to road crash injuries suffered a disability, of which 1270 people (4.1 per cent of people hospitalised) had severe or profound limitation.

While injury costing aims to capture all human costs and other costs directly related to an injured person, their families, society and governments (Table 1), the main costs—90 per cent of total injury costs—are: workplace and household losses; disability related costs; non-pecuniary costs; and medical related costs.

The workplace disruption costs and workplace and household losses due to injury and disability are illustrated in Figure 3.

**Figure 3: Relationship between injury, disability and output losses**

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




Source: BITRE 2010

In calculating workplace and household losses, disability weights were used in conjunction with age and body region to estimate the degree of impairment for each casualty. 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. Premature mortality (area C) was also estimated, as severe injuries to the brain and spinal cord reduce overall life expectancy.

BITRE (2010) estimated care costs for those with a disability using a market benchmark and the one off and recurrent costs of specialised equipment, housing and services.[10]

While workplace and household losses and medical costs significantly increased compared to 1996 (BTE 2000), there were substantial decreases in disability-related costs, non-pecuniary losses, legal costs and workplace disruption costs.

10 Rather than using BTE's (2000) approach of financial transfers as a proxy.

# 5. Vehicle and other costs

Vehicle and other costs—including a range of direct and indirect costs (Table 1)—comprised 38.5 per cent of total crash costs. The main cost items (discussed below) are vehicle damage, travel delay and vehicle insurance administration.

Minor costs—damage to street furniture and costs of emergency services response—totalled $145 million (0.8 per cent of total costs). For a detailed discussion of these minor cost elements see BITRE (2010, p.81–82).

## 5.1. Vehicle damage and vehicle unavailability

Vehicle related costs in 2006 were an estimated $4.44 billion (25 per cent of total crash costs). Costs include the repair costs (95 per cent of vehicle related costs), towing costs and the costs due to the unavailability of a vehicle.

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 this change in estimated vehicle numbers, the real cost decrease between 1996 and 2006 per vehicle involved in a crash was 12.6 per cent. This reduction in vehicle repair costs partly reflects the fact that 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).

## 5.2. Congestion related costs

Crashes cause delays which impose non-recurrent congestion impacts on other road users including:

- travel delay due to time lost queuing in traffic or from reduced travel speeds.
- increased fuel use, and
- increased health impacts from additional local air pollution.

Travel delay costs comprise the estimated value of the time lost due to queuing in traffic or from reduced travel speeds due to a road crash. BITRE (2010) modelled travel delays using a simple linear queuing (bottleneck) model to provide an average order of magnitude estimate of delay times to road users directly affected by road crashes. Total delay costs were estimated using the value of time for each road user type.

Crash selection was based on all reported crashes in metropolitan areas and reported freeway crashes in non-metropolitan areas.[11] Key data used in the delay modelling were crash location, time of day, severity outcome (fatal, injury or property damage crash), traffic flows by road type/location, and certain assumptions (including emergency services' response times). Road capacities were based on road type and number of lanes, with vehicle mix varying by time of day and week. Road users' values of time were based on Austroads (2008) by vehicle type, adjusted to 2006 values.

The mid-point estimate of travel delay costs in 2006 for the 122 000 reported crashes likely to have caused significant delays was $792 million (4.5 per cent of total crash costs).

[11] BITRE (2010) assumes all crashes reported to police meeting these criteria cause significant disruption and delay.

BITRE (2010) used risk management software to model uncertainty with respect to key parameters—notably emergency services response times and the assumed level of traffic flow restriction following a crash. Indicative delay costs ranged between $500 million and $1.76 billion at the 95 per cent confidence interval.

Travel delay costs are conservative as the bottleneck model used does not capture network congestion where a crash disrupts a major road or intersection in peak periods. BITRE (2010) also estimated the higher vehicle operating costs due to congestion (that is, the increase in fuel costs) at $48 million, and the increased health costs resulting from additional local air pollution at $53.3 million.

## 5.3. Vehicle insurance administration

BITRE (2010) estimates that the cost of vehicle-related insurance administration for 2006 was $1.4 billion (approximately 8 per cent of total crash costs).

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

# 6. Results

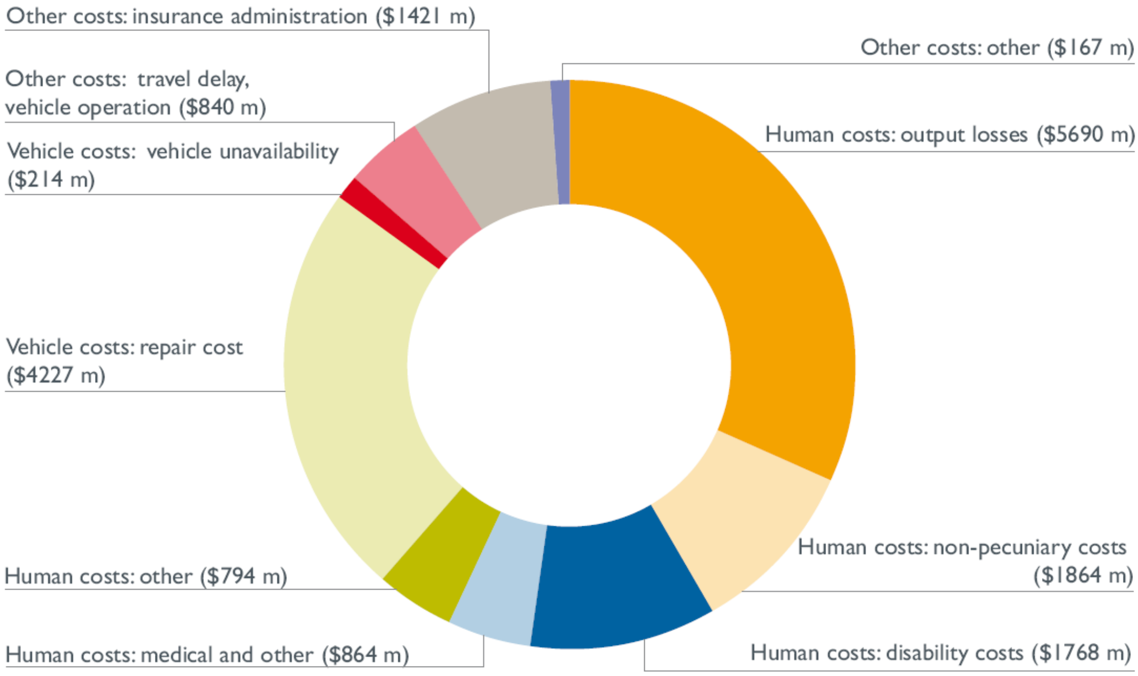
The social cost of road crashes was an estimated $17.85 billion in 2006 (1.7 per cent of GDP)—a real decrease of 7.5 per cent compared to 1996 (BTE 2000).

Human losses were 61.5 per cent of the cost of crashes.

Fatal crashes in 2006 cost an estimated $3.87 billion, injury crashes an estimated $9.61 billion, and property damage crashes an estimated $4.36 billion.

The largest individual costs (Figure 4) were workplace and household losses ($5.69 billion), vehicle repair costs ($4.23 billion), non-pecuniary costs ($1.86 billion), and disability-related costs ($1.77 billion).

**Figure 4: Social cost of road crashes by component, 2006**




Source BITRE (2010)

BITRE (2010) updates key information needed to evaluate the benefits of safety programs Including the estimated costs by injury or disability, and the average cost per crash type.

Estimated losses by injury outcome were:

- $2.4 million for a road fatality
- $214 000 for a hospitalised injury were (including disability-related costs)
- $2100 for a non-hospitalised injury.

Estimated losses for each disability case were:

- $3.82 million for each case of profound impairment
- $1.78 million for each case of severe impairment
- $542 000 for each case of moderate impairment
- $126 000 for each case of mild impairment.

The estimated costs on a crash basis were:

- $2.67 million per fatal crash.
- $266 000 per crashes resulting in at least one hospitalised injury
- $14 700 per crash resulting in at least one non-hospitalised injury
- $9950 per property damage only crash.

Table 3 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.

**Table 3 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 Table 7.6 in BITRE (2010, p.86).

## 6.1. Sensitivity testing

BITRE's (2010) assumptions are generally conservative and therefore tend to underestimate the cost to society of road crashes in Australia in 2006.

Crash cost estimates are sensitive to the approach used to value losses due to death or injury, the availability and quality of data, and the values assumed for key parameters such as the social discount rate.

If a willingness-to-pay based approach had been used to value fatality, injury and disability costs, then this would have increased the cost of crashes from $17.85 billion in 2006 to $27.1 billion—an increase of 52.0 per cent.

There is significant uncertainty with respect to the cost of travel delays, and modelling shows that this could decrease (increase) delay costs by 1.6 per cent (5.4 per cent).

While a risk-free real social discount rate of 3 per cent was used, a lower rate of 2 per cent would have increased total crash costs by $1.5 billion (8.4 per cent). A higher discount rate of 5 per cent rate would have decreased total crash costs by $2 billion (11.2 per cent).

BITRE notes that road authorities in most Australian jurisdictions are required to use discount rates in the order of 7 per cent.

## 6.1. Future work

A key objective of the crash costs project was to make these estimates more useful to policymakers, road safety practitioners, and the wider community. BITRE (2010) did this by presenting cost data disaggregated by state and territory, improving the methodology for injury costing and travel delay costing in particular, and adding a number of new cost elements (the latter increased total crash costs by one per cent).

Important areas where better data would improve future estimates of crash costs are:

- Extension of the national fatal crash database to all casualty crashes.
- Consistent collection of casualty data for crashes in all jurisdictions using 'best practice' injury definitions for serious casualties. For example, in Queensland an injured person is recorded in police crash data records as 'hospitalised', 'medically treated', or 'minor injury'.

- the incidence of unreported road crashes, particularly property damage only crashes.
- the incidence of non-hospitalised injuries resulting from crashes
- the level of disability resulting from crash-related injury and impairment.

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