Social Cost of Transport Accidents in Australia

Report

This study has refined the methodology and expanded the scope of a previous Bureau of Transport and Communications Economics study on the cost of road accidents in Australia. The human capital approach has been used in this study to estimate the social cost of road, rail, aviation and maritime accidents in Australia in 1988.

Bureau of Transport
and Communications
Economics
Report 79

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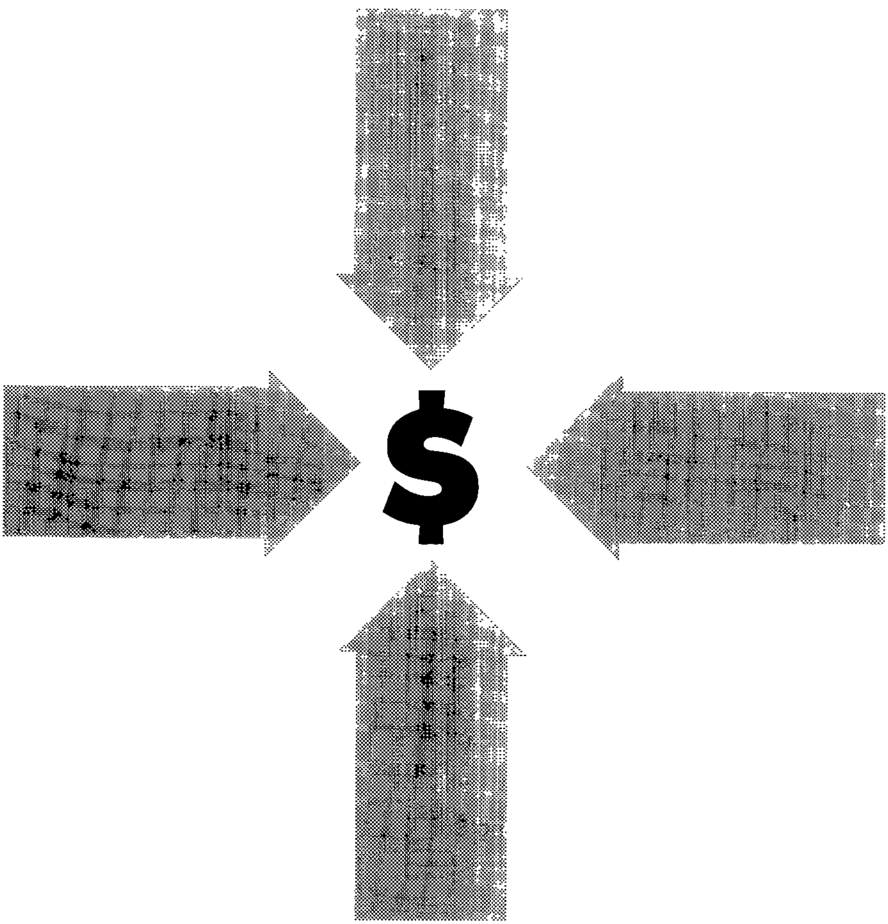

ISSN 1034-4152
ISBN 0 644 25615 X

Printed for AGPS by Better Printing Service, 1 Foster Street, Queanbeyan NSW 2620

FOREWORD

Studies on the social costs of transport accidents can assist policy makers to efficiently allocate resources to projects that reduce the incidence and severity of accidents. The results of accident costing studies can also be useful in raising the level of public awareness of the economic and social impact of transport accidents.

As a result of a request for road accident cost information from the Federal Office of Road Safety, the Bureau of Transport and Communications Economics published Occasional Paper 91, *Cost of Road Accidents in Australia*, in 1988. That study presented a limited review of the methodologies used to estimate road accident costs and estimated the costs for Australia in 1985.

The methodology adopted in Occasional Paper 91 has been further refined in this study and used to estimate the costs of road, rail, aviation and maritime accidents in Australia in 1988.

Much of the study was carried out by Dr M. Cook, assisted by Mr J. McKirgan and Mr M. O'Halloran. A substantial contribution to the study was made by Mr J. Motha, who was responsible for its completion and for the theoretical aspects of the methodology.

The assistance of the numerous organisations that provided data for this study is gratefully acknowledged.

Hugh Milloy
Research Manager

Bureau of Transport and Communications Economics
Canberra
September 1992

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ABSTRACT

This study has refined the methodology and expanded the scope of a previous Bureau of Transport and Communications Economics study on the cost of road accidents in Australia. The human capital approach has been used in this study to estimate the social cost of road, rail, aviation and maritime accidents in Australia in 1988.

Several accident cost categories have been separately estimated and combined to yield the total cost for each transport mode. These cost categories include lost earnings, forgone family and community contributions, pain and suffering, property damage, insurance administration, losses to non-victims, travel delay, hospital and rehabilitation, medical, accident investigation, legal and court, ambulance, and search and rescue. Australian working life tables and other statistical data were used to estimate the market and non-market output lost due to disability and premature death of accident victims.

Transport accidents in 1988 were conservatively estimated to have cost Australian society $6.6 billion. Road accidents contributed $6.1 billion (94 per cent) to this total. Aviation accidents cost $64 million (1 per cent), rail $94 million (1.4 per cent) and maritime $264 million (4 per cent).

Property damage, which cost $2 billion, was the largest single component of the cost of transport accidents, representing over 30 per cent of the total cost. Other cost components which amounted to $1 billion or more were pain and suffering ($1.4 billion or 22 per cent) and lost earnings ($1 billion or 15 per cent).

SUMMARY

OVERALL ACCIDENT COSTS

This study provides conservative estimates of the cost of transport accidents in Australia in 1988 (in 1988 dollars) using the human capital approach. Transport accidents in 1988 cost Australian society at least $6.5 billion. The cost of road accidents predominates in this total (figure A), accounting for 94 per cent ($6.1 billion) while maritime, rail and aviation accident costs together comprise the balance of 6 per cent. Table A details the costs of transport accidents in Australia in 1988 by transport mode and cost category.

Property damage, amounting to nearly $2 billion, is the largest single component of the cost of transport accidents, representing about 30 per cent of the total cost (figure B).

The loss of life due to accidents and the injury sustained by victims is expressed, in this study, in terms of the victims' forgone production and their pain and suffering. Forgone future production, including contributions to the family and community, accounts for about $1.7 billion or 26 per cent of the total cost of transport accidents. The greater part of this forgone production is made up of lost earnings in paid work, estimated at approximately $1 billion. The balance, $699 million, represents the value of unpaid services rendered to the family and community. The monetary equivalent of the pain and suffering endured by victims of transport accidents is about $1.4 billion or 22 per cent of the total cost of transport accidents. The other costs include insurance administration expenses, estimated at $621 million (less than 10 per cent of the total), and a variety of costs of lesser magnitude.

Figures C to H show the modal share of the total cost of transport accidents by major cost category. These figures illustrate the dominant influence of road accidents in total accident costs for all cost categories.

This study identifies several deficiencies in the data used in deriving the cost estimates, which contribute to varying degrees of imprecision in the different estimates. However, on a somewhat compensatory note, the costing methodology involves the use of Australian life tables, which is an actuarial approach lending considerable rigor to the accident costing process.

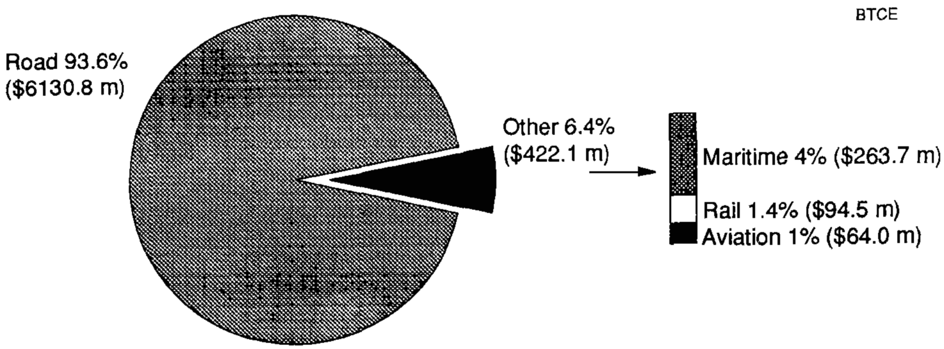
TABLE A SUMMARY OF TOTAL COSTS OF TRANSPORT ACCIDENTS BY MODE, 1988

	Earnings		*Family and community*		*Property damage*		*Insurance administration*		*Pain and suffering*		*Other*		*Total all costs*	
Mode	*$m*	*%*	*$m*	*%*	*$m*	*%*	*$m*	*%*	*$m*	*%*	*$m*	*%*	*$m*	*%*
Road	920.9	92	657.3	94	1 810.0	91	552.9	89	1 399.1	97	790.7	99	6 130.8	94
Aviation	24.9	2	13.9	2	13.8	–	5.8	1	3.5	–	2.1	–	64.0	1
Rail	34.4	3	17.2	2	28.4	1	na		8.3	–	6.2	–	94.5	1
Maritime	20.1	2	10.5	1	131.7	7	62.4	10	36.5	3	2.5	–	263.7	4
Total all modes	1 000.3	100	698.9	100	1 983.7	100	621.1	100	1 447.4	100	801.5	100	6 552.9	100

na Not applicable
– Less than 1 per cent

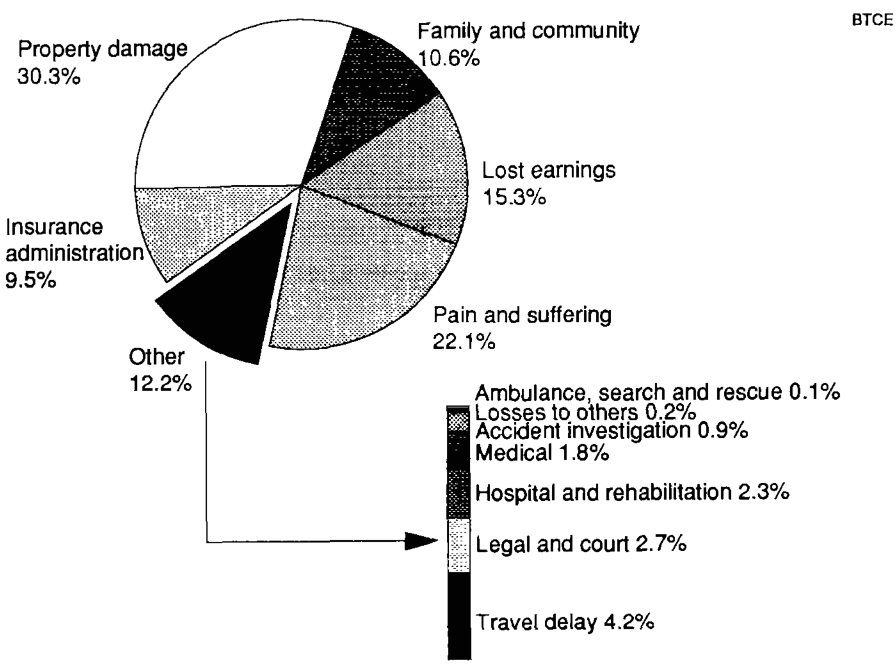
Note Figures may not add to totals due to rounding.

Source BTCE estimates.



Source BTCE estimates.

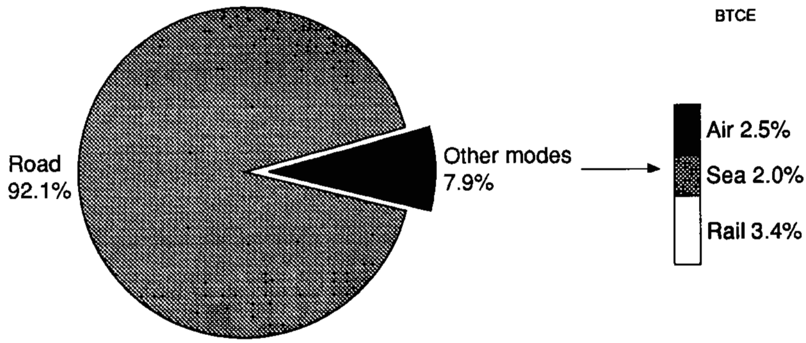
Figure A Social cost of transport accidents by mode, 1988 ($6552.9 million)



Note Certain cost categories in 'other' were not calculated for some modes.

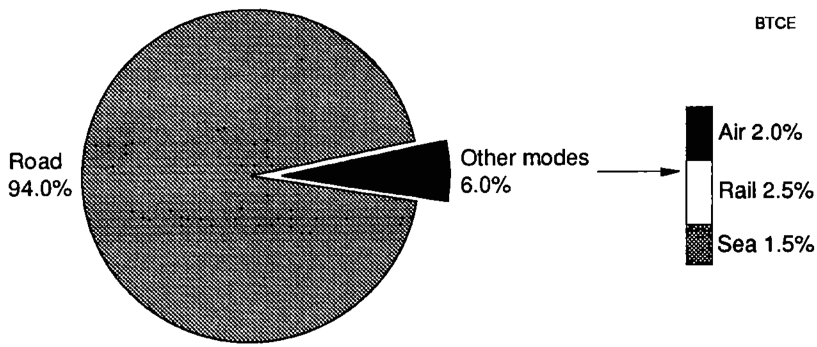
Source BTCE estimates.

Figure B Social cost of transport accidents by cost category, 1988 ($6552.9 million)



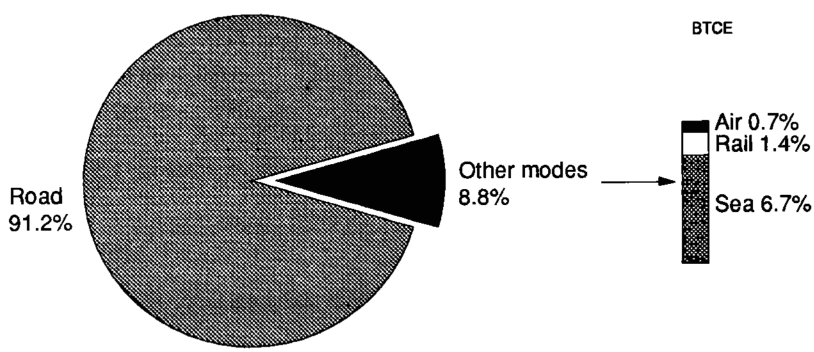
Source BTCE estimates.

Figure C Modal share of total transport accident costs: lost earnings



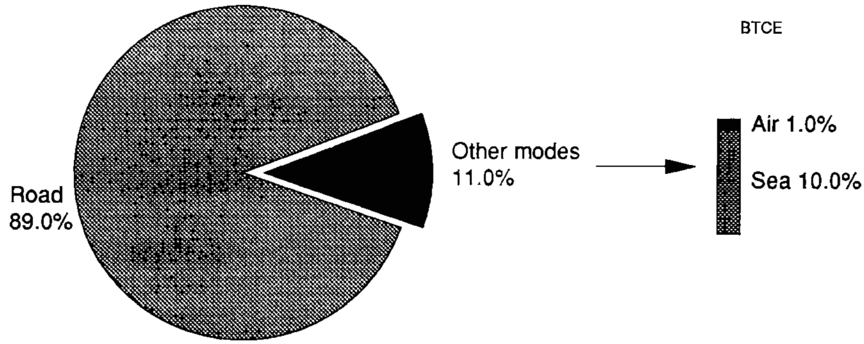
Source BTCE estimates.

Figure D Modal share of total transport accident costs: family and community



Source BTCE estimates.

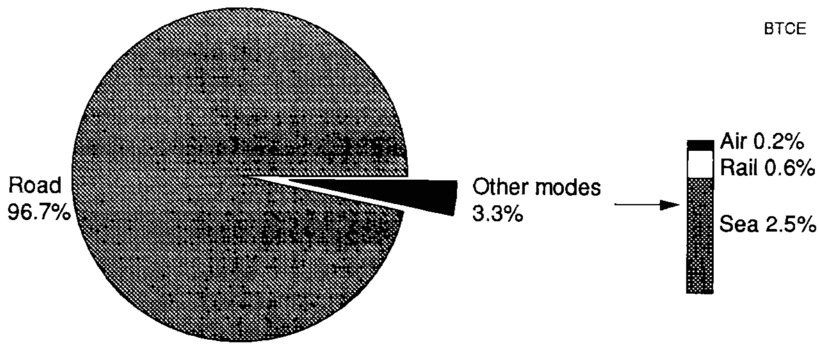
Figure E Modal share of total transport accident costs: property damage



Note Rail organisations are self-insurers and their insurance administration costs are subsumed in general administration.

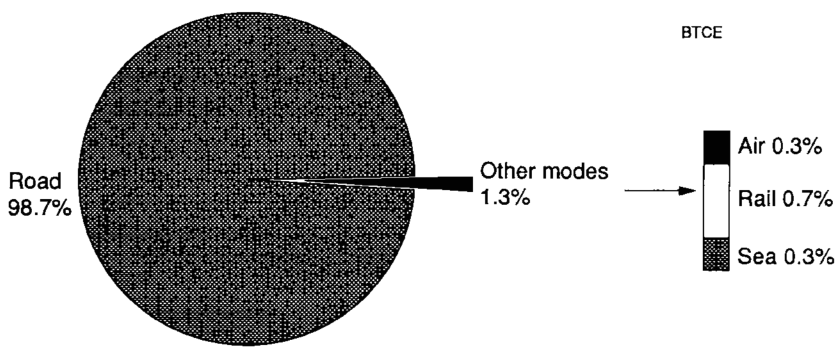
Source BTCE estimates.

Figure F Modal share of total transport accident costs: insurance administration



Source BTCE estimates.

Figure G Modal share of total transport accident costs: pain and suffering



Source BTCE estimates.

Figure H Modal share of total transport accident costs: other costs

ROAD ACCIDENTS

Figures I and J summarise the costs of road accidents in Australia during 1988. The cost of road accidents in 1988 was estimated at $6.1 billion or about $10 000 per accident.

Fatal accidents (accidents in which at least one person dies), cost about $1.6 billion, contributing 26 per cent to the total cost of road accidents. The average cost of a fatal accident was $631 000. The major cost factor in fatal accidents is the loss of productive capacity due to premature mortality. Lost earnings, together with the value of unpaid production, account for over 90 per cent of the losses in fatal accidents.

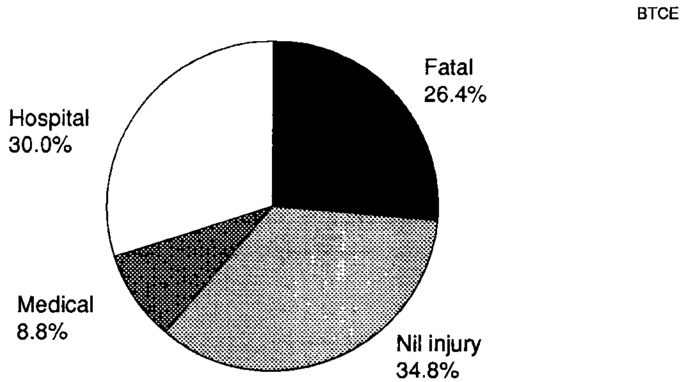
Accidents involving hospitalisation cost about $1.8 billion in total, accounting for 30 per cent of the total cost of road accidents. A hospitalisation accident cost about $95 000 on average. Pain and suffering is the major cost factor in hospitalisation accidents, contributing about 70 per cent of the cost of such accidents.

Accidents in which the most serious form of injury involved medical or outpatient treatment cost $538 million, accounting for about 9 per cent of total cost of road accidents. Nearly half of this cost is due to vehicle damage. The average cost per accident amounts to about $10 000. In aggregate, these accidents were the least costly.

On the other hand, nil injury accidents in aggregate were by far the most expensive. The contribution of these accidents to the total road accident cost was about $2.1 billion or 35 per cent. About 68 per cent of this cost resulted from vehicle damage. Nevertheless, these accidents, costing on average $4000 each, were the least costly on an individual basis.

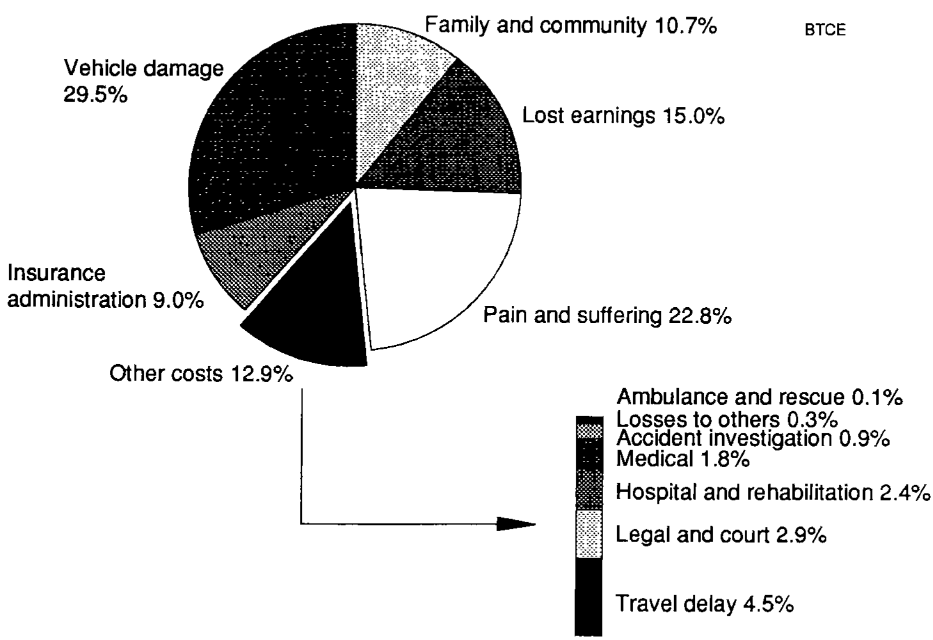
The cost of transport accidents embodies two broad components: one component is the human cost involving lost production and pain and suffering, and the other is the material cost, which is made up of property damage, insurance administration and a variety of other costs. Among the human factors, lost production of victims due to premature mortality, time spent in hospital undergoing medical treatment and time spent in recuperation are together estimated to have cost about $1.5 billion, making up about a quarter of the total cost of road accidents. Pain and suffering, estimated to have cost about $1.4 billion, accounts for 23 per cent of the total. These two cost factors, together with the costs of lost production of other road users due to travel delay and of time spent in the support of victims by their friends and relatives, account for about half the total cost of road accidents.

The material component, which comprises the other half of road accident costs, consists largely of costs associated with motor vehicle loss and repair. Vehicle damage and loss, amounting to over $1.8 billion, accounts for about 30 per cent of the total cost of road accidents. Most of this damage occurred in accidents in which there was no physical injury to vehicle occupants. On average, vehicle



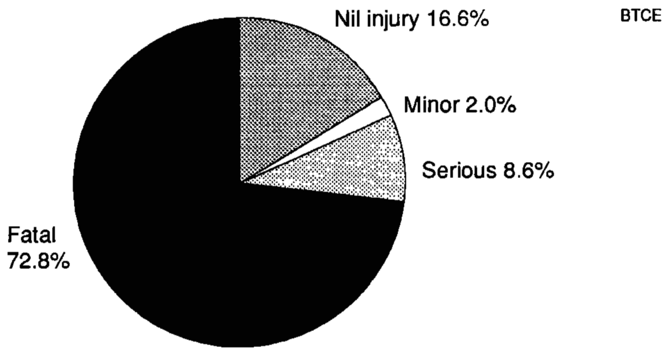
Source BTCE estimates.

Figure I Social cost of road accidents by injury class, 1988 ($6130.8 million)



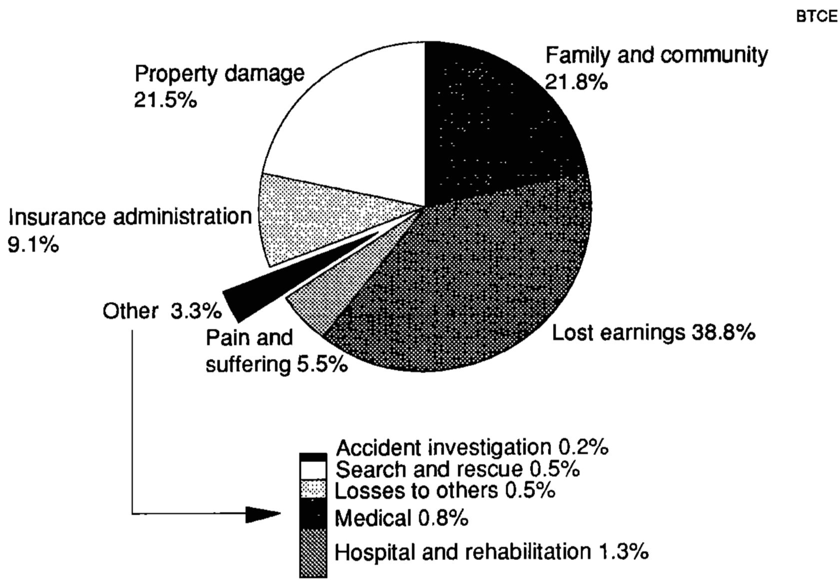
Source BTCE estimates.

Figure J Social cost of road accidents by cost category, 1988 ($6130.8 million)



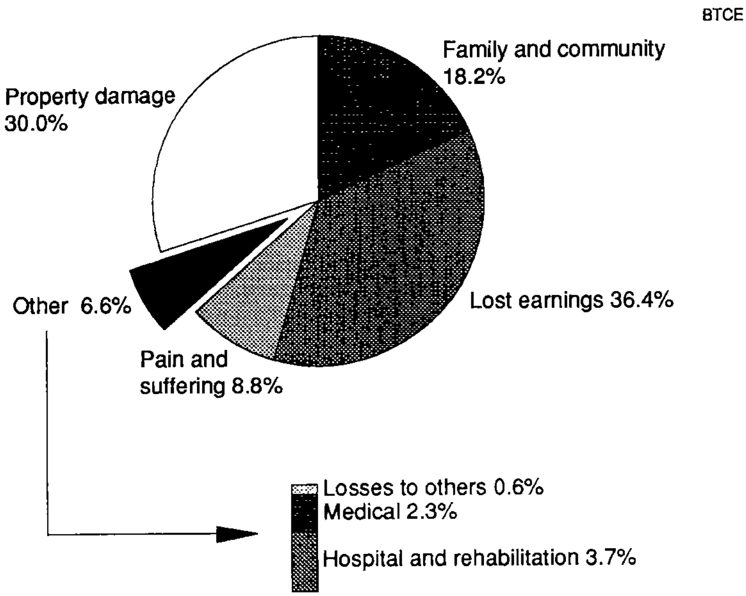
Source BTCE estimates.

Figure K Social cost of aviation accidents by accident class, 1988 ($64 million)



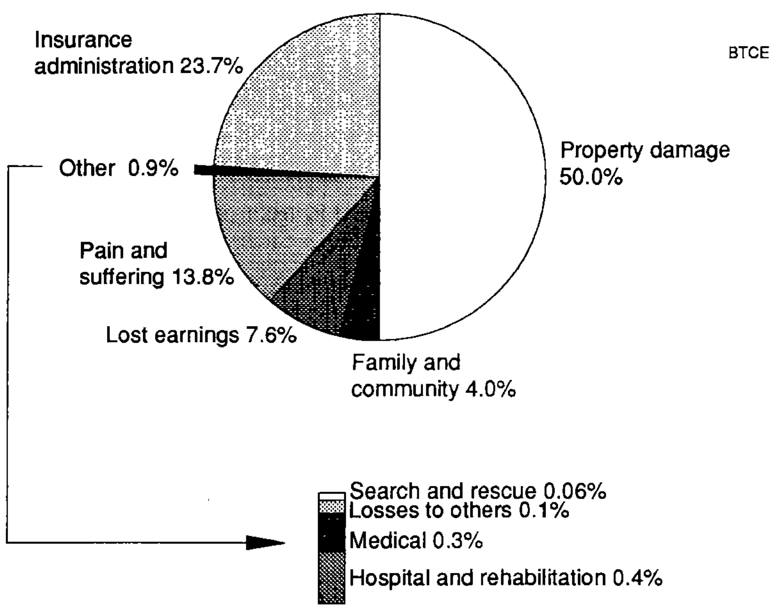
Source BTCE estimates.

Figure L Social cost of aviation accidents by cost category, 1988 ($64 million)



Source BTCE estimates.

Figure M Social cost of rail accidents, by cost category, 1988 ($94.5 million)



Source BTCE estimates.

Figure N Social cost of maritime accidents by cost category, 1988 ($263.7 million)

damage costs were about $3000 per accident or about $1700 per vehicle. The other major material cost, motor vehicle insurance administration including compulsory third party insurance, amounts to some $553 million, corresponding to about $1000 per accident.

AVIATION ACCIDENTS

Summary information relating to aviation accidents is presented in figures K and L. Aviation accidents in 1988 generated a total cost of $64 million or $195 000 per accident. Fatal accidents were the most costly at $1.26 million per accident. Fatal accident costs, at nearly $47 million, make up 73 per cent of the total cost of aviation accidents.

Over 60 per cent of the total cost of aviation accidents is made up of the loss to society of the productive capacity of the victims of these accidents, particularly the fatalities. Damage to the aircraft involved in accidents accounts for 22 per cent of the total cost. The other major cost element relates to insurance administration, which accounts for about 9 per cent of the total. Several other relatively minor cost factors make up the balance of 9 per cent.

RAIL ACCIDENTS

Rail accidents were estimated to have cost over $94 million in 1988. A little over half this cost (55 per cent) is ascribed to the loss of production associated with fatalities.

Figure M shows the proportions of the various cost components comprising the total cost. The largest single cost component, amounting to over $34 million (36 per cent of the total), is due to the loss of earnings by victims of rail accidents. The loss of family and community production accounts for $17 million (18 per cent) of the total cost. The pain and suffering component of about $8 million makes up the remainder of the human cost.

Asset damage, estimated at over $28 million, was the dominant material cost in rail accidents. The cost of insurance administration could not be estimated because rail systems, which are self-insurers, subsume this cost in their general administration.

MARITIME ACCIDENTS

Maritime accidents, whose total 1988 cost was estimated at about $264 million, ranks as the second most costly type of transport accident. The composition of the total cost of maritime accidents in terms of the various cost components is shown in figure N. The cost of property damage, inclusive of the loss of cargo, was estimated at $132 million and accounts for almost half the total cost of maritime accidents.

The cost of insurance administration and other material costs contribute $65 million, which is about 25 per cent of the total cost. The human costs represented by lost production and pain and suffering account for the remaining $67 million.

CHAPTER 1 INTRODUCTION

BACKGROUND

The loss of life and property together with the injury and damage that occur as a result of transport accidents represent a major burden on the Australian community. Arbous and Kerrick (1951) define an accident as an 'unplanned event in a chain of planned or controlled events'. Most, though not all, transport 'accidents' are the consequence of human factors and entail human costs. The definition of an accident by Cherns (1962) as 'an error with sad consequences' is more expressive of the causal element and the human costs associated with most transport accidents. The statistical estimates of years of life lost due to premature mortality and the value of output forgone as a result of accident-related injury do not adequately communicate the depth of human loss, grief, pain and suffering that follow transport accidents. However, investment decisions on transport safety and research programs need to be made, and data on accident numbers and severity, and their economic costs, can improve the quality of those decisions.

One of the prime uses of accident cost information is in assessing the benefits of various transport safety measures and programs. These measures and programs also impose costs on society, and it is necessary for governments to determine the appropriate balance of costs and benefits in order to ensure that limited resources are used in a socially acceptable and efficient manner.

Following discussions with the Federal Office of Road Safety in 1987, the Bureau of Transport and Communications Economics undertook a limited review of the methodologies used to estimate the cost of road accidents and to estimate these costs for Australia. That work led to the publication of *Cost of Road Accidents in Australia* (BTCE 1988), which presented estimates of the cost of road accidents for 1985. The methodology developed to obtain those estimates has, in this study, been further refined and applied to road, rail, aviation and maritime accidents.

APPROACHES TO ACCIDENT COSTING

The costing of accidents necessarily involves the valuation of life and safety. Several approaches have been proposed for such valuation, but only two have been used extensively in empirical work. These approaches are commonly known as the human capital approach and the willingness-to-pay approach.

The human capital approach to accident costing is an ex-post accounting approach which focuses on the victim's potential output or productive capacity. In this approach, a major cost factor is the discounted present value of the future output of accident victims that is lost due to their premature death or disability. Resource costs such as vehicle damage, medical costs and the like are added, together with inputed values for the loss of non-marketed output such as the services of those involved in home and community duties. Estimates of welfare losses such as those due to pain and suffering are also sometimes included.

The ex-ante willingness-to-pay approach is founded on the principles of welfare economics. Its fundamental premises (Jones-Lee, Hammerton & Philips 1985) are:

- that social decisions should, as far as possible, reflect the interests, preferences and attitudes to risk of those who are likely to be affected by the decisions; and
- that in the case of safety, these interests, preferences and attitudes are most effectively summarised in terms of the amounts that individuals would be willing to pay, or would require in compensation, for changes in the probability of death or injury during a forthcoming period.

In practice, the willingness-to-pay approach measures individual marginal rates of substitution of wealth for risk of death or injury.

There is a great deal of debate on the appropriate approach to be used and associated issues in relation to social cost–benefit studies involving risk to life. A discussion of these approaches and issues is presented in appendix I.[1]

The costing of accidents in this study has been undertaken within the general framework of the human capital approach. The human capital approach is actuarial in that it allows for age and gender-specific expectations of working life to be incorporated in calculations of lost output due to premature mortality and disability. This study used tables of working life and other refinements consistent with the human capital approach to estimate various facets of the social cost of road, rail, aviation and maritime accidents using the best data that were available. However, the number of factors that could be included in the costing framework was limited by data constraints. The overall accident costs presented in this study should therefore be considered lower bound estimates. All accident cost estimates in this study are expressed in 1988 dollars.

1. For a more detailed review of the human capital and willingness-to-pay approaches to valuing human life, see Motha (1990).

CHAPTER 2 METHODOLOGY

INTRODUCTION

This study closely follows and expands on the work of Atkins (1981) and BTCE (1988) in using the ex-post human capital approach to assign an economic value to the lives lost and injury sustained as a result of transport accidents in Australia, and to estimate the total cost of these accidents. The total cost estimated using this method depends on the cost factors taken into account and how these factors are calculated.

THE COSTING FRAMEWORK

As far as possible the accident was used as the basic costing unit in this study. It is important to note that an accident may involve one or more vehicles, vessels or aircraft as well as one or more persons who sustain varying degrees of injury.

The social cost of transport accidents estimated in this study embodies a quantification in dollar terms, as far as practicable, of the many resources valued by society which are lost or diminished as a result of accidents. As noted earlier, such estimates can vary widely depending on the cost factors included in the estimation and how such costs are computed. The basic framework for the estimation process used in this study consists of costs relating to the loss, or partial loss, to society of the productive efforts of accident victims and other individuals affected by accidents; the cost of resources expended in accident-related activities; and a monetary estimate of human pain and suffering.

Loss or partial loss of future production has been estimated in terms of the earnings and labour on-costs of accident victims, the productive but unremunerated contributions of victims to their families and communities, and the productive time lost by members of society other than victims.

The costs of accident-generated activity include those relating to property (including vehicles, vessels and aircraft) damage and loss; insurance administration; medical, hospital and rehabilitation; accident investigation; ambulance, search and rescue; and legal proceedings. The costs imposed upon society through environmental damage and clean-up resulting from transport accidents have not been included, and this is considered an important area for future research.

The third major element in the costing framework — pain and suffering — is perhaps the most intangible. In this study only the costing of the pain and suffering of accident victims has been attempted. Relatives and friends of those killed and injured also bear emotional costs, but these have not been estimated. Further, it has been assumed that those who died in transport accidents did not bear pain and suffering.

The aforementioned factors comprise the framework for the estimation of transport accident costs. The estimate of the social cost of transport accidents in 1988 has been generated, as far as possible, from the actual or estimated number of accidents that occurred in that year. The social cost estimates will therefore be affected by under-reporting of accidents. By their nature, transport accidents involving death or serious injury generally come to the attention of the authorities. It is reasonable to expect accident statistics to become less reliable as the degree of injury severity decreases. Unreported accidents tend to be relatively minor accidents involving only damage to property. While the individual cost of such accidents may be small, their number is large and therefore their aggregate cost is substantial. Road accidents involving private motor vehicles, and maritime accidents involving private pleasure craft, are probably subject to the most under-reporting. Estimation procedures for under-reported road accidents are dealt with in chapter 3.

Definitions of terms such as 'accident' or 'injury' may vary from one transport mode to another. Wherever possible, for the purpose of consistency, locally and internationally accepted definitions have been used. However, differences in definitions, as well as in data collection and presentation by reporting agencies, make direct cross-modal comparisons somewhat problematic. For example, aviation accidents are centrally reported to the Bureau of Air Safety Investigation (BASI) and to the Civil Aviation Authority (CAA), whereas road accidents are reported through the police to State and Territory authorities, each having their own reporting criteria. Maritime accidents may be reported to police and/or State and Territory maritime and port authorities or, under certain conditions, to the Australian Maritime Safety Authority (AMSA). Rail accident statistics are largely compiled by the various rail organisations. In this study, specific definitions are presented in the sections for each transport mode. A complete list and discussion of definitions is in appendix II.

In keeping with practice commonly adopted, transport accidents have been classified in this study according to the most severe injury occurring in the accident. For example, a 'serious' injury accident is one in which the most severe injury sustained is classified as serious. Other, less severe, injuries may also have been sustained and other damage may or may not have occurred. An accident categorised as a 'medical' injury accident is one in which at least one person sustained injuries requiring medical treatment. A 'fatal' accident is one in which at least one person died.

In the case of road and aviation accidents, the costing was based on the individual accident, which was generally well defined and reported. However, in the case of rail and maritime accidents, the basis of costing was the accident victim or casualty. This change from the preferred costing approach was due to the multiplicity of organisations involved in recording rail and maritime accidents, the non-uniformity of the definitions used and the paucity of published data. The use of the victim or casualty as the basis of the cost estimates partially overcomes these difficulties.

The scope and coverage of the data varied considerably among the States and Territories. There were also some cases of inconsistency between similar data from different sources. For example, BASI (1990) reports 70 deaths in civil aviation accidents in 1988 whereas the ABS (1989a) reports 57. The ABS figure is 19 per cent less than the BASI figure. Further, the 57 aviation accident deaths reported by the ABS may include up to 7 military deaths not included in the BASI reports.

Similarly, rail authorities report some 96 rail fatalities (excluding suicides) in 1988 while the ABS (1989a) records 60. In this case the ABS figure is 37.5 per cent lower than that of the rail authorities. These differences cannot be explained solely by the variation in the time dimension of the definitions used for fatal accidents. For both aviation and rail accidents, BASI and the rail authorities only count deaths which occur within 30 days of the accident. The ABS, in its mortality tabulation, could count deaths which occur one year or more after the accident.[1] The consequence of this difference is that ABS figures should in all cases be higher, not lower, than those of BASI and the rail authorities.

In the case of road accidents the situation is more consistent with these differences in the method of reporting accidental deaths. The ABS, in its mortality tabulation (1989a), reports some 3078 deaths resulting from road accidents in 1988. The Federal Office of Road Safety (FORS 1991), which uses the 30-day limit for fatalities, reports 2875. In this case the ABS reports 7 per cent more

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1. The death may occur some time after the accident. BASI and several road and traffic authorities report as fatal accidents those where a death takes place within 30 days of the accident. ABS mortality statistics (ABS 1989a) are based on causes of death entered in death certificates. These deaths are usually coded using the ICD-9 codes. Among the external cause of injury codes in ICD-9 are those relating to late effects of accidental injury (E929.0 and E929.1). Consequently, the ABS mortality tabulation could include deaths reported one year or more after accidental injury. Further, the ABS mortality tabulation relates to the number of deaths registered, and not those which actually occurred during the year. According to the ABS (1989a) about 5 to 6 per cent of deaths occuring in a particular year are not registered until the following year or even later. However, the ABS road traffic accident statistics (ABS 1990a) use a 30-day time period. These differences in reference periods and recording will result in statistical discrepancies.

fatalities than FORS. The ABS publication *Road Traffic Accidents Involving Casualties Australia 1988* (ABS 1990a) uses the 30-day limit for fatalities and reports 2887 road deaths. The FORS data on fatalities have been used in this study. Appendix III discusses some of the methods adopted in this study to deal with data inconsistencies.

LOST PRODUCTION

An important accident cost factor is the loss of future production or output of accident victims. Future production is represented by the net present value of future earnings and directly related on-costs[2] of accident victims plus the economic value of unpaid family and community work. In this study it has not been considered appropriate to subtract the value of the victim's lifetime consumption from the earnings stream.[3]

Calculation method

Some earlier studies on the cost of certain types of transport accidents in Australia (Atkins 1981; Brownbill 1984) calculated forgone income of accident victims by estimating the present value of their assumed future total income, taking account of their age and gender. This involved discounting the income stream to a present value from age 65 with an adjustment for future productivity gains. A key assumption was that all persons not in the labour force value their leisure at prevailing market wage rates. BTCE (1988) introduced a refinement in the form of an adjustment for employment rates.

The working life table model

This study has adopted the general approach of the earlier studies but has further refined the method of calculating lost production by using tables of working life. The working life tables describe labour force participation and movements into and out of the labour force at each age as well as expectations of years of working and retirement life. Tables of working life for Australia have been prepared by Ruzicka (1973, 1986) for males only and by Anderson and Ross (1987) for both males and females.

The working life tables by Anderson and Ross are based on 1981 Australian census data and the *Australian Life Tables 1980–82* (Office of the Australian Government Actuary 1985). Their working life tables use 1981 Australian mortality profiles and rates of labour force participation, to yield age and gender

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2. Some authors (Abelson 1986; Rice, Mackenzie and Associates 1989) have recognised the validity of certain labour on-costs in valuing lost output. These on-costs include superannuation, leave loadings and fringe benefits. In this study it was considered that the production lost to society by premature death is at least equal to the sum of the individual's earnings, labour on-costs and the value of family and community work over the individual's potential period of life, discounted to a present value (appendix I). On-costs have been estimated at 21.2 per cent of total labour costs (ABS 1990b). On-costs do not appear to have been incorporated in previous estimates of Australian accident costs.

3. For a detailed discussion of this issue see appendix I.

specific expectations, in years, of working life and retired life of persons in the labour force.

The working life table is based on an initial cohort (usually 100 000 persons) born concurrently, and describes expected life-cycle behaviour of the cohort. At successive ages, mortality diminishes the cohort. The probabilities of accession to, and secession from, the labour force likewise increase or decrease the cohort's labour force participation.

For the purposes of the life table, mortality rates are usually expressed as the proportions of individuals dying between ages x and $x+1$ among 1000 individuals living at age x. The participation and mortality rates are then used to calculate the number of survivors from birth to successive ages. It is assumed that retirement age is independent of the age of entry into the labour force and that mortality at each age is independent of labour force participation.

These two sets of probabilities — the probability of surviving from age x to $x+1$ and the probability of accession to or secession from the labour force in that year — allow for the estimation of the number of person-years of life, both working and in retirement, that can be expected by the remaining members of the cohort at each age. The sum of these person-years for the subsequent ages to the terminal age of the life table, divided by the numbers of survivors at each age, allows for the calculation of the expectation of working and retirement life at each age. Expectation of working and retired life is the average number of remaining years of life for individuals of each age assuming that they will be subject to the mortality and labour force participation rates incorporated in the life table.

One of the fundamental assumptions in preparing working life tables is that mortality and employment rates, current for various ages at a given point in time, will continue unchanged and that these rates are independent and apply to persons in employment. In addition to these general assumptions, the tables by Anderson and Ross adopt certain assumptions for labour force accessions and secessions. For males, it is assumed that accessions occur only up to a maximum participation age of 34 years, and that secessions or retirements occur thereafter. In the case of females, it is assumed that accessions occur up to age 50 but do not occur at exact age 25 (this is the only age between age 15 and age 50 where no accessions occur). It is assumed that secessions only occur after the age of 50. Secessions up to age 50 follow the trend of first nuptial and ex-nuptial births appropriately scaled to pass through retirements at age 25 and to link with retirements at age 50.

The use of the working life tables, rather than a fixed retirement age, allows for the valuing of probable remaining years of work and life, based on age and gender. Applying these expectations to all accident victims assumes that they have the potential productivity of those in the labour force.

The working life tables do not provide an expectation of working life for those members of the community less than 15 years old. It was assumed that the working life of persons from birth through 14 years will be the expected working life of a 15-year-old. The earnings stream (both paid earnings and family and community output) for each age in this group was discounted from age 15. For example, a 5-year-old was assigned the earnings of a 15-year-old discounted over 10 years.

The working life tables use a number of simplifying assumptions all of which are questionable to some extent (Anderson & Ross 1987). However, despite these limitations, the working life tables provide useful information for many applications in economics and demography, including the estimation of the cost of accidents.

Lost earnings of victims

In this study, earnings rather than income have been used in valuing the lost productivity of accident victims, as earnings are considered to be more consistent with the rationale of the human capital approach (appendix I). However, sensitivity tests carried out by BTCE (1988) on estimated Australian road accident costs for 1985 indicated that the two measures produced very similar results.

The earnings estimates used in this study for each age and gender were derived from earnings for full-time employees in their main jobs. The figures used were based on median weekly earnings (ABS 1988a). Earnings specific to age and gender together with labour on-costs were then applied to the number of years remaining in the labour force as a discounted (7 per cent discount rate) earnings stream and adjusted for annual productivity gains (2 per cent per year) over the relevant period. The 7 per cent discount rate was also used in the previous BTCE accident costing study (BTCE 1988). This procedure yielded expected earnings for each age and gender category of accident victim for the remaining period of working life.

The method described above places a value on the potential production of persons in ages often associated with retirement, and those with low rates of labour force participation. To overcome the limitations introduced by the assumption of employment, wages for each age and gender group were adjusted by the labour force participation rate for that group. This technique is similar to the adjusted opportunity cost approach used by BTCE (1988). The models used to estimate forgone production and related assumptions are described in appendix IV.

The gender and exact age of all persons involved in transport accidents in 1988 were not always available. Because of these limitations, the average forgone production of accident victims of known age and gender was applied to victims of unknown age and/or gender for each injury severity level, to derive the total cost of forgone production and average cost per accident and per victim.

While the accident victim is hospitalised and disabled, productive capacity is lost to the community. Comprehensive information on the length of the period of total or partial disability was not available and the length of stay in hospital for some accident victims could not be obtained. In a study of the costs of drug abuse in

Australia, Collins and Lapsley (1991) estimated that each day of production lost in hospital was followed by two additional days. In this study, it has been assumed, perhaps conservatively, that one additional day of production is lost for each day in hospital. The validity of this assumption could be assessed in the light of future research.

Also, in the case of the medically injured in road and rail accidents, one day of production has been assumed to be lost. In aviation accidents, those who sustained minor injuries were assumed to have to have spent, on average, one day in hospital and, in accordance with the assumption mentioned earlier, to have lost the production equivalent of two days. The value of daily production is a function of the age of the victim.

The specific estimation procedure, in the absence of complete data, is dealt with in the relevant sections for each transport mode. For reasons explained in these sections, the calculated figures should be regarded as lower bound estimates. Further, earnings estimates have not been adjusted to reflect possible differentials in the earnings of transport accident victims within each mode and in the earnings of victims of accidents between different transport modes.

Family and community losses

A large amount of productive but unpaid work is performed by both employed and non-employed persons. Such work includes work done for the household and voluntary community work. When a person dies or is incapacitated this production is also forgone and represents a social cost.

Defining and measuring household work presents some difficulties. The two approaches generally used are based on replacement cost and opportunity cost.[4] This study uses the opportunity cost approach which may yield higher estimates than with the use of replacement costs. It was assumed that the median weekly earnings by age and gender best describes the opportunity cost of performing household and community work. Therefore, the value of family and community production time lost was assumed to be equal to that of the production time lost in paid work.

The ABS survey of time use conducted in 1987 (ABS 1990c) estimated an average of two hours per day for males and four hours per day for females of productive but unpaid work performed in family and community services by full-

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4. The opportunity cost method values household and community work in terms of earnings forgone, as measured by the market wage, by performing household and community work rather than paid employment. The replacement cost approach involves two alternatives: individual function replacement cost (which assigns values to the time spent on household and community production by household members in accordance with the cost of employing a market replacement for each task or function) and the housekeeper replacement cost approach (which values the time spent on household production on the basis of the cost of hiring a housekeeper to perform the tasks and excludes community work). For a detailed discussion see ABS (1990c).

time workers. For persons not employed the estimate was three hours per day for males and six hours per day for females.

The average amount of time (including weekends) spent in household and community work, derived from the ABS time use survey, may be expressed as a proportion of the average work week. Data on average weekly hours worked by males and females were obtained from ABS (1990b). In the case of males, household and community work constitute about 43 per cent of an average work week of 40.6 hours. In the case of females, the proportion is 119 per cent of an average work week of 29.3 hours. In this approach, the number of hours of family and community service was expressed as a proportion of the hours per week worked, on average, by full-time male and female wage and salary earners.

The value of forgone family and community work was calculated using the working life tables. The hours of unpaid work were converted to an annual wage and added to the age and gender specific calculation of forgone earnings during working and retired life.

The ABS estimates of time spent in family and community work have certain limitations, which relate mainly to the wages used for the valuation of time and to sampling and non-sampling errors. The ABS time use survey was an experimental project, intended to ascertain the extent to which questions were understood and whether they could be answered adequately, rather than to produce accurate results. The sample of 1000 households selected for the study was Sydney-based and assumed to be representative of Australia as a whole. The data related to one fortnight and therefore did not take account of seasonal changes.

The ABS is currently conducting a national time use survey over calendar year 1992 and is refining the survey methodology. The more precise estimates that are likely to emerge from this survey could be used to obtain better estimates of the value of non-market production lost as a result of accidents.

In this study, the calculation of the losses due to forgone production incorporates the labour force participation rate in both the paid and unpaid production estimates. The rationale for this procedure is that the application of the labour force participation rates to the paid component of production requires that the unpaid production of those persons not in the labour force must also be taken into account. This procedure has the effect of lowering the value of paid, and raising the unpaid, production of those age/gender groups with lower rates of labour force participation. This procedure takes full account of labour force participation.

Losses to non-victims

Losses to non-victims, that is, persons not actually involved in the accident, comprise costs due to travel delay, costs to employers and costs associated with the visiting and care of accident victims. Only the forgone production aspects of these losses have been considered in this study.

Travel delay costs
Travel delays apply mainly to road accidents, and although such delays can and do sometimes occur in other transport modes they have only been estimated for road accidents in this study. Travel delay was estimated only for metropolitan road accidents occurring during morning peak-hour traffic. The technique for estimating the number of metropolitan road accidents is discussed in appendix V.

Other costs
Other costs incurred by non-victims include costs relating to visiting, transporting and caring for accident victims, and the replacement of the victims work-related inputs. In estimating these costs, the focus has also been on lost production. This study follows the approach used with US data by the National Highway Traffic Safety Administration (NHTSA 1972), which has been adopted in several subsequent studies including Faigin (1976), Atkins (1981), and BTCE (1988).

In the NHTSA approach, losses to non-victims were estimated as percentages of the total forgone earnings of victims, excluding unpaid family and community productivity. The specific percentages used were related to the degree of injury severity as described by the different levels of the Abbreviated Injury Scale (AIS). The percentages used in the NHTSA study were: 20 per cent for AIS level 1, 10 per cent for AIS levels 2 and 3, 2.5 per cent for AIS levels 4 and 5, and 1.2 per cent for AIS level 6.

In this study, the specific percentages used are not uniform for all modes and are related to the degrees of injury severity and their distribution within each mode. The percentages used by the NHTSA relating to AIS levels were adapted to the injury severity levels used in this study. The figure of 20 per cent for AIS level 1 was applied to medically injured victims, the average for AIS levels 2 to 5 (6.25 per cent) was used for hospitalised victims and 1.2 per cent for AIS level 6 was assigned to fatalities. These percentages have been applied to total forgone earnings and on-costs of the victims of road, rail and maritime accidents.

In the case of aviation accidents, losses to non-victims were also expressed as a percentage of the total forgone earnings of victims. As for the other modes, the NHTSA figures were adapted to calculate losses to non-victims. The figure of 15 per cent (the mean of AIS levels 1 to 3) was assigned to a victim sustaining minor injuries. In the case of seriously injured victims the figure used was 6.25 per cent (the mean of AIS levels 2 to 5) and for those fatally injured it was 1.2 per cent (AIS level 6). These percentages were also used in the study of aviation accident costs by Cook et al. (1990).

ACCIDENT-GENERATED ACTIVITIES

Costs of property damage and loss

Damage and loss to transport vehicles, which is probably the most tangible of accident costs, represents a considerable proportion of the cost of transport accidents. Information on such costs was derived from transport insurance claims, ABS surveys and other sources. The methods used differ for each transport mode and are described in the appropriate sections.

Insurance administration costs

Insurance industry statistics for 1988 (ISC 1989a, 1989b) indicate the aggregate expenses incurred by the insurance industry in terms of the type of insurance business. Statistical information on insurance administration costs specific to each transport mode is presented in the appropriate sections of the chapters on each mode.

The insurance industry statistics relating to administration costs include some taxes payable by the insurance industry. Taxes are transfer payments to the government and essentially involve redistribution of income. Transfer payments do not represent new goods or services produced. Therefore, taxes should not be incorporated in the social cost of accidents. However, this adjustment could not be made due to problems involved in disaggregating the data. The consequence of this is that insurance administration costs would be somewhat overstated.

Medical, hospital and rehabilitation costs

Medical costs

Medical costs resulting from transport accidents have been estimated from information provided by the Transport Accident Commission of Victoria (TAC 1991). In estimating medical costs based on TAC data, it has been assumed that Victorian medical costs in 1988 were representative of those for Australia as a whole. For road, aviation and maritime accidents, medical costs have been based on the average claim for medical costs for victims of road accidents reported to the TAC. In the case of rail accidents, medical costs have been based on the average medical costs of victims of rail accidents reported to the TAC. The average claims for persons fatally injured, hospitalised or only medically injured were each calculated separately.

The TAC paid all claims made on them for the medical treatment of hospital outpatients. They also paid claims from persons treated by private doctors where the charges exceeded $298. These practices introduce two countervailing biases into the average payments for medical treatment. The exclusion of persons who sought treatment from a private doctor only, and for whom the charges were less than $298, would tend to bias the TAC average upward. On the other hand, inclusion of outpatient charges, and the exclusion of private medical charges less than $298, for persons who were treated as outpatients and consulted a private doctor, tend to bias the TAC average downward. It was assumed that these biases cancel each other.

TAC data revealed that the average medical cost for a person fatally injured in a road accident was $832.[5] The average medical cost for a person who was injured and admitted to hospital was $3247 and for a person who was only treated medically the cost was $387. Given that persons who were admitted to hospital as a result of a road accident spent an average of 21 days in hospital (TAC 1991), it was possible to estimate the total medical cost for hospitalised persons. It follows from these figures that the medical cost of a hospitalised road accident victim was about $155 per hospital bed-day. This estimate was also used to calculate medical costs for aviation and maritime accident victims. Medical costs for rail accident victims based on TAC data are set out in chapter 5.

Hospital and rehabilitation costs

Hospital costs were estimated using average daily inpatient hospital charges in 1988 based on data provided by the TAC and the Australian Institute of Health. The estimates vary for each transport mode due to the type and severity of the injuries sustained, and their derivation is described in more detail in the chapters relating to each mode.

When estimating the number of days in hospital, it was necessary to be mindful of the admission practices of hospitals, and the reporting practices of police and other authorities. Police may report as hospitalised those persons whom they dispatch from the accident scene to hospital. This leads to an over-reporting of 'hospitalised injuries' as some of these persons are treated as outpatients and discharged. Similarly, a hospital close to the accident scene may initially admit an injured person who may subsequently be discharged and later admitted to another hospital, perhaps closer to the person's home or with better facilities for the treatment of a particular type of injury. Later, that person may be transferred to yet another hospital with facilities for long term care or rehabilitation. Likewise, a particular treatment process may involve several readmissions. Thus, several admissions can apply to the same person. Also, in the case of admissions further removed from the accident event, the diagnostic code rather than the external cause of injury code may be used to describe an admission.[6]

Hospital costs must also be taken into account in the case of fatalities. As noted earlier, a death which occurs up to 30 days and even an year or more after an accident may still be considered the consequence of that accident. Such delayed fatalities have hospital and medical costs. The estimation of hospital and medical costs in such cases is dealt with in the relevant section for each mode.

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5. This average took account of the many fatalities which involved no medical expenses as well as those victims who spent some time in hospital incurring substantial (an average of $3686) medical expenses prior to death.
6. Codes relating to external causes of injury are described in appendix II.

Some rehabilitation costs are included in the hospital cost data provided by the TAC. The TAC data yielded an average hospital stay per person (not per admission[7]) involved in road and rail accidents of about 22 days. Some of these stays were of very long duration and rehabilitation could have been a significant component of lengthy stays. As the rehabilitation costs of persons who were not hospitalised have not been taken into account in this study, the calculated hospital and rehabilitation costs must be regarded as lower bound estimates.

Accident investigation costs

There are different organisations involved in the detailed investigation of accidents in each transport mode and the estimation of investigation costs is described in the chapters on each mode. However, what is common to all the estimates is that they focus on the marginal cost of the resources expended in investigating a transport accident.

The estimates do not take into account the establishment costs of the investigating organisations and their fixed costs. The cost of coronial enquiries into fatal accidents has also not been included in the estimates. Although the cost of such enquiries could be substantial in individual accidents, it has not been possible to obtain relevant data for inclusion in this study.

Ambulance, search and rescue costs

Each transport mode has its own means and procedures for the rescue and transportation of accident victims. These details and the costs involved are dealt with in the chapters on each mode. As in the case of accident investigation, only the marginal cost to the rescue or transport organisation of the accident attended has been considered. The costs of establishing and maintaining rescue and transport organisations and the costs of their equipment have not been taken into account.

Legal costs

Some transport accidents could engender long and complex legal proceedings involving substantial legal costs. Data on legal costs for the different modes were unavailable. As specific legal cost data relating to road accidents in 1988 could not be obtained, basic legal cost data for road accidents from the study by BTCE (1988) were used. These data were distributed in accordance with the number of accidents and updated using the schedule of New South Wales legal charges (Law Society of New South Wales 1991).

In the case of aviation accidents, legal costs are partly subsumed in insurance administration costs. This is also likely to be the case with the rail mode. However, as most rail organisations are self-insurers, these costs are incorporated in general administration and are difficult to disaggregate. The

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7. As explained earlier, a person can have multiple admissions.

estimation of legal costs in maritime accidents has not been attempted because of the lack of data.

PAIN AND SUFFERING OF VICTIMS

This is arguably the most poignant and intangible aspect of accident costs and the one most difficult to value. Monetary estimates of the pain and suffering endured by accident victims were derived from BTCE (1988), in which orders of magnitude estimates were presented in preference to leaving out this cost component. The pain and suffering estimates related only to accident victims and did not include the family and friends of victims. The BTCE (1988) approach used court awards for general damages (which includes pain and suffering of the victim, loss of amenities of life and expectation of life) as a proxy for pain and suffering. The use of court awards to measure pain and suffering has its limitations and is strictly valid only if the jury makes a determination as a proxy for society as a whole; if the award is based on the extent of pain and suffering and not on the degree of guilt of the defendant; and if the sample is large enough to eliminate possible judicial bias (Faigin 1976).

In estimating the cost of pain and suffering, BTCE drew on data from Britts (1973 and later updates) relating to a sample of 213 court awards in 1985 and 1986 for persons sustaining multiple injuries in Australia. Mean award amounts were calculated for each AIS category with the exception of level 6, the fatality category, which was assigned a pain and suffering cost of zero.

The injury categories used in estimating the pain and suffering costs for road, rail and maritime accidents in this study were adapted from the BTCE (1988) approach by redistributing them into two categories: 'medical' (AIS level 1) and 'hospital' (AIS levels 2 to 5). The weighted average estimates for pain and suffering calculated for the two injury groupings were then adjusted to 1988 prices using the consumer price index (ABS 1988b). The average cost of pain and suffering per victim hospitalised in a road, rail or maritime accident was estimated at about $53 700. A victim requiring medical treatment only was estimated to have borne pain and suffering equivalent to about $635.

The BTCE (1988) approach was also used in the case of aviation accidents. For aviation accidents, the AIS injury categories 3 to 5 were equated with the 'major' injury category while AIS categories 1 and 2 were equated with the 'minor' injury category. The average cost of pain and suffering to a person sustaining a 'major' injury in an aviation accident was estimated at about $67 700, and for a 'minor' injury at about $6000.

The grouping of the AIS categories in the manner described above takes account of the degrees of severity of the injuries sustained in aviation accidents relative to those in the other modes. This grouping results in non-uniform estimates of pain and suffering per person and per accident across modes. The actual estimates for the injury categories in each mode are presented in the relevant chapters.

CHAPTER 3 COST OF ROAD ACCIDENTS

INTRODUCTION

The social cost of road accidents is the most extensively researched area of transport accident costs. The BTCE initially became involved in the costing of road accidents as a result of a request for cost estimates from the Federal Office of Road Safety. This study, covering all modes, is an extension of the BTCE's previous work on road accidents (BTCE 1988).

The definitions of terms relating to road accidents are in chapter 2 and appendix II.

Table 3.1 presents a summary, by accident class, of the total costs of road accidents in Australia in 1988. Table 3.2 summarises the average costs per accident by accident class.

ACCIDENT STATISTICS

In order to estimate the social cost of road accidents in 1988 it was necessary to first determine the number and type of road accidents that occurred during that year. Additionally, it was necessary to estimate the number of casualties, their ages and gender and the number of vehicles involved in the accidents.

Road accident statistics are compiled by various State and Territory road and traffic authorities. These bodies process information from various sources, including reports from police organisations, and publish, revise and disseminate road accident statistics. The numerous organisations and procedures involved contribute to a lack of consistency in the statistics. Fatalities and fatal accidents are generally well recorded as are accidents involving physical injury. Rather less satisfactorily recorded are the accidents in which no injury occurs, especially when property and vehicular damage are not extensive.

The costing in this study was based largely on information provided by State and Territory road and traffic authorities. In cases where data were unavailable, estimates were derived from data relating to States and Territories available elsewhere. Appendix III outlines the methods adopted for the derivation of missing data.

TABLE 3.1 SUMMARY OF TOTAL COSTS BY ACCIDENT CLASS: ROAD ACCIDENTS, 1988

	Lost production													
	Earnings		*Family and community*		*Vehicle damage*		*Insurance administration*		*Pain and suffering*		*Other*		*Total all costs*	
Accident class	*$m*	*%*	*$m*	*%*	*$m*	*%*	*$m*	*%*	*$m*	*%*	*$m*	*%*	*$m*	*%*
Fatal	851.3	92	621.6	95	10.5	1	4.3	1	83.2	6	45.3	6	1 616.2	26
Hospital	65.2	7	33.4	5	86.0	5	27.9	5	1 273.2	91	356.2	45	1 841.9	30
Medical	4.4	–	2.3	–	265.4	15	77.6	14	42.7	3	145.5	18	537.9	9
Nil injury	na		na		1 448.0	80	443.1	80	na		243.7	31	2 134.8	35
Total all accidents	920.9	100	657.3	100	1 810.0	100	552.9	100	1 399.1	100	790.7	100	6 130.8	100

na Not applicable
– Less than 1 per cent

Note Figures may not add to totals due to rounding.

Source BTCE estimates.

TABLE 3.2 SUMMARY OF AVERAGE COSTS PER ACCIDENT BY ACCIDENT CLASS: ROAD ACCIDENTS, 1988

($)

	Lost production						
Accident class	*Earnings*	*Family and community*	*Vehicle damage*	*Insurance administration*	*Pain and suffering*	*Other*	*Total all costs*
Fatal	332 392	242 715	4 117	1 669	32 471	17 728	631 092
Hospital	3 359	1 720	4 429	1 438	65 552	18 338	94 836
Medical	82	42	4 927	1 441	793	2 702	9 987
Nil injury	na	na	2 807	860	na	548	4 215
Average all accidents	1 559	1 112	3 058	936	2 365	1 348	10 378

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates.

Table 3.3 sets out the number of reported road accidents in 1988, estimates of unreported road accidents, and the numbers of vehicles, fatalities, injuries and other persons involved distributed according to accident class. In order to estimate the number of uninjured persons, an average vehicle occupancy rate of 1.43 (based on Hensher 1989) was used. The estimates of uninjured persons were obtained as residuals after taking account of all known casualties in each accident class. In the case of fatal accidents, the number of persons involved was derived from the average vehicle occupancy rate and the number of pedestrian fatalities (580) from ABS (1989a). Table 3.4 shows the average injury and involvement rates per accident which have been used to calculate overall accident costs. This table makes clear the fact that an accident may involve one or more vehicles as well as persons who sustain varying degrees of injury.

In examining data relating to hospitalisation of accident victims, it was discovered that there were significant differences in the estimates of hospital admissions due to road accidents. According to the ABS (1990a) 29 705 persons were admitted to hospital in 1988 as a result of road accidents. The Transport Accident Commission (TAC) meets the hospital and medical expenses of most hospitalised Victorian accident victims. An assessment based on data provided by the TAC suggested that the ABS figure could represent an overstatement of admissions of up to 45 per cent for individual States and Territories. It appeared that not all injured persons who received only outpatient treatment or who were detained for observation were eliminated from ABS estimates. The use of hospital admission data can also lead to an underestimate of length of stay per person because there may be persons who have had more than one admission. The ABS (1990a) estimates were modified on the basis of TAC (1991) data on the number of persons hospitalised as a result of road accidents.

Many road accidents — mainly nil injury accidents — are not reported. Searles (1977, 1980) examined a sample of insurance claims where at least one of the parties was insured by the National Roads and Motorists' Association in Sydney. Searles found that some 75 per cent of the crashes in the sample did not appear in the official statistics. Of the crashes which did not appear in the official statistics, 94 per cent were nil injury crashes.[1]

Atkins (1981) estimated that there were 6.8 nil injury accidents for each reported casualty accident and BTCE (1988), following Atkins, used a ratio of 7 to 1. Atkins' figure of 6.8 was used in this study. The application of this figure to the number of casualty accidents shown in table 3.3 (75 852), yields an estimate of approximately 515 000 nil injury accidents. As 143 100 nil injury accidents were actually reported in 1988, it is implied that only about 28 per cent of such accidents were reported. This approximates Searles' estimate of under-reported nil injury accidents in the official statistics.

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1. It is useful to point out, as Searles did, that although an accident may actually be reported to the police, that accident may not, because of damage thresholds and the like, appear in official statistics from which most accident data are derived. In addition, reporting regulations often militate against reporting accidents when the damage is slight and no injuries are involved.

TABLE 3.3 ESTIMATED (INCLUDING UNREPORTED) ACCIDENTS, VEHICLES, AND PERSONS INVOLVED BY ACCIDENT CLASS: ROAD ACCIDENTS, 1988

			Persons			
Accident class	*Accidents*	*Vehicles*	*Fatalities*	*Hospital injuries*	*Medical injuries*	*Not injured*
Fatal	2 561	3 718	2 875	1 539	722	761
Hospital	19 423	30 336	na	23 648	3 868	15 864
Medical	53 868	93 592	na	na	67 170	66 666
Nil injury						
Reported	143 100	271 100	na	na	na	387 673
Unreported	371 900	669 420	na	na	na	957 271
Total nil injury	515 000	940 520	na	na	na	1 344 944
Total	590 852	1 068 166	2 875	25 187	71 760	1 428 235

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on information provided by State and Territory road and traffic authorities (AFP 1991; NTPD 1989; ORS 1989; RTA 1989; VIC ROADS 1990; WAPD 1989), TAC (1991), FORS (1991), ABS (1990a) and Hensher (1989).

TABLE 3.4 ESTIMATED VEHICLES AND PERSONS INVOLVED PER ACCIDENT BY ACCIDENT CLASS: ROAD ACCIDENTS, 1988

		Persons			
Accident class	*Vehicles*	*Fatalities*	*Hospital injuries*	*Medical injuries*	*Not injured*
Fatal	1.45	1.12	0.60	0.28	0.30
Hospital	1.56	na	1.22	0.20	0.82
Medical	1.74	na	na	1.25	1.24
Nil injury					
Reported	1.89	na	na	na	2.71
Unreported	1.80	na	na	na	2.57
Total nil injury	1.83	na	na	na	2.61
Overall	1.81	0.005	0.04	0.12	2.42

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on information provided by State and Territory road and traffic authorities (AFP 1991; NTPD 1989; ORS 1989; RTA 1989; VIC ROADS 1990; WAPD 1989), TAC (1991), FORS (1991), ABS (1990a) and Hensher (1989).

TABLE 3.5 ESTIMATED (INCLUDING UNREPORTED) ACCIDENTS, VEHICLES, AND PERSONS INVOLVED BY ACCIDENT CLASS: METROPOLITAN ROAD ACCIDENTS, 1988

			Persons			
Accident class	*Accidents*	*Vehicles*	*Fatalities*	*Hospital injuries*	*Medical injuries*	*Not injured*
Fatal	1 324	2 138	1 431	766	359	380
Hospital	11 723	19 878	na	13 379	2 188	8 884
Medical	38 600	65 600	na	na	49 100	48 000
Nil injury	351 200	649 000	na	na	na	941 461
Total	402 847	736 616	1 431	14 145	51 647	985 482

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on information provided by FORS, TAC, State and Territory road and traffic authorities and ABS data (ABS 1990a; AFP 1991; FORS 1991; NTPD 1989; ORS 1989; RTA 1989; VIC ROADS 1990; WAPD 1989). Metropolitan estimates based on data provided by road and traffic authorities of New South Wales, Victoria and South Australia.

TABLE 3.6 ESTIMATED VEHICLES AND PERSONS INVOLVED PER ACCIDENT BY ACCIDENT CLASS: METROPOLITAN ROAD ACCIDENTS, 1988

		Persons			
Accident class	*Vehicles*	*Fatalities*	*Hospital injuries*	*Medical injuries*	*Not injured*
Fatal	1.61	1.07	0.57	0.27	0.29
Hospital	1.70	na	1.14	0.19	0.76
Medical	1.70	na	na	1.27	1.24
Nil injury	1.85	na	na	na	2.68
Overall	1.83	0.004	0.04	0.13	2.45

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on information provided by FORS, TAC, State and Territory road and traffic authorities and ABS data (ABS 1990a; AFP 1991; FORS 1991; NTPD 1989; ORS 1989; RTA 1989; VIC ROADS 1990; WAPD 1989). Metropolitan estimates based on data provided by road and traffic authorities of New South Wales, Victoria and South Australia.

Searles (1977) found that the average number of vehicles involved in an unreported nil injury accident was 1.8. Applying Searles' figure to the estimated 371 900 unreported nil injury accidents, suggests that about 669 000 vehicles were involved in unreported nil injury accidents and some 940 000 vehicles in estimated total nil injury accidents.

Estimates of numbers of metropolitan road accidents were used in estimating traffic delay costs. A description of the method used for estimating metropolitan road accidents is in appendix V. Using the ratio of 6.8 nil injury accidents to one reported casualty accident (Atkins 1981), it was estimated that some 351 200 nil injury accidents actually occurred in Australian metropolitan areas. Tables 3.5 and 3.6 display the estimates of road accidents for metropolitan Australia.

ACCIDENT COSTS

Lost production

Lost earnings and on-costs

Lost earnings and on-costs of road accident victims were calculated using the working life table method described in chapter 2. This method uses information relating to the age and gender of victims. As noted earlier, the ages and gender of pedestrians, drivers and passengers involved in road accidents were not always available. The FORS Fatal File and ABS (1990a) together provided age and gender data for over 99 per cent of fatalities and 95 per cent of hospitalised victims. These data were used to estimate the age and gender distribution of medically treated and other victims of unknown age and/or gender. The average forgone earnings and on-costs of accident victims of known age and gender were applied to all victims of unknown age and/or gender, for each injury severity level, to derive total forgone earnings and the average amount per accident.

While accident victims are hospitalised and disabled, output and earning capacity are lost to the community. The output lost during the period of hospitalisation has been taken into account. Information on the length of the period of total or partial disability was not available, nor was the length of stay in hospital for all hospitalised victims of road accidents in 1988. The cost of lost output during recuperation and rehabilitation was assumed to be equivalent to the value of one day's output for each day spent in hospital (chapter 2). The estimates of lost output have not been adjusted to reflect differentials in the earnings of road accident victims.

The TAC (1991) provided data relating to road accidents in 1988 reported to it. These data constitute a high proportion of all road accidents that occurred in Victoria. The number of bed-days of hospitalised road accident victims was calculated using the average of 21 bed-days estimated from TAC data for hospitalised accident victims in Victoria.

Table 3.7 shows the results of these calculations. Lost earnings and on-costs for all casualties of some $921 million represents a substantial loss in production,

TABLE 3.7 LOST EARNINGS AND ON-COSTS BY ACCIDENT CLASS: ROAD ACCIDENTS, 1988

	Cost per accident ($)				
Accident class	Fatalities	Hospital injuries	Medical injuries	Total	Total all accidents ($'000)
Fatal	330 722	1 651	18	332 392	851 260
Hospital	na	3 346	13	3 359	65 240
Medical	na	na	82	82	4 400
Nil	na	na	na	na	na
Overall (casualty accidents)				12141	920 900
Overall (including nil injury accidents)				1 559	920 900

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on working life table methods, table 3.3, FORS (1991), ABS (1988a, 1990a, 1990b), and TAC (1991).

TABLE 3.8 FAMILY AND COMMUNITY LOSS BY ACCIDENT CLASS: ROAD ACCIDENTS, 1988

	Cost per accident ($)				
Accident class	Fatalities	Hospital injuries	Medical injuries	Total	Total all accidents ($'000)
Fatal	241 860	846	9	242 715	621 590
Hospital	na	1713	7	1720	33 410
Medical	na	na	42	42	2 260
Nil	na	na	na	na	na
Overall (casualty accidents)				8 665	657 260
Overall (including nil injury accidents)				1 112	657 260

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on life table methods, table 3.3, ABS (1988a, 1990a, 1990c) and FORS (1991).

contributing 15 per cent to the total cost of road accidents. This loss is largely ascribed to the loss due to fatalities, which constitutes 92 per cent of the lost earnings. Lost earnings amount to over $332 000 per fatal accident or $296 000 per fatality.

Family and community losses

Apart from the loss of paid productive capacity due to premature death and disability, there is the additional loss of the unpaid contributions made by accident victims to the family and community. Table 3.8 shows the extent of this loss to be some $657 million. This considerable loss reflects the substantial number of hours which the ABS (1990c) estimated for unpaid family and community work. Fatalities contribute heavily to the loss. Over $621 million is attributed to fatal accidents, corresponding to some $243 000 per accident or about $216 000 per fatality. Family and community losses comprise about 11 per cent of the total cost of road accidents.

Losses to non-victims

Road accidents often involve losses to individuals who are not actually involved in the accident but who are affected by the accident because of their proximity to it or attachment to the victims. If an accident occurs on a road when traffic flow is at or close to maximum capacity, disruption to traffic will occur and other road users will be delayed. When an accident occurs, family members and friends often take time and incur expense in visiting, supporting and maintaining the victims.

Travel delays

Travel delays have been assumed to apply only to metropolitan accidents occurring during morning peak-hour traffic. In addition, only delays in journeys to work were considered. Production was assumed to be lost due to traffic delays and the value of lost time was estimated from average weekly earnings expressed as an hourly rate of $14 (ABS 1988a) based on the average hours worked (ABS 1990b). Other journeys which may have been disrupted at the same time were assumed to have resulted not in forgone production but in postponement of production which subsequently took place. Likewise, the productive work which may have occurred during travel delays was not considered.[2] Only the loss of paid production was considered in estimating the cost of travel delays. It was assumed that unpaid family and community work would be done at a later time.[3]

Journeys to work beginning during the peak traffic hours of 6.00 a.m. to 9.00 a.m. Monday through Friday were estimated from an ABS (1985) survey conducted in Victoria in December 1984. The survey revealed that some 83 per cent of working persons left for work between these hours. The time delay in a peak-hour road accident was obtained from Faigin (1976), who had derived the estimate from Pitman and Loutzenheiser (1972). Faigin used a time delay estimate of 340 vehicle-hours lost per accident. Faigin also used an estimate of 1.4 persons per vehicle during peak hours. Australian data suggest fewer persons per vehicle in peak hours. Hensher (1989), using data relating to a 1987 sample of travellers in the entire Sydney Metropolitan area, estimated vehicle occupancy for business commuter automobile trips as 1.2 persons per vehicle. The time delay estimate

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2. The use of mobile telephones and other communication aids may make it possible for some persons to be productive during traffic delays, but this was not considered as having been significant in 1988.

3. It is important to note that in making these assumptions what is being valued is production forgone, not travel time costs (see Hensher 1989). The inconvenience of delays relating to unpaid work has not been taken into account, nor has the cost to employers of replacing workers who were detained due to accident-related traffic delays.

TABLE 3.9 TRAVEL DELAY ACCIDENTS AND COSTS: ROAD ACCIDENTS, 1988

Accident class	*Accidents (no.)*	*Cost per delay accident ($)*	*Total all accidents ($'000)*
Delay accidents			
Fatal	164	5 712	937
Hospital	1 869	5 712	10 676
Medical	6 153	5 712	35 146
Nil	40 000	5 712	228 480
Overall delay accidents	48 186	5 712	275 238
Overall (including non-delay accidents)	590 852	466	275 238

Notes 1. Figures may not add to totals due to rounding.

2. Travel delay cost was estimated at $5 712 per metropolitan morning peak traffic accident. Travel delay accidents (those occurring during the morning peak, that is, between 6 and 9 a.m.) were estimated as constituting some 12 per cent of fatal, 16 per cent of hospital and medical, 11 per cent of nil injury and 12 per cent of total metropolitan accidents.

Source BTCE estimates based on tables 3.5 and 3.6, ABS (1985, 1988a, 1990b), VIC ROADS (1990), Faigin (1976) and Hensher (1989).

from Faigin of 340 vehicle-hours and the Australian estimate of 1.2 persons per vehicle in peak hours equate to a loss of about 408 person-hours, equivalent to $5712 per metropolitan morning-peak road accident.

Information on road accidents by accident class and time of occurrence (VIC ROADS 1990) from the Melbourne Statistical Division was applied to estimates of the number of metropolitan road accidents (table 3.5) to produce estimates of metropolitan road accidents by accident class. This information, together with an adjustment for the under-reporting of nil injury accidents, provided the basis for estimating travel delay.

Table 3.9 shows the results of applying the estimate of $5712 of lost production per road accident to the proportion of metropolitan accidents occurring during the morning peak traffic hours. Taking into account the unreported nil injury accidents which make up the bulk of the estimated 48 186 traffic delay accidents, some $275 million was estimated to have been lost in traffic delay.

Other costs

The lost production of non-victims as a result of road accidents was estimated as a percentage of the lost production of victims. As explained in chapter 2, the NHTSA (1972) approach based on AIS levels was adapted to the injury severity levels used in this study for the different transport modes. In accordance with this procedure, losses to non-victims were estimated at 20 per cent of the total forgone earnings of an accident victim sustaining medical injuries, 6.25 per cent for a hospitalised victim and 1.2 per cent for a fatality.

TABLE 3.10 LOSSES TO NON-VICTIMS: ROAD ACCIDENTS, 1988

Accident class	*Cost per accident ($)*	*Total all accidents ($'000)*
Fatal	4 076	10 439
Hospital	212	4 118
Medical	16	862
Nil	na	na
Overall (casualty accidents)	203	15 419
Overall (including nil injury accidents)	26	15 419

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 3.7 and NHTSA (1972).

Estimates of losses to non-victims due to road accidents in 1988 are provided in table 3.10. More than $15 million worth of production of other persons was estimated to have been lost, and of this amount, over $10 million was due to fatal accidents.

Accident-generated activities

Property damage and loss

Damage and loss to property, including vehicles, involves a substantial proportion of the costs of road accidents. Information on such costs was derived from Searles (1977, 1980), Sanderson and Hoque (1987), 1988 motor vehicle insurance payouts (ISC 1989a, 1989b) and the ABS *Household Expenditure Survey* (ABS 1990d).

The total payout of claims relating to motor vehicles by insurance companies in 1988 was $1838.7 million (ISC 1989a). About $215.7 million (11.7 per cent) of the total payout was for theft and other non-accidental damage and loss. The remainder, which was essentially for smash repair damage and loss (ISC 1991 pers. comm.), amounted to $1623 million.

The cost of vehicle smash repairs to Australian households for the year 1988 was estimated at $187 million based on data from the *1988–89 Household Expenditure Survey* (ABS 1990d). The ABS survey would have captured the expenditure of the non-insured, and the excess paid by insured persons before insurance payments came into effect, but not the total loss of uninsured vehicles. Adding the ABS estimates to the ISC figures yields a total, excluding the value of the total loss of uninsured motor vehicles, of $1810 million paid out for vehicle repair and loss in 1988.

A part of this payout for vehicle repair and replacement was due to taxes. These taxes should not be included as a social cost as they represent transfer payments. However, the tax component has not been factored out of the calculations because of the lack of data available to estimate it.

BTCE (1988) found, on the basis of NRMA data, that fatal accidents involve, on average, less vehicle damage than serious injury accidents. Troy and Butlin (1977) found that there was no close relationship between the severity of injury and the cost of vehicle repairs in the Australian Capital Territory. Searles (1977) found that 80 per cent of total vehicle damage costs could be attributed to nil injury accidents and 20 per cent to casualty accidents.[4]

Given the estimate of $1810 million for vehicle damage and loss in all accidents, and applying Searles' ratio, the nil injury accident component should be of the order of $1448 million and the casualty accident component some $362 million. This translates into estimates of $1540 and $2836 of damage per vehicle in nil injury and casualty accidents respectively.

The estimates of vehicle damage costs by accident class presented in table 3.11 are based on the procedure described above.[5] These costs do not include some uninsured losses but there is an offsetting influence by way of the inclusion of some taxes. Property damage and loss account for nearly 30 per cent of the total cost of road accidents.

Insurance administration costs

Insurance industry statistics for 1988 (ISC 1989a, 1989b) indicate that administrative expenses were about $529 million for motor vehicle insurance and some $87 million for compulsory third party insurance. About 88 per cent of claims relating to motor vehicles was estimated to involve motor vehicle damage, excluding fire and theft and other claims (ISC 1991 pers. comm.). Assuming this same proportion for expenses, the total administrative expenses relating to road

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4. These somewhat counterintuitive findings are ascribed to the involvement of pedestrians and cyclists in many fatal and other casualty accidents.

5. Other approaches to estimating vehicle damage costs are consistent with these estimates. In a 1975 sample of road accidents in Sydney, Searles (1977) found that the crash repair cost per vehicle in a casualty accident was $1245. Searles also found that nil injury accidents involved a vehicle damage cost of $694 per vehicle. That sample included both reported and unreported road accidents where at least one of the vehicles was insured by the NRMA. Using the consumer price index to inflate the 1975 estimates yields damage per vehicle of $3990 in casualty accidents and $2220 per vehicle in nil injury accidents for 1988. Assuming that the New South Wales figures are representative of Australia as a whole, the use of this technique would produce a total estimate of $2379 million for vehicle repair in Australia in 1988. In a similar study of nil injury accidents in metropolitan Melbourne, Sanderson and Hoque (1987) found that, in their 1985 sample, the average cost of repair or loss was $1390 per vehicle. If the Sanderson and Hoque figure relating to 1985 is used as the basis for a national estimate for 1988, the per vehicle cost in a nil injury accident would be $1767 and the total cost would be $1963 million.

TABLE 3.11 VEHICLE LOSS AND DAMAGE COSTS BY ACCIDENT CLASS: ROAD ACCIDENTS, 1988

Accident class	*Cost per accident ($)*	*Cost per vehicle ($)*	*Total all accidents ($'000)*
Fatal	4 117	2 836	10 540
Hospital	4 429	2 836	86 030
Medical	4 927	2 836	265 430
Nil injury	2 807	1 540	1 448 000
Overall	3 058	1 694	1 810 000

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 3.3, ABS (1990d), ISC (1989a, 1989b) and Searles (1977).

TABLE 3.12 VEHICLE INSURANCE ADMINISTRATION COSTS BY ACCIDENT CLASS: ROAD ACCIDENTS, 1988

	Average per accident		
Accident class	*Claims (no.)*	*Cost ($)*	*Total all accidents ($'000)*
Fatal	3.45	1 669	4 270
Hospital	2.98	1 438	27 920
Medical	2.99	1 441	77 600
Nil injury			
Reported	1.89	914	130 860
Unreported	1.80	840	312 250
Total nil injury	1.83	860	443 110
Overall	1.98	936	552 900

Notes 1. Figures may not add to totals due to rounding.
2. Total insurance administration cost of $552.9 million was distributed among 1.15 million claims, yielding an average cost of $483 per claim.

Source BTCE estimates based on ISC (1989a, 1989b) and table 3.3.

accident insurance amount to about $553 million, representing 9 per cent of the total cost of road accidents.

Table 3.12 shows the distribution of this expense per accident by accident class. The distribution was made by estimating the number of claims per accident. This was achieved by assuming that each vehicle and injured person involved were proxies for claims.[6] The average number of claims for each accident class (the non-injured persons excluded) were multiplied by the number of accidents in each class to estimate the total number of claims by accident class. It was assumed that the processing cost of each claim is the same and that this cost does not depend on accident class. The estimated $553 million in road vehicle insurance administration expense was then divided by the total number of claims, estimated at 1.15 million, to yield an estimate of about $483 per claim. This average amount was used to distribute the total of $553 million in insurance administration costs among the accident classes according to the number of claims in each class.

With this procedure, the class of accident with the highest per accident insurance administration cost will be the one with the largest number of claims per accident. However, the aggregate insurance administration cost for all accidents in that class would not necessarily have the same ranking because of the differing number of accidents in each class. Thus, on an individual basis, the fatal accident with 3.45 claims per accident has the highest insurance administration cost with an average of $1670 per accident. However, with an overall cost of $4.3 million it was the least costly class of accident in terms of insurance administration. By contrast, nil injury accidents had an average of 1.83 claims per accident corresponding to an average cost of $884, making them the least costly on an individual basis. However, the aggregate insurance administration cost of these accidents, estimated at over $443 million, makes the nil injury accident class the most costly.

It must be recognised that the estimates of insurance administration cost by accident class represent weighted average costs and not marginal costs, as is the case with several other cost categories estimated in this study. The estimates of insurance administration costs used in this study include the public and private sectors and comprehensive and third party insurance. The third party insurance administration costs include some portion of legal and court costs which have not been included in the estimate of legal and court costs (see section on legal and court costs).

Medical, hospital and rehabilitation costs

Medical costs

Medical costs were estimated using data from the TAC (1991), which revealed that the average medical cost for a person fatally injured in a road accident in Victoria was $832. Persons who were injured and admitted to hospital incurred an average medical cost of $3247 and those who were only treated medically incurred costs of $387 each.

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6. For example, it was estimated that there were 1.45 vehicles per fatal accident and it was therefore assumed that this generated 1.45 claims relating to vehicles. Likewise, there were 1.12 fatalities, 0.6 injuries requiring hospitalisation and 0.28 persons requiring medical treatment (see table 3.4) totalling 3.45 claims per fatal accident.

TABLE 3.13 MEDICAL COSTS BY ACCIDENT CLASS: ROAD ACCIDENTS, 1988

	Cost per accident ($)				
Accident class	*Fatalities*	*Hospital injuries*	*Medical injuries*	*Total*	*Total all accidents ($'000)*
Fatal	934	1 951	109	2 994	7 670
Hospital	na	3 953	77	4 030	78 280
Medical	na	na	483	483	25 990
Nil	na	na	na	na	na
Overall (casualty accidents)				1476	111 940
Overall (including nil injury accidents)				189	111 940

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 3.3 and TAC (1991).

Based on these cost estimates from TAC data, and the number of persons injured in road accidents, the cost of medical treatment per accident was estimated at nearly $3000 for a fatal accident, approximately $4000 for an accident involving hospitalisation and $483 for an accident where the most severe injury was medically treated. In total, nearly $112 million was spent on medical treatment. About 70 per cent of this expense was due to hospitalisation accidents (table 3.13).

Hospital and rehabilitation costs

TAC (1991) data indicate that on average, a hospitalised person in a road accident spent approximately 21 days in hospital at a cost of about $272 per day. On the basis of data from the Australian Institute of Health (AIH 1991), Victorian hospital costs were found to be slightly lower than elsewhere in Australia. The TAC estimate of $272 per day was used, but it was adjusted to $286 to reflect the finding that Victorian hospital costs were about 95 per cent of the Australian average. The same procedure was used with data for persons who died as a result of road accidents. Accident victims in Victoria who were hospitalised and subsequently died, spent an average of 11 days in hospital at a cost of $306 per day.

Taking all fatalities into account, the average number of days spent in hospital per fatality was 2.4. Using data for injured persons (table 3.3), the cost for accidents involving hospitalisation was estimated at nearly $7000 per accident. For a fatal accident the estimate was slightly more than $4000. Total hospital costs amount to nearly $146 million. Hospital costs by accident class are shown in table 3.14. These hospital costs include some rehabilitation costs which could not be separately identified.

Accident investigation costs

The cost of investigating an accident was calculated following BTCE's (1988) approach which used the estimates of a constable's time derived from a time and

TABLE 3.14 HOSPITAL AND REHABILITATION COSTS BY ACCIDENT CLASS: ROAD ACCIDENTS, 1988

Accident class	Cost per accident ($) Fatalities	Hospital injuries	Medical injuries	Total	Total all accidents ($'000)
Fatal	824	3 433	na	4 257	10 900
Hospital	na	6 955	na	6 955	135 080
Medical	na	na	na	na	na
Nil	na	na	na	na	na
Overall (fatal and hospital accidents)				6 640	145 980
Overall (all accidents)				247	145 980

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 3.3, TAC (1991) and AIH (1991).

motion study reported in Somerville and McLean (1981). The distribution of time was adapted from the AIS scale to the four-part accident severity scale used in this study. The cost of a constable's time in 1988 was provided by the Australian Federal Police Association (pers. comm.), and with the inclusion of on-costs was estimated at $15 per hour. Table 3.15 shows that accident investigation cost Australian society over $57 million in 1988. The investigation cost per accident was highest for fatal accidents (about $2700 per accident) and lowest (about $105 per accident) for the reported nil injury accidents.

TABLE 3.15 ACCIDENT INVESTIGATION COSTS BY ACCIDENT CLASS: ROAD ACCIDENTS, 1988

Accident class	Cost per accident ($)	Total all accidents ($'000)
Fatal	2 700	6 920
Hospital	810	15 730
Medical	360	19 390
Nil (reported only)	105	15 050
Overall (reported only)	261	57 090
Overall (including unreported)	97	57 090

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on BTCE (1988), Australian Federal Police Association (pers. comm.) and table 3.3.

TABLE 3.16 AMBULANCE AND RESCUE COSTS BY ACCIDENT CLASS: ROAD ACCIDENTS, 1988

Accident class	*Cost per accident ($)*	*Total all accidents ($'000)*
Fatal	163	420
Hospital	163	3 170
Medical	82	4 400
Nil	na	na
Overall (casualty accidents)	105	7 990
Overall (all accidents)	14	7 990

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on ACT Ambulance Service (pers. comm.) and table 3.3.

Ambulance and rescue costs

The cost of ambulance attendance at road accidents was based on Australian Capital Territory (ACT) data for 1990 (ACT Ambulance Service pers. comm.), which was assumed to be representative of Australia. The average distance travelled in the ACT was 24 kilometres at a cost of $154 for the first 16 kilometres and $4.40 for each kilometre thereafter, amounting to $189.20 per accident visited. This figure was deflated by the consumer price index to 1988 dollars to produce an estimate of $163.20.

It was assumed that one ambulance attended the scene of each fatal or hospitalisation accident. For accidents involving medical treatment only, it was assumed that an ambulance attended the scene in 50 per cent of cases and that there was no ambulance attendance at nil injury accidents.

The cost of the ambulance service was distributed across each accident group by the number of accidents with the exclusion of the nil injury group. Nearly $8 million was estimated to have been spent on ambulance services in 1988 and the distribution of this sum by accident class is shown in table 3.16.

Legal and court costs

Direct sources of information on the legal and court costs associated with road traffic accidents could not be found. The estimates for 1985 used by BTCE (1988) were inflated to 1988 levels by the changes in legal fees provided by the Law Society of New South Wales (1991). The estimates include only the cost to plaintiffs. It was assumed that defendant costs are included in third-party motor vehicle insurance administration expenses.

The distribution used by BTCE (1988) was reassigned to the fatal, hospital and medical categories with fatal equated to AIS level 6, hospital equated to AIS levels

TABLE 3.17 LEGAL AND COURT COSTS BY ACCIDENT CLASS: ROAD ACCIDENTS, 1988

Accident class	*Cost per accident ($)*	*Total all accidents ($'000)*
Fatal	3 127	8 010
Hospital	5 620	109 160
Medical	1 110	59 810
Nil	na	na
Overall (casualty accidents)	2 333	176 980
Overall (all accidents)	299	176 980

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on BTCE (1988) and Law Society of New South Wales (1991) and table 3.3.

2 to 5 and medical equated to AIS level 1. It was assumed that nil injury accidents did not generate legal costs. The results are displayed in table 3.17. A sum of about $177 million was estimated to have been expended on legal and court costs, corresponding to about $2340 per casualty accident or an average of $300 per accident.

Pain and suffering of victims

The average cost of pain and suffering for those involved in road accidents in Australia in 1985 was estimated by BTCE (1988) at $42 250 in the case of hospitalisation and about $500 for medical treatment. These values were

TABLE 3.18 PAIN AND SUFFERING COSTS BY ACCIDENT CLASS: ROAD ACCIDENTS, 1988

		Cost per accident ($)			
Accident class	*Fatalities*[a]	*Hospital injuries*	*Medical injuries*	*Total*	*Total all accidents ($'000)*
Fatal	na	32 292	179	32 471	83 160
Hospital	na	65 425	127	65 552	1 273 210
Medical	na	na	793	793	42 720
Nil	na	na	na	na	na
Overall (excluding nil injury accidents)				19 089	1 399 090
Overall (all accidents)				2 365	1 399 090

na Not applicable

a. Pain and suffering costs were assumed not to apply to fatalities

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 3.3, BTCE (1988) and ABS (1988b).

factored up to 1988 dollars by the consumer price index to yield \$53 700 for a hospitalised victim and \$635 for a medically injured person and then translated into costs per accident using the data in table 3.4.

The results of this analysis are presented in table 3.18. The estimated pain and suffering cost to the hospitalised and medically treated victims in fatal road accidents is about \$83 million — over \$32 000 per accident. This does not include an estimate of the cost of pain and suffering for those who died in the accident nor any cost for those who were bereaved. Hospitalisation accidents entailed the highest costs for pain and suffering, with an aggregated sum of \$1.3 billion, averaging \$65 500 each. The total cost of pain and suffering associated with 1988 road accidents was estimated at \$1.4 billion.

CHAPTER 4 COST OF AVIATION ACCIDENTS

INTRODUCTION

Aviation accidents are the best reported of transport accidents, as all accidents come to the attention of the Bureau of Air Safety Investigation (BASI). Aviation accidents are relatively few in number and usually occur in close proximity to an airfield and involve search and rescue authorities.

The definitions of the terms 'accident', 'fatal injury', 'serious injury', 'minor injury', 'destroyed', 'substantial damage' and 'minor damage' used in the analysis of aviation accidents are those recommended by the International Civil Aviation Organisation (ICAO 1981) and adopted by BASI (1989) (appendix II).

Table 4.1 summarises the costs of aviation accidents in Australia in 1988 by accident class and cost category and table 4.2 presents a summary of average costs per accident by accident class.

AVIATION ACCIDENTS

The estimate of the social cost of aviation accidents in 1988 was generated from the number of reported aviation accidents. Table 4.3 sets out details of the aviation accidents reported in 1988, and the numbers of aircraft, fatalities, injuries and uninjured persons involved, distributed according to accident class. An accident may involve one or more aircraft and persons with varying degrees of injury. Table 4.4 shows average injury and involvement rates on a per accident basis, which have been used in the calculation of total accident costs.

In 1988, 328 civil aviation accidents involving 334 aircraft and 633 persons were reported to BASI. Over 70 per cent of these accidents did not involve injury. BASI does not have a formal role in the investigation of military aviation accidents and the cost of these accidents has not been estimated in this study due to data constraints.

TABLE 4.1 SUMMARY OF TOTAL COSTS BY ACCIDENT CLASS: AVIATION ACCIDENTS, 1988

	Lost production													
	Earnings		*Family and community*		*Aircraft damage*		*Insurance administration*		*Pain and suffering*		*Other*		*Total all costs*	
Accident class	*$'000*	*%*	*$'000*	*%*	*$'000*	*%*	*$'000*	*%*	*$'000*	*%*	*$'000*	*%*	*$'000*	*%*
Fatal	24 491	99	13 777	99	5 028	36	2 122	36	522	15	646	31	46 586	73
Serious	363	1	146	1	760	6	321	6	2 764	79	1 113	53	5 466	8
Minor	6	–	2	–	701	5	296	5	229	6	57	3	1291	2
Nil injury	na		na		7 292	53	3 077	53	na		267	13	10 635	17
Total all accidents	24 860	100	13 925	100	13 781	100	5 815	100	3 515	100	2 086	100	63 981	100

na Not applicable
– Less than 1 per cent

Notes Figures may not add to totals due to rounding.

Source BTCE estimates.

TABLE 4.2 SUMMARY OF AVERAGE COSTS PER ACCIDENT BY ACCIDENT CLASS: AVIATION ACCIDENTS, 1988
($'000)

	Lost production						
Accident class	*Earnings*	*Family and community*	*Aircraft damage*	*Insurance administration*	*Pain and suffering*	*Other*	*Total all costs*
Fatal	662	372	136	57	14	17	1 259
Serious	10	4	22	9	79	32	156
Minor	+	+	29	12	10	2	54
Nil injury	na	na	31	13	na	1	46
All accidents	76	42	42	18	11	6	195

\+ Less than $1000
na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates.

TABLE 4.3 REPORTED ACCIDENTS, AIRCRAFT AND PERSONS INVOLVED BY ACCIDENT CLASS: CIVIL AVIATION ACCIDENTS, 1988

			Persons			
Accident class	*Accidents*	*Aircraft*	*Fatalities*	*Serious injuries*	*Minor injuries*	*Not injured*
Fatal	37	41	70	7	8	6
Serious	35	36	na	40	9	15
Minor	24	24	na	na	38	30
Nil injury	232	233	na	na	na	410
Total	328	334	70	47	55	461

na Not applicable

Source BASI (1990).

TABLE 4.4 REPORTED AIRCRAFT AND PERSONS INVOLVED PER ACCIDENT BY ACCIDENT CLASS: CIVIL AVIATION ACCIDENTS, 1988

		Persons			
Accident class	*Aircraft*	*Fatalities*	*Serious injuries*	*Minor injuries*	*Not injured*
Fatal	1.11	1.89	0.19	0.22	0.16
Serious	1.03	na	1.14	0.26	0.43
Minor	1.00	na	na	1.58	1.25
Nil	1.00	na	na	na	1.77
Overall	1.02	0.21	0.14	0.17	1.41

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on BASI (1990).

ACCIDENT COSTS

Lost production

Lost earnings

Fatalities equate to a total loss of earning capacity. The situation with other injury categories is less clear. While the accident victim is hospitalised or disabled, productivity and earning capacity are lost to the community.

Specific information on the length of the period of total or partial disability of aviation accident victims in 1988 was not available, nor was there much data on their length of stay in hospital. AIH (1991) data indicate that there were 270 hospital admissions reported in acute care[1] public hospitals as a result of air transport accidents in years close to 1988. That is, all of the hospital admissions data for the States and Territories relate to periods of one year but not necessarily to the calendar year 1988. These admissions resulted in a reported 2890 hospital bed-days, or 10.7 bed-days per admission.

Using data from Brownbill (1984) on the average daily inpatient hospital charge in 1980 (discounted back to 1977–78) and data from Atkins (1981) on accident costs for Victorian road accident fatalities in 1977–78, some of whom were hospitalised, it was estimated that these victims spent an average of about two days in hospital. Given the generally more severe nature of air crashes, it could be expected that aviation accidents would result in fewer bed-days per fatality than road accidents. This would be equivalent to assuming that a higher proportion of aviation accident victims are killed instantly relative to road accident victims. Casualty statistics tend to support this assumption. In 1988 there were an average of 1.89 fatal injuries and 0.19 serious injuries in fatal aviation accidents (table 4.4). By contrast, the corresponding figures for fatal road accidents in 1988 were 1.12 and 0.60 (table 3.4). It would therefore be reasonable to assume that the average number of days spent in hospital by a fatally injured aviation accident victim lies between 0 and 2. In the absence of more precise data, the mid-point of this range (1 day) was used in this study.

On the basis of ICAO (1981) definitions which have been adopted by BASI (appendix II), a minor injury is by implication considered to be one which involves less than 48 hours in hospital. The adoption of the mid-point of this duration for those hospitalised due to minor injuries implies that each minor injury results in one day in hospital.

Applying the foregoing assumptions and subtracting 55 bed-days for persons who sustained minor injuries and 70 bed-days for fatalities (table 4.3) from the total of 2890 bed-days, leaves 2765 bed-days. This translates into an average of 59 days in hospital for each of the 47 seriously injured persons — a figure nearly three times the average of 21 days estimated for road accident victims — once again reflecting the more severe nature of injury in aviation accidents. In addition to production lost due to time spent in hospital, production is also lost during the unknown period of time spent while disabled and recuperating after discharge from hospital. The latter was assumed to be equal to the number of hospital bed-days and has been taken into account in estimating lost production. The

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1. Acute care hospitals are establishments that provide at least minimal medical, surgical or obstetrical services for inpatients, and which provide round-the-clock comprehensive qualified nursing services as well as other necessary professional services (AIH 1991).

TABLE 4.5 LOST EARNINGS AND ON-COSTS BY ACCIDENT CLASS: AVIATION ACCIDENTS, 1988

	Cost per accident ($)				
Accident class	*Fatalities*	*Serious injuries*	*Minor injuries*	*Total*	*Total all accidents ($'000)*
Fatal	660 187	1 709	33	661 928	24 491
Serious	na	10 321	39	10 361	363
Minor	na	na	242	242	6
Nil injury	na	na	na	na	na
Overall				75 793	24 860

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on working life table methods, table 4.3 and ABS (1988a, 1990b).

estimate for lost production has not been adjusted to reflect the higher earnings of aviation accident victims assumed by Brownbill (1984) based on Canadian findings (Peat, Marwick and Associates 1981).[2]

Table 4.5 shows the results of these calculations. Lost earnings for all casualties amount to nearly $25 million, with fatalities accounting for 99 per cent of this loss. Lost earnings average over $660 000 per fatal accident and about $349 000 per fatality. Lost earnings represent almost 40 per cent of the total cost of aviation accidents.

Family and community losses

The method for calculating the loss of unpaid production to the families of the victims of aviation accidents and to the wider community has been described in detail in chapter 2. Table 4.6 shows the extent of these losses to be nearly $14 million. As with lost earnings, the major sources of loss were fatalities (about $197 000 per fatality) and fatal accidents ($372 000 per fatal accident). Family and community losses make up 22 per cent of the total cost of aviation accidents.

Losses to non-victims

Losses to non-victims in an aviation accident include costs to the friends, relatives and employers of victims. These costs include the cost of visiting, transporting, home care and support of accident victims and the cost of labour replacement. Traffic delay costs have not been estimated as this was not considered to be a significant factor in aviation accidents.

2. In the Canadian study, airline passenger and crew earnings were used to inflate the incomes of victims. Aviation accidents which occur in Australia are almost exclusively in the area of general aviation. As general aviation passengers are not necessarily similar to airline passengers and general aviation pilot salaries are not usually of the same magnitude as airline pilot salaries, the inflation of earnings of victims was not considered appropriate in the case of Australia.

TABLE 4.6 FAMILY AND COMMUNITY LOSS BY ACCIDENT CLASS: AVIATION ACCIDENTS, 1988

	Cost per accident ($)				
Accident class	*Fatalities*	*Serious injuries*	*Minor injuries*	*Total*	*Total all accidents ($'000)*
Fatal	371 636	688	13	372 338	13 777
Serious	na	4 158	16	4 174	146
Minor	na	na	98	98	2
Nil injury	na	na	na	na	na
Overall				42 451	13 925

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on working life table methods, table 4.3 and ABS (1988a, 1990c).

TABLE 4.7 LOSSES TO NON-VICTIMS: AVIATION ACCIDENTS, 1988

Accident class	*Cost per accident ($)*	*Total all accidents ($'000)*
Fatal	8 013	296
Serious	522	18
Minor	36	1
Nil injury	na	na
Overall	963	316

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 4.5 and NHTSA (1972).

Estimates for losses to non-victims in 1988 aviation accidents, based on the method described in chapter 2, are presented in table 4.7. The equivalent of $316 000 in production was estimated to have been lost by non-victims on account of aviation accidents. The dominant influence of fatal accidents is again evident, contributing almost 94 per cent of the total loss to non-victims.

Accident-generated activities

Costs of aircraft damage and loss

Aircraft damage and loss is probably the most tangible of aviation accident costs. Information on these costs was derived from aviation insurance claims as described below.

The Australian Aviation Underwriting Pool (pers. comm.) provided data for 750 aircraft-related insurance claims during the years 1987 and 1988. These claims included many which related to accidents outside the scope of the ICAO definition of aviation accidents. The aircraft insurance claims were matched with BASI records for the same two-year period using the aircraft registration numbers. BASI records indicate 623 aviation accidents involving 631 aircraft. Only 13 per cent of the insurance claims could be matched with a BASI aviation accident report and these claims correspond to 96 accidents. The claims were distributed according to the class of accident. The average cost of damage to aircraft was then estimated for each class of accident using these known insurance claims (table 4.8). The estimates of average cost of damage lack robustness on account of the very high standard errors for the matched sample.

In the absence of more reliable data, the average cost of hull damage per aircraft in each accident class in table 4.8 was used to calculate the total cost of hull damage by class of accident in 1988 (table 4.9). Total hull damage for 1988 was estimated at nearly $14 million, comprising over 21 per cent of the total cost of aviation accidents. More than half of this loss — over $7 million — occurred in accidents not involving injury. This is mainly due to the 232 nil injury accidents which constitute a relatively high proportion (71 per cent) of accidents in 1988. The high aggregate damage cost of over $5 million in fatal accidents is linked mainly to the more extensive damage occurring in these accidents (over $122 000 per aircraft) and to a lesser extent to the relatively larger number of aircraft per accident (table 4.4).

Insurance administration costs

Insurance industry statistics for 1988 (ISC 1989b) indicate that the proportion of expenses to the value of claims incurred for the marine insurance industry, which includes aviation, is of the order of 42 per cent.[3] The application of this percentage to the figures in table 4.9 yields an estimate of nearly $6 million as the total administrative expenses relating to aviation accident insurance. Table 4.10 shows the distribution of this expense by accident class. Insurance administration accounts for 9 per cent of the total cost of aviation accidents.

Legal costs

An insurance industry source indicated that there are few legal cases associated with nil injury accidents (A. Ward, Australian Aviation Underwriting Pool, pers. comm. 1990). In the case of accidents involving legal costs, such costs incurred by insurance companies are included in their administration costs as estimated above. The legal costs borne by other parties have not been estimated due to data constraints.

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3. Public sector insurance claims and expense estimates relate to the year ended 30 June 1988 (ISC 1989b). In that year, expenses made up 42 per cent of claims in marine/aviation insurance. Expenses in the private sector as a percentage of claims incurred in the years ended 30 June 1988 and 31 December 1988 (ISC 1989a) are somewhat higher at 47 and 46 per cent, respectively; 42 per cent is therefore a lower bound estimate.

TABLE 4.8 AIRCRAFT LOSS AND DAMAGE COSTS BY ACCIDENT CLASS FOR MATCHED CASES: AVIATION ACCIDENTS, 1987 AND 1988
($)

Accident class	*Average cost per aircraft*	*Standard error per aircraft*
Fatal	122 646	85 624
Serious	21 107	11 404
Minor	29 193	27 887
Nil injury	31 296	32 017
Overall	41 260	50 337

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on BASI (1990) and Australian Aviation Underwriting Pool (pers. comm.)

TABLE 4.9 AIRCRAFT LOSS AND DAMAGE COSTS BY ACCIDENT CLASS: AVIATION ACCIDENTS, 1988

Accident class	*Cost per accident ($)*	*Cost per aircraft ($)*	*Total all accidents ($'000)*
Fatal	135 905	122 646	5 028
Serious	21 710	21 107	760
Minor	29 193	29 193	701
Nil injury	31 430	31 296	7 292
Overall	42 014	41 260	13 781

Note Figures may not add to totals due to rounding.

Source BTCE estimates derived from tables 4.3 and 4.8.

TABLE 4.10 AIRCRAFT INSURANCE ADMINISTRATION COSTS BY ACCIDENT CLASS: AVIATION ACCIDENTS, 1988

Accident class	*Average cost per accident ($)*	*Average cost per aircraft ($)*	*Total all accidents ($'000)*
Fatal	57 352	51 757	2 122
Serious	9 162	8 907	321
Minor	12 319	12 319	296
Nil injury	13 263	13 206	3 077
Overall	17 730	17 412	5 815

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 4.9 and ISC (1989b).

Medical, hospital and rehabilitation costs

Medical costs

Medical costs incurred as a result of aviation accidents have been estimated using TAC (1991) data on road accidents as described in chapter 2. The aviation accident classified as 'serious injury' was equated with the road accident classified as 'hospital injury'. The TAC data yielded an estimate of $155 per hospital bed-day for medical cost. On the basis of TAC data, 'serious injury' victims spent, on average, 59 days in hospital. This results in an estimate of $9145 for medical cost per seriously injured person. Likewise, the aviation accident 'minor injury' was equated with the road accident 'medical injury', for which the medical cost from TAC data was estimated at $387 per injury. On the basis of this assumed correspondence between injury severity levels in aviation and road accidents, it would appear that the cost of an aviation 'minor 'injury may be somewhat underestimated. This is because the aviation 'minor' injury category, unlike the road 'medical' injury category, may include up to 48 hours in hospital.[4] The medical cost per fatality was estimated at $832 (chapter 2).

The estimated medical costs are presented in table 4.11. Medical costs amounting to some $509 000 were estimated to have been incurred in aviation accidents. Over 97 per cent of this cost was generated by serious injury and fatal accidents, with the former contributing $369 000 and the latter $125 000.

Hospital and rehabilitation costs

The average cost per occupied bed-day in acute care public hospitals in 1988 was estimated at $291 (AIH 1991). According to AIH data, aviation accidents (ICD-9 codes 840 to 844) were associated with 2890 occupied bed-days in acute care public hospitals in 1988. As noted in the calculation of lost earnings, an average of one day in hospital was assumed for a fatality and for a minor injury and 59 days for a serious injury.

The estimated total hospital cost for all accidents is $843 000, averaging $2571 per accident (table 4.12). Serious injuries account for 82 per cent of total hospital costs. Hospital costs amount to nearly $20 000 per serious injury accident and to about $17 000 per serious injury. Some rehabilitation costs are included in the hospital costs and possibly some medical costs as well. Other, possibly long-term, rehabilitation costs may have been incurred, but these have not been estimated. For this reason, and because of the conservative nature of the estimating procedures, these figures should be treated as lower bound estimates.

Accident investigation costs

The primary function of BASI is to investigate aviation accidents occurring within Australian flight information regions. The cost of accident investigation was derived from data provided by BASI, relating to each accident investigated in

4. The aviation accident 'serious injury' category includes AIS levels 3 to 5 and the 'minor injury' category, levels 1 and 2. The road accident 'hospital injury' category includes AIS levels 2 to 5 and the 'medical injury' category only level 1.

TABLE 4.11 MEDICAL COSTS BY ACCIDENT CLASS: AVIATION ACCIDENTS, 1988

Accident class	Cost per accident ($) Fatalities	Serious injuries	Minor injuries	Total	Total all accidents ($'000)
Fatal	1 574	1 730	83	3 387	125
Serious	na	10 451	98	10 550	369
Minor	na	na	605	605	15
Nil injury	na	na	na	na	na
Overall				1 552	509

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 4.3 and TAC (1991).

TABLE 4.12 HOSPITAL AND REHABILITATION COSTS BY ACCIDENT CLASS: AVIATION ACCIDENTS, 1988

Accident class	Cost per accident ($) Fatalities	Serious injuries	Minor injuries	Total	Total all accidents ($'000)
Fatal	551	3 248	63	3 862	143
Serious	na	19 662	75	19 697	689
Minor	na	na	461	461	11
Nil injury	na	na	na	na	na
Overall				2 571	843

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 4.3, Brownbill (1984) and AIH (1991).

1988. These data comprise the cost of goods and services provided by BASI in the course of the accident investigation, and the travel expenses of the investigators. The cost component attributed to BASI is a marginal cost, based on the assumption that BASI would have existed even if no accidents had occurred in 1988.

The total cost of accident investigation in 1988 was about $89 000 — an average cost of $270 per accident (table 4.13). Fatal accidents, each costing an average $1148, is the most costly class of accident to investigate. The costs of police investigation and coronial enquiries into fatal accidents have not been included. These costs can be substantial in individual accidents, but it has not been possible to obtain adequate data to provide a reasonable estimate of costs. The accident investigation cost estimate should therefore be considered to be conservative.

TABLE 4.13 ACCIDENT INVESTIGATION COSTS BY ACCIDENT CLASS: AVIATION ACCIDENTS, 1988

Accident class	*Cost per accident ($)*	*Total all accidents ($'000)*
Fatal	1 148	42
Serious	66	2
Minor	230	6
Nil injury	165	38
Overall	270	89

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 4.3 and BASI (1990).

TABLE 4.14 SEARCH AND RESCUE COSTS BY ACCIDENT CLASS: AVIATION ACCIDENTS, 1988

Accident class	*Cost per accident ($)*	*Total all accidents ($'000)*
Fatal	1 091	40
Serious	1 013	35
Minor	985	24
Nil injury	989	229
Overall	1 003	329

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 4.3 and CAA (pers. comm.).

TABLE 4.15 PAIN AND SUFFERING COSTS BY ACCIDENT CLASS: AVIATION ACCIDENTS, 1988

	Cost per accident ($)			
Accident class	*Serious injuries*	*Minor injuries*	*Total*	*Total all accidents ($'000)*
Fatal	12 814	1 304	14 119	522
Serious	77 409	1 551	78 960	2 764
Minor	na	9 552	9 552	229
Nil injury	na	na	na	na
Overall			10 717	3 515

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 4.3, BTCE (1988) and ABS (1988b).

Search and rescue costs

Search and rescue costs were derived from data provided by the CAA (pers. comm.). These costs amounted to $329 000 or $985 per aircraft in 1988. This cost was distributed among all accidents[5] that occurred in 1988 according to the number of aircraft involved, and details are shown in table 4.14. The military are often involved in major search and rescue operations and usually treat this community service as training. The cost of military involvement in search and rescue has not been estimated as relevant data were not available.

Pain and suffering of victims

The average cost of pain and suffering to a person sustaining a 'serious injury' in an aviation accident was estimated at about $67 700, and a 'minor injury' at about $6000 (see chapter 2 for details).

Estimates of the cost of pain and suffering by accident class are presented in table 4.15. The total cost of pain and suffering as a result of aviation accidents that occurred during 1988 was estimated to be over $3.5 million, or about $11 000 per accident. A serious injury accident was estimated to have cost nearly $79 000 in pain and suffering. Of the total pain and suffering cost of $3.5 million, $2.8 million, or 79 per cent, was due to serious injury accidents.

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5. Search and rescue alarms may be raised before there is any indication of the severity of the accident. A missing aircraft (or vessel) may be undamaged and injury to persons may not have occurred.

CHAPTER 5 COST OF RAILWAY ACCIDENTS

INTRODUCTION

There is no centralised or uniform State and Territory based reporting system for railway accidents. Rail organisations generally compile data for their own purposes. There were difficulties in attempting to standardise the rail data as rail organisations have differing reporting requirements and practices. Because of these inconsistencies, estimating the number of rail accidents in 1988 with a reasonable degree of accuracy was not considered feasible. Instead, casualty-based costing has been adopted, which is a departure from the preferred method of accident-based costing. A summary of rail accident costs in 1988 by injury severity estimated using the casualty-based costing framework is set out in table 5.1.

Rail injuries

Data on fatalities were provided by rail organisations. The rail organisations reported a total of 139 rail accident fatalities. An additional source of information is ABS (1989a) which publishes mortality data, including deaths due to rail accidents. The ABS estimates are derived from the cause of death entered in the death certificate. The causes of death are coded according to the 9th Revision of the World Health Organisation's International Classification of Diseases (ICD-9) (WHO 1977). Rail accidents are coded as an external cause of death (E code) (see appendix II). ABS (1989a) recorded 60 rail accident deaths in 1988.

The major reason for the disparity in the statistics from the two sources is the treatment of suicide. The rail system is used by some people as a means of suicide. There were 2197 reported cases of suicide in Australia in 1988 (Mathers & Greenhill 1990). As rail suicides comprise a very small proportion (probably less than 2 per cent) of reported suicides, they are not seperately reported by the ABS.

About 43 rail fatalities in 1988 were identified as suicides by rail authorities. The ABS would report these deaths as suicides, not deaths due to railway accidents. While this would account for some of the disparity, it is likely that coding and other judgmental factors cause rail deaths, as well as accidental deaths associated with other transport modes, to be under-reported in ABS statistics (see chapter 2). To compound the issue, some injuries such as a fall on railway property are included

TABLE 5.1 SUMMARY OF COSTS BY INJURY SEVERITY: RAIL ACCIDENTS, 1988

	Lost production											
	Earnings		*Family and community*		*Asset damage*		*Pain and suffering*		*Other*		*Total all costs*	
Injury class	*$'000*	*%*	*$'000*	*%*	*$'000*	*%*	*$'000*	*%*	*$'000*	*%*	*$'000*	*%*
Fatality	32 500	94	16 400	95	na		na		410	7	49 310	52
Hospital	1 900	6	776	5	na		8 264	100	5 588	90	16 526	8
Medical	4	–	2	–	na		39	–	37	–	82	–
Other	na		na		na		na		171	3	171	–
Total all accidents	34 404	100	17 178	100	28 360	100	8 302	100	6 206	100	94 450	100

na Not applicable
– Less than 1 per cent

Note Figures may not add to totals due to rounding and because asset damage cost has not been distributed among injury classes.

Source BTCE estimates.

TABLE 5.2 ESTIMATED NUMBER OF PERSONS INJURED BY AGE GROUP AND INJURY CLASS: RAIL ACCIDENTS, 1988

	Injury class				
Age	*Fatalities*	*Hospital injuries*	*Medical injuries*	*Other*	*Total*
Under 15	10	21	8	150	189
15–24	40	33	13	240	327
25–39	16	21	8	150	195
40–49	16	12	5	90	124
50–59	5	29	12	210	256
60+	10	37	15	270	332
Total	96	154	61	1 111	1 422

Note Figures may not add to totals due to rounding.

Sources Information provided by the ABS, rail authorities and the AIH (ABS 1989a; SRA 1991; PTC 1991; QR 1990; AN 1991; WR 1990; AIH 1991).

in the rail system accident reports but would be excluded from the WHO ICD-9 definition of rail accidents. After identified cases of suicide were removed from the statistics, 96 rail fatalities were left. These fatalities were distributed in accordance with the age groupings found in the reported ABS data (table 5.2).

Table 5.2 also shows the number of injured persons. These were divided into three groups: persons hospitalised (154); persons who sought medical treatment which cost more than $298 (61); and persons who suffered other injuries or material loss (1111). The degree of injury sustained by rail accident victims was not evident in all cases from the data provided by rail organisations. Data on rail accident injury costs in Victoria were provided by the Transport Accident Commission (TAC 1991). The TAC data may include some persons who fell or slipped on railway property but who may not be included in railway accident statistics. The injury severity and age distribution of rail accident casualties reported by the TAC was used to allocate the number of injuries reported by rail authorities to injury categories in order to obtain an overall Australian distribution of hospital, medical and other injury categories.

ACCIDENT COSTS

Lost production

Lost earnings

It was not possible to determine the age and gender of all persons who were involved in railway accidents in 1988. As an alternative, the distribution of reported rail deaths (ABS 1989a) was applied to the fatalities and to other injured persons reported by the rail authorities for 1988. The resulting distribution was then used to estimate the total value of lost earnings and labour on-costs, and the average cost per injury. These estimates were calculated using the working life table methodology described in chapter 2.

TABLE 5.3 LOST EARNINGS AND ON-COSTS BY INJURY CLASS: RAIL ACCIDENTS, 1988

Injury class	*Cost per person ($)*	*Total cost ($'000)*
Fatal	338 542	32 500
Hospital	12 424	1 900
Medical	70	4
Other	na	na
Total		34 404

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on working life table methods, table 5.2 and ABS (1988a, 1990b).

The results of this procedure are presented in table 5.3. Rail accident injuries were estimated to have cost over $34 million in lost earnings and on-costs, representing 36 per cent of the total cost of rail accidents. The major part of this cost (over $32 million) was lost due to premature mortality and translates into about $338 500 per fatality. An amount of $1.9 million was lost as a consequence of the hospitalisation of victims. The average period of lost production time for a hospitalised victim was 89 days (TAC 1991) plus an additional 89 days of recuperation time (chapter 2). Lost earnings and on-costs for medical injuries amounted to about $4000.

Family and community losses

Table 5.4 shows estimated lost production of over $17 million representing the forgone contributions of rail accident victims to their households and the community. Premature mortality was again the major factor in this loss, responsible for over $16 million or $171 000 per fatality. Family and community losses constitute 18 per cent of the total cost of rail accidents.

Losses to non-victims

Rail accidents generally affect persons besides those who are directly involved. An accident in an urban rail network can cause delays to passengers and freight throughout the network. However, no estimate of this type of loss for rail accidents has been made in this study because of the lack of data.

Other aspects of losses to non-victims, such as the cost of caring for and supporting the victims, may be estimated in terms of the production of non-victims. The methodology for this estimation is described in chapter 2 and the results are presented in table 5.6. Some $518 000 was estimated to have been lost due to the forgone production of non-victims, and 75 per cent of this loss relates to the fatally injured. The average loss, per fatality, of the output of friends and relatives of victims amounts to $4000.

TABLE 5.4 LOST FAMILY AND COMMUNITY PRODUCTION BY INJURY CLASS: RAIL ACCIDENTS, 1988

Injury class	*Cost per person ($)*	*Total cost ($'000)*
Fatal	170 833	16 400
Hospital	5 044	776
Medical	28	2
Other	na	na
Total		17 178

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on working life table methods, table 5.2 and ABS (1988a, 1990c).

TABLE 5.5 LOSSES TO NON-VICTIMS BY INJURY CLASS: RAIL ACCIDENTS, 1988

Injury class	*Cost per person ($)*	*Total cost ($'000)*
Fatal	4 072	390
Hospital	777	119
Medical	14	1
Other	na	na
Total	na	510

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 5.3 and NHTSA (1972).

Accident-generated activities

Asset damage costs

Estimates of asset damage due to rail accidents were obtained from all rail organisations except those in Victoria and Tasmania. The weighted cost of asset damage per train-kilometre of the rail organisations that provided data was applied to the number of train-kilometres in the Victorian and Tasmanian rail systems to derive an Australian estimate.

An estimated loss of about $28 million in asset damage was sustained by Australian rail systems in 1988. Available data did not permit the allocation of damage to specific accidents, casualties or injury classes and such an allocation would not generally be consistent with the casualty-based costing framework used for rail accidents. The cost of asset damage appears in table 5.1, and represents 30 per cent of the total cost of rail accidents.

Insurance administration, accident investigation, search and rescue and legal costs

Insurance administration, accident investigation, search and rescue and legal costs have not been estimated. Rail systems are self-insured and conduct their own accident investigations. The costs involved are subsumed in their general administration and legal costs. Data were not available for these cost categories nor for the costs of police and coronial investigations and ambulance and rescue services.

Medical, hospital and rehabilitation costs

Medical costs

TAC (1991) data indicate that the cost of medical treatment for a person killed in a 1988 rail accident was about $160. This figure, applied to all 1988 rail fatalities, produced an estimate of about $15 000. For hospitalised persons, TAC data indicate that the average cost per person for medical treatment was nearly $13 000. The total cost of medical treatment for hospitalised persons was estimated at about $2 million.

The TAC paid out an average of $585 per person for a group of persons who were injured in rail accidents and who each received medical treatment costing $298 or more. In total, these medical costs were estimated at some $36 000.

For those persons who suffered some injury entailing a medical cost less than $298, an average medical cost of $154 has been used. This amount represents the mean of $10.75, which was the minimum cost of a visit to a doctor in 1988 (Department of Community Services and Health pers. comm.) and $297 which was the maximum medical cost which the TAC would not reimburse. Based on this assumption, the total medical cost for those persons with minor injuries and other losses sustained in rail accidents was estimated at about $171 000. Medical costs by injury class are shown in table 5.6.

Hospital and rehabilitation costs

Hospital costs for persons injured in rail accidents and admitted to Victorian hospitals in 1988 were derived from data provided by the TAC (1991). The average cost per day for a person admitted to hospital in Victoria in 1988 as a consequence of receiving a non-fatal rail injury was $243. Victorian hospitalisation costs in 1988 were found to be 95 per cent of the Australian average (AIH 1991) and this has been taken into account in estimating the Australian average of $255 per person per day.

The TAC data also indicate that persons involved in rail accidents spent an average of 89 days in hospital. The hospitalisation cost for each of these persons would therefore have amounted to over $22 000. Hospital-based rehabilitation costs are likely to be included in this estimate, particularly given the relatively long stay of rail accident victims. Only a small proportion (20 per cent) of rail fatalities died in hospital. The cost per bed-day for a fatality was estimated to be $240 and

TABLE 5.6 MEDICAL COSTS BY INJURY CLASS: RAIL ACCIDENTS, 1988

Injury class	*Cost per person ($)*	*Total cost ($'000)*
Fatal	156	15
Hospital	12 818	1 974
Medical	590	36
Other	154	171
Total		2 196

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on information provided by rail authorities (SRA 1991; PTC 1991; QR 1990; AN 1991; WR 1990), TAC (1991) and table 5.3.

TABLE 5.7 HOSPITAL AND REHABILITATION COSTS BY INJURY CLASS: RAIL ACCIDENTS, 1988

Injury class	*Cost per person ($)*	*Total cost ($'000)*
Fatal	48	5
Hospital	22 695	3 495
Medical	na	na
Other	na	na
Total		3 500

na Not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on AIH (1991), TAC (1991) and table 5.3.

TABLE 5.8 PAIN AND SUFFERING COSTS BY INJURY CLASS: RAIL ACCIDENTS, 1988

Injury class	*Cost per person ($)*	*Total cost ($'000)*
Fatal	na	na
Hospital	53 662	8 264
Medical	639	39
Other	na	na
Total		8 302

na Not applicable

Note Figures may not add to totals due to rounding.

Sources Derived from BTCE (1988), ABS (1988b) and table 5.3.

Pain and suffering of victims

Based on the methodology described in chapter 2, the average cost of pain and suffering per victim hospitalised due to a rail accident was estimated to be about $53 700. When only medical injury was involved the estimate was $640. Persons who died, or received only minor medical injuries or other losses, were assumed to have not endured pain and suffering. The total cost of pain and suffering in rail accidents in 1988 was estimated to exceed $8 million (table 5.8), representing about 9 per cent of the total cost of rail accidents.

CHAPTER 6 COST OF MARITIME ACCIDENTS

INTRODUCTION

There are several organisations and agencies with different responsibilities in the area of maritime safety, and there is no centralised or uniform State and Territory based reporting system for maritime accidents. Because of the lack of data and inconsistencies in reporting, the number of maritime accidents that occurred in 1988 has not been estimated. As with rail accidents, a departure from the preferred practice of costing the accident was necessary, and casualty-based costing has been adopted.

Maritime accidents and injuries span a wide spectrum of vessel types and situations. They range from mishaps occurring to and aboard large vessels such as ocean-going cruise and cargo ships and supertankers to those involving small craft, dinghies and water-skiing activity. Table 6.1 presents a summary of maritime accident costs by injury severity for 1988.

The social cost of maritime accidents in 1988 was generated from the number of fatalities and hospital admissions resulting from maritime accidents reported in that year. It was not possible to differentiate, in the published statistics, between maritime fatalities and hospitalisations of persons working in the maritime industry and those occurring during sporting or recreational activity. Table 6.2 outlines the numbers of fatalities and hospitalisations by age group.

The process of estimating the cost of maritime accidents differs in some important aspects from the method used for road and aviation accidents, and is similar to that used for rail accidents. For road and aviation, cost estimates are based on accidents classified by degree of severity. Maritime accident cost estimates are based on published numbers of fatalities and hospital admissions/discharges. The number of accidents is unknown as is the number of injuries not resulting in hospitalisation.

MARITIME INJURIES

The definitions adopted in this study to describe maritime casualties are those used by the World Health Organisation in the 9th Revision of the International Classification of Diseases (ICD-9) (WHO 1977). These definitions are in appendix II.

TABLE 6.1 SUMMARY OF COSTS BY INJURY CLASS: MARITIME ACCIDENTS, 1988

	Lost production													
	Earnings		*Family and community*		*Vessel and cargo damage*		*Insurance administration*		*Pain and suffering*		*Other*		*Total all costs*	
Injury class	*$'000*	*%*	*$'000*	*%*	*$'000*	*%*	*$'000*	*%*	*$'000*	*%*	*$'000*	*%*	*$'000*	*%*
Fatalities	19 475	97	10 234	98	na		na		na		311	13	30 143	11
Hospital	669	3	217	2	na		na		36 500		1 876	80	39 825	15
Total all accidents	20 144	100	10 451	100	131 704		62 404		36 500		2 335[a]	100	263 674	100

na Not applicable

a. Search and rescue costs and accident investigation costs of $148 000 are included in total.

Note Figures may not add to totals due to rounding and because vessel and cargo damage cost and insurance administration cost have not been distributed among injury classes.

Source BTCE estimates.

TABLE 6.2 ESTIMATED NUMBER OF PERSONS INJURED BY AGE GROUP AND INJURY CLASS: MARITIME ACCIDENTS, 1988

Age	*Fatalities*	*Hospital injuries*	*Total*
Under 15	2	20	22
15–24	12	118	130
25–39	17	168	185
40–49	11	108	119
50–59	12	118	130
60+	15	148	163
Total	69	680	749

Sources ABS (1989a), AIH (1991).

The fatality data are drawn from the ABS mortality tabulations (ABS 1989a). These data are based on the cause of death as entered in death certificates. There are some discrepancies between ABS mortality data and other independent sources of transport fatality data. Considering the extent of ABS under-reporting relative to other data sources for some of the other modes, maritime fatalities could be under-reported by the ABS by as much as 37.5 per cent (see chapter 2). The use of 69 maritime accident fatalities reported by the ABS in the calculation of costs is therefore very likely to result in a lower bound estimate. Future research on the actual numbers of maritime accidents, fatalities and injuries could attempt to clarify this uncertainty.

Maritime hospitalisations were derived from data provided by the AIH (1991), from reported admissions to acute care public hospitals. The maritime casualties were coded with the ICD-9 codes for maritime accidents. These casualties constitute at least 70 per cent of all casualties hospitalised as a result of maritime accidents.[1]

As noted earlier, an injured person may have several admissions. According to the TAC (1991) 5656 persons were hospitalised due to Victorian road accidents. The AIH reports 7782 Victorian hospital admissions due to road accidents. This implies that there could be some 1.4 admissions per injured person in Victoria. As the AIH data for Victoria refer to financial year 1987–88 and the TAC data to calendar year 1988, part of the discrepancy may be due to the different time periods. Data from VIC ROADS (pers. comm.) on admissions to acute care hospitals in Victoria indicate that there were 6134 admissions due to road accidents during calendar year 1988. This figure and the TAC estimate of Victorian hospitalised persons, indicate that there were 1.08 admissions per person.

1. Public hospitals account for about 70 per cent of all acute care hospitals (AIH 1991). Also, very few private hospitals offer accident and emergency treatment (AIH pers. comm.)

Given the uncertainties in the data and the unclear degree of correspondence between reporting in road and maritime accidents, the 680 Australia-wide hospital admissions due to maritime accidents estimated by the AIH were treated as if each represented a person. These 'persons' were distributed by age according to the age distribution of fatalities reported by the ABS (1989a) (table 6.2). The number of persons involved in maritime accidents who sustained injuries which did not require hospital treatment has not been estimated.

ACCIDENT COSTS

Lost production

As noted for other modes, a significant component of accident costs estimated in this study is the loss or partial loss of future production of accident victims. This production comprises two major components: earnings plus labour on-costs, and unpaid household and community production.

Lost earnings

This component of lost production is expressed as the present value of potential future earnings and labour on-costs of accident victims. Fatalities result in a total loss of earning capacity, but the situation with other injury categories is less clear.

In the case of fatal injuries, the working life table estimates of years of potential working life remaining were used to calculate lost earnings. While the accident victim is hospitalised or disabled, production and earning capacity are lost or diminished. Information on the length of the period of total or partial disability was not available. Therefore, for hospitalised persons, the cost of lost production during their hospital stay and while disabled and recuperating was assumed to be equal to the value of production for the number of hospital bed-days plus that of one rest day for each day in hospital (chapter 2). The estimate obtained using this procedure must therefore be considered a lower bound.

Available hospital data relating to maritime accidents in 1988 indicate that the number of hospital bed-days was 4132 and that the number of admissions/discharges was 680 (AIH 1991), an average of about 6 days per admission.[2] In the absence of more specific data, it was assumed that each admission/discharge was equivalent to one person, and that the average length of stay in hospital was 6 days. This length of stay is substantially less than the 21 days estimated for road accident victims, the 59 days for aviation accidents and the 89 days for rail accidents, and may well reflect the different nature of maritime accident injuries and the possibly lesser degree of injury severity associated with them.

Table 6.3 shows the results of these calculations. Lost earnings for all casualties amount to about $20 million and lost earnings due to fatalities make up 97 per

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2. This takes into account the total of 69 days spent in hospital by 5 maritime accident victims who subsequently died.

TABLE 6.3 LOST EARNINGS AND ON-COSTS BY INJURY CLASS: MARITIME ACCIDENTS, 1988

Injury class	*Cost per person ($)*	*Total cost ($'000)*
Fatal	282 246	19 475
Hospital	984	669
Overall	26 895	20 144

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on working life table methods, ABS (1988a, 1990b), AIH (1991) and table 6.2.

TABLE 6.4 LOST FAMILY AND COMMUNITY PRODUCTION BY INJURY CLASS: MARITIME ACCIDENTS, 1988

Injury class	*Cost per person ($)*	*Total cost ($'000)*
Fatal	148 319	10 234
Hospital	319	217
Overall	13 953	10 451

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on working life table methods, ABS (1988a, 1990c), AIH (1991) and table 6.2.

cent of this loss. Lost earnings comprise 7.6 per cent of the total cost of maritime accidents. Lost earnings per fatality average over $282 000.

Family and community losses

The other component of lost production of accident victims is the unpaid contributions they are not able to make to their households and to the community. Table 6.4 shows that these losses due to maritime fatalities and hospitalisations exceed $10 million, representing 4 per cent of the total cost of maritime accidents. As is the case with lost earnings, this figure mainly comprises the lost production of the fatally injured. The average loss per fatality amounts to over $148 000. Hospitalised victims contribute a minor proportion (2 per cent) to the total cost.

Losses to non-victims

Losses to non-victims comprise the lost production of persons who are not directly involved in the accident but who may be inconvenienced, bereaved or involved in the support of victims. There were no data available relating to delay costs in maritime accidents. The application of the methodology described in chapter 2 results in an estimate of losses to non-victims in maritime accidents in 1988 of about $276 000 (table 6.5). The bulk of this loss was due to fatalities, the average loss per fatality amounting to about $3400.

TABLE 6.5 LOSSES TO NON-VICTIMS BY INJURY CLASS: MARITIME ACCIDENTS, 1988

Injury class	*Cost per person ($)*	*Total cost ($'000)*
Fatal	3 387	234
Hospital	62	42
Overall	na	276

na not applicable

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on NHTSA (1972) and table 6.3.

Accident-generated activities

Costs of vessel and cargo damage and loss

The tangible costs of loss and damage to ships and cargo are a major factor in the overall cost of maritime accidents. The estimated cost of insurance and related payouts for property damage in maritime accidents includes payments for hull damage and cargo loss for those risks underwritten by Australian insurers. Estimates of the payouts by overseas insurers to Australian vessel owners and the losses covered by ship owners and Protection and Indemnity (P&I) clubs have not been included.

The claims incurred during 1988 as reported by the ISC (1989a, 1989b) were considered to be representative of the costs of vessel and cargo losses during that year. The value of premiums paid to overseas underwriters and the value of the loss of Australian vessels and cargoes underwritten by overseas companies have not been estimated due to data constraints. Maritime and aviation insurance losses as well as losses due to theft and other causes are aggregated in the published ISC statistics. The amount relating to aircraft loss and damage presented in chapter 4 was removed from the aggregate ISC figure to obtain the corresponding maritime estimate. However, the amounts associated with theft and other losses were not removed. The results of this analysis indicate that insured losses amount to over $131 million and represent 50 per cent of the total cost of maritime accidents.

Insurance administration costs

Insurance industry statistics for 1988 (ISC 1989a) indicate that the aggregate marine and aviation administrative expense incurred by the insurance industry was of the order of $68 million. Based on BTCE estimates of the cost of aviation insurance administration (chapter 4) and insurance industry statistics, the cost of marine insurance administration was estimated at about $62 million, making up 24 per cent of the total cost of maritime accidents.

Legal costs

An estimate of legal costs has not been included due to the lack of data.

Medical, hospital and rehabilitation costs

Medical costs

The number of persons injured in maritime accidents who required only medical attention could not be determined. However, it is evident that injuries resulting in hospitalisation or death may involve medical costs. Drawing on TAC data presented in chapter 2, an amount of $155 per bed-day for medical cost of a hospitalised injury has been used.

The AIH (1991) estimates of 680 hospital admissions and 4132 bed-days as a result of maritime accidents, yield an average of about 6 hospital days per admission.

In the absence of actual person-based data it was assumed that one admission equates to one person, and on this basis it was estimated that the medical cost per hospitalised person amounts to about $948. The medical cost for a fatally injured road accident victim of $832 (chapter 2) was assumed to apply to a maritime accident fatality. The results of this analysis are presented in table 6.6. Medical costs associated with maritime accidents in 1988 total $701 000.

Hospital and rehabilitation costs

The cost per day of hospitalisation in 1988 in an acute care public hospital was estimated by the AIH (1991) at $291, and this cost has been assigned to the victims of maritime accidents. Persons hospitalised in maritime accidents were found to have accumulated a total of 4132 occupied bed-days (AIH 1991). It was assumed that fatalities in maritime accidents imposed some hospital and medical resource costs upon society. The average length of stay in hospital for fatalities in road and rail accidents in Victoria in 1988 was 2.4 and 0.2 days, respectively (TAC 1991). For aviation accidents, it was assumed that fatalities spent, on average, one day in hospital (chapter 4). Similarly, for maritime accident fatalities, it was assumed that the average length of stay in hospital was one day.

The average daily hospital cost of $291 (based on all acute care public hospitals and all diseases and injuries) (AIH 1991), multiplied by the 4132 occupied bed-days attributed to maritime accidents, yields a total cost of about $1.2 million (table 6.7). About $20 000 of this total is attributed to the 69 fatalities and the remainder to persons admitted to hospital. The cost per hospitalised casualty was estimated at about $1750.

Accident investigation costs

The Marine Incident and Investigation Unit of the Commonwealth Department of Transport and Communications (pers. comm.) estimated that the marginal cost associated with maritime accident investigation in 1988 was approximately $10 000. This figure does not include the cost of coronial, police or other investigations and must be considered very much a lower bound estimate.

Search and rescue costs

The Australian Maritime Safety Authority (pers. comm.) incurred a cost of $138 000 in undertaking search and rescue activities in 1988. This must be

TABLE 6.6 MEDICAL COSTS BY INJURY CLASS: MARITIME ACCIDENTS, 1988

Injury class	*Cost per person ($)*	*Total cost ($'000)*
Fatal	832	57
Hospital	948	644
Overall	936	701

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 6.2, TAC (1991) and AIH (1991).

TABLE 6.7 HOSPITAL AND REHABILITATION COSTS BY INJURY CLASS: MARITIME ACCIDENTS, 1988

Injury class	*Cost per person ($)*	*Total cost ($'000)*
Fatal	291	20
Hospital	1 750	1 190
Overall	1 615	1 210

Note Figures may not add to totals due to rounding.

Source BTCE estimates based on table 6.2, TAC (1991) and AIH (1991).

TABLE 6.8 PAIN AND SUFFERING COSTS FOR HOSPITALISED VICTIMS: MARITIME ACCIDENTS, 1988

Injury class	*Cost per person ($)*	*Total cost ($'000)*
Fatal	na	na
Hospital	53 700	36 500

na Not applicable

Note The fatality category was assigned a pain and suffering cost of zero.

Source BTCE estimates based on BTCE (1988), ABS (1988a) and table 6.2.

considered a lower bound estimate of search and rescue costs because costs incurred by police, port and harbour authorities, State and Territory governments and other agencies have been not been included.

Pain and suffering of victims

The cost of pain and suffering was estimated using the procedure described in chapter 2. The cost of pain and suffering to a person admitted to hospital as a result of a maritime accident was assumed to be equivalent to the estimate for a road accident ($53 700). The total cost of pain and suffering resulting from maritime accidents in 1988 is about $37 million (table 6.8), accounting for about 14 per cent of the total cost of maritime accidents.

CHAPTER 7 CONCLUDING ASSESSMENT

This study is the first attempt in Australia, or overseas, to estimate the costs of transport accidents in all major transport modes in a given year. The ex-post human capital methodology has been used to cost transport accidents that occurred in Australia in 1988. Given the data limitations, some estimates, particularly those for rail and maritime accidents, are preliminary and could be refined by future research. The methodology has a conservative bias and the estimates should therefore be regarded as lower bounds. The costing approach involves an accounting framework and the number of cost factors that could be included was limited by considerations of practicality and data constraints. The cost estimates incorporate most of the major direct social consequences of accidents. Certain factors, such as the cost of government agencies responsible for vehicle and road safety, and the environmental impact of accidents, have not been included.

Further, the long-term consequences of accident-related injury and the full impact of emotional trauma on accident victims and other members of society have not been costed. In fact, certain accident consequences such as quadriplegia and severe head injuries and burns are sometimes considered to be fates worse than death. A study by Miller, Luchter and Brinkman (1989) in the United States suggested that the largest public investments should be targeted to prevent or reverse very severe non-fatal injuries rather than death.

The methodology used in this study incorporates several refinements in comparison with that used in the previous BTCE (1988) study on the cost of road accidents. Most importantly, age and gender specific accounting on an actuarial basis for the calculation of lost production has been possible with the use of Australian working life tables. The use of earnings rather than income to value output, and the inclusion of labour on-costs and consumption in the lifetime earnings stream, represent best practice in the use of the human capital approach.

Australian data have been used as far as possible in estimating accident costs. However, In the absence of appropriate Australian data to estimate certain cost categories, overseas data had to be used. Data from studies conducted in the United States were used in the estimation of travel delay costs due to road accidents and losses to persons other than those directly involved in accidents. Future research could attempt to reduce the reliance on overseas data.

The lower bound accident costs computed in this study suggest that these costs provide minimum estimates of the gains that would accrue to society as a result of accident reduction. The cost of accidents is made up of several cost factors. Many of these costs could be reduced proportionately if the number of accidents and associated injuries decline. However, some of these cost factors, such as insurance administration, are relatively less sensitive to a decline in the accident rate.

The point is sometimes made that because the human capital approach assumes full employment, production losses could be overstated when economic conditions do not approximate full employment. The argument is that in times of high unemployment, labour can be easily replaced, with the possible exception of individuals with special skills. However, some costs would be incurred on account of inconvenience, recruitment and training. It must be recognised, in the context of this argument, that the cost estimates in this study relate to 1988 when economic conditions were somewhat different from current conditions. Faigin (1976) provides a different perspective by arguing that the fact that an individual might be replaced by an unemployed individual is not relevant, since the quantity being measured is the individual's value of life activity. Faigin considers that when a person dies prematurely or is disabled, the value of life activity of that individual is lost to society.

Another approach to accident costing would be to replace the lost production and pain and suffering estimates in the accounting framework with a willingness-to-pay estimate for risk reduction. If this estimate is combined with other resource costs resulting from accidents, it is very likely that the overall accident cost estimate would increase substantially. Willingness-to-pay values for risk reduction are not necessarily transposable between countries, but if results for the United States are taken as a guide, there could be as much as a four-fold cost increase. The study by Miller, Luchter and Brinkman (1989) found that, with the inclusion of willingness-to-pay estimates, the rational investment levels to prevent a road crash fatality and a fatal road crash is roughly four times the cost of these events to society computed on a human capital basis. The additional expenditure is for the prevention of pain, suffering and loss in quality of life, and for the reduction of the tendency for people to take risks.

The results of any study depend critically on the quantity and quality of the data used. In the case of aviation accidents, the centralised reporting system ensured relatively easy access to data which had a high degree of reliability. With road accidents, there was a reasonable degree of reliability, especially in regard to fatalities and serious injuries. However, the quality of data on road accidents and injuries and reporting systems tended to vary among the States and Territories. The data for the rail and maritime modes were sparse and had the lowest degree of reliability.

Better estimates of the social, economic and emotional costs of transport accidents can only be achieved with better data. Towards this end, it would be desirable to consider a more organised and coordinated national approach to the process of compiling transport accident statistics. In particular, the adoption of uniform definitions and reporting criteria would contribute significantly to upgrading the quality of the statistics.

Safety is an economic good whose provision involves the use of scarce resources. Therefore, higher levels of safety can generally only be achieved at the expense of other desirable ways in which society can use its scarce resources. Further, the provision of higher levels of transport safety involves a trade-off between reducing transport risk and other means of reducing risk to life, such as enhancing the quality of the environment, improving health care and reducing the crime rate.

The optimal allocation of the safety resource involves two basic considerations: what level of safety is desired and how this level of safety could be achieved at minimum cost. Economic theory suggests that in a perfectly competitive market with perfect information, safety would be provided up to the point where perceived marginal benefits to consumers are equal to the marginal costs of provision. Perfectly competitive markets would therefore result in optimal levels of safety. As markets are not perfectly competitive and information, including accurate perceptions of the absolute values of risk levels across modes, is generally far from perfect, government involvement in safety provision and regulation can potentially improve social welfare.

The use of cost estimates such as those provided in this study are generally used by government agencies as inputs into cost–benefit analyses involving safety programs. However, such studies have hitherto been largely confined to road safety. As essentially the same methodology has been used in calculating accident costs in other modes, the estimates provide some scope for assessing the consequences of accidents in the different modes and for comparing safety programs in these modes.

The foregoing discussion raises several safety resource allocation issues which pose a considerable challenge to researchers and policy makers. What methods and criteria should be used in public sector allocative decisions concerning risks to life? In what manner and proportion should resources be allocated to transport safety relative to other safety programs? How should resources be allocated to preventing fatalities and injuries across the different transport modes? Should the marginal allocation of resources be such that the prevention of a fatality is equal across modes? Alternatively, should implicit values of life vary for the different modes, and if so on what basis? What should be the appropriate balance of resource allocation between preventing fatalities and preventing or mitigating injuries which seriously impair the quality of life? It is hoped that this study will make a useful contribution to addressing these questions.

APPENDIX I APPROACHES AND ISSUES IN VALUING LIFE WITH REFERENCE TO ACCIDENT COSTING

The costing of transport accidents is a means of evaluating the economic and social impact of such accidents on the community. It is also a means of raising public awareness of the problems associated with transport accidents. Additionally, and often most importantly, the costing of accidents is used to assist in determining how much expenditure is warranted in reducing accident numbers and their severity.

This study provides conservative estimates of the total cost of transport accidents in Australia in 1988. Estimates have also been provided of the various components of the total cost of accidents for each mode. On the basis of these estimates, it would be possible to make certain judgments, within a cost–benefit framework, on the resources that could be saved by reducing accidents by a given amount. Consequently, the estimates may be used in formulating policies aimed at reducing accident-related mortality and morbidity.

THEORETICAL ISSUES IN VALUING LIFE

The valuation of life is generally an emotive issue fraught with philosophical and conceptual problems and ridden with controversy and debate. Broome (1978) argued that if death is to be immediate and no bequests are permitted, the monetary value of life must be infinite. He reasoned that no finite amount of money could compensate a person for the loss of life as money is of no use to a dead person. Consequently, Broome took the controversial position that cost–benefit analysis is generally inappropriate for judging any proposal involving deaths.

Despite the conceptual and practical difficulties involved in the value-of-life issue, most economists and practitioners of cost–benefit analysis are constrained to settle for a position between two possible extremes: that life is priceless or that it is worthless. The limited resources available for public projects and the consequent need for efficient resource allocation require that life saving programs, such as those relating to transport safety, be assigned a value. If such valuations are not explicitly made they will be made implicitly through decisions pertaining to whether or not certain projects are to be carried out and by the levels of funding allocated to competing projects. As Linnerooth (1979) observed, any allocative decision that affects individual risk levels implicitly places a priority or a value on human life, and a major purpose of the cost–benefit calculus is to make these values explicit.

It is considered that the term 'value of life' commonly encountered in the literature on this subject is a misnomer. The valuation of human life, per se, involves intractable problems. Fisher (1909) observed that 'it is impossible in any true sense to measure human life in terms of dollars and cents'. In this day and age, human life is not generally a marketable commodity and therefore the notion of a monetary value to be attached to life would seem intrinsically illogical. As will be discussed in this appendix, methods devised to value 'life' actually measure the value of livelihood, the value of changes in mortality probability or some such quantifiable proxy. The term 'value of life' should therefore be interpreted in this context.

APPROACHES TO VALUING LIFE

The concept of attaching a price to a human being has an ancient lineage in the slave trade. Early Anglo-Saxon law provided for a fine for homicide called the wergeld (man-money) which was paid to the clan of the deceased (Lunt 1956). In more recent times the following approaches to valuing life have been proposed.

- The *human capital* approach (also sometimes referred to as the output, productivity, livelihood, accounting or ex-post approach) values an individual as a productive entity and essentially involves discounting to a present value the future income or earnings stream of an individual using an appropriate discount factor. Issues relating to the human capital approach that have been subject to some debate include the question of whether gross output or output net of the individual's expected lifetime consumption is the appropriate measure and whether income or earnings should be used as the measure of output.
- The *willingness-to-pay* approach (also known as the probability, subjectivist, risk or ex-ante approach) is based on the amount an individual would be willing to pay for a safer life and involves individual valuations of small changes in risk to life. If a given individual is willing to pay a maximum of $\$x$ to reduce the probability of death by an amount y, the value of the risk reduction (sometimes referred to as the value of life saving or more loosely as the 'value of life') is assigned a value $\$x/y$. It would obviously not be appropriate to apply this procedure in the case where an identified person faces certain death.
- The *discounted consumption* approach measures the total gain that an individual receives for remaining alive.
- The *implicit value* approach involves determining a value of human life from the investments made by society, through its political process, which impact on mortality rates. Carlson (1963) who assessed the cost of certain safety measures, such as ejection systems in combat aircraft, was the first to adopt the approach.

- The *insurance value* approach uses the premium paid and the probability of being killed in a specific activity to calculate the value placed by an individual on life.
- The *court award* approach values life in terms of the amount awarded by the courts to the next of kin of the deceased individual as compensation from the party held to be responsible for the death.
- The *replacement cost* method involves the estimation of the cost of replacing an individual.
- The *valuation of time* approach measures the value of an individual's remaining life expectancy in terms of the aggregated value of time over this period.

All these approaches have attracted criticism and have been considered deficient in one respect or another. Accordingly, none has found universal acceptance. However, of these approaches, only human capital and willingness-to-pay have been used extensively in empirical work.

THE ORIGIN AND DEVELOPMENT OF THE HUMAN CAPITAL AND WILLINGNESS-TO-PAY APPROACHES TO VALUING LIFE

Human capital approach

Early development of an accounting approach to the valuation of life, which has come to be commonly known as the human capital approach, was an outgrowth of work relating to British taxation. The earliest known attempt to value life using an accounting approach can be traced back to the taxation-related work of Petty (1699). Petty's method involved estimating total labour income of the population of England by subtracting profit from land and other sources from total national income. National income was estimated by multiplying average income (which Petty equated with average expenditure) by the population of England. He calculated the capital value equivalent of the labour income if invested at an annual rate of interest of 5 per cent over 20 years. This capital value was divided by the population of England to yield a value per capita of approximately 80 pounds sterling. Petty considered his method suitable for calculating the value of losses to life from causes such as war and plague.

The concept of human capital refers to the notion that a trained worker is a valuable investment. Smith (1776) referred to the returns to education and likened an educated person to an expensive machine. Basically, human capital theory postulates that investment in general education and vocational training improves economic efficiency and promotes economic growth. Important contributions to human capital theory have been made by Schultz (1961), Weisbrod (1961a, 1961b) and Becker (1962, 1964). Valuing life by discounting an individual's future earnings stream has been termed the human capital approach because it is consonant with the methodology of the human capital theorists.

The approach to valuing life by discounting future earnings to a present value with recourse to a life table was pioneered by William Farr (1853). Like Petty, Farr was concerned with taxation issues, and proposed a property tax which included a tax on human capital in the form of the value of an individual's earning capacity. Farr's basic method, with various embellishments, has been applied in numerous studies involving the valuation of life. The human capital approach has been applied mainly in the areas of life insurance, accidents, education, health care and life saving programs.

In applying the human capital method, consideration should be given to the varying pattern of earnings at successive ages, fluctuating labour force participation rates and the age and gender-specific expectations of working and retirement life. Additionally, an appropriate discount rate has to be used to convert a stream of future earnings to a present value. The human capital approach assumes full employment and the absence of technological change that would alter the relative marginal productivity of different types of labour over time.

In empirical work an estimate is usually made of the future growth in real earnings or labour productivity, and this is incorporated in future earnings streams. This may be achieved by the use of an 'effective discount rate', whereby the productivity growth rate partially offsets the chosen discount rate. For example, a discount rate of 7 per cent together with a productivity growth rate of 2 per cent per year would be equivalent to an effective discount rate of 4.9 per cent ({1.07/1.02 – 1} * 100).

Willingness-to-pay approach

The idea of a probabilistic approach to valuing life and safety germinated in a paper by Dreze (1962), which appears to have considerably influenced the development of the willingness-to-pay concept, notably the early work of Jones-Lee (1969). Dreze considered the valuation issue in terms of the probability of death and individual decision making under conditions of uncertainty. Significant contributions to the development of the willingness-to-pay approach have also been made by Schelling (1968) and Mishan (1971).

Schelling (1968), in a celebrated paper that called into question the rationale of the human capital approach to valuing life, observed that there is no reason to suppose that individuals' discounted future earnings bear any particular relationship to what they would pay to reduce the likelihood of their deaths. Schelling also argued that the human capital approach essentially measures loss of livelihood due to premature death rather than the value of life and that willingness-to-pay is conceptually superior to the human capital approach. The outcome of most public programs to save lives is a reduction of mortality rates, and it was this reduction that Schelling was attempting to value. In essence, the approach involves the valuation of risk reduction and avoids directly assigning a specific value to life.

Mishan (1971) rejected the human capital approach based on output or gross national product (GNP) and considered that the proper criterion to be used in dealing with allocative problems was potential Pareto improvement. According to this criterion, a project is regarded as socially beneficial if the gainers from the project can more than compensate the losers, such that at least one person is made better off with none being made worse off. He viewed the valuation of life issue from the perspective of the potential Pareto improvement criterion and considered that willingness-to-pay was the only approach to valuing life and safety consistent with this criterion.

A project would, on balance, be likely to make some individuals better off and some worse off. From a social cost–benefit perspective, Mishan's approach involves determining the amounts gainers are willing to pay and losers are willing to accept. If the sum of the former exceeds that of the latter, there would be a potential Pareto improvement or an excess of benefits over costs and the project should be implemented. This is equivalent to stating, that for a project to be accepted, the sum of the compensating variations of all the individuals affected by the project should be positive. The compensating variation is an amount of money received by or from an individual which, after a change in welfare, leaves the individual at the original level of welfare.

ADVANTAGES AND PROBLEMS RELATING TO THE HUMAN CAPITAL AND WILLINGNESS-TO-PAY APPROACHES

Human capital approach

The most appealing feature of the human capital approach is that it is simple to use and permits a numerical estimate to be relatively easily calculated. Because the human capital approach has been widely adopted, estimates obtained by use of the method can be compared with the results of other relevant studies. Arthur (1981) pointed out that the method is actuarial in that it uses full age-specific accounting to evaluate changes in mortality.

However, there are also some problems associated with the human capital approach. It focuses exclusively on output or GNP, the maximisation of which, it may be argued, is not the sole aim of economic policy. To the extent that earnings are used to value life, the method could ascribe negative values to the very young and the aged. For instance, the application of the GNP criterion would imply that the prolongation of life during retirement would have little or no economic justification because the individual would not make a substantial contribution to increasing GNP.

The human capital approach uses the market wage as a proxy for the value of the individual's marginal product. Market wages may not represent the true value of the marginal product of some employed individuals such as women and members of minority groups because imperfections in the labour market such as wage discrimination could produce inaccurate estimates. The use of earnings to value life does not take account of the degree of intensity of desire of individuals to live and to vary their survival probability and of the valuations associated with such desire.

The human capital approach could be criticised for its limitations in taking proper account of factors that are generally outside the ambit of GNP, such as the contribution of homemakers and the value of certain non-financial externalities of a psychic, emotional and humane nature such as pain, suffering, grief, friendship, love and moral support. Another difficulty is that the human capital approach may favour more productive people over less productive people such as the aged, in a manner that may not accord with social values. By the same token, lives which have made great intellectual, artistic or cultural contributions to humanity must necessarily defy valuation by the human capital calculus.

Empirical studies in the human capital tradition have generally sought to refine the methodology and have attempted to include as many cost components as possible within its accounting framework. For example, Somerville and McLean (1981) in their study of the costs of road accidents in Adelaide calculated funeral costs, as did Ridker (1967), as the average funeral costs in the actual year of death less the present value of average funeral costs incurred at the end of the actuarially expected lifetime. However, some costs, particularly intangible elements such as pain and suffering, have proved to be very difficult or impossible to meaningfully quantify.

Willingness-to-pay approach

The early work on willingness-to-pay, particularly by Schelling (1968), Jones-Lee (1969) and Mishan (1971), has led to the espousal of the approach by many academic economists and to a widespread view that it is, theoretically, the most valid approach to valuing life. A willingness-to-pay valuation of risk reduction is perceived by many economists as comprehensively measuring the value placed on life and safety by individuals, and as incorporating subjective welfare costs such as pain, suffering and grief. However, there are several problems, mostly of a practical and procedural nature, with the approach. Mishan (1971) was alluding to both the practical difficulties of the willingness-to-pay approach and, in his view, its theoretical superiority over the human capital approach, when he stated that '... there is more to be said for rough estimates of the precise concept than precise estimates of economically irrelevant concepts'.

The results of studies to assess individuals' valuations of small changes in risk are questionable for a number of reasons. Fromm (1968) questioned the validity of the willingness-to-pay measure on the grounds that individuals usually ignore the external social costs in making personal decisions and that some actually derive a positive utility from taking small risks. The willingness-to-pay approach assumes that individuals are well informed, are capable of comprehending small changes in the risk of awesome events such as death, and are able to make rational decisions regarding their own welfare.

Conformity to a system of axioms such as that proposed by Von Neumann and Morgenstern (1947) or Savage (1954) is generally regarded as the norm for rational decision making and most economic models are constructed on the assumption that these axioms are satisfied. However, there appears to be substantial evidence in the area of behavioral decision theory that calls into question the rationality assumption in individual decision making and risk perception. Apart from problems associated with rationality, there is the possibility of 'strategic' behaviour whereby individuals deliberately misrepresent their willingness-to-pay if they believe that the good in question is likely to be publicly provided.

The application of the Pareto criterion implies that the willingness-to-pay approach is concerned, in the main, with social welfare and economic efficiency in the aggregate, while neglecting distributional issues. In fact, Robinson (1986) argued that the use of the Pareto criterion in support of the willingness-to-pay approach was in effect no different from the GNP criterion on which the human capital approach is based. Robinson also made the point that the willingness-to-pay approach, because of its subjective nature, places it in a position inconsistent with the principles of cost-effectiveness. He further argued that the approach may not be compatible with certain dimensions of social values such as when society wishes to influence the values and choices of its members, and that it suffers from circularity because the subjective valuations individuals place on government projects are often influenced by those projects.

EMPIRICAL METHODS AND ESTIMATES OF WILLINGNESS-TO-PAY

Empirical studies on the valuation of life based on willingness-to-pay have been of three types: expressed preference or contingent valuation (the use of interviews and questionnaires); revealed preference or observed behaviour relating to the purchase or consumption of safety-related items; and hedonic wages or compensating wage differentials for workers in hazardous jobs.

Two prominent studies that adopted the questionnaire approach were those by Acton (1973) and Jones-Lee (1976). Acton's pioneering study investigated people's willingness-to-pay for cardiac care facilities such as ambulances for patients suffering heart attacks. The study by Jones-Lee (1976) measured the value of reductions in risk of death by confronting individuals with a choice between two airlines with different safety records and fares.

Examples of the use of the revealed preference approach involving safety consumption include the study of car seat belt use by Blomquist (1979) and the demand for residential smoke detectors by Dardis (1980). Compensating wage differentials have been used by Thaler and Rosen (1976) and Vicussi (1978), among other researchers.

Surveys of willingness-to-pay studies by Blomquist (1981, 1982) and Miller (1989) indicate that the values resulting from individual studies tend to vary widely. For example, Blomquist (1981) surveyed several studies on the value of life saving and adjusted the values resulting from the studies to 1979 US dollars to facilitate comparison. The questionnaire approach yielded highly disparate values for the saving of a single life. The value in Acton's study was US$50 000 per life saved while Jones-Lee's study produced a value of US$8.9 million. Although disparate values, even for individuals in similar circumstances, do not constitute grounds for completely rejecting the estimates, they do tend to limit their usefulness.

Miller (1989) assessed 49 studies on the value of risk reduction and concluded that 29 of them were reasonably sound in regard to methodology. He converted the estimates reslting from these good quality studies to 1985 post-tax US dollars and made other appropriate adjustments to ensure comparabilty. An important adjustment was a correction for the fact that people behave in accordance with perceived, rather than actual, risk levels. The mean investment level to save one life was found to be $1.95 million with a standard deviation of $0.5 million. Miller observed that the level of uncertainty is no greater than that found in most countermeasure effectiveness estimates using cost–benefit analysis. He concluded that the emergence of a consistent value range from studies using different approaches and data sets suggests that methodological concerns in regard to individual studies are not very important. If the different methods produced errors, the errors were not large enough to substantially skew the values obtained.

It would seem worthwhile for a relationship to be established, if possible, between the values of life obtained using the willingness-to-pay approach and the human capital approach. Linnerooth (1979) reviewed several theoretical models in which the probability of premature death was a variable which consumers were aware of and within their control. She concluded that there were no theoretical grounds for establishing an empirically useful relationship between lifetime earnings and willingness to pay for an increased chance of survival. Linnerooth argued that any quantifiable relationship resulted from erroneously equating the utility of living with the utility of lifetime consumption.

Linnerooth also argued that, assuming the utility of lifetime consumption is a lower bound to an individual's utility of living, lifetime earnings would serve as a lower bound to willingness-to-pay for a decreased chance of premature death. Support for this view may be drawn from the work of Usher (1971) and Conley (1976), which indicates that the value of life saving is greater than future earnings. Such a situation is plausible because the value of life is based on willingness-to-pay for small changes in risk and not on amounts individuals will be prepared to pay for a definite extension of life.

Available empirical evidence in regard to the relative values of lifetime earnings and willingness-to-pay for reduced risk to life appear to support the idea that willingness-to-pay will exceed discounted lifetime earnings. Blomquist (1979) in his study of automobile seat belt use estimated the value of life in 1978 US dollars at US$370 000 which he found was more than twice the average potential forgone earnings of the drivers studied. He also found that the elasticity of the value of life with respect to future earnings was about 0.3, considerably less than the unit elasticity implied by the human capital approach.

In the study by Blomquist (1981) referred to earlier, nine studies based on willingness-to-pay were surveyed and the present value of discounted future earnings for each study was calculated. Blomquist found that the ratio of value of life to future earnings was greater than unity in all nine studies, ranging widely from 1.3 to 107. A study by Rice, Mackenzie and Associates (1989) on the cost of injury in the United States in 1985 found that the value of life estimated by the willingness-to-pay approach was about US$2.0 million compared with an average fatality cost of about US$350 000 using the human capital approach.

A recent study conducted in New Zealand used the survey method to estimate willingness-to-pay values of life saving (Miller & Guria 1991). This approach yielded a recommended average value of NZ$2.0 million and was based on willingness-to-pay of families to buy road safety for their members. The study estimated the willingness-to-pay amount to protect the public at NZ$350 000 per life saved.

ASSESSMENT OF THE APPROACHES

The human capital and willingness-to-pay approaches are conceptually different. In a philosophical sense, the human capital approach has been associated with the material welfare school in economics characterised by the work of A. Marshall and A. C. Pigou while the willingness-to-pay approach has been linked with the neo-classical welfare economics of L. Robbins and N. Kaldor (Robinson 1986). In this context, the human capital approach is consistent with the belief that the proper role of government is to actively promote individual welfare, whereas the willingness-to-pay approach is aligned with the concept of consumer sovereignty and a less interventionist role of government in society.

Both the human capital and willingness-to-pay approaches to valuing life have their strengths and weaknesses and they both have common deficiencies. For example, Arthur (1981) observed that both the human capital and willingness-to-pay approaches have the disadvantage of being partial equilibrium approaches which neglect the wider implications of prolongation of life.

In applying both approaches, the prevailing distribution of income in society is taken as given. The ex-post human capital approach measures the value of output or productivity and is therefore appropriate for evaluating the economic return from life. It estimates the direct cost of lost output due to premature death or injury and also allows an estimate of the indirect costs to be attempted within the same framework. However, as noted earlier, some of these indirect costs include such intangibles as pain and suffering, which are difficult, if not impossible, to properly measure on an ex-post basis.

The willingness-to-pay approach, on the other hand, measures the desire to live and the satisfaction to be obtained from life and encompasses various intangible and emotional costs best valued at the individual level. Individuals who value life and derive enjoyment or utility from it would be expected to sacrifice some consumption or saving to extend their lives. The willingness-to-pay approach can therefore provide some scope for estimating the impact of intangible factors such as pain, suffering, bereavement, fear and anxiety.

Willingness-to-pay values represent ex-ante or before the event estimates. They could therefore be used to assess the values individuals place on changes in welfare associated with given changes in risk. Individual preferences, as revealed through willingness-to-pay estimates, could provide useful indicators for the formulation of public policy.

The human capital approach is an empirical approach for valuing the life of a human being as a productive entity and generally provides lower estimates than the willingness-to-pay approach. Therefore, on the premise that the willingness-to-pay value would be equal to or greater than the human capital value, the human capital approach could provide a lower bound estimate of a willingness-to-pay value or, in appropriate circumstances, a rough guide to estimating it.

While human capital would generally produce lower estimates than willingness-to-pay, the values obtained using the two approaches would to some extent depend on the circumstances and population groups examined. Data from the study by BTCE (1988) indicate that in the year 1985, 54 per cent of males and 41 per cent of females admitted to hospital as a result of road accidents were between the ages of 17 and 29. Individuals in this age bracket would be expected to have relatively high values of discounted earnings streams but observed behaviour in regard to risk by these younger members of society may not indicate a substantial valuation of their own lives. Consequently, it would appear that the application of the human capital approach could result in greater emphasis being placed on road accident prevention programs for younger members of society than would the willingness-to-pay approach.

Robinson (1986) points out that as suicide victims place a low value on their lives, application of willingness-to-pay to a suicide prevention program would produce very low values, whereas the human capital approach could yield high values because of the social costs associated with suicide. It follows that the suitability of each approach depends to some extent on the situation at hand, and that the results of both approaches can be valuable inputs into the public sector decision making process. However, it should be recognised that both the human capital and willingness-to-pay approaches are intended as decision making aids and not final arbiters in the decision making process.

Robinson (1986) sums up the case for the human capital approach thus: 'the human capital approach not only provides a reliable and internally consistent set of numbers, but it has a strong theoretical foundation, and as such can provide useful information to decision makers in the public sector ... the willingness-to-pay approach is no less value-laden than the human capital approach and both reflect judgments concerning the appropriate distributions of income and health status in society'.

METHODOLOGICAL CONSIDERATIONS IN USING THE HUMAN CAPITAL APPROACH

Income versus earnings

In calculating the value of output losses due to morbidity or premature mortality the question arises as to whether earnings (the remuneration for output as measured by market wages) or income (wages, rent, interest and profit) is more appropriate.

Dublin and Lotka (1946) considered that it was only earned income that was relevant in computing the value of life by the human capital approach. They argued that income from investments and other property should be excluded since it represents essentially the return from such property rather than the reward of the current productive efforts of the individual. Mishan (1971) observed that the loss to the economy from a premature death would be the expected gross earnings or value added by the individual exclusive of any yields from non-human capital as the returns from non-human assets would continue after death.

Nevertheless, several Australian accident studies such as those by Atkins (1981), Somerville and McLean (1981) and BTCE (1988) have used income as the measure of lost output. BTCE (1988) performed a sensitivity analysis and found that in its study the use of income and earnings produced similar results. As the use of earnings rather than income is considered to be in conformity with the rationale of the human capital approach, the earnings measure of output has been used in this study.

Consumption

Whether output should be measured net or gross of consumption has been subject to some debate. Petty (1699) in his pioneering application of a crude human capital method did not deduct consumption expenditure from gross income in calculating the capitalised value of a human life. In criticising this approach, Dublin and Lotka (1946) observed that 'it is as if, in estimating the value of an industrial installation as an income producing capital, we were to omit from reckoning the cost of fuel and other materials consumed in the manufacturing process'. Farr (1853) who was the first to adopt the method of discounting to a present value an individual's future earnings stream as a measure of the economic value of the individual, used earnings net of consumption.

One of the earliest studies to depart from the net output approach was that of Fein (1958). Fein conceded that individuals consume partly in order to maintain themselves and that therefore some of their consumption may be viewed as a gross investment to take account of depreciation. However, he also perceived consumption as an end in itself and as a final rather than intermediate step in the creation of other products. According to Fein, the social economy exists for the purpose of enabling the individual to enjoy life. An individual's demise would result in the loss of production and consumption together with the enjoyment derived from the consumption. He therefore considered that although the net of consumption value is more appropriate in measuring the value of individuals to their families, the gross measure is the correct one to use in assessing the value of an individual to society.

Other proponents of the gross output approach in the valuation of life from a social perspective include Ridker (1967), Mishan (1971) and Mooney (1977). Ridker's choice of the gross output approach derives basically from his view that society should comprise all its members. The use of the net output approach would entail assigning a negative value to some members of society. This approach would have distasteful implications because, as Ridker noted, it suggests that society should not interfere with the death of a person whose net value is negative.

Mishan (1971) observed that if consumption is deducted from output there would be some persons, notably retired individuals, whose death would confer a net benefit on society. Mishan rejected the net output approach on the grounds that it has no regard to the feelings of the potential victims — it ignores society ex-ante and concerns itself with society ex-post. The use of gross earnings involves defining society as including the potential victims and therefore includes their consumption while the net earnings approach perceives society without the potential victims.

Mooney (1977) considered that the use of the net or gross output approach depends on the use to be made of the values. He argued that if the figures are to be used to provide some estimate of the loss involved in the death of an individual, the net figure is more appropriate, whereas if the figures are to be used to estimate the benefits to be obtained from saving an individual from death, the gross approach would be relevant. Mooney argued that in the former case the individual is dead, is no longer a member of society and it is therefore not meaningful to refer to a loss to a person who does not exist. In the latter case, the problem is viewed from an ex-ante perspective which makes the individuals involved relevant because if their lives are saved, they will continue as members of society and their consumption will be a benefit to society.

Weisbrod (1961a, 1961b) argued that the issue of whether or not consumption should be included hinges on the definition of 'society'. He reasoned that if society is defined to exclude the persons being valued then their value to others should be measured by their contribution to production in excess of consumption. The difference between an individual's production and consumption would be the benefit to everyone else. A definition of society, which includes the person being valued, would according to Weisbrod, imply that gross productivity (without deducting consumption) should be used as a measure of value. This line of reasoning implies that the approach to be taken depends on the problem at hand. If the value of a person to other members of society is of concern, then productivity net of consumption would be more relevant, whereas if what is of interest is the value of a person's total output then gross productivity would be more appropriate.

One somewhat misconceived notion about the human capital approach is that it treats human beings as machines. Traditionally, the human capital approach has regarded individuals as investing in their own earning potential in addition to investing in physical capital. Consumption is the main purpose of production. In the context of the various arguments relating to the treatment of consumption detailed above, it is considered that, from a social perspective, it is total output that matters and consumption is a major part of that output. Consequently, output gross of consumption has been used in this study.

Dawson (1971), in a study of road accidents, calculated loss of output on a gross basis, and this appears to have been the first major accident study that departed from the net output basis. In Australia, accident studies which have used the net approach are those by Troy and Butlin (1971) and Patterson (1972). The first Australian study to use gross output was that by Atkins (1981). Australian accident studies by Somerville and McLean (1981), Brownbill (1984), BTCE (1988), and Cook et al. (1990) have adopted the gross output approach.

Household and community production

One of the criticisms of the human capital approach is that, because of its focus on GNP, it could overlook the contribution from non-market production. However, several empirical studies have sought to include estimates of such activity, particularly the output of individuals involved in home duties.

Atkins (1981) obtained data from a US accident study by Faigin (1976) on the average amount of time spent by individuals on family and community work, which equated to 30 per cent of a 40-hour work week. This figure of 30 per cent was also used by Brownbill (1984) who closely followed Atkins' methodology. Somerville and McLean (1981) examined various studies involving household and community contributions to national output, and adopted a figure of 35 per cent of forgone income, which they assumed was a realistic measure of work performed outside a 40-hour work week. BTCE (1988), using ABS (1983) data and data from a study by Mercer (1985) on the provision of welfare services by volunteers in Victoria, estimated the time spent in home duties and community work at 41.3 per cent of a 39-hour working week.

An ABS (1990c) time use survey conducted in Sydney in 1987 resulted in actual time use data relating to household work. These data have been used in this study.

Labour on-costs

Total labour costs comprise direct wage and salary costs and labour on-costs. On-costs comprise payments of wages and salaries for time not worked, superannuation, workers' compensation costs, and other costs such as those relating to fringe benefits, clothing and training.

Rice and Cooper (1967) and Rice, Mackenzie and Associates (1989), in applying the human capital approach in the United States, adjusted earnings data upward to take account of wage supplements comprising employer contributions for social insurance, private pensions and welfare funds. In Australia, Abelson (1986) argued that the loss of marketed output should be generally valued at the discounted sum of the victim's wage and directly related on-costs.

The human capital approach involves society's valuation of the lost output or marginal product of an individual discounted to a present value. In the absence of perfectly competitive economic conditions, wages are the best, though not a precise indicator of the value of an individual's marginal product. The value of marginal product is therefore assumed to be at least equal to the marginal cost of labour. The marginal cost of labour is made up of the direct wage cost (market wage) plus labour on-costs. As the human capital approach measures the resources that society as a whole would lose if the individual ceases to exist or is disabled, consistency would require forgone earnings to be adjusted to take account of labour on-costs as has been done in this study. Labour on-costs were estimated from ABS (1990b).

SUMMARY

Human capital and willingness-to-pay are the two major approaches used to value life. However, what is actually valued is not life but specific reductions in mortality risk (willingness-to-pay) and livelihood or output (human capital). The human capital approach has been widely used and allows a numerical estimate to be calculated and compared on a reasonably consistent basis with values obtained from studies using the same approach. The willingness-to-pay approach, though associated with formidable problems of estimation, has been widely regarded as having greater theoretical validity than other approaches to valuing life.

The two approaches may be linked with two distinct views of the role of government in society. Willingness-to-pay is associated with a relatively passive role of government and upholds the concept of consumer sovereignty. Human capital is compatible with a more interventionist role of government in society.

There are considerable difficulties associated with the nature and assumptions of both the human capital and willingness-to-pay approaches. However, the results of both these empirical approaches can provide useful input into the public sector decision making process, but judgment would need to be exercised in deciding whether one approach is more appropriate than the other in a given situation.

The numerical facility associated with the human capital approach can be enhanced and the maximum benefits derived from its actuarial nature by drawing on available statistics such as the working life tables, by using the measures and methods most compatible with the overall approach and by attempting quantification of as many relevant cost factors as possible. On the basis that the human capital estimates generally provide lower bound estimates to willingness-to-pay, a carefully computed human capital figure could well be more useful than an uncertain willingness-to-pay estimate.

Determining a 'value of life' in an absolute sense might be beyond the professional scope and competence of an economic analyst or researcher. However, the value of reduced mortality risk or lost output due to premature death are amenable to quantification and are useful measures to assess projects involving the saving of lives. To this end, further development and refinement of the willingness-to-pay and human capital approaches will improve the precision of the numbers they generate which will, in turn, better aid the process of informed judgment that determines the pattern of resource allocation in society.

APPENDIX II DEFINITIONS OF TRANSPORT ACCIDENTS

Differing definitions of transport accidents, both within and between modes, can make cross-modal comparisons difficult. For example, a fall on an escalator at a railway station would be counted as a railway accident only in some rail systems and there is no comparable accident for road transport. Each mode of transport has its own administrative bodies which coordinate with statistical reporting authorities. Each mode also has several reporting authorities having their own procedures and reporting practices.

WORLD HEALTH ORGANISATION CLASSIFICATION OF TRANSPORT ACCIDENTS

The World Health Organisation (WHO) plays a major role in the standardisation of classifications in the area of mortality and morbidity — the science of nosology. As part of this responsibility the WHO develops and maintains the International Classification of Diseases of which the 9th Revision, (ICD-9) (WHO 1977) is the most recent.

In this classification system, accidental and violent deaths are classified according to the external cause or circumstances of the accident or violence which produced the injury and not according to the nature of the injury. The WHO uses a code referred to as an 'E code' to classify these external injuries. The classification system defines transport accidents such that each external cause of death is assigned a particular E code. The mortality statistics compiled by the Australian Bureau of Statistics, including those relating to the four transport modes (road, rail, air and maritime), are based on the WHO ICD-9 classification.

The WHO classification system defines a transport accident as 'any accident involving a device designed primarily for, or being used at the time primarily for, conveying persons or goods from one place to another'. WHO coding of transport accidents largely has to do with the classification of the transport mode involved. Injuries caused by aircraft and spacecraft accidents are assigned codes E840 to E845; watercraft, E830 to 838; motor vehicles, E810 to E825; railway, E800 to E807; and other road vehicles, E826 to E829. In classifying accidents which involve more than one mode of transport the above order of precedence is used.

Accidents involving agricultural and construction equipment such as tractors, bulldozers, cranes and the like are regarded as transport accidents only when these vehicles are under their own power on a highway (otherwise the vehicles are regarded as machinery). Vehicles which can travel on land or water such as hovercraft and other amphibious vehicles are regarded as watercraft when on water, as motor vehicles when on highways, and as off-road vehicles when on land but not on highways.

Excluded from the transport section of the ICD-9 are accidents which take place in sports which involve the use of transport, but where the vehicle itself is not involved in the accident, and accidents involving vehicles which are part of industrial equipment used entirely on industrial premises. Also excluded are accidents occurring during transportation but unrelated to the hazards associated with the means of transportation (for example, injuries received in a fight on a ship or a transport vehicle involved in a cataclysm such as an earthquake) and injury to persons engaged in the maintenance or repair of transport equipment or vehicles not in motion, unless injured by another vehicle in motion.

Motor vehicle accidents

The WHO ICD-9 defines a *motor vehicle accident* as a transport accident involving a motor vehicle. This definition is further divided into a traffic accident or a non-traffic accident according to whether the accident occurs on a public highway or elsewhere. Excluded are injury or damage due to cataclysm and injury or damage while a motor vehicle, not under its own power, is being loaded on, or unloaded from, another conveyance.

Motor vehicle traffic accidents. A motor vehicle traffic accident is any motor vehicle accident occurring on a public highway (that is, originating, terminating or involving a vehicle partially on the highway). A motor vehicle accident is assumed to have occurred on a highway unless another place is specified, except in the case of accidents involving only off-road motor vehicles which are classified as non-traffic accidents unless otherwise stated.

Motor vehicle non-traffic accidents. A motor vehicle non-traffic accident is any motor vehicle accident which occurs entirely in any place other than a public highway.

Public highway. A public highway (trafficway) or street is the entire width between property lines (or other boundary lines) of every way or place, of which any part is open to the use of the public for the purposes of vehicular traffic as a matter of right or custom. A roadway is that part of the public highway designed, improved, and ordinarily used, for vehicular travel. This includes public approaches to docks, public buildings and stations and excludes private driveways, parking lots and ramps. It also excludes roads in airfields, farms, industrial premises, mines, private grounds and quarries.

Motor vehicles. A motor vehicle is any mechanically or electrically powered device, not operated on rails, upon which any person or property may be transported or drawn upon a highway. Any object such as a trailer, coaster, sled or wagon being towed by a motor vehicle is considered to be part of the motor vehicle. Included are automobiles of any type, buses, construction machinery, farm and industrial machinery, steam rollers, tractors, army tanks, highway graders or similar vehicles on wheels or treads (while in transit under their own power), fire engines (motorised), motorcycles, motorised bicycles (mopeds) or scooters, trolley buses (not operating on rails), trucks and vans. This definition excludes devices used solely to move persons or materials within the confines of a building and its premises, such as a building elevator, coal car in a mine, electric baggage or mail truck used solely within a railway station, electric truck used solely within an industrial plant, and moving overhead crane.

Motorcycles. A motorcycle is a two-wheeled motor vehicle having one or two riding saddles and sometimes having a third wheel for the support of a side car. The side car is considered part of the motorcycle. Included are motorised bicycles (mopeds), scooters and tricycles.

Off-road vehicles. An off-road motor vehicle is a motor vehicle of special design, to enable it to negotiate rough or soft terrain or snow. Examples of special design are high construction, special wheels and tyres, driven by treads or supported on a cushion of air. This definition includes all-terrain vehicles, army tanks, hovercraft on land or swamp, and snowmobiles.

Drivers. A driver of a motor vehicle is the occupant of the motor vehicle operating it or intending to operate it. A motorcyclist is the driver of a motorcycle. Other authorised occupants of a motor vehicle are passengers.

Other road vehicles. An other road vehicle is any device, except a motor vehicle, in, on, or by which any person or property may be transported on a highway. Included are animals carrying persons or goods, animal-drawn vehicles, animals harnessed to a conveyance, bicycles and tricycles (pedal cycles) and streetcars. Excluded are pedestrian conveyances (see below).

Streetcars. A streetcar is a device designed and used primarily for transporting persons within a municipality, running on rails, usually subject to normal traffic control signals and operated principally on a right-of-way that forms part of the traffic way. A trailer being towed by a streetcar is considered a part of the streetcar. The definition includes inter-urban and intra-urban electric streetcars when specified to be operating on a street or public highway, trams and trolleys.

Pedal cycles. A pedal cycle is any road transport vehicle operated solely by pedals. The definition includes bicycles, tricycles and pedal cycles but excludes motorised bicycles.

Pedal cyclists. A pedal cyclist is any person riding on a pedal cycle or in a sidecar attached to such a vehicle.

Pedestrian conveyances. A pedestrian conveyance is any human-powered device by which a pedestrian may move other than by walking or by which a walking person may move another pedestrian. Included are baby carriages, coaster wagons, ice skates, roller skates, perambulators, pushcarts, pushchairs, scooters, skateboards, skis, sleds and wheelchairs.

Pedestrians. A pedestrian is any person involved in an accident who was not at the time of the accident riding in or on a motor vehicle, railroad train, streetcar, animal-drawn or other vehicle, or on a bicycle or animal. This includes a person changing a tyre of a vehicle, in or operating a pedestrian conveyance, making adjustments to a motor vehicle or on foot.

ICD-9 motor vehicle traffic accidents (E810-E819)
E810 *Motor vehicle traffic accident involving collision with a train.* Excludes: motor vehicle collision with object set in motion by railway train and railway train hit by object set in motion by motor vehicle.

E811 *Motor vehicle traffic accident involving re-entrant collision with another motor vehicle.* Includes: collision between motor vehicle which accidentally leaves the roadway then re-enters the same roadway, or the opposite roadway on a divided highway, and another vehicle. Excludes: collision on the same roadway when none of the motor vehicles involved have left and re-entered the roadway.

E812 *Other motor vehicle traffic accident involving collision with motor vehicle.* Includes: collision with another vehicle parked, stopped, stalled, disabled, or abandoned on the highway, and motor vehicle collision not otherwise stated. Excludes: collision with object set in motion by another motor vehicle, and re-entrant collision with another motor vehicle.

E813 *Motor vehicle traffic accident involving collision with other vehicle.* Includes: collision between motor vehicle of any kind and other road (non-motor transport) vehicle such as an animal carrying a person, animal-drawn vehicle, pedal cycle or streetcar. Excludes: collision with object set in motion by non-motor road vehicle, pedestrian, and non-motor road vehicle hit by object set in motion by motor vehicle.

E814 *Motor vehicle traffic accident involving collision with a pedestrian.* Includes: collision between motor vehicle of any kind and pedestrian including pedestrian dragged, hit, or run over by a motor vehicle of any kind. Excludes: pedestrian hit by object set in motion by motor vehicle.

E815 *Other motor vehicle traffic accident involving collision on the highway.* Includes: collision (due to loss of control) on highway between motor vehicle of any kind and: abutment (bridge, overpass); animal (herded, unattended); fallen stone; traffic sign; tree; utility pole; guard rail or boundary fence; inter-highway divider; landslide (not moving); object set in motion by railway train or road vehicle (motor or non-motor); object thrown in front of motor vehicle; safety island; temporary traffic sign or marker wall of cut made for road; other object, fixed movable or moving. Excludes: collision with any object off the highway (resulting from loss of control); any object which normally would have been off the highway and is not stated to have been on it; motor vehicle parked, stopped, stalled, disabled, or abandoned on highway; moving landslide; motor vehicle hit by object set in motion by railway train or road vehicle (motor or non-motor) thrown into or on vehicle.

E816 *Motor vehicle traffic accident due to loss of control, without collision on the highway.* Includes: motor vehicle failing to make curve; going out of control due to blowout; burst tyre; driver falling asleep; driver inattention; excessive speed; failure of a mechanical part; and colliding with object off the highway; overturning; or stopping abruptly off the highway. Excludes: collision on highway following loss of control and loss of control of vehicle following collision on the highway.

E817 *Non-collision motor vehicle traffic accident while boarding or alighting.* Includes: while boarding or alighting: fall down stairs of motor bus; fall from car in street; injured by moving part of the vehicle; trapped by door of motor bus.

E818 *Other non-collision motor vehicle traffic accident.* Includes: for motor vehicle while in motion: accidental poisoning from exhaust gas generated by breakage of any part; explosion of any part; fall, jump, or being accidentally pushed from; fire starting in; hit by object thrown into or on; injured by being thrown against some part of, or object in; injury from moving part of; object falling in or on; object thrown on. Collision of railway train or road vehicle except motor vehicle, with object set in motion by motor vehicle, motor vehicle hit by object set in motion by railway train or road vehicle (motor or non-motor), pedestrian, railway train, or road vehicle (motor or non-motor) hit by object set in motion by motor vehicle. Excludes: collision between motor vehicle and: object set in motion by railway train or road vehicle (motor or non-motor), object thrown towards the motor vehicle, person overcome by carbon monoxide generated by stationary motor vehicle off the roadway with motor running.

E819 *Motor vehicle traffic accident of unspecified nature.* Includes: motor vehicle traffic accident not otherwise stated and traffic accident not otherwise stated.

E820–E825 *Motor vehicle non-traffic accidents.* Includes: accidents involving motor vehicles being used in recreational or sporting activities off the highway, and collision and non-collision motor vehicle accidents occurring entirely off the highway. Excludes: accidents involving motor vehicle and aircraft or watercraft; accidents not on the public highway involving agricultural and construction machinery but not involving another motor vehicle.

Railway accidents

A *railway accident* is a transport accident involving a railway train or other railway vehicle operating on rails, whether in motion or not. This excludes accidents in repair shops, in roundhouse or on turntable, and on railway premises but not involving a train or other railway vehicle.

Railway train or railway vehicle. A railway train or railway vehicle is any device with or without cars coupled to it which is designed for traffic on a railway. This includes inter-urban electric cars and streetcars (trams) operated chiefly on their own right-of-way, not open to other traffic; railway trains using any power (diesel, electric, steam); funiculars, monorails or any two-rail subterranean or elevated trains; and other vehicles designed to run on a railway track. This definition excludes inter-urban electric cars (street cars or trams) specified to be operating on a right-of-way that forms part of the public street or highway.

Railway or railroad. A railway or railroad is a right-of-way designed for traffic on rails, which is used by carriages or wagons transporting passengers or freight, and by other rolling stock, and which is not open to other public vehicular traffic.

ICD-9 railway accidents (E800–E807)
E800 *Railway accident involving collision with rolling stock.* Includes: collision between railway trains or railway vehicles of any kind; collision not otherwise stated on railway; derailment with antecedent collision with rolling stock or not otherwise stated.

E801 *Railway accident involving collision with other object.* Includes: collision of railway train with: buffers, fallen tree, gates, platform, rock on railway, tram, other non-motor vehicle, or other object. Excludes: collision with aircraft or motor vehicle.

E802 *Railway accident involving derailment without antecedent collision.*

E803 *Railway accident involving explosion, fire or burning.* Excludes: explosion or fire with antecedent derailment and explosion or fire with mention of antecedent collision.

E804 *Fall in, on, or from railway train.* Includes: fall while alighting from or boarding railway train. Excludes: fall related to collision, derailment or explosion of railway train.

E805 *Hit by rolling stock.* Includes: crushed, injured, killed, knocked down or run over by railway train or part. Excludes: pedestrian hit by object set in motion by railway train.

E806 *Other specified railway accident.* Includes: hit by object falling in railway train; injured by door or window of railway train; non-motor road vehicle or pedestrian hit by object set in motion by railway train; railway train hit by falling earth not otherwise stated, rock, tree or other object. Excludes: railway accident due to cataclysm.

E807 *Railway accident of unspecified nature.* Includes: found dead, injured or railway accident not otherwise stated on railway right-of-way not otherwise stated.

Aviation accidents

An aviation accident is a transport accident involving an aircraft. Included are occurrences associated with the operation of an aircraft which take place between the time any person boards the aircraft with the intention of flight until such time as all persons have disembarked.

Aircraft. An aircraft is any device for transporting passengers or goods in the air. This includes airplanes of any type, balloons, bombers, dirigibles, gliders (hang), military aircraft and parachutes.

A commercial transport aircraft is any device for collective passenger or freight transportation by air, whether run on commercial lines for profit or by government authorities, with the exception of military aircraft.

ICD-9 aviation accidents (E840–E845)
E840 *Accident to powered aircraft at take-off or landing.* Includes: collision of aircraft with any object, fixed movable or moving; crash; explosion on aircraft; and fire on aircraft while taking off and landing and forced landing.

E841 *Accident to powered aircraft other and unspecified.* Includes: aircraft accident not otherwise stated; aircraft crash or wreck not otherwise stated; any accident to powered aircraft while in transit or not specified; whether in transit, taking off or landing; collision of aircraft with another aircraft, bird, or any object, while in transit; explosion in aircraft while in transit; and fire on aircraft while in transit.

E842 *Accident to unpowered aircraft.* Includes: any accident, except collision with powered aircraft, to: balloon, glider, hang glider, kite carrying a person, hit by object falling from unpowered aircraft.

E843 *Fall in, on or from aircraft.* Includes: accident in boarding or alighting from aircraft (any kind); fall in, on, or from aircraft (any kind), while in transit, taking off or landing, except when as a result of an accident to aircraft.

E844 *Other specified air transport accidents.* Includes: (without accident to aircraft) hit by: aircraft, object falling from aircraft; injury by or from: machinery on aircraft, rotating propeller, voluntary parachute descent, poisoning from carbon monoxide from aircraft while in transit, sucked into jet. Also, any accident involving other transport vehicle (motor or non-motor) due to being hit by object set in motion by aircraft (powered). Excludes: air sickness and effects of high altitude, pressure change and injury in parachute descent due to accident to aircraft.

Maritime accidents

A maritime accident is one involving watercraft and small boats.

Watercraft. A watercraft is any device used for transporting passengers or goods on the water.

Small boat. A small boat is any watercraft propelled by paddle, oars, or small motor, with a passenger capacity of less than ten. This includes a canoe, coble, dinghy, punt, raft, rowboat, rowing shell, scull, skiff, small motor boat and boat not otherwise stated. Excluded are barges, lifeboats (used after abandoning ship), rafts (anchored) used as diving platforms, and yachts.

ICD-9 maritime accidents (E830–E838)

E830*Accident to watercraft causing submersion.* Includes: submersion and drowning due to: boat overturning; boat submerging; falling or jumping from burning ship; falling or jumping from crushed watercraft; ship sinking; and other accident to watercraft.

E831 *Accident to watercraft causing other injury.* Includes: any injury, except submersion and drowning, as a result of an accident to watercraft; burned while ship on fire; crushed between ships in collision; crushed by lifeboat after abandoning ship; fall due to collision or other accident to watercraft; hit by falling object due to accident to watercraft; injured in watercraft accident involving collision; and struck by boat or part thereof after fall from or jump from damaged boat. Excludes: burns from localised fire or explosion on board ship.

E832 *Other accidental submersion or drowning in water transport accident.* Includes: submersion or drowning as a result of an accident other than accident to the watercraft, such as: fall from gangplank, fall from ship, fall overboard, thrown overboard by motion of ship, and washed overboard. Excludes: submersion or drowning of swimmer or diver who voluntarily jumps from boat not involved in an accident.

E833 *Fall on stairs or ladders in water transport.* Excludes: fall due to accidents to watercraft.

E834 *Other fall from one level to another in water transport.* Excludes: fall due to accident to watercraft.

E835 *Other and unspecified fall in water transport.* Excludes: falls due to accident to watercraft.

E836 *Machinery accident in water transport.* Includes: injuries in water transport caused by machinery on deck or in engine room, galley and laundry, or by loading machinery.

E837 *Explosion, fire, or burning in watercraft.* Includes: explosion of boiler on steamship and localised fire on ship. Excludes: burning ship (due to collision or explosion) resulting in submersion or drowning or other injury.

E838 *Other and unspecified water transport accident.* Includes: accidental poisoning by gases or fumes on ship; atomic power plant malfunction in watercraft; crushed between ship and stationary object (wharf); crushed between ships without accident to watercraft; crushed by falling object on ship or while loading or unloading; hit by boat while water skiing; struck by boat or part thereof (after fall from boat); and watercraft accident not otherwise stated.

The WHO International Classification of Diseases is used to varying degrees in most transport accident work. In costing rail and maritime accidents in this study the WHO definitions were used almost exclusively. Other definitions of road and aviation accident are set out below.

OTHER DEFINITIONS RELATING TO TRANSPORT ACCIDENTS

Road accidents

In compiling statistics on road traffic accidents involving casualties ABS (1990a) uses a definition of road traffic accidents consistent with the definitions used by road traffic authorities in each State or Territory. To be classified as an accident for statistical purposes the following conditions must be met:

- The accident resulted in:
  - the death of a person within a period of 30 days of the accident; or
  - personal injury to the extent that the injured person was admitted to hospital.
- The accident occurred on any road, street, railway level crossing or any place open to the public provided it is not outside the road reserve.
- The accident involved one or more road vehicles which were in motion at the time of the accident.

A *fatal accident* is one in which at least one person was killed or died within 30 days as a result of the accident.

An *injury accident* is a non-fatal accident in which at least one person was admitted to hospital.

A *person killed* is a person who died within 30 days of the accident where death is attributable to injuries sustained in the accident.

A *person injured* is a person involved in a road accident resulting in the person being admitted to hospital.

Complete definitions are found in ABS (1990a). For non-hospitalisation accidents and injuries the States and Territories have their own reporting conventions.

Aviation accidents

The definitions of an aviation accident, injuries to persons, and damage to aircraft, used by the Bureau of Air Safety Investigation (BASI 1989) are those recommended by ICAO (1981).

Aviation accident. An occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all those persons have disembarked, in which:

- any person suffers death or serious injury as a result of being in the aircraft, by direct contact with the aircraft or anything attached to the aircraft or by direct exposure to jet blast.
- the aircraft suffers substantial damage or is destroyed; or
- the aircraft is missing or is completely inaccessible.

Excludes: death from natural causes and fatal or serious injury to any person on board whether self-inflicted or inflicted by another person; or to ground support personnel before or after flight; or fatal or serious injury which is not a direct result of the operation of the aircraft; or which concerns stowaways.

Fatal injury. Any injury which results in death within 30 days of the date of the accident.

Serious injury. Any injury other than a fatal injury which:
- requires hospitalisation for more than 48 hours, commencing within 7 days from the date the injury was received; or
- results in a fracture of any bones (except simple fractures of fingers, toes or nose); or
- involves lacerations which cause severe haemorrhage, nerve, muscle or tendon damage; or
- involves injury to any internal organ; or
- involves second- or third-degree burns, or any burns affecting more than 5 per cent of the body surface.

Minor injury. Any injury other than as defined under 'fatal injury' or 'serious injury'.

Destroyed. Consumed by fire, demolished or damaged beyond repair.

Substantial damage. Damage or structural failure which adversely affects the structural strength, performance or flight characteristics of the aircraft and which would normally require major repair or replacement of the affected component. The following types of damage are specifically excluded: engine failure; damage limited to an engine or its accessories, or to propellers; bent fairings or cowlings; small dents or puncture holes in the skin; damage to wing tips, antennae, tyres, or brakes.

Minor damage. Damage other than as defined under 'destroyed' or 'substantial damage'.

APPENDIX III ISSUES RELATING TO DEFINITIONS AND DATA

Problems were encountered at the data collection stage for all four transport modes, due to a lack of uniformity in the data. The essential data required for the aviation and road modes, for which the accident was used as the unit to be costed, were statistics relating to accidents, vehicles or aircraft, fatalities, persons hospitalised and suffering serious injury, persons needing medical treatment and suffering minor injury and other persons involved.

For rail and maritime accidents, where costs were calculated on a per casualty or person injured basis, the results were presented on a total cost basis or on a per person basis. The major reasons for the cost of the accident not being the basis of the estimates were the definitional and data problems associated with railway and maritime accidents. Several different definitions of rail and maritime accidents were adopted by organisations responsible for maintaining records of these accidents. Therefore, determining the number of accidents and the numbers of persons involved in different types of accidents was contingent on the definitions employed.

DERIVATION OF NUMBER OF ACCIDENT CASUALTIES AND VEHICLES BY ACCIDENT CLASS

Road accidents

Fatal accidents and fatalities

All States and Territories were able to report the number of fatal accidents and the number of fatalities. The total number of fatalities in 1988 reported by ABS (1990a) was 2887 while the number of fatalities in 1988 reported by FORS (1991) was 2875 — a difference of 12 fatalities. The FORS figure has been used in this study. The number of vehicles involved was not reported by all States and Territories, and the number of vehicles involved for non-reporting States and Territories was derived by using the ratio of vehicles per fatal accident for the reporting States and Territories.

Hospital admissions

The number of hospital admissions in 1988 by State and Territory was obtained from ABS (1990a). It was found that ABS recorded 10 333 admissions for Victoria and 8668 admissions for New South Wales. According to the TAC (1991) there were 5656 persons hospitalised as a result of Victorian road accidents. The AIH (1991) reports 7782 Victorian hospital admissions due to road accidents. This implies that there could have been about 1.4 admissions per injured person in Victoria.

The ABS figure of 10 333 admissions for Victoria was considered an overestimate, possibly due to reliance upon police recording whether a person was sent to hospital. It was considered that some injured persons may have been sent to hospital but were not admitted, and that the police may have recorded these as persons hospitalised. This may also have been the case in Queensland as the ABS compiled road accident statistics for that State up to mid 1991.[1] The other States and Territories report to the ABS through the relevant road traffic authorities.

As the AIH data for Victoria refer to financial year 1987–88 and the TAC data to calendar year 1988, some of the discrepancy between the figures from the two sources could be explained by the different time periods.

Data from VIC ROADS (pers. comm.) on admissions to acute care hospitals in Victoria indicate that there were 6134 admissions due to road accidents during calendar year 1988. This figure and the TAC estimate of 5656 hospitalised persons, indicate that there were 1.08 admissions per person.

Medical treatment

Three of the States and Territories reported the number of persons injured but not hospitalised. The ratio of persons seeking medical treatment to those hospitalised was derived from these data and applied to the other States and Territories.

Uninjured persons

Not all States and Territories reported the number of nil injury accidents, the number of persons not injured and number of vehicles involved. Where data were missing they were derived from known State and Territory data. In order to allow for the under-reporting of nil injury accidents a further adjustment was made, and this is discussed in chapter 3.

The number of uninjured persons in each accident class was estimated using the average number of persons per vehicle from Hensher (1989). The procedure is described in chapter 3.

Aviation accidents

Data relating to the number of persons killed, hospitalised, injured and who suffered nil injury, the number of accidents and the number of aircraft were

1. The Queensland Department of Transport has since been the official source of road accident statistics in Queensland. Also, more recently, the function of publishing official statistics on road crashes resulting in fatailities and serious injuries has been transferred from the ABS to the Federal Office of Road Safety (FORS).

provided by the Bureau of Air Safety Investigation (BASI). The BASI data are considered to have a high degree of reliability because of the centralised reporting system and because aviation accidents generally have a high public profile. In most cases, the ages of the victims were available from BASI records. In cases where the age was not available, the gender-specific average age of victims of known age for 1987 and 1988 was used.

Rail accidents

The State and Territory rail systems provided data relating to numbers of accidents, fatalities and persons involved but, because of differences in reporting methods, appropriate adjustments had to be made to make the data from different sources compatible.

Fatalities and suicides

All rail systems reported the numbers of fatalities and estimated how many of them were suicides. These numbers were adjusted by removing known suicides as well as those involved in level crossing accidents. The age and gender of victims were not always available and in these cases the average age from the ABS distribution of ages of persons killed in rail accidents was used.

Hospital and medical

Several rail systems provided data on the number of persons injured, and the distribution of rail injuries obtained from the TAC was used to allocate these persons to injury classes. The age and gender of victims were distributed according to the ABS distribution of fatalities.

Maritime accidents

The maritime data relate only to persons killed or hospitalised. The number, gender and ages of fatalities were obtained from ABS (1989a) and were not adjusted. Data relating to persons hospitalised were provided by the AIH and included the number of persons and days spent in hospital by gender. The age distribution of hospitalised victims was not available and as an alternative the combined (male and female) age distribution of the fatalities was applied to both male and female hospitalised victims. A gender-specific age distribution was not applied to the hospitalised victims (using the fatal distribution) because of the small number of females involved in maritime accidents.

APPENDIX IV FORGONE PRODUCTION COSTING MODEL

PAID PRODUCTION

The value of forgone production of accident victims used in this study is based on median weekly earnings in 1988 for various age groups (ABS 1988a). The median earnings data were scaled up by 21.2 per cent to take account of the value of labour on-costs such as superannuation, workers compensation, leave loading and the like (ABS 1990b), to generate the value of paid production (table IV.1).

TABLE IV.1 MEDIAN WEEKLY EARNINGS AND VALUE OF PAID PRODUCTION, 1988

($)

Age group	*Male median earnings*	*Male earnings plus on-costs*	*Female median earnings*	*Female earnings plus on-costs*
15–19	212	257	209	253
20–24	359	434	329	398
25–34	451	546	397	480
35–44	500	605	378	457
45–54	470	569	366	443
55–59	424	513	352	426
60+	396	479	374	453

Sources ABS (1988a, 1990b).

UNPAID PRODUCTION

The methodology described above provides an estimate of the value of the production of an individual while engaged in paid work. However, there is also a considerable amount of non-market or unpaid production which is not included in the national accounts. The value of unpaid production was estimated using data on the average number of hours per week spent by males and females in household and community activity (table IV.2). The data were obtained from a time use survey conducted by the ABS (1990c).

TABLE IV.2 TIME SPENT IN PAID AND UNPAID WORK, 1988
(hours per week)

	Paid work	Unpaid work
Male engaged in paid work	40.6	14
Female engaged in paid work	29.3	28
Male engaged in unpaid work only	na	21
Female engaged in unpaid work only	na	42

na Not applicable

Sources ABS (1990b, 1990c).

TABLE IV.3 ANNUALISED PAID PRODUCTION, UNPAID PRODUCTION AND WORKFORCE PARTICIPATION RATE, MALES, 1988

Age	*Paid production ($)*	*Unpaid production ($)*	*Workforce participation rate (per cent)*
15–19	7 803	2 725	58.2
20–24	20 502	4 614	90.3
25–34	26 982	5 796	94.6
35–44	29 977	6 426	94.8
45–54	26 395	6 041	88.8
55–59	20 165	5 449	75.2
60+	5 409	5 089	21.6

Sources ABS (1988a, 1990b, 1990c).

TABLE IV.4 ANNUALISED PAID PRODUCTION, UNPAID PRODUCTION AND WORKFORCE PARTICIPATION RATE, FEMALES, 1988

Age	*Paid production ($)*	*Unpaid production ($)*	*Workforce participation rate (per cent)*
15–19	7 587	7 444	57.4
20–24	15 584	11 718	74.9
25–34	15 817	14 140	63.0
35–44	16 304	13 464	68.2
45–54	13 286	13 036	57.4
55–59	7 213	12 537	32.4
60+	1 230	13 321	5.2

Sources ABS (1988a, 1990b, 1990c).

The value per hour of unpaid work has been assumed to be equal to that of paid work inclusive of on-costs. Table IV.1 and table IV.2 were combined to generate the annual value of paid and unpaid production for males (table IV.3) and females (table IV.4), for various age groups.

VALUE OF FORGONE PRODUCTION OF ACCIDENT VICTIMS

Tables IV.3 and IV.4 were combined with data on working life expectancy (Anderson and Ross 1987) to generate a potential earnings stream for accident victims of a particular age and gender.

A growth factor of 2 per cent per year was applied to this earnings stream to take account of real increases in productivity over time. The earnings stream was then discounted to 1988 by applying a discount rate of 7 per cent per year, which was also used by BTCE (1988).

The value of future production for males and females of various ages, as estimated by this method, is detailed in tables IV.5 and IV.6 respectively.

TABLE IV.5 ESTIMATES OF VALUE OF FUTURE PRODUCTION, MALES, 1988

Current age	Expected age at death	Remaining paid work years	Remaining non-paid years	Production ($'000)		
				Paid	Unpaid	Total
0	72.4	45.4	27.0	148	54	203
1	72.4	45.4	26.0	159	58	217
2	72.4	45.4	25.0	170	62	232
3	72.4	45.4	24.0	182	67	249
4	72.4	45.4	23.0	195	71	266
5	72.4	45.4	22.0	208	76	285
6	72.4	45.4	21.0	223	82	304
7	72.4	45.4	20.0	238	87	326
8	72.4	45.4	19.0	255	94	349
9	72.4	45.4	18.0	273	100	373
10	72.4	45.4	17.0	292	107	399
11	72.4	45.4	16.0	312	115	427
12	72.4	45.4	15.0	334	123	457
13	72.4	45.4	14.0	358	131	489
14	72.4	45.4	13.0	383	140	523
15	72.4	45.4	12.0	409	150	560
16	72.4	44.4	12.0	421	153	574
17	72.5	43.5	12.0	434	155	589
18	72.6	42.5	12.1	447	158	605
19	72.7	41.6	12.1	461	161	622
20	72.8	40.7	12.1	475	165	640
21	72.8	39.7	12.1	477	165	642
22	72.9	38.8	12.1	479	167	645
23	73.1	37.9	12.2	481	168	649
24	73.1	36.9	12.2	483	169	652
25	73.2	36.0	12.2	485	170	655

TABLE IV.5 ESTIMATES OF VALUE OF FUTURE PRODUCTION, MALES, 1988 (cont.)

Current age	*Expected age at death*	*Remaining paid work years*	*Remaining non-paid years*	*Production ($'000)*		
				Paid	*Unpaid*	*Total*
26	73.2	35.0	12.2	481	170	651
27	73.3	34.1	12.2	476	169	646
28	73.4	33.1	12.3	471	169	640
29	73.5	32.2	12.3	466	169	635
30	73.5	31.2	12.3	461	168	629
31	73.6	30.3	12.3	455	168	623
32	73.6	29.3	12.3	449	168	616
33	73.6	28.3	12.3	443	167	610
34	73.8	27.4	12.4	436	167	603
35	73.8	26.4	12.4	429	166	595
36	73.8	25.4	12.4	420	166	586
37	73.9	24.5	12.4	408	163	571
38	73.9	23.5	12.4	397	162	558
39	74.0	22.6	12.4	385	160	545
40	74.1	21.6	12.5	372	158	531
41	74.1	20.6	12.5	365	157	522
42	74.2	19.7	12.5	345	155	500
43	74.3	18.7	12.6	331	153	484
44	74.4	17.8	12.6	316	151	467
45	74.5	16.9	12.6	300	149	449
46	74.6	15.9	12.7	287	147	434
47	74.7	15.0	12.7	274	145	419
48	74.8	14.5	12.3	260	143	403
49	75.0	13.7	12.3	245	141	386
50	75.1	12.8	12.3	229	139	368
51	75.3	12.0	12.3	213	137	350
52	75.5	11.2	12.3	196	135	332
53	75.7	10.4	12.3	179	133	312
54	75.8	9.6	12.2	166	131	297
55	76.0	8.8	12.2	141	128	269
56	76.3	8.1	12.2	127	127	254
57	76.5	7.4	12.1	112	125	237
58	76.7	6.7	12.0	97	123	220
59	77.0	6.0	12.0	82	121	203
60	77.2	5.7	11.5	65	119	184
61	77.5	5.7	10.8	63	116	179
62	77.8	5.3	10.5	61	113	174
63	78.1	4.8	10.3	60	109	169
64	78.5	4.3	10.2	58	106	164
65	78.8	4.8	9.0	56	103	159
66	79.2	6.8	6.4	54	99	154
67	79.6	7.2	5.4	52	96	148
68	80.0	7.2	4.8	51	93	143
69	80.4	7.1	4.3	49	89	138
70	80.8	7.1	3.7	47	86	132

Sources BTCE estimates based on ABS (1988a, 1990b, 1990c) and Anderson and Ross (1987).

TABLE IV.6 ESTIMATES OF VALUE OF FUTURE PRODUCTION, FEMALES, 1988

Current age	Expected age at death	Remaining paid work years	Remaining non-paid years	Production ($'000)		
				Paid	Unpaid	Total
0	79.3	38.5	40.8	92	148	240
1	79.3	38.5	39.8	98	159	257
2	79.3	38.5	38.8	105	170	275
3	79.3	38.5	37.8	113	182	294
4	79.3	38.5	36.8	120	195	315
5	79.3	38.5	35.8	129	208	337
6	79.3	38.5	34.8	138	223	361
7	79.3	38.5	33.8	147	238	386
8	79.3	38.5	32.8	158	255	413
9	79.3	38.5	31.8	169	273	442
10	79.3	38.5	30.8	181	292	473
11	79.3	38.5	29.8	193	312	506
12	79.3	38.5	28.8	207	334	541
13	79.3	38.5	27.8	221	358	579
14	79.3	38.5	26.8	237	383	620
15	79.3	38.5	25.8	253	410	663
16	79.3	34.5	28.8	258	417	675
17	79.3	31.3	31.0	262	424	687
18	79.4	28.9	32.5	268	432	700
19	79.4	27.6	32.8	273	440	713
20	79.4	27.0	32.4	278	448	726
21	79.5	26.6	31.9	276	451	726
22	79.5	26.4	31.1	273	454	726
23	79.5	25.5	31.0	270	456	726
24	79.6	26.8	28.8	267	460	726
25	79.6	27.2	27.4	263	463	726
26	79.6	27.6	26.0	258	462	720
27	79.5	27.8	24.7	256	459	714
28	79.6	27.9	23.7	256	457	712
29	79.6	27.8	22.8	247	455	702
30	79.7	27.4	22.3	243	452	695
31	79.7	26.7	22.0	238	450	688
32	79.7	25.9	21.8	233	447	681
33	79.8	25.0	21.8	228	445	673
34	79.8	23.9	21.9	223	442	665
35	79.8	22.8	22.0	217	439	657
36	79.9	21.7	22.2	211	438	649
37	79.9	20.6	22.3	204	437	641
38	79.9	19.5	22.4	197	435	632
39	79.9	18.4	22.5	189	434	623
40	80.0	17.5	22.5	182	433	614
41	80.0	16.5	22.5	179	430	609
42	80.1	15.7	22.4	165	430	594
43	80.1	14.8	22.3	156	428	584
44	80.2	14.0	22.2	146	426	573
45	80.3	13.3	22.0	136	425	561
46	80.3	12.6	21.7	129	422	552
47	80.4	11.9	21.5	122	420	542
48	80.5	11.3	21.2	114	418	532
49	80.6	10.7	20.9	105	416	522
50	80.7	10.2	20.5	97	414	511

TABLE IV.6 ESTIMATES OF VALUE OF FUTURE PRODUCTION, FEMALES, 1988 (cont.)

Current age	*Expected age at death*	*Remaining paid work years*	*Remaining non-paid years*	*Production ($'000)*		
				Paid	*Unpaid*	*Total*
51	80.8	9.7	20.1	87	412	499
52	80.9	9.1	19.8	86	406	492
53	81.1	8.7	19.4	68	408	476
54	81.2	8.2	19.0	63	404	467
55	81.3	7.8	18.5	46	403	449
56	81.4	7.3	18.1	41	399	440
57	81.5	6.9	17.6	35	395	430
58	81.7	6.6	17.1	30	391	421
59	81.8	6.2	16.6	23	387	410
60	82.0	6.4	15.6	17	383	400
61	82.2	7.1	14.1	17	375	392
62	82.3	7.4	12.9	16	366	382
63	82.6	7.5	12.1	16	358	374
64	82.8	7.5	11.3	16	349	365
65	83.0	7.9	10.1	15	340	355
66	83.2	8.6	8.6	15	330	345
67	83.4	8.8	7.6	14	320	334
68	83.7	8.6	7.1	14	311	325
69	84.0	8.7	6.3	13	301	315
70	84.3	8.9	5.4	13	300	313

Sources BTCE estimates based on ABS (1988a, 1990b, 1990c) and Anderson and Ross (1987) .

APPENDIX V ALLOCATION OF METROPOLITAN AND NON-METROPOLITAN ROAD ACCIDENTS

The numbers of accidents and injuries occurring in Sydney, Newcastle, Wollongong, Melbourne, and Adelaide were estimated by accident class using data provided by the relevant State authorities. From these data, the ratios of metropolitan road accidents and injuries to the corresponding aggregate figures for the three States of New South Wales, Victoria and South Australia were calculated. These ratios were then applied to Australia-wide accident and casualty numbers to derive estimates of metropolitan and non-metropolitan accident and injury rates for Australia as a whole.

The aggregated New South Wales, Victorian and South Australian casualty rates per accident (table V.1) show a high correlation with the Australia-wide ratios (table V.2). The aggregate metropolitan ratios pertaining to these three States were therefore applied Australia-wide with some confidence in order to derive the proportion of accidents occurring in Australian metropolitan areas (table V.3).

The numbers of vehicles involved in accidents on metropolitan and non-metropolitan roads in 1988 were not available. In the absence of these data, the ratios of the numbers of vehicles involved in road accidents in metropolitan and non-metropolitan areas were estimated using data on motor vehicle registrations from ABS (1989b). This was done by determining from the ABS data, the ratio of the number of motor vehicles registered in metropolitan and non-metropolitan areas.

This ratio was then applied to the total number of vehicles involved in road accidents in order to classify these vehicles by metropolitan and non-metropolitan areas. The assumption implicit in this technique is that the metropolitan/non-metropolitan ratio of vehicle registrations in 1988 is equivalent to the ratio of vehicles involved in metropolitan road accidents to those involved in non-metropolitan accidents in that year. A caveat in using this technique is that it is not possible to distinguish between area of registration of the vehicle and the area of use.

The number of vehicles per accident involved in each class of accident in the three States of New South Wales, Victoria and South Australia taken together, does not correlate quite so well with the Australia-wide rates (see tables V.1 and

TABLE V.1 REPORTED VEHICLES AND CASUALTIES PER ACCIDENT BY ACCIDENT CLASS: NEW SOUTH WALES, VICTORIA AND SOUTH AUSTRALIA, 1988

		Persons			
Accident class	*Vehicles*	*Fatalities*	*Hospital injuries*	*Medical injuries*	*Uninjured*
Fatal	1.61	1.12	0.60	0.28	0.92
Hospital	1.65	na	1.22	0.20	0.65
Medical	1.83	na	na	1.25	0.57
Nil injury	2.04	na	na	na	2.98
Overall	1.95	0.01	0.11	0.36	2.11

na Not applicable

Sources RTA (1989), ORS (1989) and VIC ROADS (1991).

TABLE V.2 AGGREGATED VEHICLE AND CASUALTIES PER ACCIDENT BY ACCIDENT CLASS: AUSTRALIA, 1988

		Persons			
Accident class	*Vehicle*	*Fatalities*	*Hospital injuries*	*Medical injuries*	*Uninjured*
Fatal	1.45	1.12	0.60	0.28	0.92
Hospital	1.56	na	1.22	0.20	0.65
Medical	1.74	na	na	1.25	0.57
Nil injury	1.89	na	na	0.00	3.01
Total	1.82	0.01	0.12	0.33	2.18

na Not applicable

Sources RTA (1989), ORS (1989) and VIC ROADS (1991).

TABLE V.3 PROPORTION OF VEHICLES INVOLVED, PERSONS INVOLVED AND ACCIDENTS OCCURRING IN METROPOLITAN AREAS, BY ACCIDENT CLASS, 1988

Accident class	*Vehicles*	*Persons*	*Accidents*
Fatal	0.57	0.50	0.52
Hospital	0.66	0.56	0.60
Medical	0.70	0.72	0.72
Nil	0.69	0.70	0.79
Overall	0.69	0.69	0.75

Sources RTA (1989), ORS (1989), VIC ROADS (1991) and ABS (1989b).

V.2). However, in the absence of better data, the aggregated metropolitan and non-metropolitan rates for vehicles per accident obtained from these three States were used. These rates were applied to the total number of vehicles involved in road accidents to estimate the proportion of vehicles involved in accidents in metropolitan areas (table V.3).

REFERENCES

Abbreviations

ABS	Australian Bureau of Statistics
AFP	Australian Federal Police
AGPS	Australian Government Publishing Service
AIH	Australian Institute of Health
AN	Australian National
BASI	Bureau of Air Safety Investigation
BTCE	Bureau of Transport and Communications Economics
CAA	Civil Aviation Authority
FORS	Federal Office of Road Safety
ICAO	International Civil Aviation Organisation
ICD-9	International Classification of Diseases, 9th Revision
ISC	Insurance and Superannuation Commission
NHTSA	National Highway Traffic Safety Administration
ORS	Office of Road Safety, South Australia
PTC	Public Transport Corporation, Victoria
QR	Queensland Railways
RTA	Roads and Traffic Authority, New South Wales
SRA	State Rail Authority, New South Wales
TAC	Transport Accident Commission, Victoria
WAPD	Western Australian Police Department
WHO	World Health Organisation
WR	Westrail, Western Australia

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ABBREVIATIONS

ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
AGPS	Australian Government Publishing Service
AIH	Australian Institute of Health
AIS	Abbreviated Injury Scale
AMSA	Australian Maritime Safety Authority
AN	Australian National
BASI	Bureau of Air Safety Investigation
BTCE	Bureau of Transport and Communications Economics
CAA	Civil Aviation Authority
CPI	Consumer Price Index
FORS	Federal Office of Road Safety
GNP	Gross National Product
ICAO	International Civil Aviation Organisation
ISC	Insurance and Superannuation Commission
NHTSA	National Highway Traffic Safety Administration
NOS	Not otherwise stated
NRMA	National Roads and Motorists Association
NSW	New South Wales
NTPD	Northern Territory Police Department
ORS	Office of Road Safety
PTC	Public Transport Corporation
QR	Queensland Railways
RTA	Road Traffic Authority
SRA	State Rail Authority
TAC	Transport Accident Commission
WAPD	Western Australia Police Department
WHO	World Health Organisation
WR	Westrail