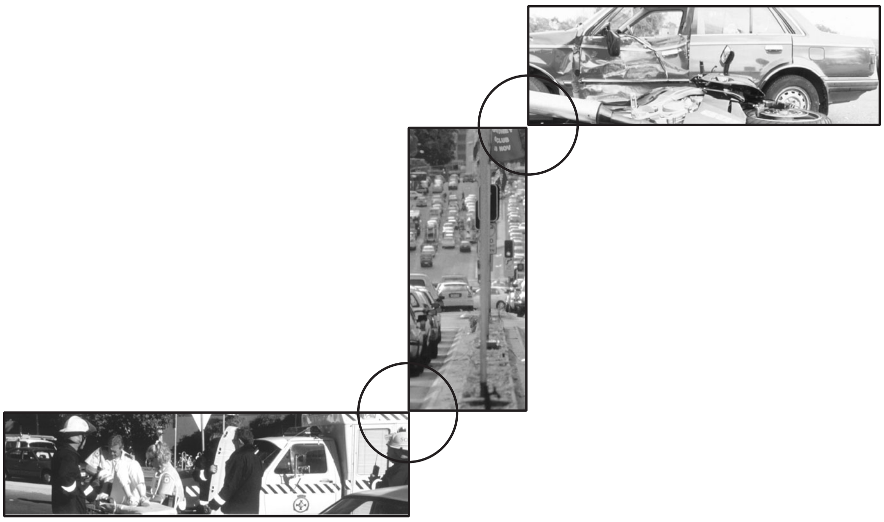
ROAD CRASH COSTS IN AUSTRALIA

REPORT 102



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FOREWORD

During the 1990s, around 2000 people per year died and over 20 000 per year sustained serious injuries on Australian roads. When the human cost is considered in combination with associated property damage and the costs of the infrastructure required to deal with road crashes, it is clear that society bears a huge overall cost.

Determining the magnitude of this cost and its components provides a better understanding of the benefits of activities that reduce the incidence and severity of road crashes. The information presented in this report allows a more rigorous costing of road safety program benefits than has been previously available.

This report builds on the methodology of a recent BTE report titled Cost of Civil Aviation Accidents and Incidents and is the third BTE report on road crash costs.

The BTE gratefully acknowledges the assistance of numerous organisations and individuals that provided information and advice during the preparation of this report. Kym Bills, Chris Brooks and Jim Wylie of the Australian Transport Safety Bureau (ATSB) and Kym Starr of the BTE provided useful comments on the draft report.

The research team comprised Emma Ferguson (Research Leader), Johnson Amoako, Michael Simpson and Erica Stott.

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May 2000

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SUMMARY

The total cost of road crashes in Australia in 1996 has been conservatively estimated at approximately $15 billion (in 1996 dollar values).

The composition of the overall cost is set out below.

Human costs	$million
Medical/ambulance/rehabilitation	361
Long-term care	1 990
Labour in the workplace	1 625
Labour in the household	1 493
Quality of life	1 769
Legal	813
Correctional services	17
Workplace disruption	313
Funeral	3
Coroner	1
Total	8 385
Vehicle costs	
Repairs	3 885
Unavailability of vehicles	182
Towing	43
Total	4 110
General costs	
Travel delays	1 445
Insurance administration	926
Police	74
Non-vehicle property damage	30
Fire and emergency services	10
Total	2 485
Overall total	14 980

Note All figures are in 1996 dollars and rounded to the nearest million dollars.

Crash costing is an inexact science. Cost estimates depend on particular costing approaches used, the number of crash cost components that can be estimated, quality and quantity of available data and the value of key parameters (such as the discount rate) used. An important influence on the overall cost is the use of the human capital or willingness to pay approach to value life and injury. The cost estimates in this report are based on the human capital approach. Higher costs would have resulted from the use of the willingness to pay approach.

Costs of crashes by injury category were:

Fatal crashes:	$2.92 billion.
Serious injury crashes:	$7.15 billion.
Minor injury crashes:	$2.47 billion.
Property damage only (PDO) crashes:	$2.44 billion

The average cost of a fatality was $1.5 million, a serious injury $325 000 and a minor injury $12 000.

The average cost per crash (all injury levels) was $24 000. The average cost of a fatal crash was $1.7 million; serious injury crash, $408 000; minor injury crash, $14 000; and property damage only crash (PDO), $6000. Table 7.1 summarises the various costs.

Estimated crash costs in 1996 have increased by $6 billion over the estimate for 1988 when both are expressed in 1999 dollar values. Among the more significant contributors to the increase were the inclusion of a cost estimate for long-term care ($2 billion) and an improved estimate of costs associated with traffic delay (about $1 billion more than the 1988 estimate). Several other cost elements that were not included in the overall 1988 cost estimate also contributed to the difference. Apart from these differences, a major contributor to the difference in costs is the use of a discount rate of 4 per cent for 1996 costs and 7 per cent in the case of 1988 costs. The 3 per cent difference in discount rates accounts for about $2 billion. Costs in 1996 have also been presented at a 7 per cent discount rate to facilitate comparison.

In 1988 there were 2875 fatalities (compared with 1970 in 1996) and almost 30 000 serious injuries (compared with about 22 000 in 1996). These injuries were the result of 2561 fatal crashes and 22 832 serious injury crashes in 1988 and 1768 fatal crashes and 17 512 serious injury crashes in 1996 (FORS 1998a). The 1988 estimates of the numbers of crashes and injuries are more recent than those shown in tables 2.1 and 2.2 in this report. These more recent estimates of 1988 crashes and injuries have been collected using the same methods as the 1996 data used in this report and are therefore comparable.

If the number of fatal and serious injury crashes in 1996 had been the same as in 1988, the 1996 cost estimate would have been approximately $3.5 billion higher than the figure given in this report (expressed in 1999 dollar values, the difference would have been $3.6 billion). This difference represents the cost saving attributable to the reduced incidence of fatal and severe injury crashes due to overall improvements in road safety. However, this saving was partly offset by an increase in the estimated number of minor crashes. Based on the unit crash costs in this report, the net cost saving from the change in crashes across all severity levels between the 1988 and 1996 figures was $3.3 billion (in 1999 dollars).

1

INTRODUCTION

Road crashes result in death, injury and property damage. For the individuals involved, the outcomes of a road crash may be devastating and it may not seem to them to be necessary or appropriate to place dollar values on these outcomes. However, to make decisions about crash prevention and risk-minimisation expenditure, it is necessary to have reasonably accurate estimates of the costs of road crashes. It is only through understanding the structure of the costs that a thorough evaluation of the cost-effectiveness of programs to reduce the incidence or severity of road crashes can be made. This information is important when scarce funds are to be allocated among programs designed to reduce the incidence of specific crash or injury types.

Another use for estimates of road crash costs is to demonstrate the burden crashes place on the community as a whole and on particular groups within the community. For instance, the cost to the medical system, employers, or emergency services can be determined. The extent to which particular sectors can potentially benefit from actions to reduce road crashes can also be determined. Understanding the relative burden due to road crashes is useful in determining the demand for specific road safety actions and assessing the social returns from road safety expenditure.

The costs imposed by road crashes, and the social benefits of avoiding crashes, are explicitly and implicitly recognised by the actions of government, industry, community groups and individuals. Governments at all levels promote road safety and this message is enforced through the police services. Motor vehicle manufacturers invest in developing safety equipment and structurally testing their vehicles, while motorists voluntarily purchase safety equipment, including air bags and child restraints and may make behavioural choices to reduce risk. These actions all contribute to the reduction of the risk of death and injury through road crashes.

Despite the considerable expenditure on improving road safety, there is still substantial risk inherent in road transport. In 1996, 1970 people were killed, and at least 22 000 were admitted to hospital due to road crashes.

These statistics must be placed in proper perspective. The number of fatalities in 1996 represents a 48 per cent reduction from the peak of 3798 fatalities in 1970. Australia is one of the safest countries in the world in which to drive. Australia currently has 9.3 road deaths per 100 000 persons, and its comparable rate at the time of the latest available international comparison (9.5 deaths per 100 000 persons in 1997) was well below the median value (11.7) deaths for OECD countries. (ATSB 1999a). Measuring deaths per 10 000 registered vehicles takes into account the level of motorisation of countries. Australia had 1.5 deaths per 10 000 registered vehicles in 1997, well below the OECD median of 2.0 deaths (ATSB 1999a). Information allowing a comparison on the basis of distance travelled is not available. However, Australia had a lower death rate than other big countries such as Canada (1.7 deaths per 10 000 registered vehicles) and the USA (2.1) (ATSB 1999a).

REPORT STRUCTURE

This report builds on, and refines, previous work (BTCE 1988, BTCE 1992 and BTE 1999).

This report comprises six chapters. Chapter 2 presents the basic statistics on numbers of crashes, vehicles involved and casualties. Chapter 3 sets out the method used to calculate the cost of road crashes, followed by an analysis of the human costs of crashes in chapter 4. Chapters 5 and 6 provide details of the vehicle-related and general crash costs, respectively. Chapter 7 brings these three broad cost elements together to provide estimates of the total cost of road crashes in 1996 and the costs associated with each injury level. Several issues arising from the costing are also examined in chapter 7. Appendix I defines many of the terms used in the report, while appendix II explains the mathematical basis of the model used to estimate traffic delay costs in chapter 6.

DEFINING A ROAD CRASH

Understanding what is meant by a road crash is essential to determining the scale of costs incurred by society. Road crashes may be classified according to a set of definitions and rules (Andreassen 1991). They can involve any of the following:

- runaway parked vehicle;
- collision on carriageway between a vehicle and a pedestrian/vehicle/ object/animal;
- collision off carriageway (such as vehicle collision with a tree after loss of control on the carriageway);
- non-collision off carriageway (such as a roll-over after loss of control on the carriageway);
- non-collision on carriageway (such as loss of load or breakdown of vehicle); or
- other factors (such as a fall from a vehicle).

Vehicles, broadly defined, include bicycles, ridden animals, non-motor vehicles, and animal-drawn transport as well as motorbikes, cars, trucks, trams and buses. This report uses the Australian Transport Safety Bureau (ATSB) definition of a crash, which requires that at least one moving vehicle be involved in the event. Using this definition, a collision between a bicycle and a pedestrian on a roadway would be regarded as a crash, whereas a collision between a pedestrian and a parked vehicle would not. Statistics involving only non-motorised vehicle crashes are incomplete.

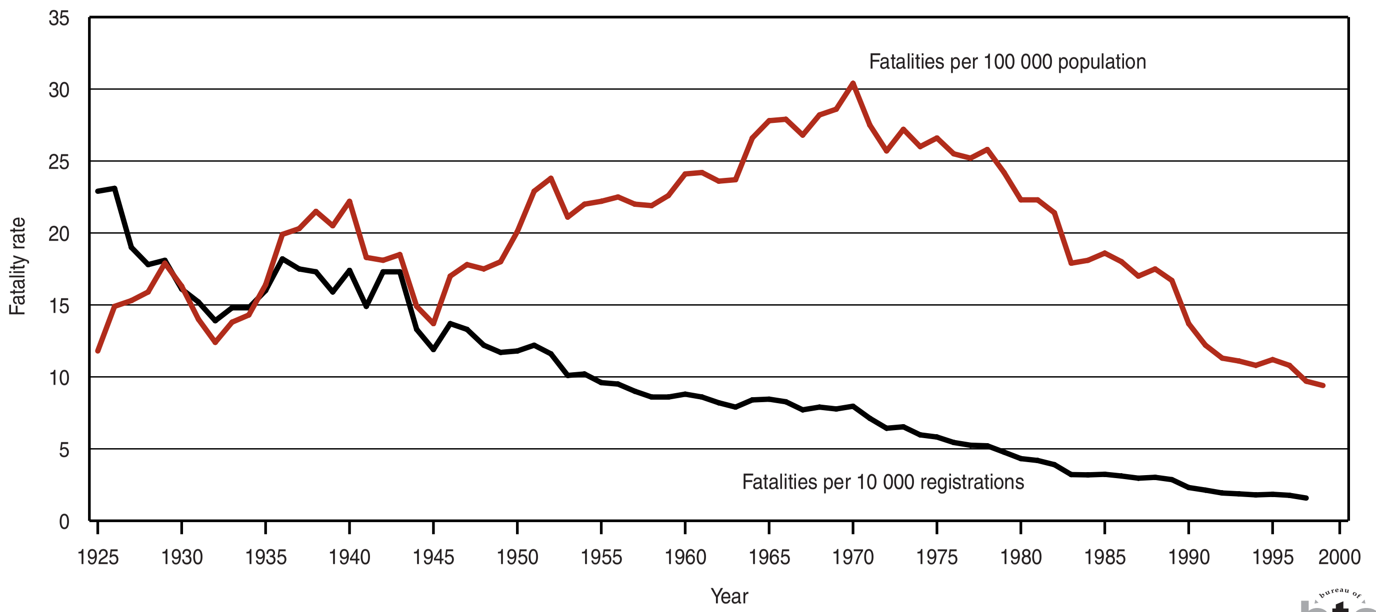
This report follows the definition of a road used by the ATSB and the former Federal Office of Road Safety (FORS) in the collection of road safety statistics. Only crashes on public roads are included in the statistics. A road is defined to cover the whole width between abutting properties. It includes carriageways, cycle paths inside the road reserve, footways, medians, separators, traffic islands, and even some beaches that are designated part of a road.

The use of the term 'crash' rather than 'accident' is intentional. It indicates that, rather than being purely a chance occurrence (BTCE 1995, p. 7), each event results from a cause, or causes, such as speed, alcohol, lack of driver experience, mechanical failure or error of judgement. Appendix I provides a definition of the major terms used in this report.

INCIDENCE OF FATAL CRASHES

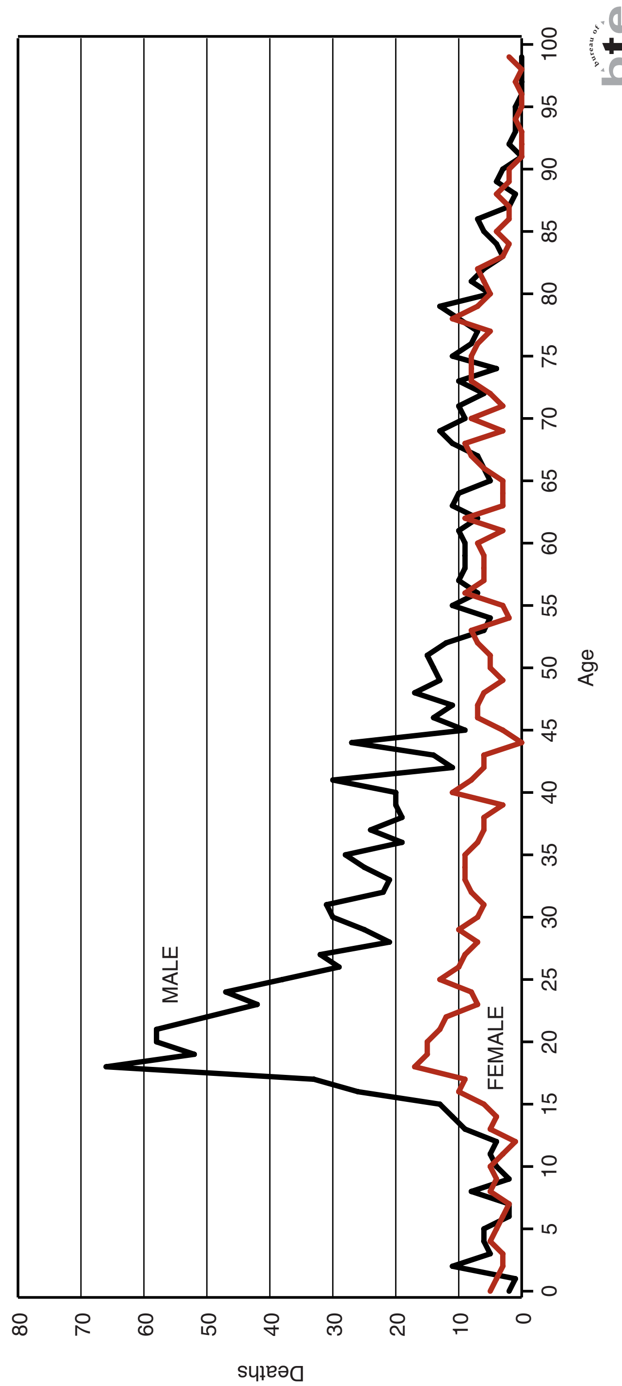
Data collected by ATSB show that road crashes in Australia involving fatalities have decreased, after a peak of 3798 deaths in 1970. When allowance is made for factors such as the increasing numbers of vehicles on the roads and increasing population levels, it is clear that the fatality rate has fallen markedly since the early 1970s (figure 1.1).

FIGURE 1.1 ROAD CRASH FATALITIES IN AUSTRALIA, 1925–1998



Source FORS (1998b).

FIGURE 1.2 FATALITIES BY GENDER AND AGE, 1996



Source FORS (1998b).

In 1996, on average, a fatal crash involved 1.1 deaths and 1.5 vehicles (ATSB 1999b). In practice, this means that the majority of fatal crashes involved a single vehicle and a single death. Two-vehicle fatal collisions comprised 36 per cent of fatal crashes. Crashes where three or more people died made up only 2 per cent of fatal crashes (ATSB 1999b).

The likelihood of death in a road crash varies with age and gender. Figure 1.2 clearly depicts the over-representation of males, particularly the 18-25 year age group, in road fatality statistics. The deaths of the young generally impose the greatest relative cost on society, resulting in many decades of potential life lost.

Statistics relating to vehicles in which fatalities occur indicate that some vehicle types involve a relatively higher risk. In relation to distance travelled, riders of motorcycles are 20 times more likely to be killed than drivers of other types of vehicles, while bus drivers are over seven times less likely to be killed in a road crash than are car and truck drivers (table 1.1). However, the sheer predominance of cars on the road means that they are involved in around 80 per cent of fatal crashes (ATSB 1999b).

Table 1.2 sets out occupant fatalities by vehicle type, while table 1.3 sets out corresponding information for all fatalities.

TABLE 1.1 DRIVER FATALITIES, BY VEHICLE TYPE, 1996

Vehicle Type	Fatalities	Fatalities per billion vehicle km travelled (BVKT)
Passenger vehicles	770	5.08
Motorcycles	179	117.30
Rigid Trucks	55	8.18
Articulated Trucks	33	6.48
Buses	0[a]	0.00
Overalll	1037	6.23

a. In the previous year, one bus driver was killed, indicating 0.7 fatalities per BVKT.

Sources ABS (1996a), ATSB (1999b), Apelbaum Consulting Group (1997, p. 29).

TABLE 1.2 OCCUPANT FATALITIES, BY VEHICLE TYPE, 1996

Vehicle	BVKT	Occupant fatalities	Fatalities/ BVKT	Btonne-km	Fatalities/ Bt-km	Billion occupant -km	Fatalities/ Bocc-km
Cars	151.44	1247	8.23			242.31	5.15
Motorcycles	1.53	196	128.44				
Rigid trucks	6.73	71	10.56	25.04	2.84		
Articulated trucks	5.09	37	7.26	89.38	0.41		
Buses	1.55	4	2.59			15.47	0.26

Sources ABS (1996a), ATSB (1999b), Apelbaum Consulting Group (1997, p. 29).

TABLE 1.3 ALL FATALITIES IN CRASHES INVOLVING EACH VEHICLE TYPE, 1996

Vehicle	BVKT	Fatalities	Fatalities/ BVKT	Btonne-km	Fatalities/ Bt-km	Billion occupant -km	Fatalities/ Bocc-km
Cars	151.44	1674	11.05			242.31	6.91
Motorcycles	1.53	206	134.99				
Rigid trucks	6.73	229	34.05	25.04	9.14		
Articulated trucks	5.09	193	37.89	89.38	2.16		
Buses	1.55	38	24.56			15.47	2.46

a. Fatalities do not sum to annual figures as crashes sometimes involve more than one type of vehicle and such fatalities are included in the tallies of each vehicle type involved.

Sources ABS (1996a), ATSB (1999b), Apelbaum Consulting Group (1997, p. 29).

2

ROAD CRASH STATISTICS

Estimating how many crashes occurred, the number of vehicles involved and the numbers of casualties is basic in determining crash costs. A variety of data sources is needed, as direct data collection is done only for fatal crashes and the most serious non-fatal crashes.

CRASHES AND VEHICLES

For fatal and serious injury crashes, data are readily available from ATSB; however, estimates are required for minor crashes. The figures presented below are used throughout this report as a basis for cost estimates.

Cars, light commercials and motorcycles

The total number of cars (including light commercials) involved in crashes was estimated using insurance company data for comprehensively insured vehicles. Insurance company figures were used because more crashes appear to be reported to insurance companies than to any other organisation. However, not all crashes are reported to insurance companies because not all vehicles are comprehensively insured. Insured owners may choose not to claim because of the insurance policy's minimum threshold, or excess, or the possible loss of no-claim bonus; and some minor damage may not be repaired at all. Anecdotal evidence indicates that uninsured vehicles and vehicles involved in unreported crashes tend to be of below-average value, so insurance claim data are expected to underestimate the number of vehicles involved in crashes and to overestimate the average cost of vehicle damage.

The Federal and State/Territory police forces are the alternative sources of crash data, but police crash statistics are far from complete. Each State/Territory has varying minimum requirements for reporting crashes—only relatively serious crashes are attended by police, and normally only those involving serious injury or death are investigated. In addition, at-fault drivers may often fail to report a crash even if it meets the reporting criteria. Consequently, only a fraction of all road crashes are reported to police. Andreassen (1992, p. 20) found that, out of a total of 3595 insurance claims in Victoria, only 18.4 per cent were listed as having been reported to police. Throwing further doubt on available statistics is the fact that not all jurisdictions fully collate crash reports—for example, if two cars are involved in a crash and both drivers report it, the crash may be counted twice.

Insurance data include some non-crash events. Assumptions were made in excluding data from further consideration. First, it was assumed that half the cars damaged while parked were not on public roads at the time. Second, use was made of an insurance company estimate that 20 per cent of claims are for theft and 'other' (non-crash) types of claim. The data were adjusted downward to reflect those assumptions.

The number of crash-related claims obtained from insurance data was then scaled upward to give an estimate for the jurisdiction under consideration using the percentage of registered vehicles insured by the relevant companies in that jurisdiction. The final step in making an estimate for the whole of Australia was to derive estimates for each jurisdiction using the total vehicle-kilometres driven in each (ABS 1998a), because both the number of vehicles and their level of usage are important determinants of road crashes.

Using the percentage of registered vehicles insured by the company in scaling up from the number of repairs recorded to the total number of damaged vehicles ensures that uninsured vehicles and those that have only third party property damage insurance (TPPD) are taken into account. It was assumed that these vehicles are involved in crashes at the same frequency as comprehensively insured vehicles, and that the crashes have the same cost distribution. However, it has been suggested that comprehensively insured drivers tend to be safer than others. The suggestion is based partly on the grounds that some drivers cannot take out insurance because of their crash record, and partly on the belief that risk-averse behaviours go together (a comprehensively insured driver will be a safer driver).

Anecdotal evidence from the Insurance Council of Australia (ICA) suggests that 10-13 per cent of all Australian vehicles are not comprehensively insured, while possibly about 4 per cent are unregistered (ICA, pers. comm., 1999). The ICA did not have any estimates of the proportion of registered vehicles that are uninsured and the proportion that have only TPPD insurance. Since the numbers of uninsured and TPPD-only insured vehicles are relatively small, there would be minimal error in assuming that their crash involvement is similar to that of fully insured vehicles.

Minor crashes that do not lead to insurance claims were not taken into account in this estimation of crash numbers. No firm basis could be found for estimating these, so the total estimate of damaged vehicles should be regarded as conservative. This is not considered a serious deficiency because it is debatable whether the majority of minor damage crashes are important from an overall road safety viewpoint. Nevertheless, the total number of vehicles involved in minor crashes could be expected to be large; and, where minor damage is not repaired, resale value may be reduced.

The belief that the number of low-damage crashes is underestimated by insurance figures is consistent with data from two large Australian vehicle fleets, comprising mainly cars. For both fleets, repairs of less than $2000 in value occur more than twice as frequently as in the insurance data. If this proportion held for all crashes, the total number of damaged vehicles would be twice that obtained from the insurance data alone (while the average repair cost would be lower).

The fleet data have not been used in this way for several reasons. The two fleets represent only a small proportion of the total stock of fleet vehicles, and fleets in turn represent a small proportion of all vehicles. The fleets may not be typical (for example, their vehicles are generally relatively new) and, in any case, the two sets of fleet data differed significantly from each other. Like insurance data, fleet data include damage not caused by road crashes, such as vandalism. However, they do not readily provide information about the proportion of these other causes of damage, which are likely to be more frequent among the lower value repairs in the fleet data.

The total number of cars involved in road crashes in 1996 was estimated at 1.132 million. According to the ATSB serious injury database, 1944 cars were involved in fatal crashes and 22 029 in serious injury crashes.

The number of motorcycles involved in crashes was estimated by the same method, and with similar data, as the numbers of cars and light commercials. However, the insurance data represented a much smaller proportion of the registered total than for cars. The estimated total number of motorcycles involved in crashes in 1996 was 18 222. The estimated number involved in fatal crashes was 207, and in serious injury crashes, 2431 (ATSB 1999b).

Trucks and buses

The number of trucks involved in crashes was estimated from Australia-wide data supplied by a specialist truck insurer. The data consisted of the total number of claims, overall average crash repair costs and the total number of trucks insured, and included data for rigid trucks, prime-movers and the trailers of articulated combinations.

The total number of damaged trucks was obtained by scaling up the number of claims using the number insured and the total number of trucks registered (ABS 1996b). The total number obtained should be regarded as conservative, because truck insurance policies typically carry an excess of one per cent of the value of the truck, averaging $500 to $600. There is a wide range around these figures; for example, a prime mover may have an excess of $2500.

Many collisions that cause considerable damage to cars may not appear in truck insurers' statistics, and the more expensive, and hence typically larger the truck, the more crashes will not be reported to insurance companies. However, the total may also include some damage from off-road crashes, such as in loading docks, although this should typically be of value too low to be claimed. The separation of prime-movers from trailers in the statistics means that it is not clear how often both are damaged in a single crash. This report assumes that half the trailer claims were separate from prime-mover claims. Since the number of trailer claims is relatively small, varying this assumption by 100 per cent changes the articulated truck crash total by only about 15 per cent.

The total number of rigid trucks involved in crashes in 1996 was estimated at 37 800. The estimated number involved in fatal crashes was 216, and in serious injury crashes, 1125. The total estimate of articulated trucks (including trailers) in crashes in 1996 was 6780. The number involved in fatal crashes was estimated at 167, and in serious injury crashes at 521 (ATSB 1999b).

The number of buses involved in crashes was estimated from Australia-wide data supplied by a specialist bus and coach insurer. Again, only overall averages were available. As for cars, information supplied by a fleet operator suggests that, due to under-reporting of minor crashes to the insurer, the true total may be considerably larger. The total number of buses involved in crashes in 1996 was estimated at 9550. The numbers of buses involved in fatal and serious injury crashes were estimated at 32 and 216 respectively (ATSB 1999b).

Vehicles per crash

The ATSB serious injury database indicates an average of 1.6 vehicles per crash. Previous reports on crash costs consistently use an average between 1.8 and 1.9 vehicles per crash across all levels of crash severity (Atkins 1981, p. 26 (1.86); BTCE 1988, p. 66 (1.81); BTCE 1992, p. 21 (1.81)). These estimates originated with Atkins, who derived his property damage only (PDO) estimate from Troy and Butlin (1971, p. 202) who, in turn, obtained this number for all crashes in a detailed study of the Australian Capital Territory in 1965-66. James (1987, p. 120) found a ratio of 1.96 cars per crash in a sample of RACV insurance claims from 1978. BTCE (1992, p. 20) combined data from official sources for casualty crashes with an estimate by Searles (1977) of 1.8 vehicles per unreported (to police) PDO crash based on NRMA insurance claims for the Sydney area in 1975.

The insurance data obtained for this report did not consistently provide the number of vehicles involved in each crash. However, the data did classify crashes as single- or multiple-vehicle. Assuming that all multi-vehicle crashes have the same average number of vehicles per crash as in the ATSB (1999b) database (2.2), the insurance data give an average of 1.83 vehicles per crash. This average is probably conservative, as anecdotal evidence points to a tendency for crashes involving more than two cars to involve minor injury rather than being fatal or serious. The estimate of 1.83 vehicles per crash was used to develop crash numbers from the vehicle data described above.

Comparison with previous reports

It is worth comparing the number of vehicles estimated in this report with estimates provided in previous reports on the cost of road crashes. Tables 2.1 and 2.2 show the estimated numbers of crashes and vehicles used in this and three previous reports.

The previous studies did not use insurance data to estimate crash numbers. Atkins' total was derived from the ABS Survey of Motor Vehicle Usage, 1971 (ABS 1973). BTCE (1988) and BTCE (1992) used Atkins' ratio of injury crashes to PDO crashes (6.8) in combination with its own estimates of the number of injury crashes. It does not seem likely that Atkins' ratio still holds after 25 years, given the substantial fall in the numbers of fatal and serious injury crashes. Unfortunately, the format of the current ABS (1998a) vehicle use survey no longer allows the calculation of crash estimates. Insurance data provide the best alternative in the absence of ABS data.

TABLE 2.1 COMPARISON[a] OF ESTIMATES OF CRASH NUMBERS

Report	Base Year	Vehicle registrations '000	Fatal crashes	Serious crashes	Total crashes	Vehicle registrations per crash	Est.[b] crashes 1996
Atkins (1981)	1978	5 462	3 268	20 419	556 823	9.8	903 000
BTCE (1988)	1985	6 734	2 628	49 705	671 976[c]	10.0	884 000
BTCE (1992)	1988	7 158	2 561	19 423	590 852	12.1	731 000
BTE (2000)[d]	1996	8 862	1 768	17 512	618 600	14.3	

a. Comparisons between reports are complicated by changes in the way the estimates have been calculated. The numbers of injury crashes may be affected by the shift to the present system of classifying injury levels beginning with BTCE (1992). Atkins (1981) and BTCE (1988) used the six-level Abbreviated Injury Scale (AIS). Since 1988, there may have been changes to the level of injury that leads to a victim's admission to hospital.

b. Est. 1996 is the total number of crashes expected in 1996, if the number of registrations per crash does not change.

c. Adjusted for under-reporting of casualties (see text).

d. This report

Sources Atkins (1981), BTCE (1988), BTCE (1992), BTE estimates.

TABLE 2.2 COMPARISON[a] OF ESTIMATES OF NUMBER OF VEHICLES INVOLVED IN CRASHES

Report	Base Year	Registrations '000	Fatal crashes	Serious crashes	Total vehicles	Registrations per crashed vehicle	Est.[b] vehicles 1996 '000
Atkins (1981)	1978	5 462	5 098	31 854	1 033 710	5.3	1 677 000
BTCE (1988)	1985	6 734	3 927	77 639	1 219 355[c]	5.5	1 605 000
BTCE (1992)	1988	7 158	3 718	30 336	1 068 166	6.7	1 322 000
BTE (2000)[d]	1996	8 862	2 681	28 124	1 132 000	7.8	

a. Comparisons between reports are complicated by changes in the way the estimates have been calculated. The numbers of injury crashes may be affected by the shift to the present system of classifying injury levels beginning with BTCE 1992. Atkins (1981) and BTCE (1988) used the six-level Abbreviated Injury Scale (AIS). Since 1988, there may have been changes to the level of injury that leads to a victim's admission to hospital.

b. Est. 1996 is the total number of vehicles expected to have been involved in crashes in 1996, if the number of registered vehicles per crashed vehicle does not change.

c. Adjusted for under-reporting of casualties (see text).

d. This report.

Sources Atkins (1981), BTCE (1988), BTCE (1992), BTE estimates.

The data from all but one of the reports indicate an increase in both crash numbers and in the number of vehicles involved in crashes. The exception is BTCE (1988), which does not fit with the apparent trend. BTCE (1988, p. 66) incorporated a correction for under-reporting of the number of crashes involving casualties. The correction was based on data from the then Motor Accidents Board (MAB) in Victoria. This increased the estimate of casualty crash numbers based on ABS and jurisdictional road authority figures by a factor of 2.4. Without this correction, the report's result for all crashes (575 616) conforms to the general upward trend. The correction in BTCE (1988) arose from the fact that its estimate of the number of vehicles involved in crashes was derived from its estimate of casualties. In the present report, the number of vehicles involved in crashes and number of crashes were derived from vehicle insurance data, independent of the estimate of casualties. Therefore, there is no need to apply any correction.

Given all these caveats, it appears that the calculations confirm each other. They also seem to display a broad trend of increasing total numbers of crashes, but a reduction in crash rate per vehicle. These changes accompany a fall in the number of both fatal and serious crashes. Is this combination of trends reasonable? Increasing crash numbers are certainly expected as vehicle registrations increase and greater distances are travelled. Most measures believed to be responsible for the fall in casualties are those that mitigate the level of injury, such as seat belts, rather than preventing the crash altogether. Designed-in crumple zones and airbags actually trade human injury for property damage, and so may increase the proportion of PDO crashes. The same is true of 'forgiving' road furniture, such as traffic signals, designed to collapse when struck by a car. The increase in traffic density over the period is likely to have increased the absolute number of crashes while reducing their severity, since denser traffic has a lower average speed.

There are also some developments that act directly to reduce the number of crashes. These include increased use of divided roads and wider clear spaces adjacent to carriageways. There may also be an effect from more subtle improvements in road design, such as improved intersection layouts, roundabouts, signs and increased use of reflective markers (see BTCE 1995). Yet another possibility is that public education campaigns have made drivers more aware of risks. In summary, the trends apparent in the estimates are consistent and suggest the effectiveness of a broad range of programs.

A further check on the estimated number of vehicles involved in road crashes was provided by the 1998 Community Attitudes to Road

Safety (CARS) survey (Mitchell-Taverner 1998). This survey had 1359 respondents, with an effective response rate of 69 per cent. It found that 18 per cent of the population aged 15 and over reported having been involved in a crash over the three years from mid-1995 to mid-1998. This result, together with ABS population figures and an average of 1.95 persons per crash obtained from the ATSB serious injury database, indicated that around 450 000 crashes involving a total of 824 000 vehicles could be expected during calendar year 1996. Since CARS is a 'self-reporting' survey—it relies purely on respondents' own memory and frankness—under-reporting is likely. Respondents are especially likely to under-report minor crashes. In addition, an unknown proportion of those answering 'yes' will have been involved in more than one crash. Given its limitations, the CARS figure suggests no reason to doubt the total number of crashes estimated in this report.

INJURY STATISTICS

The number of people injured in road crashes is a vital determinant of the cost of crashes. The severity of injury suffered was used to categorise crash victims into four groups—fatal, serious, minor and uninjured—for costing. Table 2.3 indicates the numbers of injuries and crashes in each of these groups by State/Territory.

TABLE 2.3 INJURY AND CRASH NUMBERS BY JURISDICTION, 1996

	Number of persons				Number of crashes		
Jurisdiction	Fatal	Serious	Minor	Total	Fatal	Serious	Total
NSW	581	5 967	na	6 548	538	4 880	5 418
VIC	417	6 077	na	6 494	382	4 834	5 216
QLD	385	4 469	na	4 854	338	3 551	3 889
SA	182	1 720	na	1 902	163	1 323	1 486
WA	246	2 592	na	2 838	219	2 041	2 260
TAS	64	439	na	503	53	348	401
NT	72	480	na	552	58	334	392
ACT	23	245	na	268	17	201	218
National	1 970	21 989	213 322	na	1 768	17 512	19 280

na not available.

Source ATSB (1999b).

Chapter 4 details the method used to obtain these estimates; only a summary is presented here. ATSB collects statistics concerning fatalities and serious injuries, and its estimates were used for these injury levels. Estimation of uninjured persons and those sustaining minor injury requires a number of assumptions, as there is no central organisation that compiles such numbers. The number of minor injuries was determined using a ratio relating hospital admissions to emergency department attendances and to presentations to general practitioners. This ratio is 1:3.53:3.88 and is derived from O'Connor and KPMG Peat Marwick (1993). The uninjured comprise the difference between the total persons involved in road crashes and the injured. The estimate of total persons directly involved in road crashes was derived from the estimated number of vehicles involved and an estimate of the average number of occupants in a vehicle (1.58 derived by Apelbaum Consulting Group 1997).

3

ANALYTICAL APPROACH

Government agencies and the medical, insurance and automotive sectors all have an interest in understanding the socio-economic costs of road crashes. The body of research spans general surveys of the field and analyses of specific aspects of costs. Research has contributed to the use of widely differing cost estimates. For example, a survey of 59 Australian and New Zealand organisations by Mabbott and Swaddling (1998) found that three major original sources of road crash cost data were being used (including BTCE 1988), and that each user organisation was adjusting and updating the data.

The method used to estimate road crash costs needs to be well understood to ensure that the approach and assumptions made are relevant to the particular use of the total cost or its components. This chapter describes methodological options and provides a detailed description of the method used to obtain the cost estimates presented in this report.

THE METHODOLOGICAL DEBATE

The human capital and willingness to pay approaches are generally regarded as the two alternative methods for valuing the fatality and injury components of road crashes. Transparent road safety funding decisions require an explicit value to be placed on life to allow projects with a range of outcomes in terms of saved lives and reduced injuries to be compared. Past studies have found that the values placed on life and injury tend to be a substantial component of road crash costs, making the method chosen to estimate these values important in determining the outcome.

Box 3.1 provides a brief discussion of what is meant by ‘value of life’ and whose life is valued.

The human capital approach characterises people, and therefore life, as a labour source and input to the production process. This approach argues that the value to society of preventing a death or

BOX 3.1 WHOSE LIFE IS BEING VALUED?

People generally value their own lives very highly, and often the same can be said for the lives of family and close friends. Indeed, life can be argued to be priceless, as without life money would be of no use. This view is supported by the many publicised incidents where large amounts of money have been spent to save the life of an identified person.

However, at the other end of the spectrum, much lower implicit values are placed on lives every day. Each time a decision is made regarding the allocation of funding to health and emergency services, to workplace occupational health and safety projects, and indeed to any activity which aims to save lives or prevent injuries, life has an assumed implicit value.

A particular life may be regarded as priceless, yet relatively low implicit values may be assigned to life because of the distinction between identified and anonymous (or 'statistical') lives. When a '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. The concept relates to the probability of a fatality in a given population.

This is an important distinction when examining road safety improvements, as it is not known which particular lives will be saved due to a change in the statistical probability of a crash or death/injury in a crash. Valuing an unknown (or statistical) life eliminates subjective assessments of the worth of particular individuals. A statistical life is unidentified and so does not have the emotional and moral overtones associated with a known life. In practical terms, the distinction means that much smaller sums are allocated to saving statistical lives than may be spent in saving identified lives.

injury is the saving in potential output or productive capacity. It is an ex-post accounting approach that uses the discounted present value of a victim's future earnings as a proxy for the cost of premature death or injury. The human capital approach can also be used to value non-paid work in the form of service to family and community.

The human capital and willingness to pay approaches are different in concept and, in terms of the 'value of life' issue, produce two different measures. As stated above, the human capital approach measures human output or productivity, while the willingness to pay approach attempts to capture trade-offs between wealth and risk. In other words, 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. The 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. Both the human capital and willingness to pay approaches are imperfect in estimating value of life. Fundamentally, 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 various empirical difficulties.

The two approaches have some common deficiencies. For example, both approaches involve 'partial equilibrium' in the sense that they ignore the wider consequences of extending life. The willingness to pay approach may approve of effects to prolong the life of a person provided the cost was met by those interested in that person's welfare. However, there is also a social cost involved, as the consumption of the elderly must be financed by members of the labour force. Both approaches therefore ignore inter-generational costs, such as a heavier social security burden on younger members of society.

Social equity issues arise in the application of both the human capital and willingness to pay approaches because richer members of society can have a disproportionate influence on policy outcomes. Different programs can be valued differently depending on whether human capital or willingness to pay is used. Human capital is associated with the utility of lifetime consumption (to the extent that consumption is the major objective of production) whereas willingness to pay is related to the utility of life per se. The human capital approach, however, provides a fairly reliable lower bound estimate of the social cost of crashes.

Table 3.1 provides a summarised version of the arguments for and against the use of these two approaches. BTE (1998) provides a detailed and comprehensive review of the theory and practice of willingness to pay methods.

As the willingness to pay approach includes elements that the human capital approach has difficulty in costing, the former will generally give higher values than the latter. This is particularly the case for fatalities. Higher values for safety can be expected to increase the relative priority given to safety in road projects and to also increase the priority given to road safety vis a vis other areas of government expenditure. Box 4.2 contains a brief discussion of the likely effect on the total cost of road crashes of adopting a willingness to pay value of life. Using the willingness to pay approach will have a range of policy implications needing careful consideration.

Countries using the willingness to pay approach to value human life for road safety purposes include Finland, New Zealand, Sweden, Switzerland, United Kingdom and United States. Willingness to pay values used in European countries range from A$1.8 million to

TABLE 3.1 COMPARISON OF APPROACHES TO VALUING HUMAN LIFE

Advantages	Disadvantages
Human Capital	
• Data reliable and readily available.	• Values some lives higher than others due to labour market imperfections, such as wage discrimination. If simplistically applied, the very young and old are undervalued.
• Consistent and transparent results.	• Overestimates costs in an economy with less than full employment.
• Simple to use.	• Does not reflect a key reason for investment in safety: aversion to death/injury rather than income protection.
	• Ignores the loss of 'joy of life', while values for pain, suffering and grief are often arbitrary.
	• Actuarial uncertainties regarding life expectancy and earnings.
	• Selection of the appropriate discount rate is controversial.
Willingness to Pay	
• Comprehensive.	• People have difficulty understanding and valuing small risks (generally less than 1 in 10 000).
• Incorporates subjective welfare costs.	• Individual perceptions of risk may differ.
	• Willingness to pay does not necessarily imply ability to pay.
• Reflects individual preferences.	• Differences exist between people's expenditure patterns/actions and their real preferences.
	• Aggregating individuals' willingness to pay may not produce the social willingness to pay, as individuals may ignore external social costs.
	• Difficulty in applying concept of a statistical life rather than a particular life.
	• Methodological difficulties (eg. inaccurate responses) and strategic behaviour in surveys.
	• Equity is not taken into account, as results are income-related.
	• Discrepancy in results using willingness to pay and willingness to accept approaches.
	• Value will change with incomes and variations in road safety.

Source BTE (1998).

$4.2 million (1998 Australian dollar equivalents), while in the United States a value of US$2.9m (in 1994 prices) is used for all transport accident fatalities. New Zealand, as at June 1998, was using a figure of NZ$2.25 million.

The wide variation in willingness to pay estimates of value of statistical lives is, in part, due to the fact that the value depends on circumstances and individual preferences in avoiding physical risk. This can be viewed either as a complicating and inconsistent factor, or as a strength of the willingness to pay approach in more precisely recognising people's preferences for particular crash prevention activities. The variation is also partly due to country differences. Willingness to pay is country-specific and inter-country comparisons of willingness to pay values are difficult to make as social, cultural and income factors confuse the picture.

STUDY APPROACH

The human capital approach used by the BTE in its previous road crash cost studies, and recently refined and used for the estimation of the cost of aviation crashes, is the approach used in this study. The decision to use this approach was made to ensure that the work had a basis for comparison with previous BTE (and BTCE) studies in this area and also with the study on the cost of civil aviation accidents (BTE 1999). The results also provide a benchmark to compare the results of any studies based on the willingness to pay approach produced in the future.

Costs have been classified into three types, which this report will examine in turn:

- human costs (arising from the injury to a person);
- vehicle costs (arising from damage to a vehicle); and
- general costs (not directly dependent on level of damage to vehicles or injury to persons).

This grouping allows costings to be developed for both persons and crashes. Costs are reported for fatal, serious injury and minor injury crash outcomes as well as for the cost of a fatality and other levels of injury.

Some of these costs—such as costs of medical treatment, towing, and vehicle and property repair or replacement—can be relatively easily valued using market prices. Another group of costs comprise those which are not part of the market process and cannot easily be valued in monetary terms, such as the value of time lost in crash-related travel delays, police investigation time and coroner's time.

Costs for these elements can, however, be fairly easily estimated by using a proxy, such as wage rates, for the value of time.

As described earlier, the value of life estimates were generated using the human capital approach, using lost income and lost value of unpaid labour (in the workplace, household or community). However, in recognition that life is more than labour, a non-economic loss has been incorporated to represent pain and suffering and lost quality of life.

The cost estimates in this study are markedly higher than those presented in the 1992 BTCE report, even when inflation is taken into account. More accurate costings of a number of components are partially responsible for this, as is the inclusion of additional components such as the costs of towing and vehicle unavailability, workplace disruption and long-term care. This approach builds on the refinements in the aviation crash cost report (BTE 1999). The differences these changes make in the overall cost of crash figures are highlighted in chapter 7, as well as what this means for comparability with earlier figures.

Despite the increased cost estimates, there remain a number of factors that could not be included in the costing framework due to data constraints. The limitations imposed by data are specified in the discussion of each cost element. The overall crash costs presented in this study should therefore be considered lower-bound estimates.

4

HUMAN COSTS

The human costs of road crashes are those cost elements that are directly related to personal injury—loss of output, loss of quality of life, medical costs and coronial, funeral, legal and prison costs.

VALUE OF LOST LABOUR

When individuals are killed or severely disabled, their potential labour output over their expected remaining years of life is lost to society. Only value of the labour is considered foregone, as income from non-labour sources (such as dividends and rental income) will continue regardless of the mortality/health of individuals. The loss of labour services is felt in the workplace, the household and the community and their worth to these areas must be calculated.

Labour in the workplace

The total value of labour in the workplace depends on the amount of working life a person would reasonably expect to have and the worth of the labour to the workplace. An alternative viewpoint is outlined in box 4.1.

Age- and gender-specific life expectancy tables have been used to estimate the probable length of life if the death/incapacity had not occurred prematurely (ABS 1997). For statistical purposes, death/incapacity is modelled as occurring at the mid-point of the year. Life expectancy data have been combined with similarly detailed employment rate data to model typical periods of working life.

Before a value is placed on labour, an important point regarding terminology needs to be made. The value of labour can be estimated in a number of ways and is sometimes referred to as a measure of 'labour productivity'. However, true labour productivity is a measure of the contribution to output by a unit input of labour. Care must be taken to separate the contribution of labour from that of capital and other factors, such as managerial efficiency or economies of scale (ABS 1992). This report does not use an output-based value of labour; instead, it uses the dollar amount an employer pays for a unit of labour as an input to production.

BOX 4.1 THE FRICTION METHOD OF VALUING LOSS OF LABOUR

Koopmanschap and van Ineveld (1992) argue that labour should be valued using only the lost production during the time taken to replace a missing worker (the friction period), rather than the worker's future stream of income. Real production losses are believed to be much smaller than the potential losses, as labour may be replaced by the unemployed or from labour reserves within the firm, or there may be possibilities for restructuring the organisation of production and using labour saving devices. Therefore, production may be lost only until the firm adapts to the situation. Lost labour is valued from the perspective of the workplace, rather than from the perspective of the whole of society.

This study recognises the existence of frictional costs in the workplace—such as lost output from remaining workers and recruitment and training costs—but argues that, from the social viewpoint, these are incurred in addition to the lost income stream. As such, they are examined separately later in this chapter. From a social standpoint, how soon the fatality/incapacity is replaced in the workplace will not have an impact on the value of the potential labour resource lost. This value is only affected by the probability of being without paid employment at some stage of life.

Average wage and salary data from the 1995-96 Survey of Income and Housing Costs (ABS 1996c) were used as the basis for measuring the value of labour in the workplace. This provides a measure of gross income from all jobs weighted to reflect the split between full- and part-time workers. A further advantage of this survey is that it provides age and gender differentiated data. The ABS data exclude unpaid labour; however, unpaid labour has value and needs to be taken into account. Some adjustments therefore had to be made to attribute earnings to unpaid labour. Such values were treated on the same basis as earnings from paid employment.

There has been considerable debate on the use of gross versus net earnings in valuing output (see BTCE 1992, appendix I for a discussion of this issue). Australian studies have mostly used gross earnings. Gross earnings are a measure of the amount an employer pays for employees—some funds go directly to the employee (net earnings) and the remainder goes to bodies such as government (taxes) and superannuation funds. This report also uses gross earnings, as it accurately reflects the full cost (and value) of labour.

ABS gross wages and salaries data (age- and gender-specific) were used as the basis for the estimation of the cost of labour to the employer. The gross wages and salaries data were adjusted to incorporate on-costs (such as employer payments for superannuation, payroll tax, workers' compensation and fringe benefits tax), producing a closer approximation of the cost of labour to the employer. ABS (1998b) estimated on-costs to be a weighted average of 14.8 per cent of earnings in 1996-97. The weighting accounts for the differences in earnings between full- and part-time labour. This estimate of on-costs differs from the figure for full-time workers of 24.5 per cent used in Cost of Civil Aviation Accidents and Incidents (BTE 1999). The difference reflects a refinement in method made after an examination of the factors that comprise on-costs. In addition to on-costs, an adjustment for training costs (2.9 per cent of gross wages and salaries), developed from the Training Expenditure Survey 1993 (ABS 1994), was made. The cost of welfare services and recruitment are two other costs borne by the employer. However, ABS (1995) considers that these costs are not significant contributors to total labour costs and they have therefore been excluded. The sum of these adjustments represents a 17.7 per cent increase in the base wages and salaries data.

For ease of later calculations, weekly earnings figures were annualised (using 52.18 weeks per year). A 2 per cent annual growth rate was applied to take account of real increases in labour costs over time. The resultant figure represents the overall value of labour. Only one age group was treated differently—fatality/incapacitation between 0 and 14 years of age was given a zero value of labour until the time when the legal working age of 15 would have been reached.

The value of labour at each age was applied to the potential working life of the fatalities/incapacities. At each age only a proportion of people hold paid positions, the remainder are voluntary workers, unemployed persons or those who choose not to be part of the labour force. To represent this phenomenon, the present value of the earnings stream was adjusted using age- and gender-specific employment rates (ABS 1996d). This adjustment is important in estimating the actual, rather than potential, labour loss due to road crashes.

Finally, the estimated losses were discounted to present values using discount rates of 4 and 7 per cent. Choosing an appropriate discount rate is not straightforward. An appropriate approach to determining discount rates involves the marginal opportunity cost of capital. When investment is involved, the marginal real rate of return on capital must be considered. However, when lost consumption is involved, the appropriate measure is the rate at which society is willing to trade off future for current consumption (social rate of time preference).

It is generally accepted that the real after-tax return on widely available savings instruments (such as Commonwealth Government Bonds or Treasury Bills) is an appropriate measure of the consumption rate of interest. The human capital approach to crash costing, to a large extent, represents lost lifetime consumption (to the extent that consumption is the major objective of production). Hence, the appropriate discount rate is the social time preference rate. It can be measured by the average real rate of return on Commonwealth Government bonds. For use in this report, the rate was derived by estimating the mean real rate of return on the 3- and 10-year bonds. The data available for the 3-year bond covered 1992-1999 and for the 10-year bond the period was 1969-1999. The real rates of return were 4.82 per cent and 3.15 per cent for the 3- and 10-year bonds respectively. The mean of these two rates of return is 4 per cent. A rate of 7 per cent has been used as an upper bound and for comparison of results with BTCE (1992) which used this rate. The considerable sensitivity of results to the discount rate used is evident from table 4.1.

TABLE 4.1 VALUE OF WORKPLACE LABOUR LOSSES, 1996

($million)

	Discount rate	
	4%	7%
Total loss from fatalities	1 064	684
Loss per fatality	0.54	0.35
Total loss from permanent injuries	561	361
Loss per permanent injury	0.54	0.35

Source BTE estimates based on data from ABS and ATSB.

The formulas below summarise the foregoing discussion:

$P_x = A_x V_x[(l_{x+1}/l_x)/(l_x/l_{x-1})]$

with

$V_x = W_x E_x$

where P_x is value of the lost labour for the year the victims would have been age x; A_x is the total number of people at age x who have died in road crashes and who would statistically otherwise have been alive at age x; l_x is the number of people who statistically survive to age x in a birth cohort of 100 000 (ABS 1996e); and V_x is employment rate (E_x) at age x multiplied by average earnings (W_x) at age x.

The result, P_x, for each year of statistical survival was discounted to present values (1996). That is,

$$PV = \sum_{x=i}^{\infty} \frac{P_x}{(1 + rate)^{x-i}}$$

where PV is the present value of the lost value of labour over the relevant period, rate is the discount rate and i is age at death from a road crash.

Table 4.1 shows the estimated value of lost labour. Use of a 4 per cent discount rate produces total labour losses of $1.1 billion or $540 000 per fatality.

Those permanently injured are unable to rejoin the labour force. These losses, and those from fatalities, were valued equivalently (table 4.1).

Those with serious injuries also lose time away from the workforce, although it was assumed that they rejoin the workforce at their previous capacity. The average length of stay in hospital was used as the measure of time absent from work, with an additional two days recuperation for each day of hospitalisation. This approach uses the ratio developed by Collins and Lapsley (1991) in their work on production lost due to drug abuse. More recent work relating to these costs could not be found.

The decision to use the work of Collins and Lapsley (1991), rather than the one-to-one ratio used in BTCE (1992), is less important, as more accurate hospital bed-days data now indicate an average of 8.3 bed-days per serious injury, whereas BTCE (1992) used 17 bed-days. This report uses a measure of 25 days lost labour for each serious injury (excluding permanent disabilities) and the average age of serious injuries (ATSB 1998), together with the relevant income level and the expected unemployment rate. There is no need to discount this estimate, as the whole loss occurs within a year of the crash event. In total, $37.6 million was lost due to loss of labour from this group (excluding permanent incapacitation). The labour lost from all those with serious injuries (including those unable to join the workforce) totalled $599 million, or $27 241 per serious injury.

The loss of labour from minor injuries was estimated to be relatively small—the loss was from only about 3 per cent of all minor injury victims who sought hospital treatment. Most of those who sustained minor injuries mainly visited general practitioners for short periods at a time, so the costs of these have been excluded.

The total value of labour lost in the workplace due to road crashes was estimated at $1.7 billion in 1996.

Labour in the household and community

The loss of a person in a road crash means that their contribution to the home (such as child care and housework) and to the community (including voluntary assistance to school, sporting and community groups) is foregone. Although such work is unpaid, it is essential to the quality of life for individuals, their families and the wider community.

In this report, average hours of unpaid work outside the workplace were obtained from time use data, and wage rates derived from the ABS (1996c) were applied to obtain estimates of the total value of unpaid work. The level of earnings per hour for those in the formal workforce has been assumed equivalent to the loss of potential earnings while performing these functions.

Three important factors in determining the level of productive activities are a person's age, gender and employment status. The influence of these factors on productivity should be fairly obvious and a few explanatory examples should suffice:

- People with children may be involved in a number of community groups, and have added housework, because of the children.
- As those not in the workforce have more time at home, they may tend to do more around the house.
- Traditionally, women have been the major bearers of domestic duties.

The 1997 Time Use Survey (ABS 1998c) provides average hours per week spent in work in the home and work for the community by age-group, gender and employment status for 1997. These values were annualised using an equivalent of 52.18 weeks, on the assumption that work is carried out throughout the year.

The computational method used for valuing labour in the workplace was also used for the estimation of household and community workplace labour losses. In short, for each potential year of life, the amount of household work specific to a ten-year age group was calculated and valued using the average income for that group.

This was done for employed and unemployed males and females. Employment status clearly affects the number of hours in any given week available for household and community work. The value of potential future household labour losses as a result of 1996 road crash fatalities is presented in table 4.2.

Lost household and community labour for those with permanent injuries (table 4.2) was estimated using the same approach as that adopted to estimate workplace labour losses.

Those with serious injuries will also be unable to contribute labour to the household or the community for the average 25-day period mentioned earlier in relation to workplace labour losses. The value of this labour loss was estimated assuming an average age and taking into account the variation in labour output according to employment status. In total, $28.8 million was lost in household/community labour from this group. Total labour lost from all those with serious injuries was estimated at $544 million, or $24 755 per serious injury.

TABLE 4.2 VALUE OF LABOUR LOSSES—HOUSEHOLD AND COMMUNITY, 1996

($million)

	Discount rate	
	4%	7%
Total loss from fatalities	978	569
Loss per fatality	0.50	0.29
Total loss from permanent injuries	516	300
Loss per permanent injury	0.50	0.29

Source BTE estimates based on data from ABS and ATSB.

As with workplace labour, the loss of household/community labour due to minor injuries was estimated to be relatively small and has been excluded from the analysis.

The total value of labour lost to the household and community from road crashes was $1.5 billion in 1996.

QUALITY OF LIFE

Loss of quality of life encompasses both the pain and suffering of the injured and their inability to return to their way of life before the injury. These losses cannot easily be given a dollar value. Pain, and uncertainty about recovery, affect the injured. Severe injury may lead to a permanent disability, which is likely to produce a permanent loss of quality of life. A person whose knee has been shattered may be unable to play tennis. A quadriplegic will be unable to drive or catch a bus, and will require assistance for most everyday activities, such as preparing meals. Loss of quality of life also includes loss of future quality of life, for example having to abandon career or family plans.

Death or very severe permanent injury are the most extreme consequences of road crashes. Death is difficult to fit logically into the scale of quality of life losses, because, although the loss should increase as injuries become more severe, there is no ongoing suffering after death. This report treats the quality of life effects of death as equivalent to the most extreme injury, because the losses suffered by the victim are similar.

Traditionally, the human capital method does not attempt to estimate non-economic losses. Suffering does not necessarily have any effect on an individual's ability to work or to consume. However, the inclusion of non-economic loss estimates is a valuable methodological refinement.

There are a number of methods available for measuring loss of quality of life. These range from willingness to pay techniques through to the use of proxies such as court awards and other compensation payments. The willingness to pay method has been discussed in chapter 2. In this report, the compensation paid to road crash victims in Australia is used as a proxy for loss of quality of life.

Court awards and settlements

Court awards for non-economic loss have been used to proxy lost quality of life (Cohen 1988, Viscusi 1988).

Any method of valuing loss of quality of life must satisfy the following two conditions, although they are not sufficient in themselves.

- The valuation must be consistently related to a given loss of quality of life, or at least to a level of injury.
- The valuation must have some claim to be reasonable, given the victim's loss.

It has been claimed that court awards are not consistent and that juries are capricious in the amounts they award. In contesting this claim, Viscusi (1988) provides evidence, based on data from the United States, on the predictability of court awards and out-of- court settlements for injury compensation claims. He concludes that court awards vary predictably with the type of injury, contrary to claims that they are random and capricious. This evidence is noteworthy because awards are decided by juries, usually with no restrictions other than the general rule that the compensation should be 'reasonable'. Cohen (1988) also provides some supporting evidence that United States jury awards are predictable.

Are jury awards a reasonable valuation of the victim's loss? Cohen (1988) suggests that, since United States society has chosen the court system to determine non-economic compensation, it is acceptable to use jury awards as society's assessment of quality of life losses. Jury awards have an extra claim to represent society's opinion because a jury is intended to be a random selection of ordinary people.

Viscusi (1988) concludes that out-of-court settlements understate the role of pain and suffering because settlements are smaller than court awards for similar injuries. He suggests that the main reasons for this are the chance that the plaintiff could lose in court, litigation costs and plaintiff risk-aversion. However, if settlements are smaller than court awards only to compensate for the risks and costs of litigation, it suggests that out-of-court settlements may be a more accurate reflection of the socially determined level of compensation. Only the plaintiff's risk-aversion could push the settlement below the level determined by the real risks and costs involved, and Viscusi does not offer any information on the level of risk-aversion among plaintiffs.

Cohen (1988) cites evidence that payments are not substantially increased in value simply by going to trial. Although the average values of jury verdicts are often much greater than values for out-of-court settlements, this is largely because low-value cases are unlikely to be worth the expense of a trial. Anecdotal evidence suggests that the same is true in Australia. Because of the additional stress and delay that usually accompany litigation, it is possible that plaintiffs are not losing much by accepting the settlement.

It is not surprising that settlements should be predictable and comparable with jury verdicts. Both the plaintiff's and defendant's lawyers have access to records of previous trials (for example, Britts 1973-1996). Both sides understand that, if they demand a settlement too different from the verdicts in similar trial cases, the other side will take them to court rather than settle.

Compensation awards in Australia

The frequency of compensation cases going to court in Australia is much lower than in the United States. Indeed, even when cases go to court in Australia, there are clear differences from the American system where payments are unrestricted and are freely decided by a jury. In most Australian States and Territories, non-economic compensation payments for road crashes are controlled by legislation.

All Australian States and Territories require motor vehicles to be insured against causing injury and death in road crashes (CTP insurance). In most jurisdictions the scheme is administered by a government agency, and in all jurisdictions government carries political responsibility for the size of the premium. Also, in most jurisdictions, government control of crash compensation extends to legislated upper limits on non-economic compensation payments. Often, there is a lower threshold as well. This means that the maximum level of non-economic compensation is decided by parliaments in each jurisdiction; the courts decide only the relative amounts awarded for lesser injuries. In most jurisdictions, cases that go to court are decided only by a judge.

There is considerable variation in compensation systems among jurisdictions. New South Wales, South Australia and Western Australia operate common law schemes in which non-economic awards are limited. In a common law scheme, a person seeking compensation must prove that some other insured person was negligent, and compensation may be reduced if the claimant's own negligence contributed to the crash. New South Wales and Western Australia also impose minimum thresholds on non-economic awards. If the injury is below a certain level of severity, non-economic compensation will not be paid. In Western Australia, lower impairment levels are compensated at a lower rate than higher levels. New South Wales and South Australia both require the award to be proportional to a numerical assessment of degree of impairment relative to a worst case, but these numbers are not objective.

Victoria operates a two-part compensation scheme—a no-fault scheme and a common law scheme. The no-fault scheme pays impairment and fatal injury benefits. Under certain circumstances, some of these benefits may be reduced or not paid. For example, the driver will receive a reduced impairment benefit if convicted of culpable driving, or certain other offences. The system uses an objective medical scale for rating percentage impairment. The impairment benefit, which covers non-economic losses, pays a fixed amount for each percentage point of impairment above a threshold of 10 per cent. In addition, those injured in crashes may sue at common law if seriously injured. This is normally assumed to be true for any level of impairment above 30 per cent, but the Transport Accident Commission (TAC), which administers the scheme, or a court, may issue a certificate of serious injury for levels below 30 per cent.

Common law non-economic damage awards depend on fault, and have an upper limit and a minimum threshold. Common law damages are determined subjectively and by precedent, and when they go to court, either side may request a jury. Common law non-economic damages, if paid, are reduced dollar-for-dollar up to the amount of any non-economic compensation paid under the no-fault scheme.

Both Queensland and Tasmania operate common law systems without caps or thresholds on non-economic compensation. In both States, judges decide compensation in regard to the small proportion of claims that go to court.

Few compensation claims go to court—most are settled by reference to records of previous court cases and by negotiation. This means that court decisions effectively control awards, even for cases that are not decided in court.

Table 4.3 shows the maximum amounts payable in States with legislated caps, together with the maximum amounts ever paid in Queensland and Tasmania.

Do the Australian systems provide a basis for an estimate of loss of quality of life that satisfies the requirements of consistency and reasonableness? Consistency is ensured in some States by requiring the payment to be proportional to a numerical degree of impairment. This principle has been used in this report in estimating the value of lost quality of life, together with data from Victoria based on an objective medical scale of impairment. The general magnitude of the payments is therefore predictable.

TABLE 4.3 MAXIMUM NON-ECONOMIC AWARD

State	Maximum award ($)
New South Wales	250 000
Victoria	319 000
Queensland[a]	830 000
South Australia	90 000
Western Australia	212 000
Tasmania[a]	175 000

a. These States do not have caps and the maximum award is the highest ever paid (the Queensland figure is for the period post-1994).

Sources MAA pers. comm. (1999), TAC pers. comm. (1999), MAIC pers. comm. (1999b), State Government Insurance Office (South Australia) pers. comm. (1999), Insurance Commission of Western Australia pers. comm. (1999), Motor Accident Insurance Board (Tasmania) pers. comm. (1999).

Reasonableness is a more difficult question. The amounts awarded for pain and suffering are ultimately determined by State/Territory parliaments, and so are a reflection of the value placed on quality of life by the electorate and the society from which they come. Compensation amounts are determined by the size of the premium governments are prepared to impose on vehicle owners. When premiums become excessive, in the perception of vehicle owners, it is an important political issue for State and Territory governments, as is the perceived adequacy of compensation. Currently, no government subsidises its insurance scheme.

While this process may appear to be driven by expediency, the need to balance objectives within a budgetary constraint is part of all economic valuation. Even the willingness to pay method assumes that people balance safety against other needs within their own budget. It is unlikely that anyone would suggest that the political process always brings out society's true values, but Australian compensation awards at least have the advantage that compensation amounts are balanced against what the vehicle-owning electorate is demonstrably willing to pay for compulsory third-party insurance.

This estimate of quality of life loss based on legislation is open to the criticism (Jones-Lee 1976, p. 33, p. 46) that it simply feeds back to the political process its own valuations of human misery. To some extent this is true. However, it may be appropriate to accept that there are limits to the approach used. Compensation awards form a conservative estimate of part of the human cost of road crashes that nevertheless has a basis in real choices made by Australian society. Their large contribution to the total cost of crashes shows that even a lower bound estimate is important in providing perspective on the more substantial elements of the overall cost.

Estimation of lost quality of life

This report uses estimates for loss of quality of life based on data for non-economic compensation from the TAC. The data show the spread of payments across different levels of impairment from road crashes. Additional data from the NSW and Queensland schemes were also used.

In developing an estimate of the lost quality of life, those compensated under the no-fault part of the Victorian scheme, but not under common law, were assigned the legislated non-economic compensation for their degree of impairment. This means $720 per point of impairment above 10 per cent, to a maximum of $64 741. Impairment of less than 10 per cent (including injuries that do not lead to long-term impairment) is assumed to have a negligible impact on the quality of life.

Those compensated under common law were not assigned the actual amounts paid to them because these amounts are often discounted if the victim is found to have contributed to the crash[1]. For the purposes of estimating lost quality of life, this was considered inappropriate because being partially at fault does not diminish the quality of life losses experienced. Instead, it was assumed that the payment is proportional to the degree of impairment above 30 per cent, up to the maximum payment of $319 030 (equal to the average for the 1995-96 and 1996-97 financial years).

Recall that common law compensation is reduced dollar-for-dollar up to the amount of any compensation paid under the no-fault scheme. This gave a value about 50 per cent higher than the total actually paid by the TAC in 1996. To get a better estimate of the level of non-economic compensation throughout Australia, the Victorian estimate was averaged with estimates from New South Wales (MAA 1998, p. 18) and Queensland (MAIC 1999). These two estimates were obtained from total payouts reported by the relevant agencies, assuming that the total amount of discounting for contributory fault is the same as that in Victoria. From this it was possible to

1 It is understood that the TAC has recently begun keeping records of these discounts.

extrapolate for the whole of Australia, based on the level of serious injury in each State and Territory.

Statistics on 'post amendment' claims in NSW were used to estimate the distribution of payments between hospitalisation (MAIS 2-5) and minor (MAIS 1) injuries (MAA 1998, p. 13).

For fatalities, the compensation amount allocated to 100 per cent impairment cases was assigned. This was done to place a lower bound on the intangible component of life, which those who die have lost. It is a lower bound, as it equates death with permanent incapacity. The value of lost quality of life of relatives and friends of crash victims has not been estimated in this report.

The estimated value of lost quality of life was $319 030 per fatality and $34 228 per serious injury. The estimated total cost of lost quality of life due to road crashes in 1996 was $1.769 billion, comprising $628 million for fatalities and $1140 million for injuries ($753 million for those seriously injured, and $388 million for minor injuries).

BOX 4.2 QUALITY OF LIFE UNDER A WILLINGNESS TO PAY APPROACH

If a willingness to pay valuation of life were used in this quality of life costing, there would be an impact on the total cost of crashes. As discussed earlier, a number of countries have been through the exercise of developing willingness to pay valuations, which are typically in the range $1.8 to $4.2 million per life. However, there is uncertainty as to whether these values include all or part of the income and production losses in addition to quality of life itself.

If this report had used a value of life based on the willingness to pay approach of $2 million, the total cost of crashes would be considerably higher than estimated. If the willingness to pay value is taken to represent only quality of life and is substituted for the estimate of $320 000 actually used in this report, the total quality of life loss would be about six times greater than estimated, or $11 billion. This would lead to an estimate of the total cost of road crashes of the order of $24 billion.

On the other hand, if the willingness to pay value is taken to represent the full value of life (inclusive of potential earnings losses), then the quality of life component would be obtained by subtracting the workplace and household production loss for casualties. This would lead to a lower bound estimate of roughly $19 billion.

Clearly, the adoption of a willingness to pay value of life would have a substantial effect on the estimated cost of road crashes in Australia.

BOX 4.3 QUALITY OF LIFE LOSS AND DALYs

An alternative approach to measuring quality of life loss is used in the Australian Institute of Health and Welfare's (AIHW) study on the burden of disease and injury (Mathers, Vos & Stevenson, 1999). The study uses Disability Adjusted Life-Years (DALYs) to estimate the loss suffered by the dead and disabled. The DALY is a non-monetary measure of loss; although there are methods for assigning monetary equivalents, Mathers, Vos & Stevenson (1999) did not attempt to do so. The BTE advises against using this report on road crash costs as a basis for such a valuation. The method used to estimate monetary values for quality of life losses is highly specific to road crashes in Australia, and would have no justification outside that area.

DALYs are calculated as the sum of the years of life lost (YLL) due to premature mortality in the population and the years lost due to disability (YLD). YLD is obtained for a particular condition by estimating the average number of years a person will have the condition, and multiplying by a severity weight. The severity weight represents the loss of value of life compared with perfect health. The weights are obtained from 'person trade-off' surveys, which ask subjects to choose their preferred use of limited health resources.

The road crash is the twelfth highest cause of disease burden in Australia and the seventh highest cause of YLL (Mathers, Vos & Stevenson 1999, p. 32, p. 65). Road crashes had the second highest reduction in per capita YLL for males since 1981, and the third highest reduction for females (Mathers et. al., p. 35). Table 4.4 shows some selected statistics from the AIHW report. Note that the figures for road crashes are based on data slightly different from the data used by the BTE. The YLL are based on 2050 road crash fatalities (of a total of 128 711 deaths in Australia in 1996).

TABLE 4.4 DALYs LOST DUE TO 1996 ROAD CRASHES

(Years)

	Road crashes	Other transport crashes	Unintentional injuries [a]	Ischaemic heart disease [b]	Total all causes
YLL	45 928	5392	89 068	275 778	1 348 233
YLD	9781	1977	54 052	35 552	1 162 041
DALYs	55 709	7369	143 120	311 330	2 510 274

a. Includes road crashes and other transport crashes.

b. Largest single cause of DALYs lost in 1996.

Source Mathers, Vos & Stevenson (1999).

MEDICAL COSTS

Not everyone involved in a road crash receives or needs medical attention. Only about 13 per cent sustain an injury requiring medical attention. Nonetheless, this group accounts for a substantial component of the total cost of road crashes.

The medical costs of road crashes comprise charges arising from the use of ambulance, hospital in-patient, outpatient and casualty/emergency services, general practitioners, specialists and allied health services such as radiography and physiotherapy. In addition, there is the cost of rehabilitation and long-term care, which is not always a purely medical cost, associated with ongoing medical problems.

This report considers three levels of injury arising from road crashes—fatal, serious and minor injury. A fatality is defined as a death occurring on the spot or within 30 days of a road crash. Serious injury is defined as an injury resulting in hospital admission. Consequently, medical treatment for a minor injury covers a range from a visit to a general practitioner or casualty/day patient. Those with injuries that did not require or receive medical attention were regarded as uninjured and were not considered further. Table 4.5 highlights the number of people in each category.

In determining medical costs, there are some essential items of information—the type and severity of injury and the place of treatment. All these have been considered in this report when compiling medical costs. There are some further factors that have not in all cases been considered due to lack of available information, but which may influence the true medical costs. These factors are

TABLE 4.5 PEOPLE INVOLVED IN ROAD CRASHES, 1996

Injury severity	Number of people
Fatal	1 970
Serious	21 989
Minor	213 322
Uninjured	1 533 279
Total	1 770 560

Sources ATSB (1999b), AIHW (1997a), O'Connor and KPMG Peat Marwick (1993), Mathers, Penm, Carter and Stevenson (1998) and BTE estimates.

the location and age of the patient. As medical costs differ slightly between jurisdictions, average Australian costs have been used—which is a reasonable assumption, as the death and injury rates per capita do not vary largely on a State/Territory basis. The age of a patient is particularly important when it comes to determining the amount of time spent recovering from an injury, and hence the level of ancillary medical services consumed. The lack of such detailed information means that an average age has to be assumed.

A proportion of the injuries sustained in road crashes in any particular year will require ongoing medical treatment in future years. This cost has been incorporated in the estimates through the inclusion of medical treatment administered in 1996 to crash victims from previous years.

Ambulance costs

At a crash scene, the medical costs start with the arrival of the ambulance. Ambulances are used to transport victims to hospital, treat the injured on the spot, and remove fatalities. This central role means that ambulances are called to all serious and fatal road crashes. With the spread of mobile phones, ambulances receive multiple calls to crash scenes and varying amounts of information on the crash are supplied. In such cases, a professional medical assessment of the need for an ambulance cannot be expected and caution is usually shown in the number/type of ambulances sent. Still, the possibility of more than one ambulance arriving at the crash site would tend to increase ambulance costs.

Data from New South Wales, Victoria, South Australia and Queensland suggest that, on average, road crashes constitute about 7 per cent of total annual ambulance call-outs. Attendance at fatal and serious road crashes represents about 16 per cent of the crash-related services. This share is further inflated by the use of ambulances for inter-hospital transfer of crash victims. Using an estimate of 4.2 per cent of hospital admissions being transferred to another hospital (derived from AIHW 1997b), and allocating this cost to serious injuries, indicates that 20 per cent of crash-related ambulance services are for fatal and serious crashes. The remaining 80 per cent of services result from minor crashes (68 per cent) and PDO crashes (12 per cent).

In the case of road crashes, as more than one ambulance may call at the scene, the cost of the service provided by all the ambulances present is the key estimate required. Unit costs of ambulance services are wide-ranging because of disparities between urban and country areas and between vehicle-related incidents and other emergencies. The cost of an ambulance journey varies considerably with factors such as distance travelled and extent of injuries. Table 4.6 displays both the level of ambulance activity and the average costs for each State and Territory.

Unpublished work (Clemont, pers. comm., 1997) within the South Australian Ambulance Service indicates that additional activities associated with road crashes make the cost of service about 20 per cent higher than average. It is common for ambulance crews to spend considerable time and resources (consumables such as drugs, bandages, etc.) at the scene of a crash, dealing with abrasions and shock and providing medical assistance as well as comfort. In the case of trapped victims, or severe injuries, more than one crew may contribute to the care of one patient. For example, the South Australian Ambulance Service has a policy of despatching a paramedic officer, if available, to a crash scene. On the other hand, in the case of road crashes, there is a higher proportion of ambulance attendance with no victims transported compared with other types of emergencies.

TABLE 4.6 NATIONAL AMBULANCE COSTS AND UTILISATION, 1995-96

	NSW	Vic.	Qld	WA	SA	Tas.	ACT	NT
Patients transported ('000)	510.1	267.7	na	95.1	115.7	29.3	13.3	16.2
Treated, not transported ('000)	88.5	7.7	na	0.3	6.4	3.2	1.3	5.1
Ambulance not required ('000)	83.5	131.1	na	1.2	12	2.1	0.3	0.0
Total ambulance incidents ('000)	682.1	406.4	283.9	96.5	134.1	34.6	15.0	21.3
Total cost ($million)	192.4	134.3	143.0	na	47.5	12.3	na	na
Cost per incident ($)	282	330	504	na	354	355	na	na

na Not available.

Note Columns may not add to totals due to rounding.

Sources Steering Committee for the Review of Commonwealth/State Service Provision (1998a), ATSB (1999b), BTE estimates.

A national average service cost of $282 was derived from table 4.5, reflecting the cost per emergency call-out. However, as discussed above, road crash attendance tends to cost 20 per cent more than the average call-out. Using an average ambulance cost per actual attendance of $338, the estimated total cost of ambulance services attending road crashes in 1996 was $39.6 million. On a unit basis, fatal and serious injury crashes cost $338 each, as an ambulance always attends. The cost of ambulance service per minor and PDO crash was estimated at $55 each, as these were attended by an ambulance in only 19 per cent of cases. This is a rough estimate, as the available data do not allow actual ambulance costs to be differentiated for varying levels of road crashes.

In translating these estimates into an average injury cost, several problems were encountered—no data are available on the cost differential for treating those with various levels of injury, and at an individual crash scene a number of people with a range of injuries may be treated. As a result, the same cost was applied to all those receiving treatment, and it was assumed that all fatalities and serious injuries use the services of ambulances (some more than once when ambulance transfers between hospitals are included). This approach provides an estimate of $254 for ambulance treatment per fatality or serious injury[2]. On the other hand, ambulances attend only 15 per cent of minor and PDO crashes, and even then will treat only a proportion of people involved in these crashes, thereby lowering the average per-person cost of ambulance services. Across all minor crashes, the estimated cost of ambulance treatment per person was $138.

Hospital in-patient costs

A major component of road crash costs is the use of hospital in-patient services by those injured, including some who are ultimately fatally injured. In estimating this cost, it was necessary to establish how many crash victims were admitted to hospital and their level of injury (fatal, serious or minor). To derive hospital costs by injury level, BTCE (1988) used a multiplier, developed from insurance claims for medical costs, based on a 1978 cost estimate (Atkins 1981). There are now two more comprehensive sources of such

2 This is based on an assumption of 1.52 vehicles per fatal/serious crash and 1.58 occupants per vehicle, with 10 per cent of treatment costs allocated to those with minor injuries at a fatal/serious crash scene.

records—crash scene data collected by police and collated by ATSB, and data collected by hospitals and collated by the AIHW. Each dataset has its strengths and weaknesses.

The ATSB fatal and serious data counts individual victims, but relies on police classifications of the level of injury. There is scope for error when those transported to hospitals in ambulances are not followed up. In general, these people would be recorded as a serious injury, whereas casualty areas may treat them but not admit them to hospital. On the other hand, it is known that some crashes involving hospital admissions never come to police attention. Work by O'Connor and KPMG Peat Marwick (1993) using 1990-91 data indicates that police may underestimate hospital admissions by as much as 50 per cent. However, considerable effort has since been made in improving the quality of these data and comparison of ATSB data with AIHW data shows that the issue is now much less significant.

AIHW indicates principal diagnosis or episodes. This approach may count victims more than once as they transfer within and between hospitals and are re-admitted for injuries sustained in a specific crash event. It is thought that less than 8 per cent of episodes can be accounted for in this way (O'Connor 1992). Some of those re-admitted will have been injured in previous years, although it is likely that they may not be fully allocated to road crashes. As a result, AIHW data are likely to overestimate the number of injured people but are accurate as regards total costs. Additionally, AIHW data include some with minor injuries. Indeed, 23.1 per cent of hospital separations (those leaving hospital) occur on the same day as admissions (AIHW 1997b).

In determining the number of fatalities that received in-patient treatment, the AIHW data were used, as ATSB data do not provide this detail. AIHW (1997a) indicates that 681 road crash victims died in hospital. These fatalities were costed as 'average' hospital patients, as the length of stay and level of treatment received varies across the available spectrum. This procedure provides an estimated average length of stay of 6 days.

The difficulty in reconciling data from the two sources occurs when determining the number of seriously injured. ATSB points to 21 989 people incurring serious injury in 1996. In the same year, AIHW (1997a) recorded 31 538 non-fatal hospital separations due to road crashes. Adjusting AIHW figures for double-counting due to patient transfer and re-admission results in 29 015 separations. This figure can be further adjusted to remove same-day separations, resulting in 22 313 serious injuries, which is close to the ATSB serious injury figure. The ATSB figure was used as the estimate of serious injuries and an average length of stay of 8.3 days was assumed, which takes into account longer total hospitalised periods as patients are re-admitted (based on AIHW 1997a).

An estimate of 7026 people with minor injuries who were treated in hospital is given by the difference between the ATSB serious injury figure and the adjusted AIHW separations figure. The average length of hospital stay for this group was estimated at one day (based on AIHW 1997a).

The treatment a patient receives and the length of stay determine the hospital-generated medical costs. There are a number of factors influencing these costs, such as patient age and gender, whether the treatment is in a public or private hospital, and in which State or Territory a patient is located. All this information is collected for each patient by the AIHW and is reflected in the average cost for a diagnosis-related group (DRG).

Each DRG consists of a class of patients with similar clinical conditions requiring similar hospital services. Summing these provides a total cost of hospital care for crash-related in-patients in 1996 of $129.5 million (AIHW 1997a). This figure was then allocated across the three groups of road-crash victims—fatalities ($2.7 million), serious injuries ($120.8 million), and minor injuries ($6.0 million)—on the basis of length of stay in hospital. This approach recognises the base cost of a bed-day and also assumes that the period in hospital reflects the level and costs of treatment received. This top-down approach also avoids the problem where the medical costs of multiple injuries are estimated separately and then summed, which overestimates bed-days and therefore also total medical costs when these injuries are treated simultaneously (Ryan, Hendrie and Mullan 1998).

In summary, the estimated in-patient cost of road crashes was $129.5 million. On a per injury basis, this translates to in-patient treatment of $1373 per fatality, $5493 per serious injury and $28 per minor injury.

Other medical costs

There are a number of other providers of medical services to road crash victims—hospital accident and emergency departments, outpatient clinics, general practitioners, specialists and allied health services (such as occupational therapy and physiotherapy). In addition, there is substantial use of pharmaceutical products.

Emergency departments deal with a range of admitted and non-admitted patients, but with a common focus on short-term care for urgent conditions. The key function is the initial reception and early management of patients who present themselves to the department.

Outpatient clinics in hospitals provide care to non-emergency patients not formally admitted to hospital. To attend a hospital outpatient clinic, a referral from either the hospital itself (in-patient referral) or from a primary-care physician is required. The services provided overlap with those provided by general practitioners, as well as substituting for some in-patient services. There is also some substitution for services provided by specialist medical practitioners in private practice (Duckett and Jackson 1993).

Assessing the extent of the range of medical services provided to road crash victims, and allocating these services among those with fatal, serious and minor injuries are hampered by a lack of information—particularly as medical data tend to be collected on a case basis rather than on a patient basis.

The AIHW (Mathers and Penm 1999) estimated the total medical costs arising from road crashes and the utilisation of medical services in 1993-94. This information has been used to generate a cost per use for each type of service and a health Consumer Price Index (Mathers and Penm 1999) has been applied to inflate these cost estimates to average 1996 levels. These estimates can then be multiplied by the number of times the services are used to provide a total estimate for other medical costs in 1996.

Estimating the utilisation of health services by road crash victims in 1996 is not straightforward. The population growth rate could be applied to update the 1993-94 levels of utilisation to possible 1996 levels. However, chapter 1 has shown that there is a downward trend in the estimates of crashes, which means that using the population growth rate could be inaccurate.

In the absence of better information, it was assumed that medical service utilisation in 1996 occurred at the same level as in 1993–94. Table 4.7 indicates the total cost and utilisation of these services. It must be recognised that many of these instances of service use were by those injured in previous years who were having ongoing medical problems.

The total cost needs to be allocated among fatal, serious and minor injuries. No information was available to provide a guide to the proportion of health services used by each injury type, so the time spent in hospital was assumed to represent the severity of the injury. Time spent in hospital was therefore used as a basis for estimating medical costs.

TABLE 4.7 OTHER MEDICAL COSTS, 1996

Medical service	Total cost ($ million)	Utilisation ('000)	Cost per episode ($)
Hospital non in-patient	94.6	1374.4	69
General practitioner	30.3	1143.3	27
Specialist	27.8	418.7	66
Prescriptions	11.6	679.1	17
Allied health services	27.6	1531.3	18
TOTAL	191.8	na	na

na Not applicable.

Note This excludes the cost of over-the-counter medications, related medical research and what Mathers and Penm (1999) referred to as 'other medical' costs.

Column may not add to total due to rounding.

Source Mathers and Penm (1999).

On average, fatalities spent 2.1 days in hospital and those seriously injured spent 8.3 days. Across all minor injuries, the average time spent in hospital was 0.04 days. To estimate the value of 'other medical costs' for each injury category, the total of these costs was weighted by the number of days in hospital for each injury group. In addition, it is recognised that, of the other medical service areas, fatalities will predominantly use only hospital emergency services, so none of the value of the remaining medical services was allocated to fatalities. It was estimated that the total value of other medical services amounted to $191.8 million, of which fatalities accounted for $2.0 million, serious injuries for $181.3 million and minor injuries for $8.5 million. On a per injury basis, these costs translate into $1018 per fatality, $8246 per serious injury and $40 per minor injury.

LONG-TERM CARE

For a small proportion of road crash victims, the type of injury sustained will require long-term care outside the hospital system, either in a nursing/community home or in private homes. The duration of this care (and cost) would vary with the severity of the disability. For some victims the disability will be permanent and prohibit any future employment, while for others it will not restrict them from engaging in limited employment.

ABS data were used to estimate the annual number disabled as a result of road crashes. Persons disabled as a result of vehicle crashes represented about 38 per cent of total disabled persons in 1993 and 32 per cent in 1998 (ABS 1993, 1998d). These ABS survey data also suggested that total road crash disability victims grew by about 2.4 per cent annually over 1993-98. This growth rate is slower than the growth of the national disabled population, which averaged 5 per cent annually between 1980 and 1998 (Commonwealth Department of Family and Community Services 1998). From the ABS surveys it was estimated that an average of 3997 persons are disabled in road crashes annually. This number equates to 18.2 per cent of those seriously injured in 1996 as a result of road crashes.

Using the ABS (1998b) distribution, it was estimated that, of the 3997 persons, about 26 per cent (1039 persons) suffer a permanent and severe disability affecting their core communication, mobility and self-care abilities. The severely disabled comprise 4.7 per cent of the seriously injured. The remainder have some degree of moderate to minor core disability, and for some this restricts employment or schooling.

The national annual average level of government support for the disabled encompasses expenditure on accommodation, community support and access, respite care and employment services, and was estimated at $25 822 per disabled person supported in 1996 (Steering Committee for the Review of Commonwealth/State Service Provision 1998b). This figure is the average for those with all levels of disability, and is considered representative of the average cost of caring for those disabled in a road crash, as they form around one-third of the disabled population.

The net present value of this cost over the average remaining lifespan, taking into account mortality rates, was derived using an annual growth rate of 0.3 per cent and discounted. The annual real growth rate of 0.3 per cent is very conservative, and is based on the belief that, in the long term, care will become more efficient and cost-effective given the rate of medical advances. (The annual real growth rate in expenditure on the disabled averaged 9 per cent between 1994 and 1997.)

The net present value of care for those disabled in road crashes in 1996 amounted to $2 billion. This figure is equivalent to $90 476 per seriously injured person, and excludes lost value of labour for those whose disability prohibits their working, which has been estimated elsewhere in this report.

CORONIAL COSTS

Every fatality for which the cause is violent, suspicious or unknown requires a coroner's report. Road crash deaths frequently fall into this category. Reports are compiled by the police and the medical profession and forwarded to the coroner. In many instances the procedure is purely an administrative matter, with the coroner examining the submission of reports. However, in some cases, there may be a coroner's inquest with a full hearing. The cost per lodgement in the coronial court was $466 in 1996-97, excluding the cost of autopsies (Steering Committee for the Review of Commonwealth/State Service Provision 1998a). The use of this figure gives a maximum estimated annual cost for coronial investigations into road deaths of $1.1 million, or $558 per fatality.

PREMATURE FUNERAL COSTS

A death caused by a road crash places an unexpected financial burden on the estate or family of the victim, as a funeral must be funded. People do not tend to save for funerals—generally not thinking of them at all until old age. However, a funeral is not a small expense, and savings may be used or the money required may even be borrowed. Either method of payment incurs a financial loss. Premature funeral costs represent the difference between costs at the time of death and costs at the end of the actuarially expected lifetime with appropriate discounting.

An average funeral cost was developed for each State and Territory by weighting a sample of prices by the frequency of cremation and burial[3]. Ideally, if the cost relating to the deceased person's home jurisdiction was available, it could be applied in combination with a mortality table to derive the net present value of the funeral. Instead, population levels were found to be closely related to deaths in each jurisdiction and were therefore used to obtain a weighted average funeral cost for Australia as a whole. This cost was estimated at $3200.

To determine the actual cost this imposed on the family of the fatality, an annual growth rate of 2 per cent was applied to the base cost and this was annualised for the number of years that an individual would

3 Across Australia, cremations are carried out for 54 per cent of deaths, and burials for the remaining 46 per cent (Australian Cemeteries and Crematoria Association, pers. comm., 4 November 1998).

otherwise have been expected to live and then discounted back to 1996 dollars. This procedure, using a 4 per cent discount rate, simulates a 2 per cent annual fall in the real price of funerals. The difference between the cost of a funeral in 1996 and one at the end of the statistically expected lifespan of each victim was then calculated. Premature funeral costs associated with 1996 road crashes amounted to $3.3 million or $1700 per fatality.

LEGAL COSTS

Legal costs arise from road crashes in a number of ways. They are incurred when those injured, or those who have had property damaged, in road crashes obtain legal assistance in either making an insurance claim or in contesting the ruling on such a claim. These costs are initially borne by the claimant, but will be reimbursed by the insurance company. Legal costs are also incurred when charges are laid against a party as a result of a road crash. There may also be civil damage cases where the party at fault was not insured. The latter costs are not included in these estimates, because the defendant's costs will not appear in insurance company statistics.

The legal costs arising from insurance claims are examined first, followed by the legal costs arising from crash-related criminal cases.

Legal costs from insurance claims

Over the past few years, the insurance industry has experienced increases both in the rate of litigation (the rate of appeal) and the size of the average payment in litigated cases. For instance, in 1996-97, while the TAC reported only 11 per cent of its stock of claims having a common law element, contested claims accounted for 44 per cent of total payments (TAC 1997). The NSW Motor Accidents Authority (MAA 1998) reports that, overall, the proportion of claimants with legal representation was 66 per cent in 1994-95 and that 35 per cent of cases were litigated; however, legal costs bear some relationship to claim size, with a solicitor involved in 91 per cent of large claims. More recent figures do not provide the full picture of legal costs, as these may not be evident from the commencement of a claim and claimants have three years to commence litigation. The indications are that litigation and its associated costs will continue to be a substantial drain on resources.

MAA (1998) lists 15 835 claimants for the 1996 calendar year. This may not be the final number of claims for 1996, as there may be some residual claims outstanding, but it is expected that the final figure will not deviate from this to any great extent. Applying the

35 per cent litigation rate provided an estimated 5542 litigated claims in NSW in 1996. MAA (1998) shows that legal/investigation costs represent 20 per cent of payments made on all claims since the scheme commenced in 1989. Applying this proportion to the $714 million of expected payments on claims from the 1995–96 financial year, total legal and investigation costs in NSW were estimated at $142.8 million.

Assuming that the Australia-wide claim rate is the same as for NSW, and that the number of people injured due to motor vehicle crashes is a function of the size of population, NSW costs can be scaled up to represent Australia-wide costs. The payments on 1996 crashes will be made over a number of years; however, this period is uncertain, and this, in combination with low and even negative inflation rates, means that these factors should have a negligible effect on the final legal costs. These costs were estimated to total $422 million.

These legal costs relate to claimants having CTP policies. However, CTP legal costs are also incurred by the insurance companies as well as by both claimants and insurance companies in relation to domestic and commercial motor vehicle comprehensive insurance policies. Figures for insurance company CTP costs, indirect settlement costs for commercial motor vehicles and domestic motor vehicles were taken from ISC (1997, p. 22) and (except the CTP costs) adjusted by 11.15 per cent to remove cases where damage arose from theft and vandalism. Legal costs for the crashes that occurred in 1996 were estimated to amount to at least $788 million.

The estimated costs for the provision of legal services connected with the road crashes are shown in table 4.8.

Legal costs can be allocated across injury severity levels. MAA (1998, pp. 25-27) estimates that 3 per cent of total CTP payouts go to fatalities (estimated using MAIS 6 injuries which are usually fatal), approximately 59 per cent go to those with MAIS 2-5 injuries (likely to result in hospitalisation), and the remainder to minor injury cases. The following assumptions have been applied in allocating legal costs to injury levels:

- legal services are proportional to the final payout;
- the split between injury levels is replicated for comprehensive vehicle insurance; and
- insurance company legal costs are proportional to the final payout.

TABLE 4.8 TOTAL LEGAL COSTS ARISING FROM INSURANCE CLAIMS, 1996

($ million)

Type of claim	Cost to insurer	Cost to claimant	Total
CTP	58.02	422.00	480.02
Commercial motor vehicle	26.56	26.56	53.12
Domestic motor vehicle	127.58	127.58	255.16
Total	212.16	576.14	788.30

Sources MAA (1998), ISC (1997).

It is estimated that fatal injuries account for $23.6 million of legal costs ($12 000 per fatality), serious injuries for $465.0 million ($21 147 each) and minor injuries for $269.7 million ($1 264 each). PDO accounts for $29 961. It is likely that the assumptions result in underestimation of the costs per fatality and serious injury, as these are more likely to incur legal costs than minor injuries.

Criminal prosecution costs

The second source of legal costs arising from road crashes is the cost of prosecuting individuals charged with criminal offences. The offences vary from serious homicide-related charges (driving causing death) to cases of negligent and reckless driving.

The differing legal systems within each of the jurisdictions makes it difficult to aggregate data at a national level. This is due to three main problems. First, charges often differ across jurisdictions. For example, NSW is the only jurisdiction that has a charge for ‘driving causing injury’. Second, where two jurisdictions do have the same charge, the criteria required for the charge may differ. Finally, the way statistics are presented for each jurisdiction reduces data compatibility, with some jurisdictions being very general, and others much more specific in their classifications. For the purposes of this report, the charges have been aggregated into three general classes on the basis of their frequency and the sentence received:

1. culpable driving and driving causing death;

2. driving in a manner dangerous, causing injury by driving, placing an obstruction on the road causing injury or death, traffic offences[4] ;
3. dangerous, reckless or negligent driving.

These classes are designed to encompass three levels of severity. The first deals with those acts that result in a fatality, the second relates to charges laid as a result of a serious injury and the third includes the less serious charges, usually involving minor injury or property damage. There is some overlap among these classes.

There were some other significant problems arising from the data. It was difficult to determine whether charges laid resulted from road crashes or from other traffic-related incidents. For example, drink driving charges laid as a result of a road crash were counted along with those arising from random breath testing and consequently were not included in the analysis. To balance this factor, it was assumed that all of the charges in the classifications above were crash-related.

Table 4.9 shows the data and basic cost estimates for each of the charge classes. These values were derived from consultation with the legal industry.

TABLE 4.9 BASIC LEGAL COST ESTIMATES

Class	Court time [a]	Preparation time (hours)	Barrister's fee	Solicitor's fee ($ per hour)	DPP [b] annual salary
1.	3 days	20	$1500 first day, $1000 a day thereafter.	$250	$67 000
2.	1.5 days	15	$1500 first day, $1000 a day thereafter.	$250	$67 000
3.	1 hour	2	–	$250	$67 000

a. Six hours per day at $512 per hour.

b. DPP: Director of Public Prosecutions.

Source Legal profession.

4 In Victoria, this general classification covers all offences related to road crashes. For the purpose of this analysis, it was assumed that all offences that result in a custodial sentence were related to road crashes.

In addition, there were some qualitative assumptions. First, as it is not necessary for a barrister to represent an individual in court and barristers are generally only used when it is perceived that the case is serious, it was assumed that a barrister was used when imprisonment was a potential outcome. Second, it was assumed that the preparation time for each case was the same for the defence and the prosecution. Third, it was assumed that the barrister's daily charge included preparation. Finally, it was assumed that juries were present in cases in class one and two, with each juror being paid $12 an hour on average. Productivity losses for the accused, witnesses and jurors were not estimated due to lack of data.

The legal cost associated with road crashes was calculated using the assumptions described above. Table 4.10 shows a breakdown of the costs associated with each classification and expenditure. It can be seen that there were relatively few offences in classification one, though the cost per case was greater.

In summary, the cost of prosecuting and defending individuals charged with road crash-related offences in 1996 was $24.7 million, which comprised $1548 per fatality, $448 per serious injury and $55 per minor injury.

CORRECTIONAL SERVICES COSTS

The total cost arising from providing correctional services to those who have committed a criminal offence related to a road crash has not previously been included as a cost element in the overall cost of

TABLE 4.10 CRIMINAL CASE LEGAL COSTS

Charge class	Charges laid	Court ($'000)	Barrister/ solicitor/ DPP[a] ($'000)	Jury ($'000)	Total ($'000)	Cost per case ($)
1.	170	87	2 522	441	3 050	17 940
2.	899	460	8 235	1 165	9 860	10 968
3.	13289	6 804	5 028	b	11 832	890
Total	14358	7 351	15 785	1 606	24 742	

a. DPP: Director of Public Prosecutions.

b. Minor cases do not generally involve juries.

Source Legal profession.

Australian road crashes. Due to data limitations, the cost estimation is very approximate. Jurisdictional differences in the detail and collation of information were the predominant problems encountered.

Correctional services costs encompass the cost of imprisonment, periodic detention or community service orders (CSOs). There was no detailed information available on the charges resulting in CSOs or on the length of periodic detention, so no costing of these was possible. The costs associated with fines, loss of licence for various periods or suspended sentences were not considered, as it is believed that these place a relatively low administrative cost on society. The lost productive potential of inmates has also not been estimated. Thus, the estimated correctional services cost is solely the cost arising from imprisonment.

Imprisonment can result from charges for driving causing death, or dangerous, reckless or negligent driving. In any year there are, on average, an estimated 288 individuals in prison as a result of these charges (NSW Department of Corrective Services 1999, pers. comm., Department of Justice Victoria 1999, pers. comm., ABS 1999). Clearly, these offences do not all arise from crashes occurring within the same year. Applying an estimated NSW average crash-related sentence length of 2.7 years (NSW Department of Corrective Services 1999, pers. comm.) gives an average of 107 individuals sentenced each year.

The average daily cost of maintaining a prisoner in Australia in 1996–97 was $159 (Steering Committee for the Review of Commonwealth/State Service Provision 1998a). The total estimated cost of imprisoning those convicted of crash-related charges in 1996 was $16.8 million. All of this cost has been allocated to fatalities, although an unknown proportion may have arisen from non-fatal (but serious) crashes. This approach gives an estimated cost per fatality of $8511.

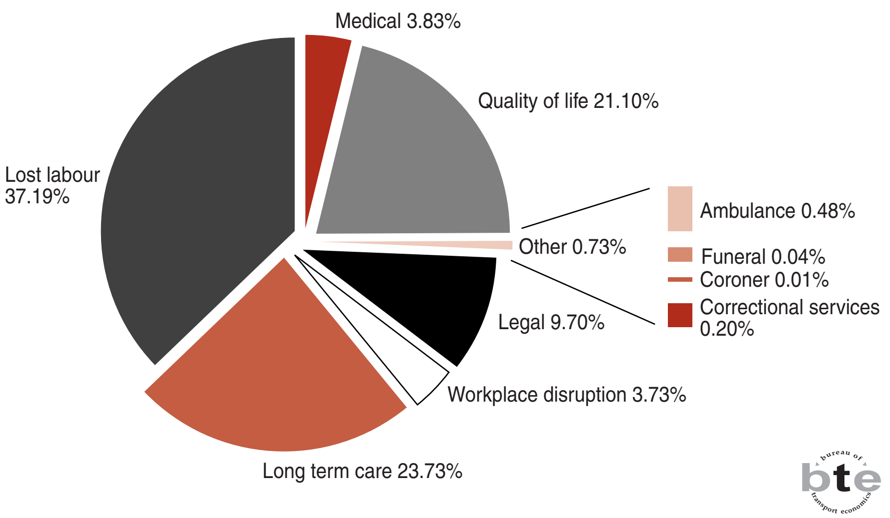
WORKPLACE DISRUPTION AND STAFF REPLACEMENT

The workplaces of road-crash victims suffer losses as a result of crashes. Productivity will decline for a time and other staff will have to work overtime or temporary staff be employed to fill the gap. The workplace may face recruitment and training costs consequent to fatalities and some serious injuries. NHTSA (1996) has estimated the extent of these costs in the case of a fatality (3 months' wages), severe injury (4 months' wages) and a minor injury (2 days' wages) and these estimates have been used in this study. The cost to the workplace is greater in the case of a severe injury than a fatality largely because of the reduced initial productivity of the person on their return to work, and the need in some cases to recruit additional labour when productivity is permanently lowered.

In 1996, fatalities cost the workplace $15.9 million in terms of disruption and reduced output, equivalent to $8077 per fatality. Serious injuries imposed an estimated $182.6 million on workplaces, or $8301 per serious injury. Minor injuries were estimated to impose costs of $114.9 million in total or $538 each. These estimates provide a total of $313.3 million for workplace disruption and staff replacement costs.

Human costs amount to $8385 million. Figure 4.1 summarises human costs associated with road crashes.

FIGURE 4.1 SUMMARY OF HUMAN COSTS OF ROAD CRASHES IN 1996



5

VEHICLE COSTS

Vehicle costs arise directly from the damage to vehicles in road crashes and comprise the cost of towing and repairing, as well as costs incurred due to the unavailability of vehicles involved in crashes.

REPAIR COSTS

To estimate a value for vehicle damage, it is necessary to know how many vehicles were damaged in crashes, the types of vehicles and the levels of damage sustained. Estimates for the numbers of damaged vehicles were presented in chapter 1.

Average repair costs were estimated for cars and light commercials, trucks, buses and motorcycles, mainly using data from insurance company claim records.

Repair costs for cars and light commercials were derived from a substantial claims database of an insurance company in one State. In addition to numbers of claims and costs, the database includes information on the scale of damage to the insured vehicle, and indicates whether it was towed.

The costs of repair in the database were adjusted to take account of the excess claim charge, which is deducted from the claim payment, as well as the salvage value of the vehicle where there was a write-off. Therefore, in applying write-off costs, the residual value of the written-off vehicle was deducted. For costing purposes, it has been assumed that all vehicle repairs were carried out in the jurisdiction in which the crash occurred, as opposed to that in which the vehicles were registered. Costs for the other jurisdictions were estimated by scaling total costs using total vehicle-kilometres in each jurisdiction together with an estimate of repair costs in each jurisdiction.

The estimated total cost of repairs to cars in 1996 was $3.5 billion, at an average cost of $3100 per repair.

The insurance database for motorcycle repair costs contained similar information to the car database, and the figures were treated similarly. The repairs to motorcycles cost an estimated $79 million, at an average cost of $4400.

The data on truck repairs came from a specialist heavy vehicle insurer. Because of the way truck insurance records are kept, the data were less detailed than those for cars. The data amounted to an Australia-wide average payment on claims for prime movers, trailers and rigid trucks only, together with numbers of claims and numbers of each type insured. The data were not adjusted for excess, and included any payments to third parties due to the insured being at fault. The data also included claims for non-crash damage, such as fire and theft. The BTE has made an adjustment for typical values of excess on the types of truck involved, and for typical numbers of non-crash claims. The total therefore has a greater uncertainty than would be desired. The final value was obtained by scaling up using the number of each type registered in each jurisdiction. The truck repair costs are comparable with figures obtained by Andreassen (1992a, p. 13).

The total cost of repairing rigid trucks for the year 1996 was estimated at $205 million, with a mean cost of $5400. For articulated trucks, the total estimated cost of repairs was $81 million, at an average cost of $11 900.

The data on repairs to buses and coaches were obtained from a specialist who insures all types of vehicles licensed to carry eight or more passengers. The data included the number of buses insured, the insurer's total payout on claims in 1996 and the number of claims. The insurer's total payout was a net figure; that is, it included amounts paid to third parties and omitted amounts paid to the insured if they were recovered from third parties. There was no breakdown by types of bus. Again, adjustments were made for typical values of excess and numbers of non-crash claims. The resulting average repair cost accorded with the experience of two bus industry professionals.

The estimated total cost of repairs to buses in 1996 was $20 million and the average cost was $2000.

The total cost of vehicle repairs in 1996 was estimated at $3885 million.

Repair costs in different jurisdictions

Using the data available for New South Wales, Victoria and Queensland, indices were found for relative wage rates for every jurisdiction except Western Australia, where a weighting for unemployment was used. This procedure provided reasonable figures for costing purposes.

Many variables will affect the relative repair costs across jurisdictions, including wage rates and the age of vehicles repaired. These two variables were tested on the data to determine whether sensible results were obtained in the light of the fact that costs are highest in Western Australia, the Australian Capital Territory and New South Wales.

In table 5.1, the first row represents average weekly earnings indexed to New South Wales, and the second row represents the unemployment rate relative to New South Wales. In all cases except Western Australia, it would seem appropriate to use the wage rate indices to adjust the repair charges across jurisdictions. In the case of Western Australia, the low unemployment rate may have had a greater influence on prices than the relative wage rates. It is known that repair costs in Western Australia are particularly high. A realistic figure was obtained by using the unemployment rate in this case. Repair costs in the Northern Territory would be far higher than in any of the other jurisdictions if the unemployment index were applied to the New South Wales cost, so in this and all other cases except Western Australia, the wage rate was used.

Information on relative repair costs is difficult to obtain. The most reliable cost information is for New South Wales due to the large sample size.

Repair costs in fatal and serious injury crashes

Ideally, this report should provide average repair costs for fatal and serious injury crashes. Unfortunately, the insurance data available contained no information about casualties in each crash, while the

TABLE 5.1 RELATIVE STATE/TERRITORY EARNINGS AND UNEMPLOYMENT INDICES

	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT
Average Earnings	100	91	85	85	90	83	95	106
Unemployment	100	110	118	119	95	129	67	109

Source BTE Estimates.

ATSB serious injury database does not contain enough information about severity of damage to relate levels of injury directly with repair costs.

There were some indicators, however. The ATSB data give details on the towing status of vehicles where the information was collected or known. As would be expected, nearly all cars involved in fatal crashes (about 84 per cent) were towed. It was also found that 70 per cent of cars involved in crashes where people were admitted to hospital were towed. The tow rate is higher for cars than for the total number of vehicles involved because there were a significant number of crashes where cars and heavier vehicles such as trucks were involved.

From the insurance data, the average repair cost for a car towed from the scene was $7069, while the average repair cost for a car not towed was $2070. Therefore, a rough estimate of the average repair cost of a car involved in a fatal crash is $6270, and the total cost of repairing such cars is $16.8 million. The estimated average repair cost of a car involved in a serious injury crash is $5570, giving a total cost of $156.7 million.

This report departs from previous Australian crash cost reports, which have rejected any relationship between injury severity and vehicle repair costs. BTCE (1992, p. 28) cites references to support the position that there is very little correlation between vehicle repair costs and levels of injury. One reason for this position is that fatal crashes involving pedestrians and cyclists may do little damage to the vehicle. BTCE (1988, pp. 88-91) assumed that fatal crashes are associated with moderate vehicle damage for this reason. However, if pedestrian and bicycle crashes were so important, one would expect fewer of the cars to need towing.

Troy and Butlin (1971, pp. 146-7, 151-4, 183-5) interpret their statistics for crashes in the Australian Capital Territory to imply only a weak relationship between vehicle damage and injury. However, their method of comparing injury severity with the total property damage cost of the collision, rather than the costs for individual cars, may obscure any potential pattern, because it makes single-vehicle crashes appear to produce less vehicle damage than multi-vehicle crashes. It must be the damage to individual vehicles that needs to be compared with injury levels. In any event, their sample is quite small—just 16 fatal crashes. Troy and Butlin (1971, p. 154) themselves comment that, when interpreting their figures, it should be remembered that seat-belt use was very rare in the Australian Capital Territory in the year of their study (1965-6).

TOWING

Towing costs are incurred when a vehicle sustains damage in a crash such that it prohibits unaided removal. Towing services are provided by numerous private companies, with charges depending on distance towed, the time of day that the towing takes place and the size of the vehicle towed. Towing charges are regulated throughout Australia. In rural areas it will often be necessary to tow a vehicle long distances, and hence the average charges are higher. This was confirmed by information available for NSW.

Towing costs were determined for sectors of the transport industry from insurance company information. For cars, light commercials and motorcycles, the insurance company claims data were used to determine the frequency of towing, and this was applied to the data presented in chapter 1 concerning the number of vehicles in crashes. Close to 21 per cent of cars and light commercials damaged in crashes required towing. In general, the more serious the crash, the more likely it is that the vehicle will be towed (71 per cent of vehicles in serious crashes were towed). The average towing charges for cars, light commercials and motorcycles reflect the proportion of rural crashes likely in each jurisdiction. Towing charges for heavy vehicles were Australia-wide averages. Lack of data for heavy vehicles meant that it had to be assumed that 20 per cent of them are towed. The total towing costs for each vehicle type are presented in table 5.2.

Total towing costs were estimated to be $42.8 million, equivalent to $38 per vehicle involved in a road crash.

TABLE 5.2 TOTAL TOWING COSTS FOR VEHICLE TYPES, 1996

$ million

Vehicle type	Per cent assumed towed	Total towing cost
Car/light commercial	21	35.5
Motorcycle	29	0.7
Rigid truck	20	3.8
Articulated truck	20	0.8
Bus/Coach	20	2.0
Total	–	42.8

Source BTE estimates.

TIME LOST DUE TO VEHICLE UNAVAILABILITY

A vehicle that has been damaged in a crash will be unavailable while being repaired, but also in some cases while being assessed for insurance or while impounded by police. Vehicle unavailability is a cost, in addition to the direct cost of repairs. For a commercial operator, this downtime may mean lost business, employee time wasted, or work delayed or cancelled. For a private owner, downtime may mean inconvenience due to a need to use public transport, lost leisure time, or some trips not undertaken at all. Valuing these individual losses is not feasible. Instead, the maximum and minimum losses expected due to vehicle unavailability have been estimated.

The person affected by the loss of a vehicle would be expected to hire a replacement vehicle only if the potential loss due to inconvenience were greater than the cost of the hire. Therefore, the maximum loss has been assumed to equal the cost of hiring a replacement vehicle. Private car owners tend not to hire replacements while their cars are off the road; they use public transport, taxis or give up making some trips. Similarly, large fleet operators normally do not hire replacements because they find a substitute vehicle from within their own fleet.

The minimum loss is assumed to equal the average total cost of owning the vehicle over the period it is unavailable. It is assumed that, as owners are paying this amount, it reflects the minimum value they place on possession and use of the vehicle.

No attempt has been made to correct the estimate for the number of cases where there is no vehicle downtime loss because the driver was killed or too severely injured to use the vehicle. Since the number of those injured is less than 200 000, while the number of damaged cars is 1.1 million, at maximum the correction can be no more than 20 per cent. Since many of those with minor injuries will still be fit to drive, while some vehicles have more than one user, and others may not be repaired until after the driver has recovered, the correction seems unlikely to be more than 10 per cent.

The loss estimates for cars are based on average downtime statistics collected by fleet users. Statistics were obtained from three fleets, two of which comprised mainly cars and light commercials, while the third was composed of cars only. Two of the fleets showed similar average repair times, while one average was significantly longer. The estimate is based on the shorter times, and so is on the conservative side because it assumes that the repair process is more efficient than the true community average. Average ownership costs for cars are those for private ownership of a standard medium sized car, the Toyota Camry, in NSW (NRMA 1996, 1997). The average cost for a car purchased new and owned for ten years is $10.24 per day. Costs of replacement rental cars are based on typical car rental quotes for the average downtime periods.

Costs of motorcycle unavailability are not included in this report. Motorcycle repairs are a small fraction of all vehicle repairs, and it is assumed that most motorcycles are not their user's main form of transport.

The cost of truck unavailability was estimated using downtime statistics from one fleet operator.

Bus unavailability costings were based on anecdotal figures from bus and coach industry professionals.

A point to note is that many cases of minor damage need not be repaired immediately, or at all. By choosing a convenient time to make the repair, the owner may reduce the cost of unavailability. However, there is reason to believe that the insurance data used in this estimation understate the number of vehicles with minor damage (chapter 1). As this will include a large proportion of vehicles that can be repaired at their owner's convenience, there does not seem to be any value in trying to correct the figures.

As explained above, the true cost will fall somewhere between $68 million and $523 million (table 5.3). There is no basis for choosing any particular value. However, as mentioned above, there are reasons for thinking that the true total is nearer the lower bound

TABLE 5.3 COSTS DUE TO VEHICLE UNAVAILABILITY, 1996

Vehicle type	Damage severity	Average repair time (days)	Minimum cost ($m)	Maximum cost ($m)
Cars	Minor(<$2000)	3.2	30	295
	Major(≥$2000)	12.1	27	183
Rigid truck	–	4	3.3	30
Prime mover	–	3	4.2	6.2
Articulated trailer	–	7	0.4	1.5
Bus	–	3	3	7.5
Total	–	–	68	523

Sources NRMA (1996,1997), fleet operators, rental firms and BTE estimates.

than the upper. A figure has been chosen that is one-quarter of the way between the lower and upper bounds: $182 million has been taken as representing the total cost of vehicle unavailability. This estimate provides a cost of $161 per vehicle involved in a crash.

Table 5.4 presents a summary of costs associated with vehicles involved in crashes.

TABLE 5.4 SUMMARY OF VEHICLE COSTS, 1996

Cost component	$ million
Repairs	3885
Unavailability of vehicles	182
Towing	42
Total	4110

Source BTE estimates.

6

GENERAL CRASH COSTS

General crash costs are those that are not directly related to the level of injury or severity of the crash.

NON-VEHICLE PROPERTY DAMAGE

Damage to property such as street furniture, fences and housing is a common outcome of vehicle crashes. The value of non-vehicle property damage varies greatly but can be substantial in some cases.

Estimation of the value of non-vehicle property damage requires knowledge of what is being damaged and how often. This estimation necessarily involves assumptions and approximations, as non-reporting is particularly high for crashes involving only one vehicle and an object. The difficulty in placing a value on property damage is compounded because, even when such crashes are reported, not every jurisdiction records the type of object hit when the object is not another vehicle. In New South Wales, 9890 crashes were recorded in 1996 (RTA 1998a) where an object (excluding pedestrians or other vehicles) had been hit. However, this figure is not associated with any estimate of the cost of damage.

An estimate of the level of property damage due to crashes can be obtained from insurance data. This estimate was derived for claims involving property damage, other than vehicle damage, caused by crashes in 1996 in New South Wales. The estimate suffers from a non-reporting problem, and is biased towards crashes where non-vehicle damage was relatively high and hence worthwhile claiming. The insurance data lead to an estimate of approximately 6229 non-vehicle property damage incidents in New South Wales. Apportioning this figure according to the relative number of vehicle registrations for all jurisdictions yields an estimate of $29.9 million.

This figure does not account for the substantial component of expenditure incurred by government agencies in replacing or repairing road furniture (such as road signs, traffic signals, guardrails and crash barriers) damaged by crashes. It has been difficult to establish the costs of damage to road furniture in crashes. Many of the crashes causing such damage are not reported. Road authorities usually cannot distinguish crash damage from vandalism and do not attempt to separate repair of crash damage from repair of other causes of damage or normal renewal due to age. The only information that could be found indicates that the New South Wales RTA spends about $1 million each year in repairing crash-damaged traffic signals in the Sydney metropolitan area.

A conservative estimate of damage to fixed property in road crashes is $30 million.

POLICE COSTS

There have been relatively few studies of police work in Australia in relation to road crashes. Previous studies of the costs of road crashes have tended to cite Somerville and McLean's (1981) time and motion study in the South Australian Police Department when valuing police crash attendance and investigation. However, this information is now dated, and does not fully reflect more recent policing practice.

The costing presented here draws on work by Queensland's Criminal Justice Commission (CJC 1997), based on a study of Beenleigh Police Station. The approach is supported by information from three other police forces on police response, attendance and investigation times. These sources of information enabled estimation of the average time spent on specific crash-related police activities. Although police spend considerable time and budget on crash prevention activities such as education and enforcement, these activities are not a direct outcome of individual road crashes and are therefore not included in this report.

Valuing police time

The Queensland CJC calculates the average cost per minute of police time based on a car responding with two officers. The average length of such a call is 1 hour and 23 seconds and the average cost is $100.90, which includes both salaries and overheads. This figure equates to an average cost per person-hour (comprising total labour costs and equipment overheads) of approximately $50 in Queensland. The estimate is considered to be fairly representative of all forms of police operation, in that it represents both the human and necessary equipment components, and is used as the basis for all related cost calculations.

Average police salaries were used to develop similar costs for other jurisdictions (Steering Committee for the Review of Commonwealth/State Service Provision 1998a). Since these are average wage rates, they reflect the organisational hierarchy of each jurisdictional police force and the balance between junior and senior officers. It has been assumed that this representation mirrors the responsibilities of the team of officers involved in any crash investigation.

Nature of police work

The cost of police attending and investigating road crashes is made up of six components that are discussed in detail and costed below. Due to differences in police procedures in each jurisdiction, the estimated times, and therefore costs, for each stage of police work may not be representative of any particular jurisdiction, instead indicating an Australian average.

Attendance time

Police attendance encompasses police response time and time at the scene. Police do not attend all crashes, but always attend crashes involving fatalities or serious injuries. Fatal crashes, particularly fatal multiple-vehicle crashes, are generally attended by a large team of specialist personnel (for example, a superintendent, a criminal investigator, a photographer and a regular police officer). This response will vary among jurisdictions, as complex crashes are dealt with in different ways (for example, the period a crash scene is left intact). Police will also attend crashes that result in minor or no injuries but have the potential to cause significant traffic disruptions.

The number of crashes police attended in 1996 was derived from the ATSB (1998) database and individual police departments. An estimate of the likely number of minor crashes attended by police was derived from the actual number of minor crashes attended in the Australian Capital Territory. This number was about 20 per cent of the reported crashes. The same percentage was then applied to the other jurisdictions.

Reported average times for attending fatal crashes varied greatly, ranging from 3 to 13 hours. The variations were undoubtedly due to the varied nature of each crash and the different ways in which jurisdictions dealt with the investigation process. One reason for variability is that attendance time data were collated for both single and multiple crashes and police indicated that single-vehicle crashes tend to require less attendance time.

It is therefore difficult to accurately estimate costs for the attendance time component. However, the degree of accuracy will be improved if single-vehicle crashes are separated from multiple-vehicle crashes and rural crashes are separated from metropolitan crashes with different attendance times assigned to these crashes due to their different characteristics (table 6.1).

Administration of reported crashes

Police deal with the public when any crash is reported and the information is processed, so some police time must be allocated to these tasks. It has been assumed that, on average, 20 minutes is expended per crash.

Notification of next of kin

When a death occurs as a result of a road crash, the police must determine the identity of the fatality, notify the next of kin, and arrange for the next of kin to formally identify the body. An estimate of four hours has been used for this task (Somerville & McLean 1981) as it appears to remain a valid estimate. Similarly, police notify the relatives of people seriously injured in road crashes. It has been assumed that, on average, this process would take 1.5 hours for each person admitted to hospital.

Coronial attendance and investigation

Preparing information for a coronial hearing and attending a hearing takes between a day and a week. Police sources estimate that an average of 30 hours should be allocated to each coronial hearing.

TABLE 6.1 POLICE ATTENDANCE FOR DIFFERENT CRASH TYPES

Crash type	No of police	Average hours per officer
Fatal	4	4.25
Serious	4	1.50
Minor	2	1.00

Note These are averages for Australia as a whole. However, calculations have taken account of the likely differences in numbers of police attending different types of crash, such as multiple, single, pedestrian, and the differences in numbers of police attending such incidents in rural as opposed to metropolitan areas. Similarly, there will be differences in the number of police attending if many people and vehicles are involved in a multiple crash. All these factors were taken into account in the cost model used.

Source BTE estimates based on information from Australian police forces.

Crash investigation

Crash investigation can be a lengthy operation comprising various tasks, including determining whether there was criminal activity; learning from each crash so that road safety can be improved in the future; interviewing witnesses; liaising with technical services regarding vehicle issues; revisiting the crash scene; attending court if necessary; and processing photographs. For minor crashes it was assumed that all investigation is carried out at the scene of the crash and costs are therefore included in attendance costs.

A police estimate of 80 hours has been used as the average time spent on investigation work that may lead to a criminal prosecution. Every fatal crash is investigated to ascertain the reason for the crash and to determine if there was a crime committed. Therefore, 80 hours has been allocated to each fatal crash for all the tasks undertaken as part of the crash investigation process. Due to the more variable nature of a serious crash, it is assumed that not all crashes would need the same detailed investigation as fatal crashes. Police time equal to 50 hours per serious crash has therefore been allocated.

Administration of fines

Following some road crashes, fines are likely to be issued to drivers for not holding a licence, for driving unroadworthy vehicles, for speeding or for being over the legal alcohol limit. For fatal and serious crashes, this police time has been included in crash investigation time. There will also be fines imposed on drivers involved in minor crashes. Although fines are issued by, and payable to, the courts, they involve police administrative time in preparing and processing all the relevant paperwork. This time has not been estimated.

Road audits

Following fatal and serious crashes, the police carry out a road audit to determine whether the road contributed in any way to the crash. According to police sources, road audits are likely to take approximately one hour per fatal or serious crash.

Total cost of police time

The total cost for police attendance and investigation was estimated at $74 million (table 6.2). Time spent on criminal investigation contributed $52 million to the overall cost. Any changes to estimates of investigation time per crash will therefore have a large impact on total police costs. Police attendance time at the scene of crashes was a relatively small proportion (11 per cent) of total police costs relating to crashes.

Police costs were $6147 per fatality, $2112 per serious injury and $32 per minor injury. At the crash level, the estimated costs were $6849 per fatal crash, $2652 per serious crash and $1758 per police-attended minor crash.

COSTS OF FIRE SERVICES

Fire services attend fatal and serious crashes whenever there is a need for their specialised fire control, hazard management and rescue assistance. The fire crew will remain at the scene of a crash until it has been cleared and there is no further hazard to motorists or to the general public.

The method of providing fire services differs significantly between metropolitan and rural areas, so the two have been costed separately. Metropolitan fire services are provided by paid, professional fire control officers in capital cities or regional centres. A full-time fire service is not economically viable outside these areas due to low population levels resulting in relatively infrequent use of the service. In these areas, volunteers, Bush Fire Brigades or State Emergency Service (SES) provide fire control services.

TABLE 6.2 SUMMARY OF POLICE COSTS, 1996

($)

	Crash Severity		
Police cost element	Fatal	Serious	Minor
Attendance	841 033	3 270 852	4 242 098
Notification of next of kin	809 506	2 247 349	ne
Coronial investigation & attendance	2 721 904	ne	ne
Crash investigation	7 258 410	45 047 372	ne
Road audit	89 882	890 283	ne
Administration	388 156	3 998 082	2 578 581
Total	12 108 891	55 453 938	6 820 679

ne Not estimated

Source BTE estimates based on information from Australian police forces.

Metropolitan services

Fire and Emergency Rescue Departments were approached in all jurisdictions for information on the number of road crashes attended, time spent at each crash and the associated costs. Building a cost structure for attending each crash was possible in only very general terms due to the different requirements of each incident and hence the variability of duration and mix of crew and equipment needed. Detailed information was collected from the Melbourne Metropolitan Fire and Emergency Services Board (MMFES) and from the New South Wales Fire Brigade, enabling averages to be estimated. As well as a cost breakdown, the MMFES provided an overall cost of $1.79 million for road crash rescues in 1996. The MMFES information relates only to the Melbourne metropolitan area, whereas the NSW Fire Brigade information relates to all urban centres in NSW. Population figures were obtained for NSW to relate to the population covered by the data.

In metropolitan New South Wales, 13 683 vehicle incidents were attended by fire crews in 1997. These incidents occurred in areas comprising 90 per cent of the population of NSW. Although the information was provided for 1997, the numbers of fatal and serious crashes have been stable, and therefore the figures are likely to be representative of 1996.

Many crashes involve much longer than the average attendance time. For example, the NSW Fire Brigade lists 26 calls where a crew of five firefighters spent an average of ten hours dealing with an oil spill or other combustible liquid spill. These figures are very different from the average time per crash figures provided in table 6.3. As a general rule, more time is spent at multi-vehicle crashes and those involving heavy vehicles.

Across the 137 fatal crashes attended by fire crews in metropolitan NSW, the size of the fire crew varied from four to 14. The average number of crew attending a road crash in metropolitan New South Wales was 5.8, while the corresponding figure for Melbourne was 5.5.

The NSW Fire Brigade 1995 schedule lists its fire service charge-out rates (NSW Fire Brigade 1998, pers. comm.), which provide an insight into the relative costs of wages and equipment. From these charges and other information, it would seem that wages comprise approximately 65 per cent of the total cost and all other operating expenses (equipment depreciation, training, fuel etc.) comprise the balance. Using this information, a cost of $3.2 million was estimated for providing fire crew emergency services in metropolitan NSW. The true total cost for metropolitan Melbourne

TABLE 6.3 FIRE SERVICES' AVERAGE TIME PER CRASH

(Minutes per crash)

Fire service	Fatal	Injury	Nil injury	All crashes
Melbourne metropolitan area	121.3	43.0	30.9	37.6
NSW urban centres	152.6	60.0	42.5	45.8

Source BTE estimates based on data from MMFES and NSW Fire Brigade.

was assumed to be representative for metropolitan cities in all jurisdictions. This Victorian figure was extrapolated on the basis of metropolitan capital city populations (ABS 1996f) to estimate costs for other jurisdictions. Across Australia, an estimated $6.0 million was spent on fire services for road crashes in urban areas in 1996.

Rural services

The New South Wales State Emergency Service (SES 1997) provides the total number of volunteer hours spent assisting with motor vehicle crashes. Although this is only a minor component of SES work (community service, assisting with the response to floods and storms, and search and rescue were more time consuming tasks), the SES units responded to 714 calls for assistance during the year which involved 9436 volunteer hours. Additional time was spent in training these volunteers, a proportion of which can be allocated to road crashes. Although these are volunteer hours where people are helping others for altruistic reasons, an average wage rate has been applied to this work, as there is an opportunity cost involved. No on-costs have been included due to the voluntary nature of the work. The equipment used is provided by individual communities with the assistance of grants from local councils and the Commonwealth. However, it would seem reasonable to also include a proportional equipment depreciation charge, as there is an opportunity cost involved in providing such funding.

The total cost of the NSW SES in attending road crashes is estimated to have been approximately $360 000 in 1996. This cost represents crashes associated with 10 per cent of the population of New South Wales. Rural populations were used as the basis for estimating similar costs for the other jurisdictions. Since the populations in other jurisdictions covered by metropolitan fire services were not known, the population remaining for each jurisdiction after the deduction of its capital's population was costed relative to the rural population of NSW. It was found that the costs for a fire crew to attend a road crash were similar for both metropolitan and rural areas. Averaging costs for both the metropolitan brigade and rural emergency services, it was calculated that the cost of attending a fatal crash was $481 and a serious crash $307.

When rural and urban costs are added, the total cost for fire crew emergency services attending road crashes in Australia during 1996 was approximately $9.8 million. The average cost was $481 per fatal crash, $307 per injury crash, and $266 per non-injury crash.

INSURANCE ADMINISTRATION

In providing insurance cover for vehicles, the insurers incur expenses known as underwriting costs, which are the costs of administering claims[5]. These claims can arise from vehicle damage (commercial motor vehicle and domestic motor vehicle insurance) or personal injury (compulsory third-party insurance).

The Insurance and Superannuation Commission records details of claims and expenses for the entire insurance industry in Australia (ISC 1997). The underwriting expenses for claims include those arising from claims relating to car theft and vandalism as well as car crashes. Canvassing a number of insurance companies provided a consistent estimate that 89 per cent of overall motor insurance claims were attributable to road crashes. The total underwriting expenses and claims for domestic and commercial vehicle insurance were adjusted using this proportion. Total underwriting expenses also included expenses for fire brigade, hospital and similar statutory expenses. These expenses have been excluded from the calculations so as not to double count as they have been taken into account elsewhere in this report.

Insurance administration expenses relating to road crashes in 1996 amounted to $926 million. Of this, $683 million related to administration costs arising from vehicle damage, and the remaining $243 million represented administering CTP claims for injury. The total of $926 million can be allocated across the claims made in 1996 to derive a cost of $598 in insurance administration costs per claim related to vehicle damage and $12 000 per claim related to injury. The injury-related claim administration costs are relatively

5 Operational costs such as building rental and general staff costs are not included in underwriting costs.

high because of information requirements, such as medical assessments.

TRAVEL DELAY COSTS

Motor vehicle crashes can result in travel delays to other motorists. A crash may fully or partially block the carriageway. Even when there is no blockage, some motorists may stop to offer assistance or may reduce speed in passing. The police and emergency services, in carrying out initial investigations and clean-up and in taking necessary precautions, may further restrict traffic flow. Such delays impose costs as the time lost queuing in traffic has a productive value.

Estimating the cost of traffic delays associated with motor vehicle crashes is an area where detailed research is lacking. The travel delay cost estimates presented below are significantly higher than those of previous studies (BTCE 1992, Andreassen 1992b). This is primarily due to the development of updated estimates of average delay times and average numbers of vehicles affected in crashes. Earlier studies have tended to rely on delay time estimates from Faigin (1976) which are based on United States traffic flows from the early 1970s.

Value of time lost

Transport analysts routinely place values on travel time saved and lost for use in policy formulation and decisions concerning investment in capital roadworks. There have been many empirical studies and reviews regarding the valuation of travel time savings (Hensher, Battellino & Daniels 1994; Waters, Wong and Megale 1994; Bradley and Rohr 1995; Miller 1996; and Wigan, Rockliffe, Thoresen and Tsolakis 1998). Miller (1996) provides a recent comprehensive review of the literature, including travel time values for several countries.

Interestingly, the value of travel time saved is not necessarily the same as the value of time lost, such as in crash-related delays. Miller (1996) and Hensher, Battellino & Daniels (1994) point out that, as crash-related delays are unexpected and travellers are generally prepared to pay a premium to avoid the unplanned delay, time lost is worth more than time saved. Hensher, Battellino & Daniels (1994) derive values of 44 to 68 per cent of the wage rate for travel time lost and 35 to 41 per cent for travel time saved.

The ranges of values calculated by Hensher, Battellino & Daniels (1994) indicate that different road users value time differently. Miller (1996) suggests a time lost value of 55 per cent of the wage rate for passengers and 75 per cent for drivers (whom he assumed to be in paid employment). The Hensher estimates are adopted in this study primarily because the values are derived in Australia and are therefore more appropriate than Miller's US figures. For time lost by freight traffic, the figures in Wigan, Rockliffe, Thoresen and Tsolakis (1998) have been used. Table 6.4 shows these values and average vehicle occupancy rates, as well as number of pallets per truck (a pallet as used here is equivalent to one tonne of load).

One further consideration when valuing time lost is the determination of whether every minute is valued equally by every person. Small (1982) demonstrated that one minute lost or saved could be valued minimally or very highly, depending on the situation of the traveller: a person may value time lost on a long trip differently from time lost on a short journey. Similarly, the amount of time lost affects its value—the first minute lost may be of lower value than the thirtieth minute lost. These issues raise the question of whether there is a pattern in the valuation of time in certain circumstances or for particular people.

Miller (1996) reviewed literature on this subject but did not find consistent patterns. Thomas and Thompson (1970) estimated that the value per minute saved was minimal for the first five minutes, then increased rapidly until savings reached about 15 minutes, then decreased. Lee and Dalvi (1969), on the other hand, found that the

TABLE 6.4 VALUES OF TIME

Vehicle type	Value of time lost: $/hr/ occupant	Value of time lost: $/hr/pallet	Occupancy-rate or pallets per truck	Value per vehicle ($/hour)
Car	9.00	na	1.62	14.58
Bus	8.38	na	18.00	151.00
Articulated truck	na	0.66	16.00	11.00
Rigid truck	na	1.40	12.00	14.00
Other	9.00	na	1.62	14.58

Note The car value used is an average of the various car travel classes used in Hensher, Battellino & Daniels (1994). The time value for bus passengers is an average of 'social trip' and 'other trip' from Hensher, Battellino & Daniels (1994). 'Other' covers motorbikes and light commercial vehicles. The value for bus occupancy applies to peak hours.

Sources Hensher, Battellino & Daniels (1994), Wigan, Rockliffe, Thoresen and Tsolakis (1998) and BTE estimates.

value of time saved consistently decreases as more time is saved. Horowitz (1978, 1980) and Hensher (1976) found that the value of time saved consistently increased, although at a decreasing rate and is a function of percentage reduction in trip length. The value of time lost varies with both the amount and the situation, and because of the uncertain nature of the relationship, no attempt was made to model any of the possible scenarios. Instead, constant values, as shown in table 6.4, were used for all time lost.

The length of any crash-related delay to other motorists, and hence the cost, depends on three factors:

- level of blockage of the road (dependent on the type of crash, severity of injuries, and road type);
- traffic flows (determined by time of day and type of road); and
- clearance time (dependent on type of crash, severity of injuries, and emergency services response time).

The type of road is an important determinant of the length of travel delay expected due to a particular crash. Different roads experience greatly differing traffic flows—compare a suburban street with a major inter-city highway. Differences are apparent in the volume and composition of traffic (for example, the ratio of cars to trucks or buses). Another important factor influencing traffic flows is the existence of alternative routes.

The conceptual framework used in this report for estimating the length of time of traffic delays and traffic queue length is based on established practice in traffic engineering and transport planning. Traffic analysts use queuing models, which estimate traffic delays and queue length, to facilitate efficient road design and traffic control, such as in determining the appropriate timing of traffic signals at intersections, the required length of right-turning bays, and the number of lanes at intersections. In this report, the approach of Mannering and Kilareski (1998) has been used to estimate the duration of crash delays and the number of vehicles affected by the delay for a typical crash and to calculate the value of the delay. Appendix II provides details of the application of this model and how crash delay costs have been estimated.

Data and assumptions

The key data used are emergency services response time, average time taken to clear the crash site and average traffic flow per hour. Average figures from various sources including VicRoads (1996) incidence response time and RTA traffic counts (1998b) have been used in this report. Using observed traffic composition data from RTA traffic counts, the vehicles affected were apportioned among cars, trucks, buses and others. The specific values for time (table 6.4) were then applied to the number of crashes in each vehicle class (derived from the ATSB database) and the average vehicle delay. The summation of the results provides the total cost of time lost as a result of 1996 motor vehicle crashes.

To estimate the value of time lost due to crashes that occurred in 1996, a number of simplifying assumptions have been made concerning which crashes are believed to cause significant delays. These formed rules for interrogating the ATSB crash database.

Traffic flow

Ideally, it is best to assign traffic flows by individual roads. However, doing so in this instance would be impractical because of the enormous number of road sections involved. In order to maintain a manageable computation to estimate delay for each road in the crash database, the crash data were sorted into three traffic flow scenarios on the basis of local government areas:

- Sydney and Melbourne crashes (including both suburban and city);
- crashes in other capital cities; and
- highway and rural crashes (on roads outside capital cities with speed signs of 70 kph or more).

In this way, traffic flows per hour that are reasonably representative of each group could be assigned. For instance, in Sydney and Melbourne an average traffic flow per hour of 1137 vehicles has been used. Table 6.5 shows the flows used for each group.

It is recognised that the 'highways' scenario probably contains the most diverse set of roads. While the traffic flow selected is more representative of major interstate highways than many of the single-lane rural connector roads also in the over-70 kph speed zone category, this is believed to be appropriate as the majority of crashes occur on the higher-flow roads.

Speed

The traffic flow scenarios presented above contain an implicit assumption concerning speed. Crashes that occurred in 60 kph or less zones have been excluded. The assumption is that 60 kph zones are generally in built-up areas with many alternative routes, should one be blocked by a crash. Traffic flows are also generally light. It

TABLE 6.5 TRAFFIC FLOW AND COMPOSITION

		Proportion in traffic (%)			
Traffic zone	Traffic flow/hr	Cars	Bus	Artic. truck	Rigid truck
Sydney & Melbourne	1137	87	1	2	10
Other capitals	679	87	1	2	10
Highway/rural	233	78	0.8	16	5

Sources RTA (1998b) and BTE estimates.

would be correct, though, to assume that those who divert would in most cases add some distance (and time) to their journey. Resultant costs have not been estimated.

Time of crash

For crashes occurring in Sydney, Melbourne and all other capital cities, it has been assumed that delays would be caused to traffic only between the hours of 6 am to 8 pm[6]. That is, crashes occurring outside these hours have been excluded from the computation. It has been assumed that at other times traffic flow is significantly lower, so any crashes will be bypassed with minimal delay. For crashes occurring on highways, the period has been expanded to between 5 am and 10 pm. An RTA traffic survey on the Hume Highway (Sydney–Melbourne) shows that traffic drops off only marginally overnight, due to the use of such routes by interstate freight traffic (RTA 1998b).

Number of vehicles involved in crash

Single-vehicle crashes have been excluded from the highway scenario. These crashes are believed generally to occur off the carriageway, and so cause little, if any, blockage. In the urban scenarios, single-vehicle crashes have been included only where the crash resulted in a fatality or a severe injury. Multiple-vehicle crashes with fatalities or serious injuries have been regarded as causing significant traffic

6 This assumption has a distortionary effect when it comes to an allocation of costs by jurisdiction, as Victoria has significantly higher crashes in the daylight hours than would be expected on the basis of population. This makes the NSW/Victoria relativities in terms of costs counter-intuitive.

delays in all three scenarios. Fatalities and serious injuries involving pedestrians and cyclists have also been included in the scenarios.

Crashes that cause delays

When the above conditions were imposed on the ATSB database of serious and fatal crashes in 1996, only 1418, or 8 per cent, of the fatal and serious crashes were considered to cause significant traffic delays involving costs. The analysis shows that, on average, for a crash in the Sydney/Melbourne scenario it takes 38 minutes for the road to be cleared. In this time, about 833 vehicles will be affected, with an average delay time per vehicle of about 16 minutes, the longest delay time being about half an hour.

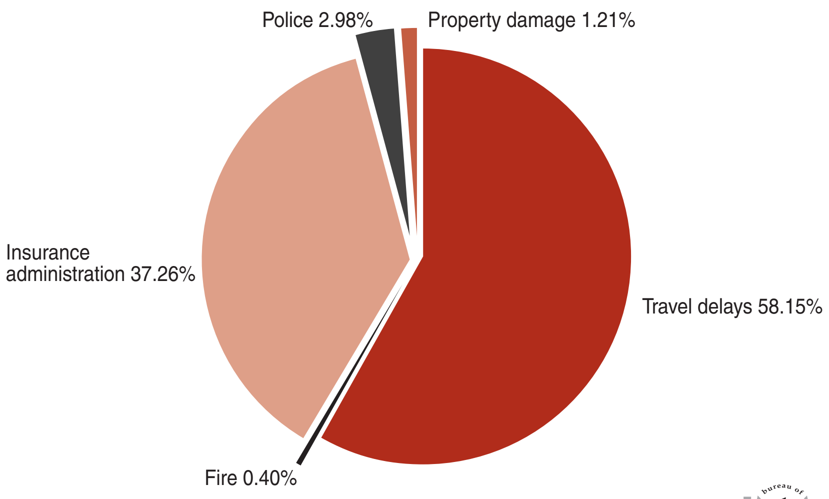
Total travel time lost

The value of time lost to road users as a result of 1996 motor vehicle crashes amounts to $1.45 billion.

TOTAL GENERAL CRASH COSTS

General crash costs amounted to $2485 million. Figure 6.1 summarises the components of general crash costs.

FIGURE 6.1 SUMMARY OF GENERAL CRASH COSTS



Source BTE estimates.

7

TOTAL COSTS

Chapters 4 to 6 discuss the various costs associated with road crashes and present estimates of these costs. This chapter brings these costs together and examines the contributions to the total cost of each cost element.

The total cost of crashes in 1996 was estimated at $14.98 billion.(1996 dollars). Crash costs for 1996 are summarised in table 7.1.

The average cost per crash (all injury levels) was $24 216. The average cost of a fatal crash was $1.7 million; injury crash, $408 000; minor crash, $13 776; and PDO crash, $5808.

Figure 7.1 and table 7.2 show the total cost by cost element.

COMPARISONS WITH PREVIOUS COST ESTIMATES

The total cost of crashes estimated in this report is substantially greater than the cost estimates presented for 1985 in BTCE (1988)

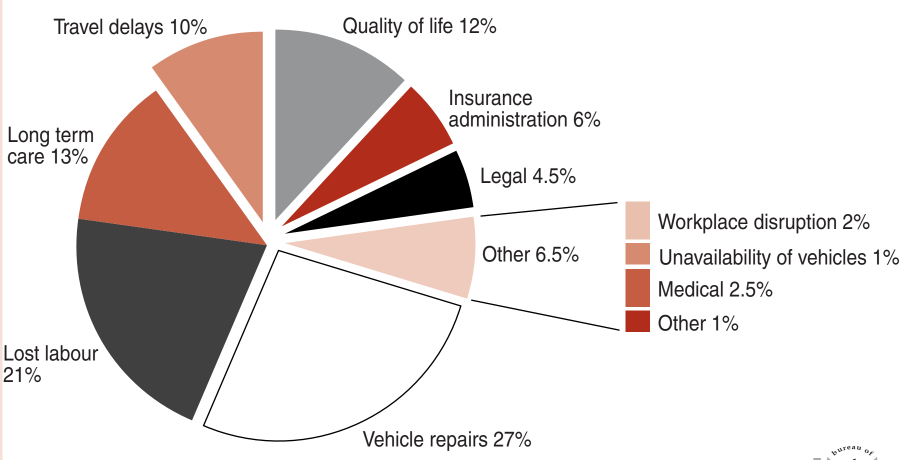
TABLE 7.1 SUMMARY OF CRASH AND INJURY COSTS, 1996

Crash severity	All crashes ($bn)	Per crash ($)	Per person injured ($)
Fatal	2.92	1 652 994	1 500 000
Serious	7.15	407 990	325 000
Minor	2.47	13 776	11 611
PDO	2.44	5 808	0
Overall	14.98	24 216	na

na. Not applicable.

All costs are in 1996 dollars.

FIGURE 7.1 COST OF ROAD CRASHES BY COST CATEGORY, 1996



Source BTE estimates.

and for 1988 in BTCE (1992), even when all estimates are expressed in 1999 dollar values. Almost all of this apparent increase is due to improved data, inclusion of additional cost components, and the use of more refined costing methods.

There have probably been some real cost increases (for example, the total cost of medical treatment has probably increased over this period as medical advances save some lives that would have been lost a decade ago) but these would not have affected the estimated totals significantly.

Table 7.3 provides a comparison of both the absolute levels and proportion of total costs for each cost element presented in BTCE (1988), BTCE (1992) and this report. The table provides estimates of all costs in June 1999 dollar values to facilitate comparison. However, it is important to bear in mind that each cost element depends on the estimated crash and casualty distributions for the specific year and costs are therefore not strictly comparable with corresponding costs for other years. The need for caution in comparing costs in different years is particularly important when absolute and relative frequencies of crashes of different degrees of severity have changed markedly.

TABLE 7.2 ROAD CRASH COST COMPONENTS, 1996

$million (1996 dollars)

Cost component	Costs at given discount rate 4%	7%
Human costs		
Medical/ambulance/rehabilitation	361	361
Long-term care	1 990	1 372
Labour in the workplace	1 625	1 045
Labour in the household	1 493	870
Quality of life	1 769	1 769
Legal	813	813
Correctional services	17	17
Workplace disruption	313	313
Funeral	3	3
Coroner	1	1
Total human costs	8 385	6 564
Vehicle costs		
Repairs	3 885	3 885
Unavailability of vehicles	182	182
Towing	43	42.8
Total vehicle costs	4 110	4 110
General costs		
Travel delays	1 445	1 445
Insurance administration	926	926
Police	74	74
Property	30	30
Fire	10	9.8
Total general costs	2 485	2 485
Total all costs	14 980	13 159

Source BTE estimates based on data from various sources.

TABLE 7.3 COMPARISON OF BTE STUDIES (ALL COSTS IN 1999 DOLLARS)

	Costs ($ million)			Proportion of total costs (per cent)		
Cost element	1985[a]	1988[b]	1996[c]	1985	1988	1996
Forgone income	2321	1302	1666	24.57	15.02	10.85
Workplace disruption	x	x	321	x	x	2.09
Family and community losses	958	929	1531	10.15	10.72	9.97
Medical/rehabilitation	350	365	329	3.71	4.21	2.14
Long-term care	x	x	2040	x	x	13.28
Legal and court proceedings	271	250	833	2.87	2.89	5.43
Insurance administration	501	782	949	5.30	9.02	6.18
Crash investigation	189	81	x	2.00	0.93	x
Police	x	x	76	x	x	0.49
Fire	x	x	10	x	x	0.07
Ambulance	x	11	41	x	0.13	0.27
Coroner	x	x	1	x	x	0.01
Correctional services	x	x	17	x	x	0.11
Losses to others	58	22	x	0.61	0.25	x
Property damage	x	x	31	x	x	0.20
Vehicle damage & towing	2659	2560	4027	28.15	29.52	26.22
Unavailability of vehicles	x	x	187	x	x	1.21
Traffic delay	396	389	1481	4.19	4.49	9.65
Pain and suffering	1742	1978	x	18.44	22.82	x
Quality of life	x	x	1814	x	x	11.81
Premature funeral	x	x	3	x	x	0.02
TOTAL	9445	8669	15358	100	100	100

a. BTCE (1988) used data for 1985.
b. BTCE (1992) used data for 1988.
c. BTCE (2000) used data for 1996.
X no estimates (or included in other categories).
Source BTE.

Cost components that were not included in previous BTE studies but have been included in this report are:

- cost of long-term care of victims;
- economic losses attributed to the unavailability of damaged vehicles;
- cost of towing damaged vehicles;
- premature funeral cost;
- coronial investigation cost;
- correctional services cost;
- cost incurred by employers (workplace disruption);
- quality of life.

In the case of quality of life, although previous reports included an estimate for 'pain and suffering' for those injured, a value was not assigned to fatalities. In this report, the loss of quality of life has been estimated for both fatalities and injuries. The total estimate for lost quality of life in this report is less than the previous estimate for pain and suffering (although the previous estimate only related to serious and minor injuries).

Estimated crash costs in 1996 have increased by $6 billion over the estimate for 1988 (1999 dollar values). Among the more significant contributors to the increase were the cost of long-term care ($2 billion) and an improved estimate of traffic delay cost (about $1 billion more than the 1988 estimate). Other cost elements listed above also contributed to the difference. Apart from these differences, a major contributor to the difference in costs is the use of a discount rate of 4 per cent for 1996 costs as against 7 per cent in the case of 1988 costs. Costs for 1996 have also been presented at a 7 per cent discount rate to facilitate comparison. The 3 per cent difference in discount rates accounts for about $2 billion.

The difference in Australian estimates of costs of crashes between 1988 and 1996 is consistent with trends in the United States. For example, in 1986 the National Highway Traffic Safety Administration (NHTSA) estimated that US crash costs were US$74.2 billion. However, when an approach similar to the one used in this report was applied by NHTSA to crashes in 1994, the costs increased to US$150.5 billion (NHTSA 1992 and 1996).

In 1988 there were 2875 fatalities (compared with 1970 in 1996) and almost 30 000 serious injuries (compared with about 22 000 in 1996). These injuries were the result of 2561 fatal crashes and 22 832 serious injury crashes in 1988 and 1768 fatal crashes and 17 512 serious injury crashes in 1996 (FORS 1998a). The 1988 estimates of the numbers of crashes and injuries are more recent than those shown in tables 2.1 and 2.2 in this report. These more recent estimates of 1988 crashes and injuries have been collected using the same methods as the 1996 data used in this report and are therefore comparable.

If the number of fatal and serious injury crashes in 1996 had been the same as in 1988, the 1996 cost estimate would have been approximately $3.5 billion higher than the figure given in this report (expressed in 1999 dollar values, the difference would have been $3.6 billion). This difference represents the cost saving attributable to the reduced incidence of fatal and severe injury crashes due to overall improvements in road safety. However, this saving was partly offset by an increase in the estimated number of minor crashes. Based on the unit crash costs in this report, the net cost saving from the change in crashes across all severity levels between the 1988 and 1996 figures was $3.3 billion (in 1999 dollars).

APPENDIX I

DEFINITIONS

Collision   An event which occurs on any carriageway of a road and in which a vehicle hits another vehicle(s) or a pedestrian, or an object or an animal.

Driver/Rider   Any person who supposedly has a vehicle under his or her physical control from the driving position, including the rider of a bicycle.

Employed   Person aged 15 and over who was employed for pay for one hour or more in the reference week or worked one hour or more unpaid in a family business. Also includes employees who were not at work.

Household and community production   The costs associated with lost productivity in the home and elsewhere in the community. Such losses are calculated for the employed and the unemployed.

Household productivity lost   The present value of lost productive household activity, valued at the market price to hire someone else to accomplish these tasks.

Insurance administration costs   The administrative costs associated with processing insurance claims resulting from motor vehicle crashes.

Legal/Court costs   The legal fees and court costs associated with civil litigation resulting from road crashes.

Medical costs   The cost of all medical treatment associated with motor vehicle injuries, including ambulance transport, emergency room and in-patient costs, follow-up visits, physical therapy, rehabilitation, prescriptions, prosthetic devices and home modifications.

Medical cost prior to death   Any medical costs incurred where the patient died as a result of the crash.

Motor vehicles Include motorcycle, motorcycle with sidecar (including moped); trolley bus, grader, roller, farm machinery and motorised wheelchair used on road.

Non-collision An event/crash where no 'collision' (see definition) occurs on any road. This includes:

- 'overturning', where vehicle rolls over or falls onto its side;
- occupant falls in or from vehicle;
- vehicle goes off carriageway;
- a person is hit while boarding/alighting a vehicle;
- occupant hit by moving or falling portion of the vehicle (or its load) in which the occupant is travelling;
- breakage of the vehicle;
- bridge or road collapsing while the vehicle is on/under it.

Non-motor vehicles Include pedal cycle, ridden animal, tram, trailer, caravan and wind powered vehicle.

Pain and suffering Pain and suffering is taken to include the pain and distress endured by the parties directly involved in road crashes, excluding the pain and suffering of bereaved families and friends.

Participation rate The labour force (persons employed and unemployed) expressed as a percentage of the civilian population aged 15 and over (including all those able to work but voluntarily not working or looking for work).

Pedestrian Any person on foot, moving or stationary, lying or sitting on the road, other than driver/rider or passenger, including:

- pushing, pulling or otherwise attending to a vehicle, eg. changing a tyre;
- leading or herding animals;
- in, operating, or riding such devices as prams, wheelchairs without engines, toy cycles, or other toy vehicles;
- person on skateboard, rollerskates, billycart, rollerblades;
- people in backyards or in house and hit by vehicle;

Premature funeral costs The difference in the funeral cost in the present versus the funeral cost at the actuarially expected lifespan.

Productivity losses in the workplace Productivity losses in the workplace due to fatalities and serious and minor injuries. The assumption is that, had the crash not happened, the victim would have worked and made contributions to the community.

Property loss and damage Loss and damage to any property (excluding vehicles involved in the crash) as a result of a road crash.

Quality of Life Valuing lost quality of life involves placing a dollar value on the pain, suffering and lost quality of life that road crash victims suffer.

Rehabilitation and long-term care The cost of returning the victim to functionality, and when that is not possible, the cost of long-term care and attention required by the victim.

Road crash A vehicle collision or non-collision event.

Travel delay The value of travel time delay for persons who are not involved in traffic crashes, but who are delayed in traffic congestion caused by these crashes.

Vocational rehabilitation The cost of job or career retraining needed due to disability caused by motor vehicle injuries.

Workplace cost The cost of workplace disruption due to the loss or absence of an employee, including the cost of retraining new employees, overtime needed to accomplish the work of the injured employee and administrative costs of processing personnel changes.

APPENDIX II

FRAMEWORK FOR ESTIMATING TRAVEL TIME LOST OR SAVED

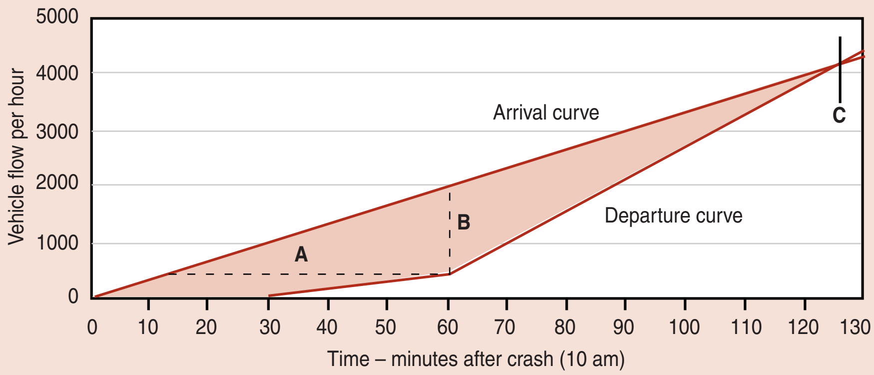
The concept of queuing is based on assumptions about vehicle arrival and departure characteristics at a point of reference such as a crash site; queue discipline (for example, first-in-first-out); and the number of available departure channels. The two common approaches are:

- exponentially distributed time interval, derived from assumptions of Poisson distributed arrival, with a deterministic departure time and one channel of departure; and
- equal time intervals, derived from the assumption of uniform deterministic arrival and departure, also with one departure channel.

The latter approach has been used. Deterministic queuing models are simple and lend themselves to an intuitive graphical or mathematical solution as illustrated in figure II.1. On the other hand, the Poisson distributed model has been found to be realistic in light traffic conditions, but is inappropriate in heavily congested traffic conditions (Mannering and Kilareski 1998).

A practical example demonstrates the application of the deterministic queuing model (demonstrated graphically in figure II.1). A crash occurs on the Hume Freeway at 10 am and blocks the westbound carriageway. Emergency services arrive 20 minutes after the crash (10.20 am) and after 10 minutes (10.30 am), one channel is opened for traffic to flow slowly through. The traffic flow in this restricted condition is down to 30 per cent of the flow prior to the crash (that is, 600 vehicles per hour, rather than an observed normal flow of about 2000). At 11 am, an hour after the crash, the wreckage is completely cleared from the road to allow traffic to depart at the freeway practical capacity flow level (3500 vehicles per hour). At point C, in figure II.1, the flow normalises. The delay to all vehicles

FIGURE II.1 TRAFFIC QUEUING MODEL



Note A = longest vehicle delay, B = longest vehicle queue, C = point of queue dissipation.

Source Adapted from Mannering and Kilareski (1998).

affected by the crash is equal to the shaded area (figure II.1) between arrival and departure curves (triangular and trapezoidal areas).

This scenario can also be represented mathematically (as shown in equations a to d) to allow computation of total traffic delays arising from crashes and values to be assigned to these delays. The total number of vehicles affected in the period between the crash and the complete dissipation of the queue (point C in figure II.1), is

$$Q_f = (\mu_r * t_r) + (\mu * (t_n - t_c)) \quad \text{a}$$

where Q_f is the total number of vehicles delayed by the crash; μ is full capacity departure flow rate per minute; μ_r is restricted departure flow rate per minute; and t is time in minutes after the crash (r = restricted flow allowed; c = crash cleared; n = normal flow resumed).

As t_n is unknown, the queue dissipates at the point when departing vehicles are equivalent to those arriving, that is

$$\lambda * t_n = (\mu_r * t_{30}) + (\mu * (t_n - t_{60}))$$

$$Q_f = (\lambda * t_n) \quad \text{b}$$

where λ is observed normal traffic flow per minute.

The delay to all vehicles affected by the crash is equal to the shaded area (figure II.1) between arrival and departure curves. This can be expressed as:

$$D_t = 0.5(t_r * \lambda * t_r) + 0.5(\lambda * t_r) + (\mu_r * t_c)(t_c - t_r) - 0.5(t_c - t_r) * (\mu_r * t_c) + 0.5(\lambda * t_r) - (\mu_r * t_c) * (t_n - t_c) \qquad c$$

where D is the delay time in traffic queue, with subscript denoting total (t) delay.

The average delay per vehicle can be determined from equation c.

$$D_v = {}^{D_t}/(\lambda * t_n) \qquad d$$

where D is the delay time in traffic queue, with subscript denoting average (v) delay.

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ABBREVIATIONS

A$	Australian dollar
ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
AGPS	Australian Government Publishing Service
AIHW	Australian Institute of Health and Welfare
AIS	Abbreviated Injury Scale
ATSB	Australian Transport Safety Bureau
Bocc-km	Billion occupant-kilometres
BTE	Bureau of Transport Economics
BTCE	Bureau of Transport and Communications Economics
Bt-km	Billion tonne-kilometres
BVKT	Billion vehicle-kilometres travelled
CARS	Community Attitudes to Road Safety
CJC	Criminal Justice Commission (Queensland)
CSOs	Community Service Orders
CTP	Compulsory third party (insurance)
DALY	Disability Adjusted Life-Year
DPP	Director of Public Prosecutions
DRG	Diagnosis-related group
FORS	Federal Office of Road Safety
ICA	Insurance Council of Australia
ISC	Insurance and Superannuation Commission
km	kilometre
kph	kilometres per hour
MAA	Motor Accidents Authority (NSW)

MAB	Motor Accidents Board, Victoria (now TAC)
MAIC	Motor Accident Insurance Commission (Queensland)
MAIS	Maximum Abbreviated Injury Scale
MMFES	Melbourne Metropolitan Fire and Emergency Services Board
NHTSA	National Highway Traffic Safety Administration (US Department of Transportation)
NRMA	National Roads and Motorists' Association
NSW	New South Wales
NZ	New Zealand
OECD	Organisation for Economic Cooperation and Development
PDO	Property damage only
RACV	Royal Automobile Club of Victoria
RTA	Roads and Traffic Authority (NSW)
SES	State Emergency Service
TAC	Transport Accident Commission (Victoria)
TPPD	Third party property damage insurance
YLL	Years of life lost (due to premature mortality)
YLD	Years of life lost due to disability
US	United States (of America)
USA	United States of America