THE ECONOMIC AND SOCIAL COSTS OF ROAD ACCIDENTS IN AUSTRALIA:

WITH PRELIMINARY COST ESTIMATES FOR AUSTRALIA 1978

prepared by
A.S. ATKINS

Centre for Environmental Studies
University of Melbourne

Project Sponsor:
Office of Road Safety
Department of Transport Australia

June 1981

DEPARTMENT OF TRANSPORT

OFFICE OF ROAD SAFETY

DOCUMENT RETRIEVAL INFORMATION

Report No.	Date	ISBN	Pages
CR 21	June 1981	0 642 51202 7	128

Title and Subtitle

THE ECONOMIC AND SOCIAL COSTS OF ROAD ACCIDENTS IN AUSTRALIA:
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Author

Alan S. Atkins

Performing Organisation (Name and Address)

Centre for Environmental Studies
University of Melbourne
Parkville, Victoria, 3052

Keywords

Accident Costs, Reviews/Summaries

Abstract

This report contains a review of recent accident cost estimation studies and proposes a unit cost framework which is considered appropriate from both conceptual and empirical view points for the estimation of the social costs of road accidents in Australia. A detailed set of unit and total cost estimates for Australia in 1978 is presented, based mainly on existing data sources, supplemented by accident claims data from a sample of insurance companies and the Motor Accidents Board of Victoria. These preliminary cost estimates are also classified according to injury severity. Problems associated with accident statistics and data sources are discussed together with the estimation procedures. The report concludes that social costs provide only *minimum* estimates of the benefits gained from accident reduction, and also that the use of average cost levels is constrained by the skewed distribution of most accident cost characteristics. Further research directed towards refinement of the conceptual and empirical bases of these estimates is recommended.

ACKNOWLEDGEMENTS

This study has benefited from access to the statistical collection and library resources of the Office of Road Safety and from various O.R.S. staff during the course of the project including Mr. B. Lancashire, Mr. W. Callaghan and Ms. C. Boughton.

The assistance of the Motor Accidents Board of Victoria in the provision of a number of special accident data tabulations under the guidance of Mr. D. Kearsley is gratefully acknowledged. Several of the major motor vehicle insurers in Victoria responded to requests for special tabulations of claims data, and the co-operation of Australian Associated Motor Insurers Ltd. (A.A.M.I.), Insurance Council of Australia, R.A.C.V. Insurance Pty. Ltd., and the State Insurance Office of Victoria is much appreciated.

Also, in January 1980 the author was able to undertake useful discussions with Mr. J. O'Day of the Highway Safety Research Institute of the University of Michigan, and Ms. D. Somerford and Ms. B.M. Faigin of the National Highway Traffic Safety Administration in Washington D.C.

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CHAPTER 1

INTRODUCTION AND OUTLINE OF STUDY

1.1 INTRODUCTION

This report presents the results of a study of the social costs of road accidents in Australia commissioned in 1979 by the Office of Road Safety within the Commonwealth Department of Transport. The main objective of this study is to review the scope of previous work on the valuation of accident costs with the aim of extending the coverage and measurement of road accident costs in Australia to reflect a comprehensive concept of social cost and welfare. The potential application of such cost estimates is to assist government agencies with the planning and evaluation of road safety programmes.

The overall study was envisaged initially in two stages in which the first stage was mainly to consist of a review of alternative methodologies for quantifying the socio-economic costs of road accidents together with a preliminary estimate of the total cost of road accidents in Australia for a recent year.

The second stage envisaged subsequent development and refinement of the cost framework developed in the earlier stage including the estimation of separate accident costs for a range of accident types (each showing details of estimates for the earlier established cost categories).

1.2 SCOPE OF REPORT

The concept of social cost, as it relates to road accidents, is considered in Chapter 2, and the distinction between financial, economic and social costs is outlined.

The use of *changes* in cost levels as measures of social benefit in benefit-cost analysis is discussed including the significant implications that these applications of accident costs have for the definition of accident cost concepts. The three principal approaches to the valuation of life problem in the economic literature are considered, leading to a preference for the human capital approach in the context of accident evaluation. The existence of a relatively large and often controversial literature in this area is acknowledged.

Chapter 2 also includes a summary review of recent accident cost estimation studies for the U.S.A., Australia, New Zealand, Japan, and Canada (these studies are reviewed at greater length in Appendix A-1).

While deficiencies in accident records and cost data are found to be a general source of difficulty in cost estimation procedures, the resultant cost levels are shown to be more subject to variation resulting from the use of alternative cost concepts than from estimation accuracy. The studies reviewed are found to employ a wide range of cost concepts and estimated unit cost levels.

Chapter 3 proposes a framework for the estimation of unit costs of road accidents in Australia, together with a set of preliminary estimates of average and total costs for the year 1978. An important characteristic of the cost framework adopted in this study is the requirement to distinguish all accident costs by *injury severity level.*

The estimation procedure for foregone income of fatalities and casualties, one of the key components of accident costs, is outlined together with the effects on this item of changes in the discount rate, the age distribution of victims, and the use of alternative definitions of income. These results are outlined in some detail.

Estimates of medical, hospital, and related costs of road accidents are presented, based extensively upon data provided by the Motor Accidents Board of Victoria. Vehicle damage costs are then considered and the basis of estimation is outlined. The source of all other costs included in the proposed framework is briefly considered.

Next, a detailed summary of cost estimation procedures traces through the unit cost framework proposed in this report and outlines the derivation of all average cost estimates for Australia in 1978 (other details of data and estimation sources are contained in Table footnotes). This section is followed by calculations of *total* cost estimates which show the effects of excluding certain cost categories from the overall cost framework. Finally, a brief consideration of the need for further research to support the proposed cost framework concludes chapter 3.

Chapter 4 presents the conclusions and recommendations arrived at in this report. The conclusions incorporate both conceptual and empirical problems associated with the proposed cost estimation framework. The recommendations relate to further progress envisaged for subsequent development of the present study, together with other recommendations for further research into Australian accident costs drawn from the results of the present report.

Appendix A-1 contains reviews of the seven accident cost estimation studies discussed in chapter 2. These reviews are intended to complement and bring up to date the reviews contained in the earlier study of Paterson (1973) and provide tables summarising the cost estimation procedures employed.

Supplementary tables and computation details are contained in Appendix A-2, while Appendix A-3 contains preliminary results of the fitting of gamma probability distributions to several sets of accident cost data. This work has the aim *inter alia* of providing a generalised basis for classifying accident costs into injury severity categories based on probability of occurrence.

CHAPTER 2

THE CONCEPT OF SOCIAL COST AND A REVIEW OF RECENT COST STUDIES

2.1 THE CONCEPT OF SOCIAL COST AND ROAD ACCIDENTS

It is the purpose of this discussion to provide an outline and a brief discussion of the concept of social cost, especially in relation to road accidents.

First it is evident from the titles of this and other studies concerned variously with "social cost", "societal costs", and "socio-economic costs" that these terms imply an attempt to distinguish between *social* costs and conventional *financial* costs within the economic system. In fact there are three distinct concepts of cost which overlap, and are both a source of confusion and some controversy in public sector decision-making, namely *financial* costs, "real" economic or *resource* costs, and *social* costs.

Financial costs refer to the recorded transactions or accounting costs associated with day to day receipts and payments throughout the economy. Real economic costs (sometimes called "opportunity costs") are an attempt to measure the value of scarce resources produced and consumed in the economy, as reflected in national income accounts. The term "real" is used to mean that the costs are measured in "constant dollars" so that the effects of changes in the general price level between time periods is eliminated. Such *economic* costs exclude some financial transactions, for example the sale and purchase of land or a used motor vehicle is a financial cost to the individual or firm, but is not considered to be a real resource cost in economic terms, since no new scarce resources are produced or consumed in the transaction (other than the services of sales people - which do count) and it is excluded from economic costs as a transfer of existing resources.

The concept of social cost is more embracing and more difficult to measure. Social costs - and benefits - refer to the value of those goods and services generally provided by the public sector of the economy (i.e. by governments and public authorities) which have the characteristics that monetary values for these commodities may not always be established in conventional markets, and their costs and/or benefits may not be confined to the producer or consumer. In the private sector of economies efficient resource allocation and distribution is theoretically achieved by reaction to prices and consumer demand (in the absence of certain market distortion factors). The supply of goods and services which have "public goods" characteristics such as externalities or interdependencies cannot be efficiently achieved in the private sector, and has become the responsibility of the public sector of the economy, including the supply of services of roads, education, justice, and defence etc. More recently the concept of undesirable "spillovers" of private economic activity, in the generation of environmental pollution (e.g. associated with the discharge of industrial wastes to air and water systems, the noise and disruptive effects of urban freeways, etc) has been recognised as a further category of social cost involving the imposition of external costs upon society which are not fully met by the producer or consumer. Public "bads" such as external costs imposed upon society which are not compensated for in private markets are thus also seen as the responsibility of the public sector. (cf. Musgrave and Musgrave, 1976).

The costs associated with road accidents belong clearly in the *social* cost category, since they include external or "spillover" cost effects upon others, such as traffic delay, resulting from peak-hour traffic disruption caused by road accidents ambulance, police and hospital services, and also because they include a significant component of non-market and intangible costs such as the pain and suffering arising from accidents, traffic delays, and inconvenience to families and the community. However, because many of the costs associated with road accidents can be measured in terms of financial transactions, such as vehicle repairs, there has been a tendency to focus on the *financial* costs of road accidents, and to exclude from consideration any non-monetary effects.

More recently the literature concerned with valuation of road accidents has turned to the problem of economic valuation of accident effects (*vide* NHTSA, [1972]; Faigin, [1976]; and the discussions in Lawson, [1978]; and Mooney, [1978]).

The attempt to incorporate intangible and other difficult to measure non-market costs into accident cost estimates has resulted in some controversy, generally with the theme that otherwise reliable estimates of tangible financial effects of accidents are depreciated by the addition of components with less acceptable or less reliable values. There has also been some controversy as to the appropriate valuation of purely economic costs of accidents. Some consideration of the *economic* concepts of cost and value may be helpful.

Economic analysis is largely concerned with dollar values determined in markets and situations where goods and services are exchanged. The concept of *value* itself has several economic aspects - in addition to important non-economic dimensions. It is not a unique or absolute measure, but for convenience, economic analysis is mostly confined to value-in-exchange, and the resultant prices from such exchange (*cf.* Fraser, 1947). Similarly the concept of *cost* has several aspects, but costs determined in market exchange are of most interest. A cost is viewed as a *loss of resources* (or money, as a claim on resources) to obtain some equivalent gain through exchange. Thus, a market price may simultaneously represent a cost (loss) and revenue (gain) in exchange.

Economic costs generally refer to *opportunity costs*, which simply mean the resource costs involved in producing any commodity or service. Economic accounting in national income and expenditure accounts, for example, is intended to show in resource-cost terms the total flow of goods and services *produced* within the time span and nation or area covered. It does *not* necessarily correspond with *financial* accounting and records. For example, it excludes the sale and purchase of all "transfer" items.

The relevance of *opportunity cost* concepts to the present study is as follows: accident "costs" are here termed *societal costs*, meaning that they include social *and* economic costs associated with road accidents. *Social* costs are here defined to mean *measurable* costs (or benefits) which may not be valued in a conventional market (*i.e.* social costs may involve non-marketed resources). They are generally excluded from national accounts. In the literature relating to accident costs many writers, including the Australian studies of Troy and Butlin (1971) and Paterson (1973), have argued for an *economic* definition of accident costs comparable with national accounting definitions. Others have aggregated *financial* costs and revenues associated with accidents only, which falls short even of national accounting concepts (*cf.* Reynolds [1956]; Japan [JRCTP 1978]; Dyson [1975]). The view is adopted here that the use of national accounting concepts as a basis of accident cost valuation, although not incorrect in any technical sense, is not appropriate for accident costs because it may often be misleading in application. However the uncritical use of financial costs alone is considered to be *generally* misleading and is rejected. The basis for this view is that national income cost concepts are more relevant as measures for predominantly marketed commodities and resources, especially those within the private sector of the economy, and are not adequate for the formulation of accident costs and evaluation policy.

The increasing importance of the public sector of the economy, which is responsible for the allocation of resources to roads, defence, safety, and other "public goods" areas outside the conventional market exchange system, has necessarily led to the development of more refined concepts of *social cost* and *benefit* to aid public decision-making about resource allocation to and within these activities without the guidance of conventional market values. Benefit cost analysis, and more embracing system-planning techniques, such as multiple objective planning, have been developed to overcome some of the problems of guiding resource allocation in the public sector of the economy. These techniques all seek to simulate the value to the community of non-marketed benefits and costs accruing from the service of roads, irrigation water, and social costs such as industrial and noise pollution for which losses are incurred by some members of society but no compensation is paid by the market mechanism.

Costs versus benefits: An important problem which arises from the *use* of estimates of road accident costs, apart from the issue of cost concepts, is that of treating *changes* in accident cost levels as a measure of benefit, for example in evaluation of safety measures. The practice of interpreting changes in cost levels as a measure of economic and social benefit is quite common in many applications of benefit-cost analysis, especially in transport economics where the principal benefit from investment in improved roads is a reduction in user operating and travel time costs. In fact, transport evaluations also attempt to measure the contribution to project benefits of the benefits of improved road safety through reductions in the frequency and cost of accidents.

While various financial and narrowly defined economic cost estimation concepts may be internally consistent and useful for many comparative purposes associated with road accidents, these concepts become quite inadequate when the requirement of the cost measures is to estimate the benefits to society resulting from changes in the level of accidents or the risks associated with road transport.

Here the objective is to measure society's valuation of road safety, or in other words, the aggregate demand for road safety. In social benefit-cost analysis, it is necessary to measure the *willingness to pay* for some given level of changes in road safety: this is a concept which goes beyond the market price valuations consistent with national accounting (and for which, cost estimates may serve as a reasonable proxy for market value), in that it incorporates the concept of *consumer's surplus* in addition to market price. Most benefit-cost evaluations of public projects measure social benefits as the change in consumer's surplus resulting from introduction of the plan concerned.

Theoretical welfare economics has refined the concept of consumer's surplus as a measure of social gain somewhat further, and has defined a more correct concept of *compensating variation* as the generally appropriate benefit measure. For most practical applications, however, the difference between compensating variation and consumer's surplus is not significant, and it is considered acceptable to use the latter measure. While the theoretical issues underlying these measures of benefit are beyond the direct scope of this report, they are raised to emphasise that acceptable and consistent accident *cost* estimates are not likely to meet the more stringent criteria required if they are to be interpreted as benefit measures (*vide* Dasgupta and Pearce, [1972]; Harrison, [1974]; Layard, [1972]; and Mishan, [1971] and [1976]; and Winch, [1971]; for discussion of the benefit measurement criteria for social benefit-cost analysis).

The more important of these issues are discussed at greater length in the reviews of recent cost estimation studies (see Appendix A-1, especially Lawson, [1978]. A major problem encountered in practice which influences the perception of the value of road safety is that the information on accident costs is much more amenable to measurement than the non-market demand side of accidents and road safety. Most empirical accident cost studies, including the present report, have produced a set of accident social *cost* estimates, despite an acceptance of the theoretically correct demand valuation concept, namely the valuation of changes in accident risk, which has so far proved to be extremely difficult to measure (*cf.* Freeman, [1979]; Jones-Lee, [1969] & [1974]; and Williams, [1979].

2.2 ECONOMIC CONSIDERATIONS AND THE VALUE OF LIFE

The following discussion presents a brief assessment of the theoretical and conceptual issues relating to attempts to value human life. As noted by Mooney (1978), most research into the value of human life and suffering has been concerned with mortality rather than injury and non-fatal illness. The need to consider values and costs relating to the value of life and health which affect resource allocation arises not only in the context of road accidents and public health services (*vide* Mooney, *op.cit.*, Mushkin, [1962], but more recently in the policy area of environmental quality, the need to evaluate the effects of proposed public environmental standards upon community health (*vide* Freeman, [1979]) has raised similar issues.

The valuation of life problem arises because, whether occurring explicitly or implicitly, public and private decisions are made which affect exposure of the population to risk of death and injury. Public investment in roads and private investment in and use of motor vehicles is just one example. Others include public health and hospitals, building and industrial regulations, crime prevention, and more recently, environmental protection standards (e.g. for air quality).

The socio-economic objective in valuing life and suffering is to help determine how much society is prepared to spend on policies to save life or reduce risk, morbidity and injury. Economic analysis suggests a need for consistency in measuring the opportunity cost of life saving measures, that is, like lives should be valued alike. The normal economic concept to be applied is that the consumer is the best judge of his own utility, and of changes in welfare, as measured by compensating variation. This is termed the *consumers' sovereignty* approach to economic decision-making (i.e. the consumer preferences always dominate). This concept is sometimes considered questionable in the context of value of life, since it involves prior assumptions that the consumer can and does make whatever value judgements involving risk and the value of his own life are necessary in a rational way.

Individual perception of risk, especially small changes in risk, is often held to be deficient, and may lead to no resultant change in behaviour in the face of slightly increased risk. But the community as a whole may respond positively to any increased risks and for example, through its elected governments has reacted to increased road accident fatalities by enforcing vehicle safety regulations which restrict private choice, including compulsory wearing of seat belts and motor cycle helmets. In the language of the economics of public finance, road safety appears to have become a *merit good* (i.e. a commodity not sought by individual preference, but desired by the community as a whole in apparent contradiction of individual choice including restrictions on seat belts, liquor sale, and certain drugs etc.).

In the literature it is possible to distinguish three approaches to the value of life problems, namely:

(i) *willingness to pay*, e.g. for reduction in risk;

(ii) *human capital*, or the lost future income approach to individual productivity; and the (iii)*implied value of life,* implicit in public decision making.

From a technical point of view the *willingness to pay* approach is consistent with consumer sovereignty. It requires the consumer to be willing and able to choose between a reduction in risk (e.g. of death, and/or serious injury) and a payment which would leave his welfare unchanged, termed his compensating variation. This concept might have practical application for example, in situations where the probability of accidental death from various activities is relatively small. In such instances a conceptual "value of human life" multiplied by this probability would provide an estimate of the *maximum* amount an individual would be prepared to pay for the small increase in probability of survival. This would apply only when the risk concerned was small (e.g. 10^{-5}). If the probability of death increased, for example to 50 %, then individuals would rapidly indicate infinite values of life, indicating that this valuation scale is non-linear. There exists a further problem that theoretical relationships (and, also for example, accident reduction projects) are based on classical or objective probabilities generally drawn from frequency distributions, while the actual perception and behaviour of individuals with respect to risk is based on subjective assessments of probability. Some writers in this field, including Mishan (1971) consider that the subjective measure of risk is the correct one for use in economic valuation, even if it is subsequently shown to be wrong, for example when the individual later regrets his choice after an accident. Others (*cf.* Mooney, 1978) consider that although Mishan may correctly judge the behaviour of an individual, he overlooks the merit good issue: that governments will attempt to close any such gap between expected and realised utility. Such behaviour suggests that perhaps individuals in these circumstances are prepared to be directed as to what their compensating variation should be, as in the example of legislation for compulsory wearing of seat belts.

The human capital approach has a long history in which one particular concept of the value of life is equated with individual productivity in the form of a discounted stream of future earnings. In the context of the present report the income stream consists of that portion occurring between the time of accidental death and normal life expectancy. Such a calculation can be expressed as gross lifetime earnings, or *net* of future consumption. It is generally considered (after Mishan, [1971]) that the *gross* earnings figure is appropriate for proposed "life-saving" projects. Net values are only relevant for determining the historical or *ex post* effects of past accidental deaths on society in national income terms.

The main shortcoming of the human capital approach is that it does not include any measure of consumer surplus over and above the income measure, as does the willingness-to-pay method. It thus yields a value of lost output which represents only the minimum estimate of what society should be willing to pay to save an average life. To compensate for this shortcoming some researchers have added subjective estimates of the costs of pain and suffering and grief to their estimates of lost output from accidental death (*cf.* Dawson, [1967]). Such values may be considered "non-economic" in that they are not incorporated in national income measures, but they clearly affect socio-economic welfare in a way which should in principle be quantifiable.

Other problems of the human capital approach include misleading effects of age and life-cycle characteristics, for example, in *net* income calculations children and the elderly can be shown to have negative present worth. Such measures are inappropriate and can lead to absurd interpretations of social preferences. Also the problem of how to attribute an appropriate value to housewives' services needs to be resolved. Clearly their exclusion from national accounting values is somewhat arbitrary, since in the Australian National Accounts an estimate for the imputed value of owners' house rent is included, while the imputed value of housewives' services is excluded, although the latter services are clearly of value to both households and the community.

The implicit value of life approach suggests that a study of past public sector decision-making associated with life-saving or accident reduction activities should reveal a distribution of realistic implicit values of life. For example, in respect of road safety, public health, fire prevention, and building regulations (*cf.* Green and Brown, [1978]), it is reasoned that the implicit values of life, or the mean of a distribution of such values, can be interpreted as the appropriate "public sector value". This revealed value should be consistent both within and between differing public programmes. If divergent values above or below the mean are encountered, then some investigation is called for to evaluate the likely over- or under-investment in these areas. This approach is advocated by Harrison (1974) and Mooney (1978) in the U.K., who proposed appropriate conditions under which future investment decisions affecting life-saving programmes could be validly based on a revealed "public sector value" of life. In practice this estimate might show an excessively wide range (Mooney cites implicit values of a single life ranging from $40 million from building regulations to less than $100 associated with certain medical diagnostic testing).

Court awards for compensation may also offer some evidence of implied valuations of life but in the United Kingdom it is considered that court awards as a result of death are often misleading because they reflect only pecuniary losses to relatives, rather than an attempt to value the life lost. However court awards for non-fatal injuries appear to be more appropriate and more recently have incorporated some assessment for pain and suffering. Legal awards may nevertheless be distorted by any assignment of *culpability*. Other problems concern the non-homogeneity of lives saved (e.g. some may be young, some old; some may recover, some be incapacitated)/. Implied values may also show that society may irrationally fear one form of death or risk of the same probability more than another such as fire more than road accidents).

From the viewpoint of economic theory, both the implicit public sector value, and the human capital measure reflect some lack of consumer preference orientation. Schelling (1968) noted this deficiency and reasoned that to evaluate a programme to save lives one should ask"....what is it worth to those who benefit from it?..." Mishan (1971) further developed this approach. In effect it argues that consumers do not have a unique value of life, but instead value small changes in the risk of death. The problem remains of how to evaluate these small changes in risk. Mishan proposes an unsentimental categorisation of these risks for valuation purposes: (i) direct and voluntary; (ii) direct and involuntary; (iii) financial risk to others; and (iv) psychic risk to others.

In theory, the human capital approach and reduction in risk methods should be equivalent, but implied values of life may reflect past non-rational or inconsistent public decisions. In practice many other issues are important, for example if national income measures are adequate for monitoring the particular public programme objectives, then the human capital approach is acceptable, but if political judgements are to be refined in allocating resources to social objectives, then the implied value approach offers a method of achieving consistency.

An ethical approach to social welfare favours the individual to judge his own value of reduced risk, but errors of perception and limitations in the ability to measure risk limit its application. Also, external social costs need to be accounted for in any such assessment.

A general conclusion arising from this discussion of approaches to the social valuation of life (and serious injury) is that if road safety, in the form of accident reduction, is considered to be partly a merit good, then the human capital approach to valuation of life is favoured, supplemented by more appropriate estimates of non-market valuations consistent with the concept of national welfare which is to be maximised in any evaluation model.

2.3 A REVIEW OF RECENT ACCIDENT COST STUDIES

Estimates of the cost of road accidents at a national level in many of the developed economies have been produced since the 1950's, reflecting the side-effects of the rapid growth after 1950 in motor vehicle ownership and usage in those countries. However, interest in the economics of risk and safety preceded accident cost work, so that a theoretical framework was available, at least in principle, for accident analysis.

The purpose of this critique is to review the principal cost estimation studies undertaken in the decade of the 1970's. These studies, seven in number, are considered at greater length in Appendix A-1 of this report. Appendix A-1 is designed both to complement and to bring up to date the detailed reviews of methodology in accident cost estimation between 1950 and 1971 contained in chapter 3 of Paterson (1973), and includes a review of the Paterson report. Some eleven cost estimation studies are reviewed in the Paterson report, including the early work by Reynolds (1956) and subsequently Dawson (1967) in the United Kingdom, some early studies in the U.S.A., and several Australian studies including the work of Thorpe (1970) in Victoria, and the major study in the Australian Capital Territory undertaken by Troy and Butlin (1971).

The literature on the value of life and its relationship to road safety, and public sector decision-making is now quite extensive. Writing in 1956 Reynolds, in making one of the first official estimates of the costs of road accidents in the United Kingdom, cited only six related works. In the present study a selective bibliography contains more than fifty such references, and an exhaustive listing would be much larger. Fortunately, however, the number of innovative contributions is much smaller than the latter list, and current accident cost studies generally follow a common pattern. It is evident, nevertheless, that some of the main differences between conceptual issues and empirical studies in accident cost estimation have not been resolved, a fact which is reflected in continuing controversies in the literature.

This review summarises seven accident cost estimation studies, namely: Fox *et al.* (1979), Australia; Lawson (1978) Canada; Japan (JRCTP, 1978); Sherwin (1977), New Zealand; Faigin (NHTSA 1976), U.S.A.; Paterson (1973), Australia; and NHTSA (1972), U.S.A. Reviews of most other major cost estimation work up to 1971 can be found in Paterson (1973), chapter 3.

The Melbourne (Australia) roadside pole collision study by Fox *et al.* (1979) is by intention a partial coverage of road accidents in a metropolitan area, but it is a study of major size and significance which, *inter alia*, collected and analysed cost data and developed and applied detailed accident cost estimates in benefit-cost evaluations of proposed accident countermeasure programmes. After reviewing the cost estimation literature, Fox *et al.* adopted the social accounting framework of accident costs contained in the U.S.A. study of Faigin (1976). However, because of the apparently unresolved controversy in the literature as to the method of valuation of *foregone income* of accident victims, three sets of average accident costs were presented: current resource costs *only;* total resource costs *net* of consumption expenditure; and total resource costs. All three bases of unit costs were disaggregated by injury severity classes, using a standardised Abbreviated Injury Scale (AIS) developed in the U.S.A. (*vide* Table 38,p.94). Fox *et al.* collected a wide range of data from some 879 pole accidents, including selected medical and property damage information. Of particular interest is the recognition that the considerable variability in accident characteristics required a classification of costs by injury severity. Because accident data was not classified according to injury severity, Fox *et al.* fitted the Melbourne sample to the U.S. - derived Abbreviated Injury Scale.

The Melbourne study produced estimated accident costs resulting from pole accidents summarised as follows:

Costing Method	Average Costs *per accident* $	*per fatality* $	Total Costs *per annum* $m
Current resource costs:	3,400	6,800	7.0
Total Costs *net* of consumption:	8,200	118,500	16.9
Total Costs:	11,200	204,600	23.1

The study suggested that with annual social costs of $23 million per year in Melbourne resulting from pole accidents, a range of accident countermeasures should be developed and evaluated according to benefit-cost criteria. Fox *et al.* also pointed to the conflict in social objectives evident in the approach of some public agencies responsible for roadside poles: by installing or replacing poles of a non-breakable ("non-frangible") type to avoid average costs to the agency of approximately $300 per accident, total average social costs of over $11,000 are incurred.

The paper by Lawson (1978) contains a set of accident cost estimates for Canada for the years 1976 and 1978, together with an overview and assessment of the theoretical literature relevant to accident cost concepts and estimates.

Lawson points out that road safety is a significant component of both public and private expenditure programmes and therefore the need to evaluate the allocation of resources to safety is inescapable. Although benefit-cost analysis is in principle a suitable method for such safety evaluations, Lawson argues that the use of estimated *costs* incurred through accidents instead of the theoretically correct concept of *willingness to pay* for accident reduction as a measure of programme benefits greatly weakens the effectiveness of such evaluations. Social accounting cost estimates can only consist of *minimum* estimates of the true levels of cost which society is willing to expend in order to avoid accidents. This important conclusion applies not only to benefit-cost applications, but also to cost-effectiveness analysis (the former can in principle rank accident programmes with differing effects, while the latter is applied to determine the least-cost method of achieving some single accident reduction objective). In his review of some twelve cost studies Lawson rejects the *net* income concepts used in estimating foregone future income of accident victims (e.g. in the studies by Reynolds, [1956]; Dawson, [1967] in the U.K.; and Troy and Butlin, [1971]; and Paterson, [1973], for Australia). He cites Mishan (1971) as resolving this conceptual debate by asserting that the *ex ante* concept of income, involving a definition of society *including* the accident victim - (i.e. it includes his income and consumption) is the appropriate basis of measurement in assessing foregone income resulting from accidents. The net income concept measures only what happens to national income *after* an accident: it does not provide correct information to decision-makers about the true worth of preventing accidents before their occurrence.

The problem of measuring *intangible* losses resulting from road accidents is less tractable, particularly that of pain and suffering. Lawson concludes that measurement of the psychic and emotional losses due to accidents, although a valid social cost, so far has eluded acceptable quantification, ensuring that remaining "loss accounting" methods will produce only minimum cost estimates which require much caution in their application to safety programme evaluation.

Minimum cost estimates for Canada for three aggregated categories of cost only are produced in this paper:

Cost Category	Average Cost per accident C$m	Total Cost C$m
Lost production: (income)	180,000 (per fatal)	900
Health care:	200	100
Property damage (*and* compensation administration):	1,500	1,500
Total	4,500	2,500

The Japan Research Centre for Transport Policy (JRCTP) produced estimates of "social losses" from road accidents in Japan for the year 1974. The JRCTP study adopted a loss accounting approach based on "objective social losses", although it recognised the validity of "subjective" social losses including pain and grief arising from road accidents, but concluded that they cannot yet be satisfactorily measured. The report then goes on to estimate accident losses for the following cost categories:

Cost Category	Average Cost A$*	Total Cost A$m.*	
Lost *net* income	39,020ø(per fatality)	1,402	34.3%
Medical	470 " "	554	13.5%
Vehicle damage	310 (per vehicle)	1,372	33.5%
Other costs ø̸	170 (per vehicle)	764	18.7%
Total:	930 (per vehicle)	$4,092m	(100%)
	1,770 (per accident)		

**Yen values converted to A$ at 1974 average rate. ø̸ Insurance administration comprised 85% of other costs. ø compares with $9,440 per injury.*

The JRCTP study followed closely the methods of Dawson (1967), although estimation techniques were often modified by available Japanese accident and cost data. The Japan study chose to employ the *net income* concept in the calculation of present values for lost future income. This was achieved by deducting 40% of average *adjusted* income, to exclude consumption expenditure. In addition to this deduction, average workforce income levels for each age group were multiplied by the proportion of the workforce to the total population in each age group, (i.e. workforce participation rates). This latter adjustment had the effect of averaging incomes over the total population in each age group, and thus imputed this lower income figure to all members of the population whether housewives, unemployed, or employed. Details of these calculations are contained in Appendix A-1. The effect of these adjustments is to reduce the relative size of foregone income in the total cost estimates.

Sherwin's paper presents some generalised total cost estimates for road accidents in New Zealand for 1975, together with an assessment of the estimation task. Total accident costs were estimated at between NZ $160 million and NZ $170 million for that year, of which foregone *net* income comprised about 16%, and property damage was about 42%.

New Zealand data sources are considered to be not yet adequate to support more detailed cost estimates. Sherwin used a modified form of the "life model" approach developed by Paterson (1973) as a basis for computing the present value of foregone incomes. This technique has the effect of averaging income levels across the total population, and allocates education costs to the under 19 years age group. Sherwin rejected the *net* calculation employed by Paterson to avoid the problem of interpreting negative values for children and the aged. A discount rate of 10% p.a. was assumed in all present value calculations as recommended by the Treasury Department for public sector evaluation.

Sherwin did not quote *average* accident costs and raised a most significant feature of accident statistics, namely that they are generally characterised by highly *skewed* distributions. This means that the use of a simple average costs is therefore often meaningless, and may also be of limited usefulness in public decision-making.

The work of Faigin (1976) resulted in detailed road accident cost estimates for the United States of America in 1975, produced by the National Highway Traffic Safety Administration (NHTSA) within the U.S. Department of Transportation. The Faigin study completed a programme of accident cost research initiated by the NHTSA after its preliminary estimates of the societal cost of road accidents for 1971.

Total United States accident costs in 1975 are summarised as:

Accident Category	Average Cost U.S.$	Total Cost (1975) U.S.$billion
Fatalities	287,200	13.4
Injuries	3,200	12.8
Property Damage Only	520	11.4
		37.6

The major feature of this study is the development of an expanded range of societal cost categories, each classified by six classes of injury severity according to the "Abbreviated Injury Scale" (AIS) developed by NHTSA with the assistance of the American Medical Association *et al.* Thus a detailed matrix of unit accident costs was produced (see Appendix A-1, tables 37 and 49) with the objective, *inter alia*, of facilitating social benefit-cost evaluations of safety programmes with differing effects on injury severity.

The Faigin study involved a thorough researching of available accident cost data and other relevant studies to produce what are probably the most detailed and reliable estimates of accident effects and costs possible given the limitations of existing information. Faigin noted that there was only a slight improvement in the cost data base between 1971 and 1975, and that a significant improvement in basic sources was necessary to further improve unit cost estimates. Other features of the 1975 study include the omission of estimates for "pain and suffering" costs which were included in the preliminary estimates for 1971. Treatment of foregone income followed the usual form of calculating the present value of average income levels (for median ages within each age group). Although separate male and female income levels by age groups were calculated, consumption expenditure was *not* excluded, and the average income levels for those members of the workforce were imputed to *all* members of the population in each age group. *This is equivalent to assuming an opportunity cost income level for housewives and those unemployed equal to the average income of those in the workforce.* This procedure is also adopted in the present study: it is considered to be more appropriate than the approach adopted in Paterson (1973) and Japan (1978), for example, in which the effect of averaging workforce incomes across the total population is equivalent to imputing a *zero* income and opportunity cost to those not in the workforce.

The extensive research into the effects of (non-fatal) injuries upon work time lost and levels of permanent impairment in the case of more serious injuries, which was undertaken in the course of the Faigin study has produced the most reliable and detailed injury cost estimates presently available.

Expressed as average work days lost, or by degree of permanent impairment for each of the six AIS classes of injury severity, the injury severity estimates compiled in the Faigin report have been adapted for use in several other accident studies, including the present study.

The unit cost framework outlined in the Faigin report is considered to be the most appropriate and complete example of the social loss accounting approach to road accident cost estimation. For this reason, the unit cost framework adopted in the present study closely follows Faigin. However, the latter report clearly acknowledges that the concept of societal loss goes beyond economic welfare, and that adequate quantification of all accident effects in dollar terms is therefore not possible. Because of these issues Faigin emphasised that the *total* cost estimates derived from the unit cost figures are simply indicators of the magnitude of the road accident problem, and their use as benefit measures in benefit cost analyses is limited because they are only partial measures of the willingness-to-pay criterion.

The Australian study of the cost of road accidents undertaken by Paterson (1973) produced national cost estimates for 1969 framed in strict national accounting terms. This study draws extensively upon unit costs and other accident relationships established in the earlier Australian study by Troy and Butlin (1971), although the Paterson report developed its own "life model" to estimate the *net* contribution to national income of the average member of the community, divided into three age groups. The results of the Paterson report estimates are:

Cost Category	Cost per unit	Total Costs (1969)	
	$	$m	
Fatalities	25,300	88.7	18.5%
Injuries*	1,030	90.6	18.9%
Vehicle repairs *(per vehicle)*	220	199.7	41.5%
Other Costs	210	101.4	21.1%
Total:	$1,010 *(per accident)*	$480.3	100%

The report produced disaggregated estimates for a proportion (68%) of total accident costs for each state and territory for 1969, with costs for each region classified according to five types of accident (collision between vehicles; overturned, or left road; collision with pedestrian; collision with fixed object; and all other accidents).

As with the present study, the Paterson report estimated the total number of road accidents indirectly since only casualty accidents are recorded in most Australian states. Troy and Butlin found that approximately 90% of all accidents in the Australian Capital Territory did not involve personal injury, and ratios for each accident class derived from the latter study formed the basis of Paterson's estimates of the total number of accidents in 1969. The basis of other cost estimates in the Paterson study is outlined in Appendix A-1. What is

* The term injuries' is used throughout the present report to mean persons non-fatally injured as a result of road accidents (see also footnote on p.24).

somewhat novel in the Paterson report is the "life model" basis for calculating the present worth (at 5% discount rate) of foregone income. This technique results in an average 1969 income loss or "value" of $25,300 for all accident fatalities, but is further separated into non-pedestrians with a "value" of $30,500, and pedestrians with a "value" of $8,700. The lower figure for lost income of pedestrians reflects the relatively high proportion of older persons involved in pedestrian accidents: in the economic life cycle assumed by Paterson, persons over 65 years of age were estimated to "contribute" a net withdrawal of about $1,600 per annum, resulting in a negative "income" for this group. The use of discount rates above 5% in the present value calculations of the Paterson "life model" (*vide* Tables 44 and 45, p.100) would change the net contribution of some age groups under 19 years from positive to negative amounts.

While these estimates and assumptions are consistent with the criterion adopted in the Paterson report, namely that of *ex post* agreement with the *net* potential contribution of accident victims to national income, this approach certainly does not constitute a community value, or values, placed upon the lost life and/or income, as established by Mishan (1971), and discussed by Lawson (1978), Mooney (1978) *et al.* As a result of these "life model" assumptions, the Paterson report is considered to greatly overemphasise the relative importance of property damage in total accident costs, a criticism which can also be made of the interpretation of accident costs by Troy and Butlin.

The Paterson report also contains a comprehensive bibliography and selective review of accident cost literature up to 1971, together with a useful critique of accident statistics in Australia. Although cost estimates were partially allocated by states and accident types, the report concluded that available data did not support estimates of the separate costs of fatal, casualty, or property damage accidents. It also noted the skewed cost distributions revealed by Troy and Butlin, which limit the usefulness of *average* values.

The final cost estimation study reviewed is the 1972 preliminary report of the U.S. National Highway Traffic Safety Administration (NHTSA). This report defined its concept of accident costs as well beyond financial and material loss accountable measures: it adopted the principle that quantifiable losses are experienced by the community regardless of whether they have values established in market transactions. As a result, the NHTSA 1972 report included estimates for the value of pain and suffering, community services, and losses to others, in addition to the usual material costs. The cost estimates for the U.S.A. in 1971 are summarised as:

Cost Category	Cost per Unit	Total Cost (1971)
	US$	*US$billion*
Fatality *(per accident)*	200,700	11.0 (24%)
Injury *(per accident)*	7,300	27.6 (60%)
Property Damage Only	300	7.4 (16%)
Total *(per accident)*	1,650	46.0 (100%)

The 1972 report included some more approximate estimates of certain costs including "pain and suffering" on the basis that a reasonable estimate of this magnitude is preferable to its omission - which implies a zero value for that item. In the view of the report, this practice in the past has possibly led safety agencies to direct a greater than optimal amount of resources towards the prevention of property damage, because of the difficulties experienced in measuring fatality and injury costs. But, as in the later Faigin study, this report emphasises that fatality and injury costs do *not* purport to establish a unique value for human life. They consist rather of minimal estimates of society's willingness to pay to avoid such events. The estimation work initiated in this 1972 study was considerably advanced in the later Faigin study (*op.cit.*).

CHAPTER 3

A FRAMEWORK FOR AUSTRALIAN COST ESTIMATES

3.1. A PROPOSED ACCIDENT COST FRAMEWORK

A principal objective of this present study is to propose a framework suitable for the estimation of the social costs of road accidents in Australia, and to present a preliminary set of such cost estimates based upon existing data sources consistent with such a framework. Together with these preliminary estimates a discussion of existing data sources and their deficiencies was envisaged.

In this chapter a set of preliminary road accident cost estimates for Australia in 1978 is presented, containing both average unit costs and total accident costs classified according to the specific cost framework proposed. It is convenient to consider in turn throughout this chapter the relevance of each component cost category within this framework together with the estimation procedures and attendant data difficulties.

The cost framework adopted is predominantly based on that of the Faigin (1976) official study for the National Highway Traffic Safety Administration, of the U.S. Department of Transportation. This latter study developed and published the most comprehensive set of unit accident cost estimates in the literature, and identified some eleven categories of "societal", or social and economic, costs attributed to road accidents. The Faigin study also undertook definitive research into the composition of unit cost estimation procedures resulting in a seven class disaggregation of all accident costs according to injury severity. Adoption of the resultant cost matrix, consisting of eleven rows and seven columns, is considered to be somewhat ambitious in the light of existing Australian data sources, but its use as the basis of a set of preliminary Australian accident cost estimates is considered desirable to retain the most complete conceptual framework available. A significant benefit from the use of a comprehensive cost concept is that it avoids the implicit judgement that a valid cost category which is excluded is attributed a zero value.

Categorisations of social and economic costs such as the Faigin cost matrix are intended to go beyond the narrow loss-accounting procedures of many earlier studies. However, it is emphasised that this present study both recognises and suffers from the remaining deficiencies inherent in these cost formulations as cited in Lawson

(1978) and acknowledged by Faigin, namely that social *cost* estimates, however complete, can represent only *minimum* estimates of the true value society places upon the benefits from accident reduction. Therefore the use of the following cost estimates, however accurate, as indicators of the benefits to be gained from accident reduction is subject to some limitations. In the present study the view is taken that it is desirable to estimate unit accident costs according to injury severity levels to permit any such average cost levels to be usefully interpreted and applied. The support for this view is threefold: firstly, application of these estimates in the appraisal of any accident prevention project or policy evaluation usually requires such a distinction between the severity of accident effects: second, the statistical distributions of most accident characteristics are generally highly skewed so that the use of simple averages may be misleading; and finally that the nature of the accident source data is such that reliable empirical estimation procedures are frequently best achieved by undertaking estimates of costs grouped by severity levels.

A relatively large number of unit accident costs is contained in the following estimates, and the approach adopted in this presentation has been to show both the effects upon costs of different conceptual approaches, and also of changes in the levels of the key parameters of the estimation method. An overall judgement based on the experience of this present study is that in effect the minimum level of detail required to develop a set of even preliminary accident cost estimates in this detail for Australia is very high.

TABLE 1

AVERAGE ACCIDENT COSTS BY INJURY SEVERITY LEVEL
AUSTRALIA 1978: PRELIMINARY ESTIMATES (10% Discount Rate)

COST CATEGORY	Abbreviated Injury Scale (AIS) Level:						*Property Damage Only*
	6 *Fatal*	5 *Critical*	4 *Severe*[2]	3 *Severe*[1]	2 *Moderate*	1 *Minor*	
	$	$	$	$	$	$	$
1. Foregone Income	113,510*	63,840*	28,000*	1,210	650	50	-
2. Family, Community Losses	*34,050**	*19,150**	*8,400**	*365*	*195*	*15*	-
3. Hospital	670	36,000	11,900	7,100	1,900	150	-
4. Medical	310	3,120	1,730	1,000	380	75	-
5. Rehabilitation etc.	800	3,300	1,320	560	235	50	-
6. Legal & Court	*2,200*	*1,650*	*1,100*	*800*	*150*	*140*	*10*
7. Insurance Admin.	865	865	865	740	610	170	100
8. Accident Investig.	*200*	*200*	*100*	*100*	*50*	*50*	-
9. Losses to Others	*1,400*	*1,500*	*700*	*120*	*60*	*10*	-
10. Vehicle Damage	3,000	4,000	3,000	2,600	1,400	1,400	350
11. Traffic Delay	*80*	*60*	*60*	*160*	*160*	*160*	*160*
TOTAL	157,085	133,685	57,175	14,755	5,790	2,270	620

* *Calculated using a 10% discount rate (and 3% p.a. "productivity")*

2 *AIS Class 4"Severe: life-threatening, survival probable"*; 1 *AIS Class 3"Severe: not life-threatening"*

In the following discussion a consistent set of cost estimates is presented throughout based on, *inter alia*, the choice of a discount rate of 10% per annum. Alternative results using discount rates of 7% and 13% were obtained for the main cost items, but detailed results using the latter rates are contained in Appendix A-2 (*vide* Tables 49 to 52).

The fundamental set of unit cost estimates for road accidents in Australia, reflecting the underlying framework of cost categories and accident severity levels adopted in the present study, is contained in Table 1.

Table 1 shows a matrix of unit or average accident costs for eleven cost categories, each separated according to six categories of injury severity, based on the Abbreviated Injury Scale (AIS) (*vide* Table 5) and accidents involving only property damage. The unit cost figures shown in Table 2 in italic type represent direct unit cost estimates drawn from other studies (mainly Faigin,1976). This summary matrix shows the existence of a wide variation in unit cost components by accident class, both in total and across each row. The average cost of a single fatality was over $157,080 in 1978, compared with $2,270 for a minor injury and only $620 for an accident involving only property damage. This reflects a maximum ratio of over 250:1 between unit cost levels indicating the extreme range of cost levels associated with road accidents. Within each injury severity class, it is apparent that the foregone income component comprises a major proportion of fatality and serious injury costs (ranging from 72% to 49% respectively). Table 1

TABLE 2

SUMMARY OF TOTAL ACCIDENT COSTS: AUSTRALIA 1978

(10% Discount Rate)

Cost Category	Fatalities	Injuries			Property Damage Only	Total
		Major*	Minor*	Total		
	$m.	$m.	$m.	$m.	$m.	$m.
Foregone Income	420.5	45.5	19.1	64.6	-	485.1
Losses to Family Community	126.2	13.7	5.8	19.5	-	145.6
Hospital, Medical etc.	6.6	57.5	79.6	137.1	-	143.8
Vehicle Damage	11.1	14.0	129.6	143.6	322.9	477.6
Other costs	17.6	11.2	61.2	72.4	249.0	339.0
TOTAL	582.0	141.9	295.3	437.2	571.9	1591.1

* *Major Injury is defined as the sum of AIS classes 3,4, & 5; Minor injuries are the sum of AIS categories 1 & 2 in Table 1.*

also includes several non-market cost estimates, including the value of lost income (and services) of accident victims to families and to the community, losses to employers, and the cost of traffic delays and congestion caused by road accidents. The derivation of each of the unit cost estimates is discussed later in this chapter. Before considering these unit costs in more detail, a set of *total* accident costs (calculated by multiplying the unit costs of Table 3 by the accident numbers in Table 5 below) is shown in Table 2.

Table 2 shows that the estimated *total* cost of road accidents in Australia was over $1,590 million in 1978; or equivalent to nearly 2 % of Gross Domestic Product in 1977/78 (although, as indicated elsewhere in this report, national income comparisons are not always the most relevant for road accident costs). Foregone income was the largest cost category comprising 31% of the total, followed by vehicle damage at 30%. Medical and hospital costs combined were relatively small at 9 percent of the total. By category of accident, fatalities represented 37%, injuries 27%, and vehicles with property damage only were 36 percent of total costs. Based on the summary in Table 2, an abbreviated set of unit accident costs is shown in Table 3, both according to average costs *per person* (and per vehicle for property damage only) and *per accident*.

TABLE 3

SUMMARY OF AVERAGE ACCIDENT COSTS - AUSTRALIA 1978
(10% Discount Rate)

Cost Category	Fatalities	Injuries			Property Damage Only	Total
		Major	Minor	Total		
	$	$	$	$	$	$
I - PER PERSON & PER VEHICLE						
Foregone Income	113,510	8,870	210	660	-	-
Losses to Family, Community	34,050	2,660	60	200	-	-
Medical, Hospital	1,780	11,220	860	1,400	-	-
Vehicle Damage	3,000	2,730	1,400	1,470	350	-
Other Costs	4,745	2,190	660	740	270	-
TOTAL	157,085	27,670	3,190	4,470	620	-
II-PER ACCIDENT	$	$	$	$	$	$
Foregone Income	128,690	12,750	300	950	-	870
Losses to Family, Community	38,600	3,830	90	290	-	260
Medical, Hospital	2,020	16,140	1,230	2,010	-	260
Vehicle Damage	3,400	3,930	2,010	2,110	670	860
Other Costs	5,380	3,150	950	1,060	510	610
TOTAL	178,090	39,800	4,580	6,420	1,180	2,860

The unit cost estimates in Table 3 represents a consolidation of Table 1 figures and need to be interpreted with some caution, not because of unreliability, but because comparison of Table 3 with the average costs in Table 1 demonstrates clearly that *average* accident costs change significantly according to any re-grouping of accident classes.

From Part II of this table it can be seen that while the average cost of any accident in 1978 was $2,860 the cost of a fatal accident was $178,090, vehicle-damage-only averaged $1,180, and injury accidents ranged from $4,580 for a minor injury accident to $39,800 for a major injury accident. When the range of separate costs for these two combined injury groups is compared with the average cost of all injury accidents of $6,420 it is evident that such averages should be interpreted with caution.

A major source of variation in these cost estimates is the choice of discount rate. In Tables 1 to 3, the two cost categories of *foregone income* and *losses to family and community* are significantly affected by changes in the discount rate selected. A rate of 10% per annum is used for these tables, but the effects of increasing and decreasing this rate from 7% to 13% respectively are shown in a corresponding set of cost tables contained in Appendix A-2. The issues surrounding choice of the discount rate are discussed later in this chapter, but the effects of lowering and increasing the rate, from 7% to 13%, can be summarised as resulting in a range of $1,448 million to $1,850 million in *total* accident costs, and a range of $138,000 to $250,000 in the average cost of a fatal accident, and a comparable range of $36,000 to $46,600 in the unit cost of major injury accidents. Other cost categories are not affected, by the discount rate although the average overall accident cost shows a range of $2,600 to $3,300.

3.2 OUTLINE OF COST COMPONENTS AND DATA SOURCES

The estimation procedures and data sources for Tables 1 and 2 are now outlined and discussed briefly.

Number of Road Accidents. One of the most basic and obvious statistics required for the derivation of unit and total cost estimates is the number of road accidents and accident victims. The Australian Bureau of Statistics (A.B.S.) compiles statistics of casualty accidents from police accident reports prepared in the various States and Territories. The A.B.S. has recently drawn attention to the existence of significant differences in the definitions and coverage of casualty accidents between the States, and has suspended publication of certain aggregated statistics for Australia after 1977. The basic accident statistics of interest in the present study are the total number of casualty* accidents, the number of fatalities and injuries, and certain cross-classifications of the foregoing information including details of

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* The term "casualty" is used to include fatal and non-fatal injury accidents; "injury" is used to cover only non-fatal injury accidents.

the nature of accident, and age and sex distribution of victims. Details of published total road accident statistics in Australia for the years 1975 to 1978 are shown in Table 4.

TABLE 4

ROAD ACCIDENTS INVOLVING CASUALTIES - AUSTRALIA 1975-1978					
YEAR	ACCIDENTS		CASUALTIES		
	Number of Fatal Accidents	Total No. of Casualty Accidents	Fatalities	Injuries	Total
1975	3,246	65,788	3,694	89,499	93,193
1976	3,156	64,282	3,583	87,808	91,391
1977	3,161	67,693	3,578	91,818	95,396
1978	3,268	71,334	3,705	97,685	101,390

Source: Road Traffic Accidents Involving Casualties, December Quarter 1979, A.B.S. Canberra (Catalogue No. 9402.0). Explanatory notes to this publication indicate that there is some variation in the definition and reporting of casualty accidents between the States and Territories.

Because the present study adopts a cost estimation procedure based on injury severity classes it was necessary to re-classify the casualty accident data of Table 4 according to appropriate injury severity groupings. It was also necessary to derive estimates of the large and generally unrecorded number of road accidents which involve vehicle and/or other property damage *only*, without causing any injuries. The injury severity classification adopted was the six-category "Abbreviated Injury Scale" (AIS) which has been developed specifically for road accident research in the United States of America. The Abbreviated Injury Scale is outlined in the review of Faigin (1976) in Appendix A-1 (see Table 38). In the present study an allocation of Australian accident numbers and costs was made to Abbreviated Injury Scale categories, (based on statistical analysis of a sample of Australian accident-cost distributions, together with the U.S.-derived proportions (see page 48 and Appendix A-3), and the resultant distribution of accident numbers is shown in Table 5.

TABLE 5

ESTIMATED CLASSIFICATION OF ACCIDENTS BY INJURY SEVERITY - AUSTRALIA 1978 (Preliminary Ø)

Estimated Accident Classification*	Number of Accidents	Number of Injuries	Number of Vehicles
A.I.S. 6 (*fatal*)	3,268	3,705	5,098
A.I.S. 5 (*Critical: survival uncertain*)	143	205	223
A.I.S. 4 (*Severe: life-threatening*)	687	987	1,072
A.I.S. 3 (*Severe: not life-threatening*)	2,736	3,937	4,268
A.I.S. 2 (*Moderate*)	16,853	24,187	26,291
A.I.S. 1 (*Minor*)	47,647	68,369	74,329
Total casualties	71,334	101,390	111,281
Property Damage Only (P.D.O.)	485,489	-	922,429
TOTAL	556,823	101,390	1,033,710

Source: fatal and injury accident totals, and total fatalities and injuries are obtained from A.B.S. data (cf. Table 4); the total number of vehicles involved in accidents is estimated in Table 22; P.D.O. vehicles are obtained by subtracting vehicles in casualty accidents; these latter are estimated by multiplying the number of accidents (column 1) by 1.56, representing the estimated ratio of vehicles per casualty accident (based on 1977 A.B.S. data); the number of P.D.O. accidents is obtained by dividing P.D.O; vehicle numbers by 1.9, representing the estimated ratio of vehicles per P.D.O. accident (after Troy and Butlin, 1971, p.202).

The allocation of accident and casualty numbers between Abbreviated Injury Scale (A.I.S.) classes 1 to 5 is based on the 1975 U.S.A. proportions in these A.I.S. categories after Faigin (1976 Table 2) together with some adjustments based on the distribution of accident injury costs contained in Motor Accidents Board (M.A.B.) data for Victoria. Because of some apparent differences between the distributions of accident characteristics for the U.S.A. and Victoria, 70% of non-fatal accident numbers were allocated to A.I.S. category 1 compared with 85% for the U.S. distribution: the remaining A.I.S. classes 2 to 5 were allocated as in Faigin (1976).

Ø These estimates by category are provisional estimates only: a more refined classification of Australian road accidents by injury severity level will require a separate study based upon improved data.

**Abbreviated Injury Scale (see Table 38)*

Estimation methods are summarised in the footnotes to Table 5. These estimates employ certain key estimation ratios from the detailed Australian accident study of Troy and Butlin (1971), and use is also made of new data unique in Australia for the size-distribution of medical and related accident costs for casualties obtained from the Motor Accidents Board of Victoria.

Foregone Income Calculations. One of the more significant accident cost components in Table 1 is the unit cost of $113,510 representing the present value of lost future income which would have accrued in the period between accidental death and normal life expectancy. The calculation and conceptual basis of this cost component has been the subject of some controversy in the literature, therefore in the present report the basis of this estimate and its sensitivity to changes in the main assumptions and alternative concepts is examined in some detail. A range of foregone income levels for road accident fatalities in 1978 is presented in Table 6.

TABLE 6

FOREGONE INCOME: ROAD ACCIDENT FATALITIES - AUSTRALIA 1978

Age Group	Number of Fatalities (1)	Present Value of Average Gross Income Foregone at:- (2) (3)								
		7%(disc) 2.5%(prod)	7% 3%	7% 3.5%	10% 2.5%	10% 3%	10% 3.5%	13% 2.5%	13% 3%	13% 3.5%
		$	$	$	$	$	$	$	$	$
0-4	104	83,078	97,168	113,987	35,429	41,801	48,076	18,916	[illegible]	24,284
5-6	50	107,962	124,607	144,319	50,907	57,704	65,528	26,050	29,076	32,511
7-16	[illegible]	135,927	152,359	171,316	75,849	83,424	91,990	46,587	50,499	54,844
17-20	746	207,296	224,731	244,372	[illegible]	148,701	158,785	[illegible]	102,213	[illegible]
21-29	864	218,281	233,962	251,355	54,277	163,101	172,765	[illegible]	103,536	[illegible]
30-39	394	184,557	194,837	205,959	139,537	146,084	153,116	96,944	102,872	[illegible]
40-49	285	136,369	141,610	147,1[illegible]2	111,553	115,289	119,106	86,[illegible]67	88,696	91,449
50-59	317	73,956	75,426	76,954	66,316	67,571	68,856	54,783	55,757	56,755
60+	604	36,033	36,371	36,712	34,201	34,513	34,828	31,003	31,277	[illegible]
AVERAGE GROSS INCOME FORGONE (4) per fatality		151,301	162,264	174,532	107,541	113,510	120,072	80,356	84,076	88,117

(1) Total number of fatalities was 3705 in 1978 [illegible] with age not specified

(2) Discounted to 1978 values at discount rates as shown; also incomes were incremented by annual productivity increases as indicated (7% discount with 3% productivity increase is comparable with the U.S.1975 figures in Tables 1 and 3 in Faigin (1976).

(3) Average figure for each age group is calculated as a weighted average of male and female incomes (e.g. for [illegible] 0-4 years age group [illegible] is the sum of [illegible] of the male average of [illegible] plus [illegible] of the female average of $60,941.

(4) The overall average income loss per fatality is calculated as the weighted average of the estimates for all age groups.

Table 6 shows the present value in 1978 dollars of average income foregone for each age group and an overall total, for each of six sets of discount rate and income productivity rate assumptions. The estimate of $113,510 in Table 1 is drawn from the estimates in the fifth column of Table 6 (i.e. 10% and 3%). The resultant figure is a "weighted" total of the lost income for each of the age groups shown in the first column of the table. The method of computation is similar to that employed in Faigin (1976), modified to comply with Australian data sources. In addition to the need for data on average annual income levels by age groups (*vide* Table 7) the figures in Table 6 incorporate the effects of the age and sex distributions of the particular sample of road accident fatalities in 1978, that is the foregone income figures will vary with the age/sex distribution of road casualties as well as with changes in income. This fact is of particular significance because the age and sex characteristics of road accident victims are significantly different from the national and state population averages. The foregone income figures for each separate age group in Table 6 show the average income loss for persons of median age in each group (e.g. $163,101 is the present value at 10% of average future income for a person of 25 years).

In addition to the foregoing sources of variation in Table 6, the concept of *income* adopted for these calculations also has a significant effect on the resultant estimate. Because of the number of parameters capable of variation, together with the relative complexity of the calculation method, the effects of changes in these key parameters upon the result estimates of the present value of lost income are explored in some detail.

The principles underlying the concept of foregone *gross* income adopted in this present study as an indicator of social loss follow closely the approach of Mishan (1971), a useful discussion of which is contained in the recent Canadian research of Lawson (1978). In this approach the level of personal gross income foregone (or its gross production equivalent) is taken to be the loss to the community from accidental death or serious injury, where the society or community is defined so as to *include* the person killed or injured. The alternative concept of *net* income, or net production, whilst consistent with national income definitions (in the sense that it measures the change in national income which occurs as a result of road accidents) is not considered to be appropriate to the concept of social loss from road accidents, nor to that of gains from accident prevention. The effects of these differing income definitions upon the resultant accident cost estimates are outlined below.

The basic data required to undertake foregone income calculations are mean income per capita classified by age groups, contained in Table 7, and the age-distribution of road accident casualties. The 1978 income figures by age are based on a 1973-74 survey undertaken by the Australian Bureau of Statistics and updated by price indices for the present study. More recent survey data would improve the overall reliability of the income estimates.

TABLE 7

MEAN INCOME by AGE GROUPS AUSTRALIA 1978		
Age Group	Male	Female
(Years)	$	$
15-19	3,520	3,021
20-24	8,663	5,231
25-34	12,275	4,319
35-44	13,142	4,785
45-54	13,160	5,150
55-59	11,409	4,805
60-64	10,893	3,852
65+	5,179	3,285
TOTAL	10,524	4,379

Source: *based on 1973/74 figures from the Survey of Income Distribution 1973-1974, Australian Bureau of Statistics: (i) incremented by a factor of 1.843 (representing the increase in Average Weekly Earnings between 1973/74 and calendar 1978) for both male and female incomes and (ii) female incomes were incremented by a further 10% to allow for the relative rise in female incomes as a proportion of male incomes between 1973/74 and 1978 (e.g. figures for earnings are not available, but female wage rates rose from 85% of the male rate in 1973 to 94% in 1977).*

Choice of Discount Rate. The choice of discount rate has a most significant effect on the present value of foregone income as shown in the discounted present value calculations of Table 6. In this table projected future income is incremented by an annual labour productivity rate, in addition to the discounting calculations. These two rates have opposing effects upon the foregone income figure: the higher the discount rate the lower the present value of foregone income; while the annual productivity rate (or increase in real income) operates to increase income.

The effects of varying these two parameters is shown in Table 6 which shows three discount rates (7%, 10% and 13%) combined with three productivity rates (2.5%, 3% and 3.5%). The present-value algorithm used in these calculations utilises the fact that, for example, 10% discount together with a 3% productivity increase is equivalent to an effective discount rate of $\left[\frac{1.10}{1.03} - 1\right]$ % or 6.8%.(It is therefore not correct simply to subtract the productivity rate from the discount rate in these calculations).

The preferred income productivity rate for this study is 3 % per annum (*vide* Appendix A-2, Table 65 for the basis of the productivity estimate based on Australian data over the period 1967 to 1978).

The issues surrounding the appropriate choice of discount rate in benefit-cost analysis are somewhat complex and are also the subject of continuing controversy (*vide*: Treasury [1978]; Layard [1972]; Dasgupta and Pearce [1972]. The basis of the approach adopted here is outlined briefly.The need to discount future (projected) streams of costs and revenues public and private sector investment analysis arises because benefits (i.e. revenues, etc.) and costs occurring in different time periods are valued differently by the community. This is sometimes termed a positive rate of time preference in the economic literature, implying that individuals tend to prefer consumption in the current time period (to saving income) rather than to defer it to some time in the future. Thus the discount rate "r" which equates some given dollar amount one year hence with the same amount in the present represents the time-preference rate for that individual. Because of the existence of externalities and interdependencies associated with the benefits and costs to the community, from public sector investment (or, what are termed the *public* or "social" *goods* characteristics of public investment: *vide* Musgrave & Musgrave [1976] chapter 3), the true community rate of private time preference, or *Social Time-Preference rate of discount*, cannot be derived readily from individual rates. For practical purposes the Social Time-Preference (or STP) rate of discount is generally taken to be some amalgam of the implicit rates determined by voting practices and political decision-making.

A significant problem in selecting a rate of discount is that estimates based on the Social Time Preference concept are considered likely to diverge from rates based on the principal alternative discount rate concept, namely the *Social Opportunity Cost* of capital (or SOC rate). The Social Opportunity Cost rate is intended to measure the marginal productivity of capital investment, or in effect the present cost to society of diverting resources away from investment in private sector projects, to public (i.e. government) sector projects. Under certain theoretically ideal conditions, these two rates-STP and SOC-are equivalent. In practice they diverge, it being generally assumed that a Social Time Preference rate will be less than the Social Opportunity Cost rate of discount. More complex issues concerning the choice between STP and SOC rates of discount are considered at length in the literature, and the main issues are outlined in summary in the draft discount rate guidelines prepared by the Federal Treasury Department (*vide:* Treasury [1978]). In the latter Treasury document, a case is argued for a choice of discount rate based on the Social Opportunity Cost concept rather than Social Time Preference, and the recommended discount rate for use in benefit-cost analysis of public projects is 10%, with sensitivity tests of the results to be completed at rates of 7% and 13% per annum.

In the interests of consistency and comparability, the accident cost estimates in this present study (or those specific cost components affected by discounting calculations) have been estimated using the recommended rates of 10%, 7% and 13% per annum. However two bases of disagreement with the conclusions of the Treasury draft document as general prescriptions can be noted: first, that the argument in favour of an SOC-based discount rate may give too much weight to the issue of *displacement* or the optimal distribution of total investment between the private and public sectors of the economy in the current time period, rather than to a measure of the community's collective preference for public goods which are not optimally provided by the private sector.

Second, in the case of public sector provision of commodities such as improved road safety the use of a higher discount rate is seen to discriminate markedly in practice between those accident cost measures which involve fatalities and/or major injuries, and those in which property damage costs predominate. Inevitably, this also raises "value of life" issues which are not readily resolved, such as whether it is feasible or desirable in public decision-making to trade-off accident prevention (especially death and serious injury) against more conventional measures of social and economic benefit (*vide* Freeman [1979], Schelling [1968], and Mishan [1971]).

TABLE 8

THE EFFECT OF THE DISCOUNT RATE ON FOREGONE INCOME
(at 3%p.a. productivity increase)

Discount Rate (p.a.)	Foregone Income For*		Australian Population Average
	Fatalities	Injuries	
	$	$	$
5%	219,791	225,309	170,787
7%	162,264	163,548	121,428
10%	113,510	112,004	81,729
13%	86,641	84,076	60,762
15%	74,965	72,096	51,853
20%	56,835	53,768	38,246

* *Differences in income figures between accident victims and the national population average reflect differing age distributions.*

In summary the view adopted in this present report is that the need for comparability in public sector evaluation outweighs arguments for the use of a lower discount rate specially determined for road safety evaluations. Therefore, a discount rate of 10% p.a. is employed in the main average and total accident cost tables in the body of the text. However a fairly comprehensive range of tables showing the divergent cost estimates obtained at rates of 7% and 13% is contained in the appendices and, where significant, these alternative results are referenced in the text. The overall result of this investigation of discount rate effects is a proliferation of tables in this report which are needed to display the range and sensitivity of the main cost estimates to changes in the discount rate together with other estimation parameters.

In Table 8, the effects of varying the discount rate from 5% to 20% per annum upon the estimated remaining lifetime income which would be lost as a result of premature death in a road accident is shown for three separate age-groups sample populations. Table 8 compares estimates of the present value of total income foregone between age at time of accident and normal life expectancy, weighted by the age group of the sample of the population recorded in (i) road accident fatalities; (ii) non-fatal injuries; and (iii) by the total population age-groups. Thus, two types of variation are shown: within each column, the 1978 present value of remaining income can be compared; and across the three columns, the effects of the differing age groups is compared.

In general Table 8 shows that the present value of foregone income for accident fatalities and injuries is comparable, but the equivalent results for Australian average population are approximately 30% lower. The effects of age group weighting are discussed further below. The principal outcome of this table is the significant decline in the present value of foregone income, as the discount rate is increased. For fatalities, foregone income at a 7% discount rate is 43% greater than at a 10% discount rate, and at 13% this value falls 24% below the 10% level. Similar (though not identical) differences occur for injury and average Australian population age groups. The effects of these discount rate variations between 7%, 10% and 13% upon unit (average) accident costs can be seen by comparing Table 1 with Tables 50 and 51. The first three entries in rows 1 and 2 of these tables (marked with an asterisk) are dependent on the foregone income calculations: these items also account for a major share of variation in the overall cost estimates.

Age Distribution of Fatalities and Injuries. Details of the age and sex distributions of road accident victims are contained in Tables 9 and 10.

TABLE 9

AGE DISTRIBUTION OF ROAD ACCIDENT FATALITIES AUSTRALIA 1978						
Age Group	Males	%	Females	%	Total	
(Years)						(%)
0-4	48	*(46.2)*	56	*(53.8)*	104	*(2.8)*
5-6	32	*(64.0)*	18	*(36.0)*	50	*(1.4)*
7-16	199	*(60.1)*	132	*(39.9)*	331	*(8.9)*
17-20	589	*(79.0)*	157	*(21.0)*	746	*(20.1)*
21-29	716	*(82.9)*	148	*(17.1)*	864	*(23.3)*
30-39	293	*(74.4)*	101	*(25.6)*	394	*(10.6)*
40-49	193	*(67.7)*	92	*(32.3)*	285	*(7.7)*
50-59	211	*(66.6)*	106	*(33.4)*	317	*(8.6)*
60+	342	*(56.6)*	262	*(43.4)*	604	*(16.3)*
Not stated	9		1		10	*(0.3)*
Total	2632	*(71.0)*	1073	*(29.0)*	3705	*(100.0)*

Source: Office of Road Safety (ORS) Working Document No. 16 (3/80) (A.B.S. Data)

The recorded age distribution ranges for road accident statistics differ from the age ranges for which income data are recorded, and some re-estimation was required to derive the income levels for injuries in Table 11.

TABLE 10

AGE DISTRIBUTION OF ROAD ACCIDENT INJURIES AUSTRALIA 1977						
Age Group	Males	%	Females	%	Total	
(Years)						(%)
0-4	1474	*(54.8)*	1217	*(45.2)*	2691	*(2.9)*
5-6	950	*(59.2)*	656	*(40.8)*	1606	*(1.8)*
7-16	6377	*(58.5)*	4526	*(41.5)*	10900	*(11.9)*
17-20	14614	*(68.7)*	6661	*(31.3)*	21278	*(23.2)*
21-29	14426	*(66.5)*	7273	*(33.5)*	21698	*(23.7)*
30-39	6091	*(60.0)*	4063	*(40.0)*	10155	*(11.1)*
40-49	3951	*(56.9)*	2989	*(43.1)*	6940	*(7.6)*
50-59	3388	*(55.1)*	2762	*(44.9)*	6150	*(6.7)*
60+	3328	*(51.3)*	3158	*(48.7)*	6486	*(7.1)*
Not stated	2184	*(58.8)*	1528	*(41.2)*	3712	*(4.1)*
Total	56783	*(62.0)*	34833	*(38.0)*	91616	*(100.0)*

Source: Road Traffic Accidents, (December Quarter 1977), A.B.S. (Catalogue No. 9403.0)

Separate average income estimates were required for calculation of the foregone income of injuries, and these income levels are shown in Table 11.

TABLE 11

AVERAGE INCOME OF ROAD ACCIDENT INJURIES (1) AUSTRALIA 1978						
Age Group	Per cent of 17-64 years total (2)	Proportion: Male	Proportion: Females	Average Annual Income (3) Male	Average Annual Income (3) Female	Weighted Average Income
	%	%	%	$	$	$
17-20	(17.7)	68.7	31.3	5,064	3,684	4,632
21-29	36.2	66.5	33.5	9,955	4,827	8,237
30-39	17.0	60.0	40.0	12,666	4,531	9,412
40-49	11.6	56.9	43.1	13,150	4,949	9,615
50-59	10.3	55.1	44.9	12,079	4,886	8,849
60-64	(7.2)	51.3	48.7	10,893	3,852	7,464
WEIGHTED AVERAGE 1978 INCOME *per* INJURY ;						$7,963

(1) *Calculated on the basis of male/female weighted average for each age group: the overall weighted average is based on the proportion of each age group to the 17-64 years total (see note 2).*

(2) *These percentages are based on 1977 Road Accident Statistics, excluding those with age not specified, and adjusted (i) to include half the 17-20 years group (assumed to be in the workforce); and (ii) to include two-thirds of the 60+ age group (comprising 60-64 years group).*

(3) *Adjusted to conform with age groups for injury accidents (by linear interpolation between medium incomes for each group, and recalculation of averages)*

The foregone income calculations for road accident injuries, comparable with the figures for fatalities in Table 6, and based on the income and age distribution data in Tables 7 and 11, are shown in Table 12.

TABLE 12

REMAINING LIFETIME INCOME(1): ROAD ACCIDENT INJURIES - AUSTRALIA 1978										
Age Group	Number of Injuries (1977) (2)	Present Value of Lifetime Gross Income(3)								
		Disc.rate: 7% Prod.rate: 2.5%	7% 3%	7% 3.5%	10% 2.5%	10% 3%	10% 3.5%	13% 2.5%	13% 3.0%	13% 3.5%
		$	$	$	$	$	$	$	$	$
0-4	2,691	88,792	103,935	122,020	38,740	44,493	51,22[illegible]	17,880	20,222	22,911
5-6	1,606	104,308	120,372	139,329	49,331	55,861	63,407	26,830	29,961	33,515
7-16	10,900	134,371	150,595	169,31[illegible]	75,04[illegible]	82,525	90,985	47,046	51,005	55,402
17-20	21,278	193,302	209,458	227,659	130,644	139,056	148,380	103,687	108,923	114,644
21-29	21,698	192,894	206,788	222,199	136,2[illegible]0	144,022	152,578	117,605	123,007	128,853
30-39	10,155	164,898	174,099	184,052	124,61[illegible]	130,469	136,762	110,849	115,240	119,923
40-49	6,940	125,228	130,037	135,105	102,463	105,973	109,660	93,706	96,570	99,568
50-59	6,150	67,478	68,623	70,203	60,534	61,675	62,843	59,989	61,061	62,[illegible]59
60+	6,486	34,314	34,636	34,961	32,570	32,866	33,166	32,556	32,844	33,135
AVERAGE LIFETIME INCOME per Injury		151,879	163,548	176,649	105,761	112,004	118,888	83,030	86,641	90,553

(1) Calculated at median age for each age group, assuming an income earning period from 15 to 64 years of age. The totals are weighted averages of male and female incomes for each age group,

(2) The total number of injuries in 1977 was 91,61[illegible]; the table excludes 3712 injuries with age not specified. The year 1977 was the latest year for which A.B.S. has published Australia-wide statistics for injuries,

(3) Discounted to 1978 values at discount rates as shown; also, incomes were incremented by annual productivity increases at the rates indicated for each column.

TABLE 13

THE EFFECTS OF AGE GROUP WEIGHTING ON DISCOUNTED INCOMES*-AUSTRALIA 1978					
Age Group	Present Value of Future Income at Median Ages: 10% Discount; 3% Productivity				
	Male	Female	Total I: Weighted by Fatalities	Total II: Weighted by Injuries	Total III: Population Weighted
	$	$	$	$	$
0-4	58,617	27,387	41,801	44,493	43,408
5-6	71,399	33,358	57,704	55,861	52,797
7-16	105,931	49,492	83,424	82,525	78,491
17-20	168,500	74,520	148,721	139,056	122,315
21-29	183,051	66,588	163,101	144,022	125,373
30-39	173,899	65,395	146,084	130,469	121,160
40-49	143,564	56,283	115,389	105,973	101,272
50-59	84,755	33,364	67,571	61,675	59,222
60+	47,960	16,960	34,513	32,866	31,946
AVERAGE TOTAL INCOMES compared:		Male:	140,845	146,635	117,519
		Female:	46,627	55,233	45,788
		Total:	113,510	112,004	81,729

** Based on average gross incomes: the present value of male and female incomes is the same for all these calculations. The differences between Totals I, II and III are entirely the result of differences between the age and sex composition of fatalities, Injuries and the overall population*

The row totals show the effects of variations in the male-female proportions for each age group, while the weighted-average column totals reflect the proportion of the total number in each age group.

Both accident samples differ markedly from the population proportions (e.g. 71% of fatalities and 61% of Injuries are male compared with 50% for the total population. Also, the 17 to 29 age group represented 43% of fatalities and 47% of Injuries, but comprises only about 22% of the total population.).

The significance of differences in the age distributions of accident fatalities and injuries when compared with the population average age is reflected in the respective weighted-average discounted income values in Table 13 (these figures indicate the basis of the Table 8 estimates).

It is evident that there is only a slight variation between the average foregone incomes for fatalities and injuries (although there are more marked variations between particular age groups), but both these levels are over 30% greater than the population average income. These differences mainly reflect the disproportionately large number of younger males in the accident statistics, compared to the average population.

The Effects of Gross, Net, and Adjusted Income Concepts. To complete this analysis of the foregone income estimates, the effects upon the present value of foregone income of changing the *income* concept in the foregoing income calculations for fatalities is outlined in the following tables. A comparable set of tables for road accident injuries is contained in Appendix A-2 (*vide:* Tables 59 to 61).

Adjusted Income. The effects of averaging *gross* income levels across the total population in each age group is shown in Table 14.

TABLE 14

FOREGONE ADJUSTED INCOME(1): ROAD ACCIDENT FATALITIES - AUSTRALIA 1978

Age Group	Number of Fatalities	Present Value of Income Foregone (Averaged over Population)					
		Discount: 7% Productivity: 2.5%	7% 3%	7% 3.5%	10% 2.5%	10% 3.0%	10% 3.5%
			$	$	$	$	$
0-4	104	64,892	75,803	88,772	28,442	32,666	37,593
5-6	50	89,746	103,551	119,787	42,169	47,843	54,395
7-16	331	111,658	125,074	140,483	62,089	68,385	75,490
17-20	746	181,757	196,756	213,566	122,592	130,604	139,451
21-29	864	196,410	209,814	224,605	140,886	148,630	157,075
30-39	394	158,647	166,832	175,640	122,255	127,611	133,337
40-49	285	106,743	110,468	114,377	88,883	91,664	94,574
50-59	317	48,436	49,300	50,184	43,954	44,693	45,449
60+	604	17,736	17,903	18,071	16,835	16,988	17,143
AVERAGE INCOME FOREGONE: *per fatality (Adjusted for Workforce participation)*		127,870	136,990	147,151	91,042	96,104	101,654

(1) Average incomes were multiplied by the Workforce participation rate for each age group (to average incomes over the population in each age group).

These *adjusted* income levels are approximately 85 % of the foregone gross income levels in Table 6. They reflect the factoring of incomes by the average 1978 workforce participation rate of 79 % for males, and 44 % for females.

The effect of the workforce participation adjustments to incomes in Table 14 is equivalent to assuming a zero income for all persons between 17 and 65 years of age who are *not* in the workforce, including housewives as well as the unemployed. It has the effect of attributing the lower population average of incomes to all people in the accident sample. This approach was explicitly employed in the Japan (1978) study, and the effects of the Paterson (1973) "life-cycle model" appear to be very similar (*vide* Appendix A-1, Tables 35,43 & 44). In contrast, the income assumptions underlying Tables 6 and 13 assume that all members of the accident sample earn the average workforce income levels of each age group. Thus both housewives and those unemployed are attributed an opportunity cost income level equal to the workforce average. In the present study, this latter assumption is preferred since it is considered to more accurately reflect the community's valuation in income terms of such activities.

Net Income. To show the effects on the estimate of using the net income concept in calculating foregone income as employed in the cost studies of Dawson (1967) Troy and Butlin (1971), Paterson (1973), and Japan (1978) (*vide* Appendix A-1), an average level of private consumption expenditure of 31 % of household income was derived from the 1977/78 Australian National Accounts, and all income levels in Table 7 were reduced by 31 % before calculation of the present value of figures. The results of these assumptions for net income are contained in Table 15.

Finally, in this series of foregone income comparisons, the results of assuming both:(i) lower incomes averaged over the population, and (ii) of excluding consumption expenditure from future income are shown in Table 16.

An equivalent set of tables showing the effects of these changed assumptions upon *injuries* is contained in Appendix A-2 (*vide* Tables 59 to 61).

TABLE 15

FOREGONE NET INCOME*: ROAD ACCIDENT FATALITIES - AUSTRALIA 1978							
Age Group	Number of Fatalities(1)	Present Value of Average Income Less Consumption expenditure at:- (2) (3)					
		7%(disc) 2.5%(prod)	7% 3%	7% 3.5%	10% 2.5%	10% 3.0%	10% 3.5%
		$	$	$	$	$	$
0-4	104	25,753	30,121	35,334	11,292	12,957	14,903
5-6	50	33,465	38,634	44,735	15,788	17,886	20,311
7-16	331	42,133	47,227	53,104	23,510	25,858	28,513
17-20	746	64,253	69,658	75,747	43,281	46,095	49,215
21-29	864	67,667	72,528	77,920	47,825	50,561	53,556
30-39	394	57,215	60,402	63,850	43,258	45,287	47,467
40-49	285	42,279	43,904	45,616	34,589	35,775	37,020
50-59	317	22,928	23,387	23,858	20,559	20,948	21,347
60+	604	11,170	11,275	11,381	10,603	10,699	10,797
AVERAGE NET INCOME FOREGONE per fatality:(4)		46,902	50,301	54,104	33,336	35,187	37,221

* *Based on 31% of gross incomes for all age groups to exclude consumption expenditure.*

(1) *Total number of fatalities was 3705 in 1978: table excludes 10 with age not specified.*

(2) *Discounted to 1978 values at discount rates as shown; also incomes were incremented by annual productivity increases as indicated.*

(3) *The average figure for each age group is calculated as a weighted average of male and female incomes.*

(4) *The overall average income loss per fatality is calculated as the weighted average of the estimate for all age groups.*

TABLE 16

FOREGONE NET ADJUSTED INCOME* - ROAD ACCIDENT FATALITIES - AUSTRALIA 1978							
Age Group	Number of Fatalities(1)	Present Value of Adjusted Income Net of Consumption at:(2) (3)					
		7% (Disc) 2.5%(prod)	7% 3%	7% 3.5%	10% 2.5%	10% 3.0%	10% 3.5%
		$	$	$	$	$	$
0-4	104	20,116	23,498	27,519	8,817	10,126	11,653
5-6	50	27,821	32,101	31,134	13,072	14,831	16,862
7-16	331	34,614	38,772	43,549	19,247	21,199	23,401
17-20	746	56,344	60,994	66,205	38,003	40,487	43,230
21-29	864	60,888	65,043	69,628	43,675	46,076	48,694
30-39	394	49,180	51,717	54,448	37,898	39,559	41,334
40-49	285	33,091	34,246	35,458	27,555	28,417	29,319
50-59	317	15,013	15,281	15,555	13,624	13,853	14,087
60+	604	5,498	5,550	5,602	5,219	5,266	5,314
AVERAGE NET ADJUSTED INCOME FOREGONE(4) per fatality:		39,640	42,467	45,617	28,223	29,792	31,512

* *Based on 31% of gross incomes (to exclude consumption expenditure) and multiplied by workforce participation rates by age groups (to average net incomes across the total population in each age group).*

(1) *Total number of fatalities was 3705 in 1978: table excludes 10 with age not specified.*

(2) *Discounted to 1978 values at discount rates as shown; also incomes were incremented by annual productivity increases as indicated.*

(3) *Average figure for each age group is calculated as a weighted average of male and female incomes.*

(4) *The overall average income loss per fatality is calculated as the weighted average of the estimates for all age groups.*

Medical and Related Accident Costs. Perhaps the major shortcoming affecting the range and quality of Australian data available for estimation of accident costs is the absence of any recent study comparable to the pioneering work of Troy and Butlin (1971) in which a virtual census of road accidents was undertaken in the Australian Capital Territory during 1965/66. This work, which established a world bench-mark in road accident research yielded, *inter alia*, a joint distribution of medical and vehicle damage costs. Such information is vital in order to relate injury severity levels to other important cost categories, especially vehicle damage. In a more recent Australian study by Paterson (1973) this relationship was referred to but no estimates by accident severity were presented (although other parameters drawn from the Troy and Butlin study were extensively utilised). The resultant cross classification of injury and vehicle repair costs compiled by Troy and Butlin is summarised in Table 17.

TABLE 17

INJURY COST LEVELS by VEHICLE DAMAGE: A.C.T. 1965/66
(Units are: number of collisions)

VEHICLE DAMAGE	Cost Intervals for Personal Injury									
	$0	$0-$200	$200-$400	$400-$1,000	$1,000-$2,000	$2,000-$4,000	$4,000-$6,000	$6,000-$8,000	$8,000+	Total
$										
0-200	763	10	1	2	1	1	.	.	.	778
200-400	1,367	48	4	7	1	.	.	.	1	1,428
400-600	819	86	7	13	9	6	1	2	.	943
600-800	259	65	8	12	8	1	2	.	.	355
800-1000	75	28	6	6	2	1	1	.	1	120
1000-1200	42	12	2	7	.	1	.	.	.	64
1200-1400	13	10	2	.	.	.	1	.	.	26
1400-1600	4	5	2	.	.	1	.	.	.	12
1600-1800	4	7	2	.	.	.	.	.	.	13
1800-2000	4	3	1	.	.	.	.	.	.	8
2000+	3	4	-	1	2	1	.	.	.	11
TOTAL	3,353	278	35	48	23	12	5	2	2	3,758

Source: *based on Table 8.3 (p.18) of Troy P.N. & Butlin (1971) as the sum of parts A to F. Note that table 27 (p.49) in Paterson (1973) is compiled from the same source, but excludes parts B and D ("Run off road" and "stationary object").*

Because of its relative age and restricted sample region the cost data in Table 17 is considered inadequate by itself for the purposes of the present study. Fortunately, a valuable source of medical and related data from road accident cases is now being compiled by the Motor Accidents Board of Victoria (M.A.B.), an agency which has operated in Victoria since the introduction of a "no fault" compensation system in that State in 1974. As yet it is not possible to cross-classify both medical and property damage arising from accidents, but a valuable set of individual frequency distributions of medical, hospital and related accident costs has been specially tabulated for the present study by the Motor Accidents Board.

Details of some $19 million paid in claims by the Motor Accidents Board of Victoria in respect of hospital, medical, ambulance, loss of income, and certain other costs resulting from road accidents occuring in the year to 30th June, 1978 are considered in Tables 18 to 21.

TABLE 18

CLAIMS ARISING FROM ROAD ACCIDENTS IN YEAR TO JUNE 1978
ACCEPTED BY THE MOTOR ACCIDENTS BOARD, VICTORIA.

Type of Accident	Number of Persons Claiming	Amounts Paid					
		Hospital	Medical	Ambulance	Loss of income	Other*	Total
		$m	$m	$m	$m	$m	$m
Fatality	797	0.171	0.074	0.050	0.322	0.520	1.137
Major Injury	10,863	9.945	1.973	0.603	4.121	0.479	17.121
Minor Injury	19,606	0.206	0.178	0.289	0.006	0.024	0.703
TOTAL	31,266	10.322	2.225	0.942	4.449	1.023	18.962

Source: based on *Bulletin of Statistics of Persons Killed or Injured in Road Accidents Occurring (in) Year Ended 30th June 1978* (for which claims were registered with the Board); Motor Accidents Board of Victoria, June 1980; together with additional (unpublished) computer tabulations providing frequency distributions of claims by categories.

Note: that these figures cover claims accepted by the M.A.B. up to 11th November 1978 only (it is estimated that subsequent Major Injury claims will comprise about 10 per cent of the above total).

* "Other" costs include chemist, dental, funeral, housekeeping, physiotherapy, etc.

A summary of these payments by category and type of accidents is contained in Table 18. Tables 19 and 20 show frequency distributions for cost categories and total claims respectively, while Table 21 shows further details of total cost by category.

TABLE 19

HOSPITAL, MEDICAL & OTHER COSTS OF ROAD ACCIDENT CASUALTIES
VICTORIA 1977-78 : MOTOR ACCIDENT BOARD

Cost Interval	(1) HOSPITAL		(2) MEDICAL		(3) LOSS OF INCOME		(4) AMBULANCE		(5) OTHER *	
	Number of Claims	Total Payment	Number of Claims	Total Payment	Number of Claims	Total Payment	Number of Claims	Total Payment	Number of Claims	Total Payment
$		$m		$m		$m		$m		$m
"Minor injuries"	*n.a.*	*0.206*	*n.a.*	*0.178*	*n.a.*	*0.006*	*n.a.*	*0.290*	*n.a.*	*0.024*
"Major injuries"	*6,090*	*0.174*	*8,306*	*1.049*	*1,729*	*0.396*	*7,363*	*0.524*	*3,400*	*0.353*
0-500	*n.a.*	0.920	*n.a.*	1.227	*n.a.*	0.402	*n.a.*	0.814	*n.a.*	0.377
500-1000	1,047	0.759	724	0.495	659	0.475	76	0.050	99	0.066
1000-1500	514	0.638	187	0.221	329	0.405	4	0.004	17	0.021
1500-2000	340	0.587	65	0.112	257	0.449	9	0.015	4	0.007
2000-2500	208	0.465	18	0.039	151	0.338	3	0.007	7	0.016
2500-3000	161	0.440	9	0.024	129	0.354	1	0.003	2	0.006
3000-3500	159	0.516	5	0.016	95	0.306	.	.	.	.
3500+	801	5.826	4	0.017	278	1.397	.	.	2	0.011
Sub-total Major injury:	*9,320*	*9.945*	*9,318*	*1.973*	*3,627*	*4.121*	*7,456*	*0.603*	*3,531*	*0.479*
Total - All Injuries	*n.a.*	10.151	*n.a.*	2.151	*n.a.*	4.127	*n.a.*	0.893	*n.a.*	0.503
Fatalities:	255	0.171	239	0.074	91	0.322	687	0.050	670	0.520
TOTAL - All Claims.	*n.a.*	10.322	*n.a.*	2.225	*n.a.*	4.449	*n.a.*	0.943	*n.a.*	1.023

Source: Bulletin of Statistics of Persons Killed or Injured in Road Accidents Occurring Year Ended 30th June 1978 (for which claims were registered with the Board), Motor Accidents Board, Victoria, June 1980, together with unpublished computer tabulations of frequency distributions supplied by the M.A.B.
Note. that these figures cover claims accepted by the M.A.B. up to 11th November 1978 only (it is estimated that subsequent Major Injury claims will comprise about 10 per cent of the above total).

n.a. = not available by individual category: total minor injury claims (defined as non fatal claims less than $100) numbered 19,606 amounting to $0.703 million).

** "Other" costs include chemist, dental, funeral, housekeeping, physiotherapy, etc.*

The Victorian M.A.B. data in these tables are of considerable importance to the present study since they provide the principal estimation basis for the hospital and medical costs in Table 1 and in later tables.

TABLE 20

TOTAL COSTS CLAIMED BY ROAD ACCIDENT INJURIES (*) VICTORIA 1977-78 (MOTOR ACCIDENTS BOARD)					
Cost Interval	Number of claims	%	Total Payment	%	Average Payment
$ **			$m		$
("Minor Injuries")					
0-100	*19,606*	*64.3*	*0.703*	*3.9*	*36*
("Major Injuries")					
100-500	*5,701*	*18.7*	*1.253*	*7.0*	*220*
0-500	25,307	*83.1*	1.956	*11.0*	77
500-1000	1,575	*5.2*	1.122	*6.3*	712
1000-1500	827	*2.7*	1.014	*5.7*	1226
1500-2000	528	*1.7*	0.925	*5.2*	1753
2000-2500	360	*1.2*	0.804	*4.5*	2233
2500-3000	258	*0.8*	0.706	*4.0*	2735
3000-3500	225	*0.7*	0.730	*4.1*	3245
3500 +	1,389	*4.6*	10.567	*59.3*	7608
Sub-total Major Injuries:	*10,863*	*35.7*	*17.121*	*96.1*	*1576*
TOTAL (all injuries)	30,469	*100.0%*	17.824	*100.0%*	585

Source: *Bulletin of Statistics of Persons Killed or Injured in Road Accidents Occurring Year Ended 30th June 1978, Motor Accidents Board, Victoria, June 1980, together with unpublished supplementary computer tabulations of frequency distribution by cost interval supplied by the Board. These figures cover claims accepted by the M.A.B. up to 11th November 1978 only: it is estimated that subsequent major injury claims will increase the above total by more than 10%.*

(*) *Payments by the M.A.B. include claims for Hospital, Medical, Ambulance, Loss of Income, and Other costs (Chemist, Dental, Housekeeping, Physiotherapy, etc.) arising from road accidents.*

** *Minor Injury claims are defined as non-fatal claims for which total payments are less than $100.*

TABLE 21

ROAD ACCIDENT COSTS - VICTORIA 1977/78
(based on Motor Accidents Board data)

COST CATEGORY*	FATALITIES			MAJOR INJURIES			MINOR INJURIES			TOTAL		
	No.	Total	Average	No.	Total	Average	No.	Total	Average	No.	Total	Average
		$m	$		$m	$		$m	$		$m	$
Hospital	255	0.171	672	9,320	9.945	1,067	-	0.206	-	-	10.323	-
Medical	239	0.074	312	9,318	1.973	212	-	0.178	-	-	2.226	-
Ambulance	687	0.050	73	7,456	0.603	81	-	0.290	-	-	0.943	-
Loss of Income	(91	0.323	3,544)	3,627	4.121	1,136	-	0.006	-	-	4.449	-
Other	670	0.520	777	3,531	0.479	136	-	0.024	-	-	1.023	-
TOTAL	797	1.139	1,429	10,863	17.121	1,576	19,606	0 703	36	31,266	18.963	606

Source: based on *Bulletin of Statistics of Persons Killed or Injured in Road Accidents Occurring Year Ended 30th June 1978*, registered with the *Motor Accidents Board* of Victoria. The statistics cover claims accepted up to 11th November 1978 (a further 10% of major injury claims are expected to arise). These statistics have been extended by the provision of unpublished computer tabulations made available by the Board.
Minor Injuries are defined as non-fatal claims of less than $100.

* The category 'Loss of Income' includes payments of up to a maximum of $200 per week.

These accident cost levels and their frequency distributions are used to estimate cost levels, and to allocate medical and related costs according to the injury severity grouping. Although this Victorian data is of considerable value in the present estimation task there are some significant assumptions implicit in this use of M.A.B. data.

In particular, it is assumed that the observed frequency distributions of accident claims in ascending order of average costs provide a reasonable indication of injury severity. This relationship has been investigated in the work of Fox *et al.* (1979) in the course of a major study of pole accidents in Melbourne in which survey data was compared with M.A.B.cost codings. Because the Motor Accidents Board is dependent upon accident medical records compiled using the International Classification of Diseases (I.C.D.) code as a guide, conversion to an injury *severity* assessment presents many difficulties.

An attempt to re-classify the I.C.D. code to conform with the Abbreviated Injury Scale groupings is contained in Table 63 in Appendix A-2. This work is not complete and further research is needed to establish the feasibility of deriving a suitable injury severity scale for accident recording in Australia. In the present study, the M.A.B. cost relative distributions were used to modify for Australian conditions the groupings for U.S.A. data compiled by Faigin (1976).

Vehicle Damage. A further problem of significance in these estimates concerns the classification of vehicle damage costs by injury severity level. Total vehicle damage costs were obtained from 1978 statistics of motor vehicle insurance claims of $545 million in Table 24. However, because of the need to estimate damage to uninsured vehicles, estimated by Thorpe (1970) to be as high as 35 % of total motor vehicles, 1971 data from the A.B.S. Survey of Motor Vehicle usage was projected forward to 1978, showing the estimated number, cost and range of vehicle repairs. These results are contained in Tables 22 and 23.

TABLE 22

PRELIMINARY ESTIMATE OF MOTOR VEHICLE ACCIDENT REPAIRS AUSTRALIA 1977-78						
Cost of Repairs	Reported*		Not Reported		Total	
	No.	Total Cost	No.	Total Cost	No.	Total Cost
$		$m		$m		$m
under $100	141,000	10.6	192,000	14.4	333,000	25.0
$100-$500	271,000	81.3	71,000	21.3	342,000	102.6
$500+	331,000	314.5	28,000	26.6	359,000	341.1
TOTAL	743,000	406.4	291,000	62.3	1,033,710	468.7
Estimated "Excess" paid by owners:		66.9				535.6

<u>*Source:*</u> *based on an approximate update of 1971 data from the Motor Vehicle Usage Survey (see Table 23) by incrementing accident numbers by the increase in motor vehicles on register between 1972 and 1978 (adjusted for the casualty accident rate), and the mean cost of repairs by the implicit price index for Gross National Expenditure over this period. The distribution of repair costs between ranges was also adjusted.*
"Excess" payments assume that 90% of reported claims require the owner to pay the first $100 of each claim.
**"Reported" claims are those reported to insurance companies.*

TABLE 23

MOTOR VEHICLE ACCIDENT REPAIRS - AUSTRALIA 1971 (YEAR to 30th SEPTEMBER 1971)						
Cost of Repairs	REPORTED ø		NOT REPORTED		TOTAL	
	Cars & Stn Wagons	Total*	Cars & Stn Wagons	Total*	Cars & Stn Wagons	Total*
$						
under 50	93,304	130,666	154,814	178,341	248,118	309,007
50-200	288,919	344,118	65,648	74,932	354,567	419,049
200+	190,260	214,583	14,302	16,228	204,562	230,811
TOTAL	572,482	689,366	234,765	269,501	807,247	958,867

<u>*Source:*</u> <u>*Survey of Motor Vehicle Usage*</u> *for twelve months ended 30th September, 1971, A.B.S. Canberra, 1973.*
ø Reported to insurance company.
** Excluding motor cycles.*

Details of motor vehicle insurance claims, both comprehensive and "third party" (i.e. personal injury) claims are shown in Table 24 which also contains the share of insurance costs allocated to motor vehicle claims.

TABLE 24

MOTOR VEHICLE INSURANCE CLAIMS etc.
AUSTRALIA 1977-78

State	Premiums		Claims		Management Expenses		
	M.V. Comprehensive	Compulsory Third Party	M.V. Comprehensive	Compulsory Third Party	Total	Allocated to:-	
						M.V. Comp.	Third Party M.V.
	$m	$m	$m	$m	$m	$m	$m
N.S.W.	305.5	214.3	235.4	132.1	160.6	45.1	2.5
Victoria	216.4	208.0	131.5	238.2	141.9	37.9	5.5
Queensland	99.7	42.4	68.6	49.0	57.5	15.9	2.7
South Australia	62.0	60.5	37.6	75.2	38.9	11.4	1.8
Western Aust.	64.2	27.2	44.1	40.7	33.4	9.4	0.8
Tasmania	20.2	10.6	14.6	9.5	12.9	3.4	0.3
A.C.T.	9.1	10.2	10.3	11.3	5.2	1.3	0.5
N.T.	3.6	4.2	3.2	6.4	2.4	0.6	0.1
TOTAL	780.6	577.4	545.4	562.3	452.9	125.0	14.1

Source: *Statistics of General Insurance Australia 1977-78, Australian Bureau of Statistics (Catalogue No. 5620.0) October 1979.*

Note: that these figures relate to the financial years of the organisations which ended during 1977-78 (and not to a uniform accounting period).

Claims: comprise payments made during the year 1977-78 plus the estimated amount of outstanding claims at the end of the year, less the estimated amount of outstanding claims at the beginning of the year.

A sample of motor vehicle property damage claims was undertaken during this present study, including some of the principal motor vehicle insurers in the State of Victoria (including A.A.M.I.Ltd., the State Insurance Office, and also the insurance industry group, the Insurance Council of Australia). Tabulations of vehicle damage claims were received covering a proportion of total claims paid. When a sufficient coverage is achieved it would be possible to apply these proportions derived from Australian data to redistribute property damage accident costs by injury severity in Table 1 *et al* to replace the modified U.S.A. allocations used in the current Australian estimates.

TABLE 25

MOTOR VEHICLE INSURANCE CLAIMS: 1979 *
(Cars and Station Wagons)

Claim Size $	Number of Claims (No.)	Amount of Claims $m	Average Claim $
less than 200	29,347	2.205	75
200-300	4,880	1.186	243
300-400	3,449	1.187	344
400-500	2,696	1.203	446
500-600	2,061	1.124	546
600-700	1,693	1.092	645
700-800	1,325	0.990	747
800-900	1,112	0.951	855
900-1000	869	0.821	945
1000+	6,856	14.499	2,115
TOTAL:	54,288	25.249	465

* *Excluding "excess" payments which are estimated at $127 per vehicle.*

The data in Table 25 relates to property damage (vehicle repairs) only, and is compiled independently of the injury costs.

3.3 SUMMARY OF ESTIMATION PROCEDURES

In the following section the method of derivation of the unit cost estimates presented in Table 1 (and related cost Tables) is outlined in summary form. The effects of deleting certain cost components from the overall cost framework are then examined.

In some instances details of the estimation procedures and data sources used to compile cost items are contained in the explanatory footnotes to selected tables, including estimates of *Foregone income, Medical* and *Hospital* costs, and *Vehicle Damage* in Tables 5 to 7, and 11 to 16 of section 3.2 above.

The accident cost categories of Table 1 are now considered in order.

(1) *Foregone Income:* these estimates are based on the present value of income estimates for fatalities and injuries in Tables 6 and 12 together with the degree of impairment or lost work associated with each level of the Abbreviated Injury Scale (AIS) for road accidents The AIS

proportions of work-time lost or permanent impairment are drawn from the detailed U.S. study of these components by Faigin (1976) and are considered appropriate for Australian road accident conditions in the absence of an equivalent local medical assessment (*vide* Appendix A-1, especially Tables 37 and 38). Details of the *Foregone Income* calculations by AIS level are as follows:

AIS Level		Estimated Days Lost or %Impairment	Estimated 1978 Loss (per day or p.a.)	Value of Lost Income 1978
			$	$
1	*Minor injuries*	1.6	31	50
2	*Moderate*	21	31	650
3	*Severe-I*	39	31	1,210
4	*Severe-II*	25%	12,004	28,000
5	*Critical*	57%	12.004	63,840
6	*Fatal*	100%	113,510	113,510

The estimated loss per day of $31 in 1978 is based on the income figures of Table 11 divided by annual work days. The 25% and 57% levels of pérmanent impairment associated with AIS levels 4 and 5 respectively are applied to the present value of income figures (at 10% discount, 3% productivity) from Table 12. The fatality income figure is from Table 6.

(2) *Family, Community Losses:* This cost category is intended to represent the opportunity cost value of accident-caused losses for work and services performed outside the normal working week: (a) for the family and home, and (b) for voluntary services to the community. The opportunity cost method of valuation is preferred to replacement cost, because the former is consistent with the market income concept. The average time devoted to identified functions (e.g. home maintenance, household tasks, care and upbringing of children, etc) was estimated for the U.S. by Faigin (1976) as 10 hours per week for home and family, and 2 hours per week for voluntary community activity, representing 30% of the working week.

This time-based estimate is also supported by other U.S. studies which suggest that the equivalent market value of household production represents about 25% of total household income in National income terms (*vide* Gronau [1973], and Faigin [1976]).

The proportion of 30% of market income derived by Faigin is thus adopted as the basis of the category 2 estimates in Table 1 which thus represent 30% of the lost income costs in row 1.

Categories (3),(4), and (5): Hospital, Medical and *Rehabilitation* costs: These cost estimates are based on the frequency distributions of 1977/78 cost data from the Motor Accidents Board of Victoria *(vide:*

Tables 18 to 21) together with the estimated proportions of casualty numbers in each AIS injury severity level.

As indicated in the footnotes to Table 5, the proportion of accident cases in each of the (non-fatal) AIS levels 1 to 5 is based on a modification of the U.S.A. proportions derived by Faigin (*op.cit.*) resulting from an inspection of the M.A.B. distributions of hospital and medical costs for the State of Victoria, summarised in Tables 19 and 20. The U.S. proportions allocate 85% of all injury accident cases to AIS level 1 (minor injuries), whereas this seems too high a proportion of the Australian injuries, based on the M.A.B. data and assuming cost levels as a proxy for injury severity. Thus for the Australian proportions for injury severity, AIS level 1 was set at 70%, and the remaining proportions for classes 2 to 5 were calculated as for the U.S. estimates in Faigin [*op.cit.*]. Although this adjustment is somewhat arbitrary, it is more consistent with Australian cost data both for Victoria in 1977/78, and with the Australian Capital Territory study for 1965/66 (*vide* Table 17), and may reflect under-reporting of minor casualty accidents in Australia compared with U.S. data. The results of these adjustments to AIS class proportions are summarised below, together with the resultant average cost ranges based on these proportions.

AIS Class		U.S.A. %	est. AUST. %
1	(minor)	85.08	70.00
2	(moderate)	12.31	24.77
3	(severe-I)	2.01	4.03
4	(severe-II)	0.50	1.00
5	(critical)	0.10	0.20
	Total	100.00	100.00

The Range and Average Costs for these AIS classes are:
(from M.A.B. data)

Hospital		Medical		Rehabilitation	
Average $	(Range)	Average $	(Range)	Average $	(Range)
158	0-$707	75	0-$199	50	0-$143
1,919	$707-$5000	382	$199-$768	235	$143-$431
7,100	$5000-$10,500	1,015	$768-$1468	561	$431-$864
11,928	$10,500-$30,000	1,738	$1468-$2472	1,322	$864-$2214
36,000	$30,000 +	3,123	$2472 +	2,214	$2214 +

The Australian AIS cumulative proportions were applied to the frequency distributions of MAB claims for hospital, medical and other costs, respectively (*vide* Table 19), giving, for example, in the case of hospital costs the first 70% of claim *numbers*, ranging from zero to $707 in amount, with an *average* cost of $158 were taken to represent *minor* injuries (AIS level 1). Similarly the next 24.8% (or from 70.0% to 94.8% of claims according to cumulative frequencies) ranging from $707 to $5000 in amount, showed an average value of $1919 which represents AIS level 3 in Table 1. *Medical* and *Other* (Rehabilitation) average costs were determined by injury severity category in the same way, thus yielding the unit cost estimates for rows 3,4, and 5 of Table 1. The values for fatalities (AIS level 6) are from Table 21, where the entry in column 1 of row 5 represents funeral costs.

It is evident from the relationship between the *average* costs by injury level, and the respective *range* of costs for each category, that the frequency distribution of M.A.B. data is significantly *skewed* (such that the average value for each range is much closer to one of the range boundaries than to the midpoint).

In Appendix A-3, the preliminary results of an attempt to fit a suitable theoretical probability distribution to M.A.B. medical data, and other accident costs are presented. This work is at an early stage but early results suggest that a range of accident costs and characteristics may be usefully represented by the *gamma* distribution. Such a result, if confirmed, would be very useful *inter alia* in re-classifying accident costs into any desired set of accident classes based on probability of occurrence (e.g. in a specially defined injury classification for Australian conditions), as well as providing a valuable summary of respective accident characteristics.

The preliminary estimates for Hospital, Medical and Other related accident costs in Table 1, however, are based directly on the M.A.B. data referred to above, and not upon theoretical distributions fitted to these data (*vide* Appendix A-3).

(6) *Legal and Court costs:* This cost category is as defined in Faigin (*op.cit.*), representing the economic resource costs consumed as a result of road accidents, including the costs of both public and private legal activity generated by accidents.

No recent Australian data were available to the present study, and the figures in row 6 of Table 1 are (rounded) estimates from the U.S. 1975 cost study by Faigin (*op.cit.*). Some Australian researchers in this field have suggested a relationship between legal and court costs and motor vehicle insurance claims paid (*vide* Thorpe[1970], Troy and Butlin [1971], and Paterson [1973]). Based on their 1965/66 study in the Australian Capital Territory, Troy and Butlin suggested that up to 30% of third party, (i.e. personal injury) insurance claims in the A.C.T. were for legal expenses. The Paterson (1973) study adopted a lower proportion of 25% in its 1969 accident cost estimates resulting in a 1969 unit legal cost per collision of $72 (or $88 including police and court costs *vide* Table 40). In the present study *total* estimated legal and court costs (based on the U.S.-derived unit costs) are $35.2 million (from Table 52), which represents only 6.3% of the total third party payments in 1978 of $562 million (from Table 24). These costs represent $63 per accident, $364 per casualty accident (and $256 per casualty), and are much lower than the figures suggested by Paterson *et al.* Moreover, they are preferred to the former, until more information is provided by further specific Australian research on the grounds that it seems likely that a significant proportion of the large third-party claim payout relates to court valuation of "pain and suffering" arising from road accidents, and associated legal costs. This latter cost category is specifically excluded from the cost framework proposed in this present report (mainly because no analysis of these payments has been undertaken).

Thus the U.S.-based unit costs provide the cost estimates for row 6: Clearly this cost estimate would be greatly improved by investigation of third party claim payments.

(7) *insurance Administration:* the resource costs of insurance management expenses associated with motor vehicle comprehensive insurance are derived from the published totals in Table 24, together with the injury severity allocations (AIS levels) derived in the Melbourne study by Fox *et al.* (1979) (*vide* Table 29). Cost figures from the Fox *et al.* study were increased by a factor of about 2.5 to agree with the total for management expenses in Table 24.

(8) *Accident Investigation:* these costs represent the resource costs relating to investigation of both casually and property damage accidents. The estimates in row 8 represent a modified version of the Fox *et al.* (1979) cost levels for this category, adjusted to relate more closely to the Faigin injury severity levels.

(9) *Losses to Others:* this cost category is a non-market estimate similar in concept to category 2 (losses to family, community). It is defined to cover losses caused to employers and others resulting from road accidents, including labour replacement costs, time spent in visiting, transport, home care, etc. It is thus the opportunity cost of the time spent in these accident-generated activities. The estimates in Table 1 are based on the U.S. N.H.T.S.A. study (1971) proportions for these items, and represent the following percentages of lost income in row 1: AIS 1:20%; AIS 2 to 3:10%; AIS 4 to 5:2.5%; and AIS 6:1.2%.

(10) *Vehicle Damage*: this is a direct cost of motor vehicle accidents, namely vehicle damage repair costs, and represents one of the major components in total accident costs. The allocations of average costs to AIS classes was based on application of the AIS class proportions (i.e. cumulative probabilities) to a frequency distribution of insurance vehicle damage claims (e.g. shown in total in Table 24, and a sample frequency distribution in Table 25). The calculations also assume that vehicle damage generally increases with accident injury severity (although the $4000 vehicle damage cost for critical injury accidents is higher than the $3000 average for fatal accidents in Table 1. This difference is not very significant because of the relatively small number of vehicles in AIS class 5 compared to class 6: *vide* Table 5).

(11) *Traffic Delay:* these unit costs are taken directly from the U.S. study of Faigin (*op.cit.*), and are based on calculations of the time lost in person hours in the proportion of accidents occurring in urban week-day peak-hour traffic, and a value-of-time cost per person-hour of $2.63. The U.S. proportions, based on 1973 accidents, show that approximately 26% of all accidents occur during peak hour traffic, including 18% of fatal accidents and 26% of injury and property-damage only accidents. Thus the average traffic delay cost of vehicle-damage-only and less serious injury accidents is higher than that for more severe injury and fatal accidents, reflecting the higher proportion of the former occurring in urban peak hours. These figures are preferred to the Australian estimates of Fox *et al.* (*vide* Table 29) which relate specifically to serious injury accidents. However a relatively modest study based on Australian data would improve these estimates.

Effects of Deleting Selected Costs

In Table 1 the estimates for certain cost categories are shown in italic type, generally signifying that no Australian data is presently available to provide a basis for cost estimation. These rows include *Family & Community Losses, Legal & Court Costs, Accident Investigation, Losses to Others* and *Traffic Delay Costs.* Since these cost estimates are largely based on U.S. experience, notably the 1976 study of Faigin, it is of some interest to investigate the effect on unit costs (and their relativity by AIS level) and on total costs of deleting these items.

The effects of excluding these five cost categories in Table 1 upon total unit costs and total costs is shown in Table 26.

Table 26: EFFECTS OF DELETING SELECTED COST CATEGORIES*

AIS Level	Average Cost Before $	Average Cost After $	Total Cost Before $m	Total Cost After $m
6	157,085	119,155	582	441
5	133,685	111,125	27	23
4	57,175	46,815	56	46
3	14,755	13,210	58	52
2	5,790	5,175	140	125
1	2,270	1,895	155	130
P.D.O.	620	450	572	415
Total	[-]	[-]	1,591	1,232

* *The "before" columns are from Tables 1 and 52, and the "after" columns exclude cost categories 2,6,8,9 and 11 from Table 1.*

It can be seen that the principal effect of excluding these five cost categories is to reduce the relative significance of fatal accidents compared to other casualty accidents, since the largest change is to the cost of a fatality. Total accident costs are reduced by $359 million, or 23% as a result of these cost exclusions.

It is considered that it is more desirable to improve the basis of estimation of these cost categories, thus preserving a more systematic concept of social cost, rather than exclude any of the categories cited above.

The Need for Further Research

The socio-economic cost framework adopted for this study consists of accident-caused losses to economic and social welfare which are reasonably commensurable. The framework is thus an extension of the "loss accounting" approach (e.g. of Reynolds [1956], and Dawson [1967] in the United Kingdom and Japan [JRCTP, 1978]) by progressively broadening the definition of cost from more narrowly defined financial/accounting losses resulting from accidents, first to that of economic resource costs (comparable with national accounting measures), eventually leading to a socio-economic measure of those costs borne by the total community which takes fully into account externalities, interdependencies, and other non-market effects of accidents *which are reasonably capable of commensurate valuation.*

Thus some cost categories are included because a judgement is made that there is sufficient acceptance of the concept and basis of valuation even though the estimates may be empirically rough (e.g. family losses, traffic delay costs, etc). However certain other costs, such as pain and suffering arising from accidents, are excluded only because no generally accepted basis of valuation has yet been established (although the courts make judgements about the dollar value of compensation for pain and suffering and other non-market quantities, resulting in the allocation of large sums in compensation for accident losses. Such a settlement in N.S.W. exceeded $1 million in total in 1980 [*National Times,* Sept 21, 1980, page 24] and it is thus apparent that the basis and relative amounts of such judgements warranted further study). The reliability of many of the cost components in Table 1 would be improved both by further research into existing data sources, and the collection of relevant new information by survey.

Both the separate and joint distributions of vehicle damage and medical costs require additional research to further substantiate the assumptions made about injury severity classification in the course of these estimates. There has been no study since Troy and Butlin (1971)which has attempted to measure these joint relationships in Australia, such as the U.S. work of Flora, Bailey, and O'Day (1975) and Marsh, Kaplan and Kornfield (1977) on the financial consequences of vehicle accidents in Michigan.

Other Unit Cost Estimates. As discussed earlier, several of the cost items contained in the unit cost framework of Table 1, (including categories 2,5,6,8,9, and 11) were not directly established from Australian data sources (in several cases the U.S.A. relationship derived by Faigin were applied directly, or slightly modified). Improved local estimates would result from further research into cost categories such as *traffic delay, legal and court costs, and accident investigation.* The concept of *losses to family and community* for example is considered to be an important and valid category of social cost, but the estimation basis (30 % of foregone income, after Faigin) needs further assessment and interpretation to calibrate an acceptable Australian community valuation of this item. Similarly, *traffic delay* costs could be more accurately calculated for Australian accident and traffic conditions in a separate study. The problem of assessing a valuation for *pain and suffering* resulting from road accidents could be approached by establishing its value at some acceptable proportion for foregone income: again, the validation of such a social value would require a separate study.

The unit cost format of Table 1 is considered to represent the minimum set of cost categories for which accident costs need to be derived. It is, in the view of the present author, less misleading to present a conceptually complete set of cost estimates containing direct, indirect and "translated" but comparable foreign cost estimates, rather than to attribute implicit zero values to valid social cost categories by their exclusion.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 *Conclusions*

The proposal for this study envisaged that some modification of the "loss accounting" approach to accident cost measurement would prove acceptable for Australian application. If this were so, most of the subsequent research and investigation would have concentrated on the refinement of estimates and assessment of the adequacy of relevant Australian data sources in supporting these estimates.

In the light of the foregoing review in chapters 2 and 3 (and Appendix A-1) of the conceptual and empirical literature on road accidents, the present study strongly supports the view that the loss accounting approach to accident cost measurement - whilst useful in some areas of accident policy - is of limited usefulness in respect of its principal objective: the evaluation of accident reduction programmes. Moreover the debates which have arisen concerning the acceptability of certain non-market or "intangible" cost components, such as pain and suffering, losses to families, the community, employers, traffic congestion delays arising from road accidents, reflect the unsatisfactory nature of financial or economic resource-cost estimates as a measure of the social benefits to be gained from accident reduction.

In this respect this conclusion follows closely that of Lawson (1978) in Canada, and the conceptual requirements in Mishan (1971), with some modifications as to the scope for development and application of existing cost framework (*vide* Chapter 2, section 2.3; and Appendix A-1).

It is therefore considered that the "loss accounting" approach to accident cost measurement, whether financial, or consistent with the opportunity cost concepts and national income accounts, is *inadequate* for the purposes of accident policy evaluation.

The conceptually correct measure of what the community would be willing to pay for accident reduction is a direct measure of the *demand* for such a benefit (for accident reduction). The economic resource costs of road accidents represent only the *minimum* estimates of what the community would be willing to pay for accident measures, and attempts to place a value on on the range of intangible accident effects, including pain and suffering reflect an attempt to bridge the gap between financial costs and the "social value" of accidents.

However, the view of Mishan (*op.cit.*) that only direct attempts to measure the demand for safety and accident reduction are acceptable is not supported in the present study. Most such valuation attempts have had limited success in terms of empirical estimates of acceptable reliability, commensurate with other costs (*vide* Blomquist [1979]; Freeman [1979]; Jones-Lee [1974]; and Thaler and Rosen [1975]). Therefore until a breakthrough occurs in the area of direct measurement of the aggregate demand for reduction in risk it is considered desirable to continue to extend and refine the previous "economic" cost frameworks of Dawson (1967), Troy and Butlin (1971) and Paterson (1973), for example, towards the expanded social (or "societal") cost framework proposed in Faigin (1976). This latter cost framework, which forms the basis of that proposed in the present study, incorporates all identified resource costs which are displaced as a result of road accidents, together with certain non-market and intangible accident "costs" which reflect the attempt to measure the required extra compensation above market cost levels which the community would be willing to allocate to achieve accident reductions. Further research is considered to be worthwhile to advance both the non-market and empirical components of this accident cost framework.

Some problems remain concerning the concept and estimation basis of the foregone income component of accident costs. Although the often unintended and generally inappropriate effects of the various "net" and "adjusted" income concepts applied in earlier studies (as discussed in chapter 3, section 3.2, and Appendix A-1) can be readily avoided, several questions are also posed by the effects of the age and sex distributions of accident victims, and the discount rate selected, upon the relative importance of foregone income in total accident costs. The figures in Table 13 in chapter 3 suggest that the community apparently values the lost income of a road accident fatality as one-third higher than that of an average population member, although this simply reflects the higher proportion of younger males in the accident sample. Certain ethical and moral considerations may intrude: does society really value lives saved consistent with present values by age? For example, in the calculus of section 3.2, the lives of the elderly, who are disproportionately involved in pedestrian accidents, are still "worth" less in income terms than younger people. Whilst the foregone income calculations may reflect an unsentimental assessment based upon individual cases, the community as a whole may consider that *morally* all lives are equal in their right to be saved, regardless of differences in age or economic or social status. Further research into the implications for accident prevention policy of the effects of and attitude to the age distribution factor may be warranted to clarify these issues.

In the meantime a reasonable interpretation of Table 13 values for foregone income suggests that accidents resulting in fatalities or serious injury are of greater relative importance to society than other categories of social cost such as property damage accidents. This distinction becomes of even greater significance when accident costs are disaggregated according to injury severity. The relative importance of these individual cost items to the total cost framework should be borne in mind, however, in considering the need for data improvements. In Table 2 of chapter 3, the two categories of foregone income and losses to family and the community, together represent over 51 % of total accident costs, vehicle damage is 28 percent and the insurance administration component in "other" costs is 5.2 %. These four categories together comprise 84 % of total accident costs, and variations in their estimation procedures and sources are likely to overshadow refinements to other remaining cost categories including medical costs, legal, court, and emergency service costs, and traffic delay.

Conclusions in respect of the adequacy of existing Australian data sources are briefly stated for each of the cost categories considered (together with respective text references).

(i) *Foregone income* resulting from fatalities and injuries: a more recent incomes survey would improve the present estimate (Chapter 3,p 28);

(ii) *Family and Community losses:* estimated at 30% of (i) after Faigin (1976): further research is needed to calibrate a current valuation for Australian conditions (3.2 p.53)

(iii) *Medical, Hospital and related costs:* The Motor Accidents Board in Victoria is the only known source of such medical cost data in Australia at present, a major survey by States would be required to further improve these estimates (p.43); (see also item iv);

(iv) *Legal and Court costs:* no studies of Australian data are readily available: a survey of court award claims paid by State insurance offices undertaking third party motor vehicle insurance would be required (p.53); Such a study should also provide data on medical costs etc, and any compensation for pain and suffering;

(v) *Insurance administration:* adequate source data is collated by the Australian Bureau of Statistics (p.45);

(vi) *Accident Investigation* (including the cost of emergency services): data is only available from special studies: this item is relatively small and a sample survey would be needed to refine the estimates (p 53);

(vii) *Losses to others:* no data is available from Australian studies, and the U.S. data was applied: a socio-economic survey of the workforce and industry effects of accidents is required (p 50);

(viii) *Vehicle damage:* the fundamental statistics for this estimate are not available (since property damage only accidents are not recorded in most States) and 1971 A.B.S. survey data was required for these estimates. General improvement in the statistical base and consistency in accident recording is required, but in the meantime surveys of comprehensive motor vehicle insurance claims are considered to be the most fruitful source of improved estimates, together with appropriate sample estimates from future surveys of motor vehicle usage conducted by A.B.S. Estimates relating to uninsured vehicles and the "excess" proportion of claims paid by owners would also be derived from these surveys (p 43);

(ix) *Traffic delay:* modified U.S. data were applied for the present estimates: a fairly small-scale study of the metropolitan/other urban/rural distribution of traffic and road accidents by states, and data on the appropriate distributions of traffic flows, would provide more refined time and cost estimates for Australian conditions (p 53);

(x) *Pain and Suffering: no* Australian studies are available and *no* cost estimate was included in these preliminary estimates, but two approaches are considered warranted to facilitate estimates for Australia (p 53):

(a) a survey of the composition of third party (personal injury) compensation awards, with the assistance of state government insurance offices (see item iv, above); and

(b) an associated theoretical study to assess whether it would be appropriate to relate "pain and suffering" costs levels derived from (a) as a proportion of foregone income.

Finally, it is concluded that the framework of unit costs in Table 1 proposed in this study, from which the preliminary estimates of total accident costs were derived provides a set of *minimum* social cost estimates for Australia capable of useful application in the evaluation of road safety programmes. However these cost estimates need careful qualification in use and further refinement of individual estimates. In particular, the retention of a classification of costs according to injury severity which reflects Australian conditions is considered necessary to permit the use of this cost framework to facilitate comparison of alternative accident reduction programmes.

4.2 *Recommendations*

These recommendations arise from the issues covered in the course of this present report, but also reflect the view that further work might best proceed by varying the initially envisaged content of later stages of this study. Based on acceptance of the cost framework proposed in the foregoing, it is recommended that:

(i) the preliminary estimates of unit and total accident costs for Australia in 1978 should be further developed and standardised to form the basis of a regularly produced set of social accident cost estimates to guide accident research and policy;

(ii) improvement across a broad range of accident records and statistics relevant to these estimates is a necessary but long-term programme; in the meantime a range of surveys and studies of individual cost components is required to achieve more immediate improvement in the accuracy and application of these estimates; these include:

(a) further analysis of medical,hospital and related costs of motor vehicle accidents from the records of the Motor Accidents Board of Victoria;

(b) a survey of third party (personal injury) claims on one or more State government insurance offices, to determine legal and court costs, court awards for pain and suffering, and other such cost items;

(c) further survey and analysis of comprehensive motor vehicle insurance claims to improve the estimates of vehicle property damage costs, and their statistical distributions (including consideration of the "excess" paid by owners, and the problem of uninsured vehicles);

(d) a series of relatively small socio-economic studies of the non-market value of certain accident effects in Australian conditions, including accident losses attributed to families and community, employers and industry, traffic delays, and to pain and suffering;

(e) a study of the need for and feasibility of deriving an injury severity classification of accident cost data for Australian conditions, together with an appraisal of its use in the evaluation of road safety programmes.

(iii) the production of more detailed accident cost estimates (in the format of the present report) by type of accident and by region (urban/rural) as envisaged in subsequent stages of this study should be proceeded with according to prescribed areas and classifications.

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