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REVALUATION OF THE COST OF ROAD ACCIDENT CASUALTIES: 1992 REVISION

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CONTENTS

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ABSTRACT

Since 1988, the Department of Transport has used a Willingness to Pay approach to value road accident fatalities by considering what people would be willing to pay to reduce the risk of being killed in a road accident. The value of non-fatal accidents has continued to be based on a Human Capital approach. The methods used for costing accidents are being revised so that non-fatal accidents are costed in a comparable way to fatal accidents, and to ensure that the costs are based on up-to-date information about the consequences of road accidents. The report summarises TRL research on casualty-related costs: the distribution of injury severity among casualties with 'serious' and 'slight' injuries, studies of the value of avoidance of road accident injuries, and estimates of the lost contribution to the economy which result from road accident injuries. The report presents revised estimates of the average cost per casualty; a further report will consider accident-related costs. The implications of the revised costs for total accident costs and their application to cost benefit analysis of road schemes and road safety measures are discussed, and comparisons are made with accident costing in other countries.

1. INTRODUCTION

The benefits of new roads, road improvements, safety schemes and other transport projects are calculated in terms of the saving of time and accidents. To assess the value of proposed schemes, the costs of implementation are offset against the benefits; benefits are estimated in monetary terms so that they can be directly compared against the costs. The distribution of spending on road safety also depends partly on the value of savings in accident costs which are likely to result from such spending. Thus estimates of the cost of road accidents are required for decisions on a variety of transport issues, at a national and a local level.

The Department of Transport (DOT) is committed to revising the methods used for costing road accidents. A programme of TRL research on accident costing was commissioned to provide information for use in revising the costs. This report summarises the results of some of the initial projects in the programme, leading to an estimate of the present value of the economic consequences of road accidents occurring in Great Britain in 1990. A further report will cover results of the later projects and research on the consequences of road accident injuries which are, of necessity, carried out over a longer time period.

2. DEVELOPMENT OF ROAD ACCIDENT COSTING

2.1 FATAL ACCIDENTS

Most countries use one of two approaches to costing road accident casualties: Human Capital or Willingness To Pay to reduce the risk of injury.

Between 1968 and 1987, DOT costed all road accident casualties using the Human Capital approach. A value is placed on the contribution which the casualty would have made to the economy if the accident had not happened, and to this is added the cost of medical treatment and pain, grief and suffering. Accident-related costs (costs of damage to vehicles and property, and police costs and administration costs for insurance), are distributed between the casualties in the accident.

Since 1988, DOT has used a Willingness To Pay approach to value road accident fatalities by considering what people would be willing to pay to reduce the risk of being killed in a road accident. The direct economic costs (net output and medical costs) are added to the amount derived from the willingness to pay valuation to produce a total cost of a fatality. The new approach was adopted following recommendations from a review of relevant research (Dalvi, 1988), and consultation among road safety experts and other interested parties (Department of Transport, 1988). The consultation showed strong support for the proposed valuation of £500,000 for a fatality, including the direct economic costs, and this figure was adopted in 1988 and has been uprated each year for changes in prices and GDP. The figure of £500,000 was substantially higher than £283,000, which was the previous value of a fatality based on the Human Capital approach, in 1987 prices.

This new approach developed from welfare economics, and was consistent with cost-benefit analysis in that decisions reflect the preferences and attitudes to risk of those likely to be affected by them. These preferences are best measured in terms of what people would be willing to pay to reduce the probability of being involved in an accident, which reflects their willingness to pay for an improvement in safety. The values used for road accident fatalities were derived from stated preference surveys of the general public (Jones-Lee, Hammerton and Philips, 1985) and revealed preferences from research on wage rates in high risk occupations. The stated preference method is similar to that used to derive the value of leisure time savings, which is another important component in the cost benefit analysis of road schemes.

2.2 NON-FATAL ACCIDENTS

At the time when fatalities were re-valued, there was no similar research evidence for valuing non-fatal injuries using revealed or stated preference methods, so estimates of the costs of road accident injuries have continued to be based on the Human Capital approach.

Three main elements of cost are included:

- medical costs incurred in providing hospital and ambulance services;
- loss of output resulting from the injury;
- a notional allowance for pain, grief and suffering experienced by the casualty, and relatives and friends.

This method used for valuing injuries was originally devised in the 1960s (Dawson, 1967 and 1971). The estimates have been uprated annually for inflation and GDP growth and published in the Department of Transport's annual publication 'Highways Economics Note 1'. However much of the data on which the estimates are calculated were collected in the 1960s. The only major changes since costs were first calculated were a change from net output to gross output (Dawson, 1971) and an arbitrary increase of 50 per cent in the 'pain, grief and suffering' component following the Leitch Committee report in 1978. More minor changes occurred when medical costs were updated from 1977 and when lost output was re-calculated in 1979 using 1978 data on earnings and activity rates, but using assumptions similar to those made by Dawson about the consequences of road accident injuries. In addition, there was an interim increase in 1986 at the same time as the value of time was increased.

While the two contrasting approaches are in use, the costs of injury accidents are not comparable with the costs of fatal accidents, and the relative weight given to fatalities is disproportionately higher than the weight given to injuries.

2.3 CURRENT ACCIDENT COSTS

Table 1 shows the costs derived for casualties and accidents in 1990. The table shows the four main categories of accident and injury for which costs are calculated: fatal, 'serious', 'slight' and damage only. The definitions are listed in Appendix A, but it is important to note here that the 'serious' category is broad, ranging for example from a fractured finger, to death more than 30 days after the accident.

Table 2 shows the average cost per accident derived for 1990. The costs are higher than the average cost per

TABLE 1

Accident costs in 1990

Severity	Cost per casualty (£)	Total accident cost (£M)
Fatal	664,940	3,527
Serious	20,160	1,321
Slight	410	495
Damage only	-	1,426
All	14,070	6,768

Source: Department of Transport, Highways Economics Note 1 (Nov 1991)

TABLE 2

Average cost per accident in 1990 (£)

	Casualty-related			*Accident-related*		
Type of accident	Lost Output	Medical & Ambulance	Pain, grief & suffering	Police & Insurance Admin	Damage to Property	Total
Fatal		739,420		490	2,930	742,840
Serious	2,380	2,910	17,530	390	2,270	25,930
Slight	40	140	330	300	1,630	2,440
Injury		18,580		320	1,780	20,680
Damage only	-	-	-	100	830	930

Source: Department of Transport, Highways Economics Note 1 (1991) casualty of the same severity shown in Table 1. There are two reasons for this. The severity of accidents is defined by the severity of the most seriously injured casualty involved, but because there is on average more than one casualty per injury accident, this increases the average cost per accident. Also, the costs can be divided into two groups - those associated with the accident, and those associated with the casualty; the average cost per casualty does not include the accident-related costs.

The table shows that the accident-related costs (damage to vehicles and property, costs of the police service and the administrative costs of accident insurance) are relatively low compared with the casualty-related costs (loss of output, health service costs and pain, grief and suffering). The difference between fatal accidents and less severe accidents in the techniques used to estimate costs is reflected in the fact that the casualty-related costs of fatal accidents are presented as a single figure, rather than split into separate components.

The costs shown in Tables 1 and 2 are derived for accidents and casualties reported to the police and recorded in Stats 19, the national accident statistics database. Accidents are not all recorded, and research shows that rates of under-reporting are higher for those involving less severe injuries (James, 1991). Thus it is likely that the average cost per injury accident, or per damage only accident, would be lower if account were taken of the number of un-reported accidents. This report covers the cost of accidents reported in Stats 19. Research is planned which will enable future cost estimates to be derived to include accidents which are not reported in Stats 19.

2.4 OPTIONS FOR REVISING THE COST OF NON-FATAL CASUALTIES

The Department of Transport consulted a number of experts in the field of transport and health economics about the most appropriate technique for re-valuing injury accidents. Five groups were commissioned to review the techniques and consider whether it was appropriate to use similar methods for valuing both fatal and non-fatal casualties.

The review considered relevant experience in Britain and other countries, the feasibility and cost-effectiveness of different techniques and the scope for linking the valuation of injury with the value of life.

The options considered by the experts as alternatives to the human capital approach are summarised here.

- **Individuals' willingness to pay to reduce the risk of injury**. There are several approaches to eliciting values in this type of investigation. These can be separated into two groups; stated preference methods (known in the USA as conjoint analysis), and revealed preference methods. First, there are four approaches based on stated preference.

a) Contingent valuation - how much individuals would be prepared to pay to reduce the risk of injury from a defined level to another specified level.

b) Standard gamble - individuals specify the level of risk at which they would opt for treatment for an injury, which if it succeeded would return them to normal health, and if it failed would result in more severe consequences, or in some cases, death.

c) Risk change ratio - individuals trade off changes in risk of different types of injury.

d) Contingent ranking - values are inferred from individuals' ranking, in order of preference, alternative injury types; scaling or scoring is a refinement of this approach. An example is the visual analogue scale; respondents are presented with a scale from 0 to 100 (least to most desirable) and asked to place injury types at the point on the scale which reflects their feeling about that injury.

Two of the approaches use revealed preferences.

e) Consumer market or avertive behaviour - the purchase of safety devices is related to the consequent reduction in risk of injury. Consumers are assumed to perceive the risks involved accurately.

f) Hedonic wage, or compensating wage differential - wages in high risk occupations are seen as a balance between the amount the employer is willing to pay for safety measures and the amount the employees require to compensate them if risks are higher. This approach assumes a free market without national agreements, and that compensation payments are borne entirely by employers; there is no clear parallel between workplace and transport risk.

- **Health status measures**. The health status index approach is used to evaluate health care options. Two applications of this approach were considered: through the concept of the quality-adjusted life year (QALY), and through willingness to pay.

  Using the QALY approach, a patient's expected life span is adjusted to take account of the quality of that life expectancy, given the expected consequences of their illness. The approach was considered to need further development before it could be applied to injuries.

  The concept of descriptors of typical health profiles which are used to derive health status measures was considered to be a useful one to apply to the willingness to pay methodology. This involves dividing road accident injuries into a set of typical injuries. For each injury a descriptive profile of the common sequence of events following such injuries would be developed. These 'injury state descriptors' could then be presented to samples of the general public, asking their willingness to pay to reduce the risks of incurring injuries with these consequences.

- **Loss of relative utility approach**. Utility is a concept for assessing the value an individual places on the consequences of different actions. The relative utility loss approach has developed from health status and quality of life measurements in health care. Indices for measuring utility have been developed by health economists and could be applied to road accident injuries, presented as 'injury state descriptors', to produce utility scores reflecting the relative undesirability or loss associated with each of the injuries.

- **The common law treatment of damages for personal injury**. Court awards are tailored to the individual circumstances of each case but with reference to a 'tariff' derived from other cases, so values for different injuries could be determined. However there is no corresponding value for death and awards can be adjusted to reflect contributory negligence.

- **Life assurance and accident insurance**. Values reflect compensation for family members after death, rather than personal value of life. There can be various social and economic motivations for buying such insurance, such as investment, or as a requirement to cover a loan or mortgage. Also, accident insurance could be argued to encourage risky behaviour by creating an illusion of increased safety.

- **Valuations implied from public investment decisions**. Public sector-spending on safety and legislative decisions associated with safety show wide variations, suggesting that decisions are not based on a consistent valuation of life or injury.

  A number of the options considered had clear limitations which suggested that they were either unsuitable for application to valuing road accident injuries, not sufficiently developed for use in this field, or were not compatible with the willingness to pay approach used to value fatal accidents. The consensus among experts in health and transport economics was that the willingness to pay approach should be applied, using injury state descriptors as in health status measurement, but that the various methods of eliciting values needed to be tested before deciding which to use. In parallel, further work investigating relative utility loss approaches was recommended.

2.5 RESEARCH PROGRAMME

A research programme was designed to derive valuations for injuries following the recommendations of the experts. The costs borne by society are an important component of the cost of injury and other research projects, on resource costs and the number of casualties with injuries of different levels of severity were also initiated.

The estimation of casualty costs combines WTP values and the value of lost output and medical costs. The research on injury valuation is designed to elicit *ex ante* values: the values as assessed *before an accident has happened*, or the value of avoiding an injury. The research on resource costs is aimed at identifying *ex post* costs or values: the cost to society of *accidents which have happened*.

The components of the research programme, covering casualty and accident costs, are outlined in Figure 1 and explained in more detail below. This report is concerned only with casualty related costs.

Distribution of casualties by severity. Hospital data are linked with police-reported accident data to identify in more detail the distribution of casualties within the Department's 'serious' and 'slight' categories. The detailed distributions are used in ascribing weights to individual injury state descriptors which together comprise injuries classified as 'serious'; the weights are used in grossing up injury valuations and estimates of direct economic costs to a national level.

Costs of medical and support services and personal costs. Two in-depth studies among road accident patients are in progress. One covers patients with two specific types of 'slight' and 'serious' injury ('whiplash' and limb fracture injuries) which have a high incidence of residual disability, while the other study covers patients with other types of injury. A technique for identifying the costs of lost output, medical treatment, provision of support services, personal costs and social security payments has been developed, taking account of any long-term disability resulting from the injuries.

Police costs. A survey of the time spent by police officers dealing with road accidents of different levels of severity is in progress.

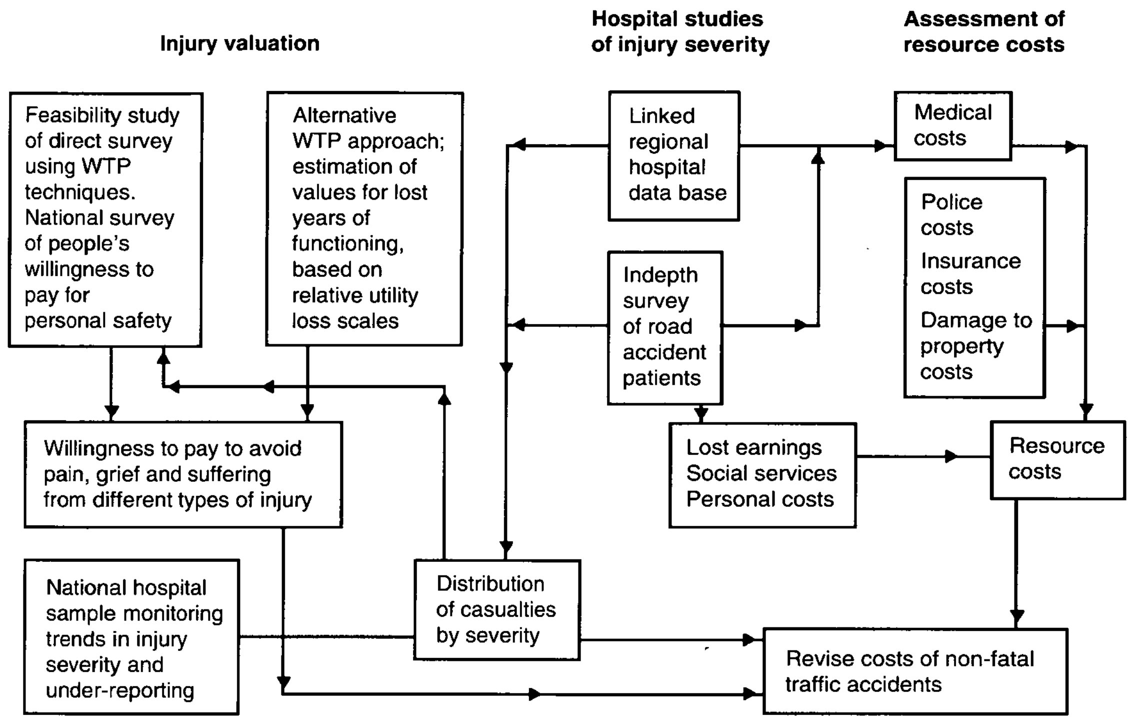
Damage and Insurance costs. A survey of motorists involved in accidents has been completed and a study of motor insurance claims is in progress.

Willingness to Pay for Safety. Feasibility studies assessed the effectiveness of a variety of techniques to determine people's value of road safety. These tested different ways of eliciting Willingness To Pay and recommended the techniques to be used in a large scale study. National sample surveys were carried out to elicit values from the general public. From the individual valuations for a range of injury state descriptors of different severity, aggregate values were derived, reflecting the average people are willing to pay to avoid pain, grief and suffering from road accident injuries. This is interpreted as being equivalent to willingness to pay to reduce the risk of being involved in an accident.

Relative utility loss. Work on the relative utility loss approach examined alternative valuation methods. A set of health status and quality of life measures were selected and used by experts in health care and economics to derive utility scores for the range of injury state descriptors used in the Willingness to Pay surveys.

National hospital study of road accident injuries. A continuous sample survey of road accident patients

FIGURE 1
ACCIDENT COSTING RESEARCH



treated at hospitals is commencing in 1992. It will provide detailed information on road accident injuries, including cases which are not reported to the police. The results will be used in estimating accident costs in future. It will enable costs to be estimated for accidents which are not recorded in Stats 19, thus contributing to estimates of the full cost of road accidents to the community.

These research projects were designed to cover and update the elements of road accident costs which had been included in previous estimates. However the research programme does not cover all aspects of the cost to the community arising from road accidents, and indeed current calculations of accident costs are recognised to be minimum estimates because not all elements are quantified.

Four components of the cost of accidents are excluded. The first is the cost of delays to road users which follow from the congestion caused by road accidents. In cases where injuries result in an extended period of impairment, the cost of caring for that individual - in anxiety, stress and loss of earnings for the carer - may be considerable, but these costs are not covered here. Injuries such as these may also reduce life expectancy, which in itself affects the cost of accidents, for example by reducing the time period over which the casualty is contributing to the economy through production and consumption. There is no information on the association between life expectancy and disability, so this has not been taken account of in the past, or in these revised estimates.

The fourth element which is excluded is Willingness to Pay for other people's safety; the experts who considered the various options for revising the cost of non-fatal accidents recommended that this should be included. However this was not done, for two reasons. The results of the feasibility study suggested that there was no practical way of eliciting a value for altruism in a questionnaire survey. Moreover, recent theoretical work had suggested that it may not be appropriate to take account of willingness to pay for other people's safety in public sector decision-making, because aggregating individuals' values would involve an element of 'double counting' (Bergstrom, 1982, Jones-Lee, 1991 and 1992). It would be possible to augment values of safety in the future, to take account of altruism, if it proved possible to identify and measure altruistic concern in future research.

The remainder of the report presents the results of the research on some of the projects on casualty-related costs listed above. Section 3 summarises work on the distribution of casualties with injuries of different levels of severity. Section 4 looks at injury valuation and presents the values derived for avoidance of a serious injury. Resource costs related to casualties are examined in Section 5. The research on medical costs is not yet complete, but values are derived for lost output. Section

6 compares the approach adopted here with that used in other countries. Section 7 summarises the elements of casualty-related costs and describes the implications for total accident costs and for the application of accident costs to cost benefit analysis and appraisal of road safety measures. Some of these sections present new research on fatal accidents, while others are confined to non-fatal accidents. A further report on accident-related costs is in preparation.

3. THE DISTRIBUTION OF INJURY SEVERITY AMONG ROAD ACCIDENT CASUALTIES

Section 2 mentioned that the injuries defined by DoT as 'serious' cover a wide range, from a fractured finger, to those resulting in death more than 30 days after the accident. Some injuries classified as 'slight' can have long term effects; 'whiplash' neck injuries are the prime example, often resulting in a prolonged period of temporary disability. In contrast, the majority of 'slight' injuries are minor cuts and bruises which have only limited short term consequences.

The distribution of injury severity within the 'serious' and 'slight' categories is subject to change. For example the introduction of road safety measures can lead to reductions in injuries of a particular type and severity. To derive injury costs it was important to subdivide the two standard injury groups where possible, estimate costs for the sub-groups and then calculate weighted average costs for 'serious' and 'slight' injuries. Changes in the distribution of injury severity in future years could then be taken into account by re-weighting, and would not require further research on the actual costs.

Two approaches to defining sub-groups of casualties were adopted. Statistical analysis of data linking police and hospital records of road accident patients was carried out to estimate statistical distributions of injury severity for different types of road user, using clinical information to describe severity. The information provided by such a distribution will become increasingly useful as links between 'threat to life' type scales and disability scales improve.

In addition, a set of injury state descriptors was derived, which together comprised the range of 'serious' injuries, and which summarised in plain English the consequences of injuries. The descriptors were derived for use in the injury valuation research, to be presented to members of the public and experts to elicit their valuations; these are described in Section 3.2.

3.1 STATISTICAL ESTIMATES OF THE INJURY SEVERITY DISTRIBUTION - SERIOUS CASUALTIES

Data on road accident casualties treated at hospitals which had been linked with casualty records in police road accident data were used to estimate a national distribution of injury severity among casualties with injuries classified by DoT as 'serious'. The research and main results are summarised here; a more detailed technical report is available from the authors.

The main source of hospital data was regional data from Scotland; there is no comparable complete dataset for England and Wales. Scottish Hospital In-Patient Statistics (SHIPS) provide clinical information on injuries, length of stay in hospital, age, gender and road user type. At TRL, injuries are assigned scores on the Abbreviated Injury Scale (AIS), which is explained in more detail below. TRL also matches SHIPS records statistically with Stats19 police records for Scotland on the basis of basic details of the casualty which are held in both databases.

The matched SHIPS casualties coded as 'serious' by the police comprise 55 per cent of all 'serious' casualties in Stats19 records for Scotland. The remaining 45 per cent are casualties who were not treated as in-patients and cases whose records could not be matched, through mis-coding or lack of details on the items used for matching records. One of the research projects in the programme involved manual matching of police and hospital records of casualties in the Greater Manchester area. This showed that a quarter of the casualties recorded by the police as 'serious' were treated as out-patients, which suggested that a large proportion of the un-matched cases in Scotland were likely to be people treated as out-patients.

The SHIPS data were used to estimate a severity probability distribution in terms of selected accident variables (or the probability of an injury falling into a particular severity category, given certain accident circumstances). Two measures of severity were used, producing two severity distributions - the Maximum Abbreviated Injury Scale (MAIS), and length of stay in hospital. These measures were selected because they could be derived from the SHIPS data, and also in other sources of information to be used in the programme of work currently or in the future. However neither of the two measures is ideal for the purpose; a scale which is specifically designed to measure disability arising from road accident injuries would be more suitable for accident costing because it could reflect the economic consequences of road accident injuries. Work on such a scale is in progress in the USA and it may be possible to apply it to accident cost estimates in future.

SHIPS data for the years 1983 to 1988 were combined to generate satisfactory sample sizes. The data were disaggregated across MAIS or length of stay by those variables affecting injury severity (age, gender, road user type and road type). Probability distributions were calculated for each disaggregate group so that major differences between Scotland and Great Britain in factors associated with severity were taken into account before deriving the national estimates. The resulting probabilities were applied to the 1989 national accident data (the most recent year available at the time) to produce an estimate of the national distribution of injury severity within the 'serious' category.

3.1.1 MAIS distribution

The Abbreviated Injury Scale (AIS) was developed for road accident research, and takes account of threat to life, permanent impairment and energy dissipation required to cause the injury. It provides equivalent rankings of different types of injuries in different body regions. Injuries are scaled between 1 (minor) and 6 (maximum, virtually unsurvivable). The Maximum AIS (MAIS) is the highest single AIS score assigned to a casualty and can be used to describe the overall injury severity. Some of the categories were combined before the severity probability distribution was calculated, and casualties were classified according to whether they had no or minor injury (MAIS 0-1), moderate injury (MAIS 2), serious injury (MAIS 3), or severe, critical or life-threatening injury (MAIS 4-6).

Separate probability distributions were calculated for the proportion of national Stats19 casualties who were likely to be in-patients and non in-patients. The distribution for in-patients was based on the MAIS distribution of the matched casualties in SHIPS. The MAIS distribution for the un-matched casualties was assumed to be the same as the distribution for in-patients who stayed in hospital for less than two nights who were of the same age, gender and road user type. (This assumption was supported by comparison of data on people treated as in-patients and out-patients in Oxford and Greater Manchester.) The in-patient and non in-patient distributions were then combined into an estimate of the national distribution for all 'serious' casualties, disaggregated by age, gender, road user type and type of road (urban, rural and motorway). The separate road type distributions were then summed to produce an overall estimate for all types of road in Great Britain. The 95 per cent confidence intervals for the distribution were estimated on the basis of the standard errors and sample sizes of the severity distribution for in-patients.

The resulting distributions for each road type are very similar, as Table 3 shows, with between two-thirds and three-quarters of injuries in the MAIS 2 group; examples of such injuries in the DoT 'serious' category are: concussion, dislocation of shoulder, traumatic amputation of thumb/finger/toe. The proportion of casualties with life-threatening injuries was very small - generally between 1.5 and 3 per cent; examples of such injuries are: injury to heart and lung, crushing injury of hip/thigh, traumatic amputation of leg(s) at or above knee.

Table 3 shows that on urban and rural roads, more vulnerable road users (pedestrians, cyclists and motorcyclists) are more likely to sustain injuries of MAIS 3 and less likely to sustain injuries of MAIS 2, compared with vehicle occupants. 'Serious' injuries to car occupants on rural roads and motorways were rather more likely to score MAIS 3 or more than injuries on lower speed roads in built-up areas. Similarly, 'serious' injuries to pedestrians and cyclists on rural roads were more likely to score MAIS 3 or more on rural than on urban roads.

3.1.2 Length of stay in hospital

Length of stay in hospital was selected as an alternative indicator of injury severity. It is a good measure of in-hospital medical costs (Galasko, 1986) and is also correlated with disability (Galasko, 1986, Guria, 1990). The SHIPS data includes total length of hospital stay arising from road accident injuries by accumulating the individual episodes of in-patient treatment. This was the best available measure of disability resulting from road accident injuries. On average, in-patients with 'serious' injuries stayed in hospital for 10.25 nights.

Length of stay in hospital was grouped into the following categories: 0 nights; 1-3 nights; 4-10 nights; 11-30 nights; 31+ nights. Significance tests showed this to be the optimum grouping, given that the objective was to divide casualties into four or five groups. The 0 nights category consisted of people admitted to hospital for treatment as in-patients but who were discharged on the same day; 6 per cent of in-patients were in this category.

The method used to estimate a national distribution was the same as for the MAIS data, except that un-matched casualties were all assumed to be in the 0 nights category. This assumption is open to question and may result in an under-estimate of severity, in that some un-matched casualties were in-patients for whom insufficient data were available for matching; however there was no other basis on which to assign un-matched casualties to length of stay groups. Evidence from the research in Greater Manchester suggests that this assumption may have over-emphasised the proportion of casualties in the 0 nights category; of the casualties with 'serious' injuries recorded in Stats 19, 30 per cent were either not treated in hospital or did not stay overnight.

Assigning un-matched casualties to the 0 nights category resulted in this being the largest group, accounting for almost half of the casualties. Over all types of road and road user, the proportion of casualties falls as length of stay rises, as Table 4 shows, with around a quarter of casualties in the 1-3 nights category and an eighth in the 4-10 nights category.

The proportion of casualties staying between 0-3 nights is marginally greater on urban roads than rural roads, reflecting the difference in injury severity shown in the MAIS distribution. Pedestrians and motorcyclists are more likely to stay in hospital for longer periods of time than other road users.

Length of stay in hospital was longer for older people than for other casualties in the same road user group injured on the same type of road; this is particularly true of car occupants, pedal cyclists and pedestrians, and in the case of pedestrians and cyclists, child casualties are more likely to have a long stay in hospital than young adults. This may be accounted for by differences in recovery rates or dependence on care, because the MAIS distribution does not show such variations with age.

TABLE 3

Estimated national distribution of injury severity (MAIS) - 'serious' casualties

Road type/User	MAIS	% of Casualties	95% Confidence Limits	No. of casualties (100%) [No. In-patients for CI]
Urban Roads				
Car occupant	0-1	21	19 to 21	10100 [2828]
	2	68	66 to 71	
	3	9	8 to 11	
	4-6	2	1 to 2	
Motorcycle	0-1	16	13 to 18	7639 [1890]
	2	63	60 to 67	
	3	19	17 to 21	
	4-6	2	1 to 3	
Pedal Cycle	0-1	13	9 to 16	3864 [824]
	2	76	71 to 80	
	3	10	7 to 12	
	4-6	2	1 to 3	
Pedestrian	0-1	12	11 to 13	13852 [7510]
	2	71	70 to 73	
	3	15	14 to 16	
	4-6	1	1 to 2	
Other	0-1	21	16 to 27	1454 [532]
	2	67	61 to 74	
	3	10	7 to 13	
	4-6	1	0.6 to 1	
Urban total	0-1	16	15 to 17	36909 [13584]
	2	69	68 to 70	
	3	14	13 to 14	
	4-6	2	1 to 2	
Rural Roads				
Car occupant	0-1	20	18 to 21	13652 [6244]
	2	66	64 to 68	
	3	12	11 to 13	
	4-6	3	2 to 3	
Motorcycle	0-1	15	11 to 18	3205 [1185]
	2	62	58 to 67	
	3	20	17 to 24	
	4-6	3	1 to 4	
Pedal cycle	0-1	13	6 to 20	789 [264]
	2	74	66 to 82	
	3	12	6 to 17	
	4-6	1	0.6 to 2	
Pedestrian	0-1	12	7 to 17	844 [548]
	2	67	61 to 74	
	3	18	14 to 22	
	4-6	3	1 to 5	
Other	0-1	21	16 to 26	1388 [684]
	2	65	59 to 70	
	3	13	10 to 16	
	4-6	1	1 to 2	
Rural total	0-1	18	17 to 20	19878 [8925]
	2	66	64 to 67	
	3	14	13 to 15	
	4-6	2	2 to 3	

TABLE 3 CONTINUED

Road type/User	MAIS	% of Casualties	95% Confidence Limits	No. of casualties (100%) [No. In-patients for CI]
Motorway				
	0-1	19	12 to 27	
	2	67	58 to 76	1008
Car occupant	3	12	7 to 17	[244]
	4-6	2	0.00 to 5	
	0-1	21	14 to 27	
Motorway total	2	67	59 to 75	1418
(all users)	3	11	7 to 16	[332]
	4-6	1	0.00 to 3	
All Roads				
	0-1	20	18 to 22	
	2	67	65 to 69	24760
Car occupant	3	11	10 to 12	[9316]
	4-6	2	2 to 3	
	0-1	15	12 to 19	
	2	63	59 to 67	10967
Motorcycle	3	19	17 to 22	[3093]
	4-6	2	1 to 3	
	0-1	13	9 to 17	
	2	75	70 to 80	4653
Pedal cycle	3	10	7 to 13	[1090]
	4-6	2	0.6 to 3	
	0-1	12	11 to 14	
	2	71	69 to 73	14721
Pedestrian	3	15	14 to 17	[8080]
	4-6	2	1 to 2	
	0-1	22	16 to 27	
	2	66	59 to 72	3105
Other	3	11	8 to 14	[1262]
	4-6	1	0.6 to 1	
	0-1	17	16 to 18	
	2	68	66 to 69	58206
Grand total	3	14	13 to 14	[22841]
	4-6	2	2 to 2	

3.1.3 Length of stay and MAIS compared

The two methods of summarising injury severity produced rather different distributions, but many of the differences between types of road and road user were reflected in both sets of distributions. This can be explained by an association between length of stay in hospital and MAIS, with MAIS and road user type being reasonable predictors of length of stay for casualties with 'serious' injuries which are not life-threatening. More severe injuries use more medical resources and may result in longer periods out of productive employment, but some of the more disabling injuries are not life-threatening.

The length of stay distribution is highly skewed. The MAIS distribution is slightly skewed, with more casualties having minor injuries than life-threatening injuries, but peaks in one of the intermediate categories (MAIS 2). The length of stay distribution shows a more even spread of casualties between categories than the MAIS distribution. This is partly because MAIS is a discrete, non-linear variable, whereas the length of stay distribution has been created by combining categories in a continuous, linear variable.

TABLE 4

Estimated national distribution of length of stay in hospital - 'serious' casualties

Road type/user	Percentage distribution (nights)					No. of Casualties
	0	1-3	4-10	11-30	31+	(=100%)
Urban roads						
Car occupant	55	27	11	5	2	11117
Motorcycle	49	21	14	10	6	8217
Pedal cycle	58	24	10	4	3	3997
Pedestrian	41	27	14	10	8	14657
Other	65	19	8	5	3	1612
Urban total	49	25	12	8	5	39600
Rural roads						
Car occupant	49	26	13	7	4	14824
Motorcycle	44	23	15	11	7	3441
Pedal cycle	51	23	13	9	4	798
Pedestrian	41	24	12	12	11	904
Other	51	25	12	7	4	1538
Rural total	48	25	14	8	5	21505
Motorways						
Car occupant	51	266	13	7	3	1119
Motorway total (all users)	51	26	12	8	3	1526
All Roads						
Car occupant	51	27	12	7	3	27060
Motorcycle	48	22	14	10	6	11783
Pedal cycle	57	24	11	5	3	4795
Pedestrian	41	27	14	10	8	15590
Other	58	23	10	6	3	3438
Grand total	49	25	13	8	5	62666

3.1.4 A national distribution

The suitability of this method of using the regional database to derive national estimates was tested by estimating a national severity distribution for in-patients and comparing this with the actual severity distribution for in-patients in Scotland. The difference between the two distributions was minimal, which proved this to be a robust basis for deriving national estimates. However the database is rather small, which means that at the tail of the MAIS distribution the confidence intervals show that the range in the proportion of casualties in the group is wide in comparison with the size of the group. Given that the cost of injuries in this group is likely to be high, this uncertainty could have a significant effect on overall accident costs.

The data for about 200 casualties recorded in Stats19 who had been treated in Greater Manchester hospitals suggest a rather different distribution of injury severity; fewer casualties had injuries scoring MAIS 2 (half as many as estimated from SHIPS), more scored MAIS 3 and over (twice as many as estimated from SHIPS) and more had a long hospital stay (15 per cent over 30 nights compared with the SHIPS estimate of 5 per cent) (Hopkin et al, 1992). These figures have not been applied to national accident statistics to produce national estimates, but they do suggest that data for different areas may produce different estimates of the severity distribution. The distributions based on local and regional studies should therefore be regarded as provisional, providing the best estimates available; the national sample hospital survey will in time provide a large sample of road accident casualties from which better estimates of the distribution of injury severity will be derived.

3.2 DEVELOPMENT OF INJURY STATE DESCRIPTORS FOR 'SERIOUS' INJURIES

A set of descriptors of the range of injury states comprising injuries defined by DoT as 'serious' was developed for use in the injury valuation research. The objective was to develop a set of descriptors which summarised the consequences of injuries in terms which could readily be understood both by members of the public in the sample survey of willingness to pay for safety, and by experts valuing injuries using the Relative Utility Loss Approach. A maximum limit of ten injury state categories was set (including normal health and death), because this was considered to be the largest number of injury groups which could be presented to members of the general public and experts in the valuation surveys. This meant that some simplification and generalisation was necessary to ensure that the complete spectrum of 'serious' injuries was summarised in eight groups.

Injuries were summarised in terms of a number of dimensions: extent and duration of pain or discomfort, period of treatment in hospital, recovery period, consequences for home and working life and level of residual disability. The descriptors were developed by a working group consisting of the research team carrying out the in-depth studies of road accident patients (led by Professor Galasko, Manchester University), the teams working on injury valuation, researchers at TRL and representatives of DoT and the Department of Health. The team drew extensively on the experience of Professor Galasko in treating road accident patients and researching the consequences of their injuries.

The descriptors are listed in Table 5, which also shows a shorthand letter code which was used for reference to individual injury states during the survey work.

Before valuations for each injury descriptor could be combined into an overall average value for all 'serious' injuries, the probability of a serious injury falling into each of the categories described had to be estimated. There is no source of data on the incidence of road accident injuries which covers all the dimensions of the injury state descriptors; most importantly, there is no information at a national level on the extent and duration of disability arising from road accident injuries and the restrictions of such disability on home and working life. There are two research projects in this programme on this topic, but results for a range of injuries are not yet available.

The probability distribution was estimated on the basis of the results of the statistical studies of police and hospital data, work led by Professor Galasko on linking police and hospital data for road accident casualties in Greater Manchester, and the expert clinical judgement of Professor Galasko.

The probability distribution was developed in a two stage process. The first stage was to estimate the order of magnitude of the incidence of each type of injury for presentation to respondents in the valuation surveys as the relative risk of incurring these injuries. This estimate was based largely on the clinical judgement of Professor Galasko and his colleagues, informed by the early results of the statistical estimates, and initial results of research at Manchester University linking police and hospital records. The figures were presented to respondents as the annual risk in 100,000 of incurring an injury (calculated on the assumption of an annual average mileage by car of 10,000) and are shown in the right hand column of Table 6.

The starting point for the second stage estimated probability distribution was data on patients treated over a 6 month period at three hospitals in Greater Manchester (Hopkin et al, 1992). The hospital records were linked with police records, and 200 of the patients were found to be recorded in the police accident statistics and classified as having 'serious' injuries. Professor Galasko's team then examined the information from the medical records on the injuries sustained by those patients, and assigned each patient to one of the injury states.

Before a probability distribution was calculated, some adjustments were made to ensure that descriptors comprised the best possible representation of the spectrum of 'serious' injuries. Some patients with 'slight' injuries had been mis-classified by the police as 'serious'. These were assigned to the most appropriate category in the distribution; for those with 'whiplash' neck injuries, this was group X because such injuries typically involve some pain or discomfort, some restrictions to work and leisure, with return to normal health within 1 to 3 years. In addition, the Stats19 data for the area covered by the hospitals were compared with the number of patients treated by the hospitals, and this showed that a small number of casualties were classified as 'serious' but did not appear in the hospital records. These may have been patients who attended the hospital but did not wait to be treated, people treated by GPs, or casualties whose injuries were incorrectly classified by the police as 'serious'. To ensure that the probability distribution reflected casualties recorded in Stats 19, these casualties, which together comprised about 5 per cent of 'serious' casualties in Stats 19, were added to those in injury group F. Similarly, patients with no injury who were mis-classified by the police as 'serious' were assigned to this group. The justification was that group F was the category for casualties not treated as in-patients which did not involve any permanent disability.

The final estimated probability distribution is shown in Table 6. This is the distribution which was used to weight values derived in the injury valuation studies to derive an overall average value for avoidance of a 'serious' injury.

TABLE 5

Injury state descriptors

Injury code	Description	Summary description
F	No overnight stay in hospital (seen as an out-patient); experience slight to moderate pain for 2-7 days followed by some pain/discomfort for several weeks; some restrictions to work/leisure activities for several weeks/months; after 3-4 months, return to normal health with no permanent disability.	Recover 3-4 months (Out-patient)
W	In hospital 2-7 days in slight to moderate pain; after hospital, some pain/discomfort for several weeks; some restrictions to work and/or leisure activities for several weeks/months; after 3-4 months, return to normal health with no permanent disability.	Recover 3-4 months (In-patient)
X	In hospital 1-4 weeks in slight to moderate pain; after hospital, some pain/discomfort, gradually reducing; some restrictions to work and leisure activities, steadily improving, after 1-3 years, return to normal health with no permanent disability.	Recover 1-3 years
V	No overnight stay in hospital (seen as out-patient); moderate to severe pain for 1-4 weeks; thereafter, some pain gradually reducing but may recur when you take part in some activities; some permanent restrictions to leisure and possibly some work activities.	Mild permanent disability (Out-patient)
S	In hospital 1-4 weeks in moderate to severe pain; after hospital, some pain gradually reducing, but may recur when taking part in some activities; some permanent restrictions to leisure and possibly some work activities.	Mild permanent disability (In-patient)
R	In hospital several weeks, possibly several months in moderate to severe pain; after hospital, continuing permanent pain, possibly requiring frequent medication; substantial and permanent restrictions to work and leisure activities; possibly some prominent scarring.	Some permanent disability with scarring
N	In hospital several weeks, possibly several months; loss of use of legs and possibly other limbs due to paralysis and/or amputation; after hospital, permanently confined to a wheelchair and dependent on others for many physical needs, including dressing and toiletting.	Paraplegia/ quadriplegia
L	In hospital several weeks, possibly several months due to head injuries resulting in severe permanent brain damage; after hospital, mental and physical abilities greatly reduced permanently; dependent on others for many physical needs, including feeding and toiletting.	Severe head
K	Immediate unconsciousness, followed by death	Death
J	Your normal state of health	Normal health

TABLE 6

Percentage distribution of injury state descriptors: 'serious' casualties

Injury state	% of casualties
Recover 3-4 months (Out-patient): F	19
Recover 3-4 months (In-patient): W	15
Recover 1-3 years (In-patient): X	31.5
Mild permanent disability (Out-patient): V	6
Mild permanent disability (In-patient): S	13
Some permanent disability with scarring: R	14
Paraplegia/quadriplegia & severe head injuries: L & N	1.5
Total	100

3.3 CASUALTIES WITH 'SLIGHT' INJURIES

To develop estimates for some elements of accident costs, casualties with injuries defined by DoT as 'slight' were to be divided into two groups - those with 'whiplash' neck injury, and those with other injuries.

The only source of data available for estimating the incidence of 'whiplash' among casualties with 'slight' injuries recorded by the police is the data from the study at Manchester University linking police and hospital records. The study included about 1000 patients who were treated in hospital and recorded by the police in Stats19 as having 'slight' injuries. Of these, 32 per cent had a 'whiplash' neck injury.

Casualties with minor injuries do not all seek hospital treatment, so this proportion was modified to take account of the fact that there were likely to be casualties with non-whiplash 'slight' injuries recorded in Stats19 but not in the hospital database. Data from Stats19 for the immediate area around the hospitals showed that 61 per cent of the casualties recorded in Stats19 as 'slight' had been treated in hospital. It was assumed that the casualties not receiving hospital treatment did not have 'whiplash' neck injuries. The probability of a casualty recorded by the police as 'slight' having a 'whiplash' neck injury was then estimated to be 20 per cent.

Until results of research in other areas is available, this estimate is clearly a rather unsatisfactory basis for estimating the proportion of 'slight' injuries in national accident statistics which are 'whiplash' injuries. A survey of road accident patients treated at three hospitals in different types of area in July and August 1991 showed that a quarter of patients with 'slight' injuries had 'whiplash'; this suggests that the Manchester results are not atypical, but because the sample casualties have not been matched against police records, it is not possible to assess how many casualties recorded by the police had 'whiplash' injuries. The result does however suggest that the figure of 20 per cent of 'slight' injuries having 'whiplash' is likely to be a reasonable approximation.

3.4 INJURY SEVERITY MEASURES APPLIED TO COMPONENTS OF ACCIDENT COSTS

The various measures of the distribution of injury severity were applied to different components of accident costs. The way in which injury information was applied to the various elements of cost are summarised in Table 7.

Some sources of information only provided sufficient detail on injuries to enable casualties or accidents to be classified broadly as 'fatal', 'serious', 'slight' or 'damage only'. Thus in the case of police time, for example, an overall average cost was estimated for each of these categories.

The sample for the work on lost output and medical costs is drawn from hospital casualty records, so clinical measures of injury severity will be available. Cost estimates can be based on aggregating average costs for subdivisions of the 'serious' and 'slight' categories weighted according to the estimated probability distribution. The preliminary estimates developed in this report are however calculated without subdividing the severity categories, because they are based on early results from the hospital studies.

For the estimates of injury valuation, values were calculated for each injury state descriptor, and an overall average value calculated by weighting according to the relative probabilities estimated for each injury state.

4. VALUATION OF NON-FATAL ROAD ACCIDENT INJURIES

Section 2 showed that the components of accident costs to be incorporated in the revised calculations are divided into two groups: the resource costs, and the subjective costs, or the value placed by society on avoiding road accident injuries. This section summarises the research which derived values for avoidance of 'serious' and 'slight' injuries.

TABLE 7

Application of severity distributions

DOT Severity	Subdivided by	Component of cost
Fatal	-	Police, damage, lost output, medical
Serious	-	Police, damage
Slight	-	Police, damage
Damage only	-	Police, damage
Serious	MAIS and length of stay distribution	Medical, support, lost output
Slight	'Whiplash' & other injuries	Medical, support, lost output, value of avoidance of injury
Serious	Injury state descriptors	Value of avoidance of injury

The aim of the research was to derive values which were linked with the DoT figure for the value of avoidance of a fatality (£500,000 in 1987 prices) so that the costing methods for fatal and non-fatal casualties would be consistent and therefore the figures used would be directly comparable. It was also important to derive values for a range of injuries of different levels of severity within the 'serious' category which could be weighted to produce an overall average value of avoidance of a 'serious' injury. This would enable the figures to be reworked to take account of any future changes in the distribution of injury severity within the 'serious' category, without collecting new data.

The approach adopted was to derive indirect estimates of the value of non-fatal injuries relative to the value of a fatality. Values were derived for the injury state descriptors for 'serious' casualties (shown in Table 5) in relation to 'normal health' and 'death'. The value for some of the 'slight' injuries was derived in a similar way. The pilot survey for the willingness to pay study showed that respondents considered 'whiplash' neck injuries to be a little better than 'serious' injuries in group X (recover in 1-3 years), but markedly worse than those in group W (recover in 3-4 months). The values of injuries in groups X and W relation to death could be used to determine a value for 'whiplash' neck injuries. For the remaining 'slight' injuries, respondents in the Contingent Valuation survey provided a valuation for an injury involving minor cuts and bruises.

Two research projects were carried out. One applied the willingness to pay approach through surveys of the general public; the research was carried out at the University of Newcastle upon Tyne and the University of York, with the survey carried out by the TRL interviewers. The other project applied the relative utility loss approach through a group of experts, but also drew on previous work with the general public; this work was carried out by the University of East Anglia. The results were then examined by Dalvi, an independent expert who had been closely involved in deriving a value for the avoidance of a fatality, and consensus estimates for the overall value of avoidance of a 'serious' and a 'slight' injury were suggested. The basis for the values therefore took account of both public opinion and the views of experts in health economics and health care of road accident casualties. Public consultation among transport and safety professionals was also carried out to ensure that the values had the support of practitioners.

This approach contrasts markedly with the way in which values for the subjective element of injury costs, termed 'pain grief and suffering', were derived in the past.

4.1 PAIN, GRIEF AND SUFFERING

The values set by Dawson in 1967 for what he termed the subjective cost of casualties were £5,000 for a fatality, £200 for a 'serious' injury and £0 for a 'slight' injury.

Dawson argued that there must be a cost which the community would be prepared to pay to avoid the suffering and bereavement which follow from injury or death. If this was not so, then adopting the strictly financial view would mean that the loss to society of a road accident fatality could be measured by the present value of their future paid work minus the present value of their future consumption. For people not in paid employment this resulted in a negative value, which implied that society would benefit, for example, from pensioners being killed in road accidents. The value of £5,000 for a fatality was the minimum amount which ensured that the total average cost of a death calculated in this way was positive for fatalities in each age and sex group; in other words it was approximately equivalent to the discounted value of future consumption of an average non-productive individual.

Having set the minimum amount which society is prepared to spend to save a life at £5,000, Dawson then set an arbitrary average value of £200 for avoidance of pain, grief and suffering in the case of 'serious' injuries. For 'slight' injuries and damage-only accidents, Dawson argued that the value was so small that it would have little effect on the total cost, and it was therefore set at £0. Valuing 'subjective' accident costs at this level meant that they comprised 20 per cent of the total cost of accidents.

In 1971, when Dawson revised the basis of costing lost output from net output to gross output, he decided to retain the value of £5,000 per fatality for pain, grief and suffering. However the value for a 'serious' injury was more than doubled, to £500, and a value of £10 was set for a 'slight' injury, at 1968 prices; thus the value for a 'slight' injury was set at 2 per cent of the value for a 'serious' injury.

These values per casualty were up-rated for inflation and GDP until 1978. In 1977, the Leitch Committee on Trunk Road Assessment reviewed accident costs applied by DoT (Leitch, 1978); by comparison with those in use in other countries, the figures were considered to be too low. The committee recommended that to increase values for accident costs without changing the overall approach, the allowance for pain, grief and suffering should be increased by 50 per cent. The argument in favour of increasing this element was that the principals of cost benefit analysis justified using an amount which the average individual would be willing to pay to reduce the risk of injury or death in a road accident, and that DoT should find out what this amount was. Research on spending to reduce risk suggested that values based on this approach would be substantially higher than those based on Dawson's reasoning. Since 1978, therefore, the 'pain, grief and suffering' component has been a more significant element of accident costs.

In June 1990 prices, the value of 'pain, grief and suffering' for a 'serious' casualty was £15,205, which represented 75 per cent of the total cost. For a 'slight' injury, the value was £267, or 65 per cent of the total cost; as when originally set by Dawson, this figure is 2 per cent of the value for a 'serious' injury.

4.2 WILLINGNESS TO PAY FOR SAFETY

The theoretical basis of this approach is that public sector decisions which improve safety lead to a reduction in the risk of an individual being killed or injured. Thus a safety improvement can be regarded as avoiding a 'statistical' injury. For small reductions in risk, Jones-Lee (1989) has shown that the aggregate value for society's willingness to pay to avoid a statistical injury can be approximated by the marginal rate of substitution of wealth for the probability of incurring an injury, and that the mean of individual values across the affected population represent the aggregate marginal rate of substitution of wealth.

Within the context of a utility-maximising framework, Jones-Lee (1989) has also shown that at all levels of variation in the risk of injury and death, the ratio of the marginal rate of substitution of wealth for the risk of all injuries to the marginal rate of substitution of wealth for the risk of death can be approximated by the ratio between the change in risk of injury and the change in risk of death.

The techniques used in the willingness to pay surveys and the relative utility loss approach all applied this theory in different ways. After testing the feasibility of a range of approaches in the pilot surveys, the willingness to pay surveys used two techniques: standard gamble and contingent valuation, in combination with contingent ranking.

4.2.1 The national sample survey

A national sample survey of individuals aged 17 and over who had experience of car travel as a driver or passenger in the last year was carried out in the summer of 1991. The sampling units were stratified into conurbations and other areas, and further stratified by the proportion of households in a professional/managerial socio-economic group and the proportion of households with a car. The addresses were randomly selected from the Postcode Address File for each of the sampling units. Within each household identified at these addresses, a random selection procedure was used to identify one eligible person for interview; the results were subsequently weighted by household size.

Two questionnaires were used, one containing standard gamble (SG) questions and the other containing contingent valuation (CV) questions; both questionnaires included contingent ranking questions and tests of risk comprehension. Respondents were randomly allocated to two samples, one for each of the two questionnaires.

Completed questionnaires were obtained for over 900 respondents, split between the two samples. About 100 of the respondents completed both questionnaires by taking part in a second follow-up interview which also explored the reasons for some of the responses to the initial questionnaire. This enabled direct within-subject comparisons to be made of the responses to the SG and CV questions.

The samples were shown to be representative of the population of Great Britain in terms of age, gender, occupational background and household income. However there were more drivers in both samples (74 per cent in the SG sample and 66 per cent in the CV sample) than in the population (52 per cent) and there were more people in car-owning households in the SG sample than in the population; this was to be expected given that the questionnaire was presented as being focused on road safety, which is probably of more interest to drivers than non-drivers.

The response to the risk test questions was good, with 85 per cent of responses correct in the SG sample and 97 per cent correct in the CV sample. This was attributed to the thorough explanation of risk at the start of each interview, and the credibility of the scenarios presented in the risk tests.

In answering the questions, respondents were asked to concentrate only on the personal, non-financial effects (such as pain, distress and disability), and ignore direct financial effects. Over 90 per cent of respondents in the SG sample and over 80 per cent of the CV sample subsequently reported that they had been able to do this.

The survey is summarised more fully in Jones-Lee, Loomes, O'Reilly and Philips (1993); this section presents an outline of the methods and the results and shows how they were used to derive overall values for avoidance of injury.

4.2.2 Contingent ranking

Respondents in both samples were asked to rank the 10 injury state descriptors shown in Table 5 so that respondents' views of the relative 'badness' of the injuries could be assessed and to familiarise respondents with the ten injury state descriptions. They were then asked to place each injury state on a scale from 0 (worst) to 100 (best). The results were similar for the two samples. They showed that many people regarded severe permanent brain damage (injury L) as being as bad as or worse than death, and that quadriplegia/paraplegia (injury N) is on average considered to be only slightly better than death. The results also showed that the less severe injuries tended to be placed further away from normal health and closer to death, than had been expected.

4.2.3 Standard gamble

Respondents were asked to suppose that they had suffered a given road accident injury which, if treated in the normal way, would have a given prognosis. They were then asked to suppose that an alternative medical treatment was available which, if successful, would return them to normal health, but if unsuccessful, would leave them in a specified health state that would usually be regarded as worse than the prognosis associated with normal treatment.

In some questions this 'worse' health state was K (death); where this was not so, the combinations of injury states for treatment and as the 'worse' prognosis were such that it was possible to derive values in relation to death from pairs of other responses. To avoid overloading respondents, the questions covered a sub-set of the injury states shown in Table 5 (K, R, S, X, W and J). The results of the Contingent Ranking exercise were used to interpolate estimates for L, N, V and F, by interpreting these states as equivalent to those for which questions had been asked: L=N=K, V=X, and F=W.

For each proposed 'treatment', respondents were asked to state:

i) the greatest risk of failure at which they were sure they would accept the alternative treatment;

ii) the lowest risk of failure at which they were sure they would reject the alternative treatment;

iii) the risk of failure which would make it most difficult for them to decide whether or not to take the alternative treatment.

The questionnaire presented respondents with a range of possible risks in 100 to choose from, each set out both in terms of chances of success and chances of failure. There were was also an option to specify a risk of failure of less than 1 in 100, and an option not to accept the treatment at any risk of failure.

The greatest risk of failure selected for accepting the risky treatment was interpreted as the minimum estimate for that respondent of the ratio of the marginal rate of substitution for risk of injury for the two injury states (or of injury to death, in some of the questions). The lowest risk of failure at which the risky treatment would be accepted was interpreted as the maximum estimate for that respondent. The point where it was most difficult to decide was interpreted as the probability of failure at which the respondent was indifferent between accepting and rejecting the treatment, or the 'best estimate' for that respondent.

The ratio of the marginal rate of substitution of wealth for the risk of 'serious' injury to the marginal rate of substitution of wealth for death was calculated as the weighted average of the corresponding ratios for each of the individual injury states. The weights used were those estimated as the probability of a 'serious' injury reported by the police in accident statistics being of that type; the probabilities are those shown as the proportion of casualties in Table 6. The results are summarised in Section 4.2.5, and in more detail in Jones-Lee, Loomes, O'Reilly and Philips (1993).

4.2.4 Contingent valuation

Respondents were asked how much they were prepared to pay for a hypothetical safety device that could reduce the risk of given injuries by a specified amount, and that had to be renewed annually.

The injury states presented to respondents were K, R, S, X and W, with the results being interpolated for the remaining injuries in the same way as for the SG questions. The six risk reduction scenarios were: reduce the annual risks of K, R and S by 4 in 100,000 (denoted as K1, R1 and S1) and reduce the annual risks of S, W and X by 12 in 100,000 (denoted as S2, W2 and X2). For each scenario, a showcard was used to depict the current level of risk as shaded squares on graph paper. The two different risk reductions presented for injury S meant that it was possible to test each respondent's ability to adjust for different risks.

The current level of risk presented to respondents was that shown in the right hand column of Table 6. At the time of the survey, this was the best estimate available of the magnitude of these risks. However as explained in Section 3.2, these differ from the risk levels used as weights in combining the results to overall values for a 'serious' injury; these are depicted as the proportion of casualties in Table 6.

For each proposed reduction in risk of injury, respondents were asked to state:

i) the largest annual amount that they were sure they would pay for the safety device;

ii) the smallest annual amount which they were sure they would not pay for the safety device;

iii) the annual amount which would make it most difficult for them to decide whether or buy the safety device.

The questionnaire presented respondents with a range of possible sums of money to choose from, from £0 through varying intervals to £500, and then 'more than £500'.

The largest sum selected as the amount they would pay was interpreted as the minimum estimate for that respondent of willingness to pay to reduce the specified risk of incurring that injury. The smallest sum selected as the amount they would not pay was interpreted as the maximum estimate for that respondent. The point where it was most difficult to decide was interpreted as the 'best estimate' of that respondent's willingness to pay.

The marginal rates of substitution were estimated by dividing the reported amounts people were willing to pay by the corresponding reduction in risk. The weighted value for all 'serious' injuries was calculated using the same weights as for the SG results. Two overall values were produced, based on the responses to the two different risk reductions for injury S. The results are outlined in Section 4.2.5, but are summarised more fully in Jones-Lee, Loomes O'Reilly and Philips (1993)

4.2.5 Results of the national surveys

Table 8 shows the ratios of marginal rates of substitution of wealth for risk of injuries to marginal rates of substitution of wealth for the risk of death (M_K), based on the means of individual ratios. The table also shows the weighted overall ratios for all 'serious' injuries (M_I/M_K); these have been calculated on the basis of the proportion of casualties in each injury state shown in Table 6[1]. In each case, results for respondents' 'best' estimates and minimum and maximum ratios are shown. Other ratios were also calculated, based on the medians of individual ratios, and based on the ratios of overall means and medians. For the purpose of deriving an overall value of a 'serious' injury, it was decided that for consistency with social cost-benefit analysis, it would be most appropriate to use mean values. Thus the results presented here are based on means; for analysis of the median responses, see Jones-Lee, Loomes, O'Reilly and Philips (1993).

The table shows that the best estimate of the overall ratio for the SG sample was 0.095, with a minimum of 0.086 and a maximum of 0.122. The ratios obtained using the CV technique are mostly three or four times larger than those using the SG technique, and ten times larger in the case of W, the least severe injury type. Thus the best estimates of the overall ratio based on different levels of risk reduction in S were 0.375 and 0.328, with minimum values of 0.29 and 0.25 and maximum values of 0.54 and 0.47.

The disparities between the estimates were accounted for largely by upward biases affecting the CV responses. The results for injury S showed that respondents in the CV sample were insensitive to the risk reductions being presented to them. Also, respondents in the CV sample appeared not to have differentiated adequately between the levels of severity represented by the injury descrip-

[1] The ratios of M_I/M_K differ from those presented in the main text of the summary report of the survey, which was based on the earlier estimates of probabilities presented to respondents in the survey.

TABLE 8

Ratios of marginal rates of substitution of wealth for risk of injuries to marginal rates of substitution for risk of death*

	Standard Gamble			*Contingent Valuation*		
Injury type	Best	Minimum	Maximum	Best	Minimum	Maximum
M_R/M_K	0.233	0.203	0.310	0.872	0.661	1.272
M_S/M_K	0.151	0.122	0.195	-	-	-
M_{S1}/M_K	-	-	-	0.631	0.482	0.928
M_{S2}/M_K	-	-	-	0.263	0.202	0.384
M_X/M_K	0.055	0.051	0.069	0.229	0.176	0.336
M_W/M_K	0.020	0.022	0.036	0.207	0.160	0.299
All serious						
M_I/M_K	0.0947	0.0859	0.1219	-	-	-
M_{I1}/M_K	-	-	-	0.3754	0.2906	0.5414
M_{I2}/M_K	-	-	-	0.3275	0.2542	0.4707

*based on means of individual responses

tions. The result is that the marginal rates of substitution estimated for the CV sample do not decline as fast as might be expected, between the more severe and the less severe injuries. As mentioned earlier, this result was also apparent in the ranking and scaling questions.

The researchers offered two possible explanations for the apparent bias in the CV responses: some respondents appeared to have a 'personal safety expenditure budget' which they assigned to all safety improvements, regardless of the severity of the injury or the reduction in risk; in the case of some of the temporary injury states, respondents may not have taken account of the duration of pain in relation to their life expectancy, and therefore overestimated their valuations.

In contrast, the researchers considered that the SG responses did not appear to have been subject to any major biases. The scenario presented to these respondents was simple and credible. They could focus more readily on risks to themselves, independently of others, than in the case of the CV questions. Also, the scenario forced people to weigh up their future lifetime in one injury state against their future lifetime in another, thereby avoiding placing excessive weight on the relatively short initial period of pain and discomfort associated with the less severe injuries.

The results of the follow-up surveys, in which a subsample of respondents answered both sets of questions, showed that the disparities between the two samples also occurred between individuals. For most people answering both questionnaires, the value of injury implied by the SG questions was lower than that implied by the CV questions, and the disparity became more marked with decreasing severity of injury.

The fact that respondents in the CV questionnaire did not seem to take account of the different reductions in risk offered for injury S, suggests that the difference between the risk levels presented in the questionnaire and those implied by the final estimates of the probability of incurring those injuries will not have had any significant effect on the results.

Analysis of the variations in valuations with socioeconomic and demographic characteristics suggested that most of the variance was accounted for by differences in individual personality and psychological disposition, rather than demographic or economic factors, or previous accident experience.

In the course of the work on willingness to pay, the researchers developed a procedure which produced estimates of M_i/M_K purely on the basis of the ranking data; this was termed the Rank-Ratio Argument. The advantage of this technique was that it enable a third set of estimates to be derived, which were independent of the SG and CV results, and which applied to both samples of respondents. For details of the procedure, see Jones-Lee, Loomes, O'Reilly and Philips (1993); in summary, it relies on there being a 'standard order' for the ranking of injury states, and a group of respondents whose replies do not conform to this standard. By 'trimming out' different proportions of the respondents with the most disordered rankings, a 'conservative' estimate of M_i/M_K was obtained. The results suggested a 'best' estimate of M_i/M_K of 0.085; the significance of this figure lies in its proximity to the estimate of 0.095 obtained from the SG sample.

4.2.6 Willingness to pay and the value of a 'serious' injury

The researchers working on the willingness to pay survey recommended that the value of avoidance of a 'serious' injury should be set in the range of the 'best' estimates derived from the Rank-Ratio and Standard Gamble results. These suggested values of 8.5 per cent to 9.5 per cent of the value of avoidance of a fatality. Section 5.1 will show that for fatalities, the current estimate of medical and ambulance costs is £434, and Section 5.2 derives a new estimate for net lost output. Subtracting these estimates of net lost output and medical and ambulance costs from the June 1990 total for the average casualty-related cost of a fatality leaves a figure of £617,672 for the willingness-to-pay component of the value of avoidance of a fatality. At June 1990 prices, this implies a value of between £52,500 and £58,500 for the pure willingness to pay component of the value of avoidance of a 'serious' injury.[2]

4.3 RELATIVE UTILITY LOSS

Section 2.4 showed that the group of experts working with DoT to develop the research programme on injury valuation recommended exploratory work on relative utility loss, in parallel with the willingness to pay study, to produce utility scores reflecting the undesirability or loss associated with road accident injuries.

The first stage of this study reviewed international research and literature on measuring relative utility loss and identified four indices which might be suitable to apply to road accident injuries (Ives and Kemp, 1992). No single scale was considered to be entirely appropriate, and in the long term, it was suggested that DoT should examine the feasibility of applying a functional capacity index which is currently under development in the USA.

In the second stage, utility losses were calculated for the injury state descriptors shown in Table 5, using four indices recommended in the review, plus a Visual Analogue Scale. These were then converted into a monetary value by calculating the number of lost years of functioning associated with each type of injury, weighting the injury states to combine them into an overall number of years lost for all serious injuries, and then using the DoT value of a fatality to represent lost years as a monetary value. Full details of the research are reported in Ives, Soby, Ball and Kemp (1993), but an outline of how overall values for a 'serious' injury were derived using the various indices, is presented here.

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2 These values are different from those presented in the project reports for two reasons. As mentioned earlier, the improved estimates of the probabilities of occurrence of the various injury states became available after the main text of the report was completed. In addition the original reports were based on rounded estimates of the value of lost output for a fatality which determines the size of the willingness to pay component of a fatality.

4.3.1 Utility scales

Visual Analogue Scale. As in the Contingent Ranking section of the willingness to pay survey, raters were asked to place each injury state on a scale ranging from 0 to 100.

Rosser's Classification of Illness States. This index was constructed by Rosser and Watts (1978) to assess severity of illness on the basis of two dimensions - disability and distress. There were eight levels of disability (ranging from no disability to unconscious) and four levels of distress (from no distress to severe distress), which combined into 29 possible health states. A group of 70 people, consisting of doctors, nurses, medical patients, psychiatric patients and healthy volunteers were asked to rate the 29 states. A 'magnitude estimation' method of scaling was used by asking respondents to compare pairs of health states and say how much worse they thought one was, compared to the other. No upper limit was set on the possible values, which caused problems for interpretation of the results because the psychiatric patients provided some extreme ratings. Each health state was considered in two different ways; first, they were to think of them as treatable, but stable if left untreated; then they were to be considered as permanent and untreatable.

Torrance's Health Classification Index. The original purpose of this index was to assess the health outcome for newborn children receiving intensive care treatment (Torrance, 1982). There were several levels on each of four dimensions - physical function (mobility and physical activity), role function (self care and role activity), social-emotional function (emotional well-being and social activity) and health problems - which combined into 960 health states. A sample of 112 parents of school children were asked to rate the levels of each dimension using a visual analogue scale, and assuming that each health state was permanent. To find the relation between the dimensions, Time Trade-Off (derived from Standard Gamble) was used to elicit people's preferences for being in a health state for a specified time, or being healthy for a shorter period of time and then dying; by varying the duration of these states, a point of indifference between the two alternatives could be established. The data were combined to produce values for the 960 health states.

EuroQol Descriptive Index. A group of experts from several European countries is developing a standardised method of describing and valuing health states which is not specific to particular diseases, and which can be used in large scale self-completion surveys of the general public in different European countries (EuroQol Group, 1990). The index has six dimensions - mobility, self-care, main activity, social relationships, pain and mood - and each of these has two or three dimensions, which combine into 216 possible health states. Samples of the general public in different countries have rated the scales using 'magnitude estimation', with the range of possible scores limited to between 0 and 100, and assuming that the illness lasts for a year.

Rosser-Revisited/York Valuation of Health Project. The health states were developed from those used in Rosser's Classification of Illness States. Compared with the original study, a larger and more representative sample of people were used to provide ratings (140 members of the general public), and they were asked to imagine that the health state would last for 20 years, after which they would die. The valuation matrix used in this study was based on the results of scaling using magnitude estimation (with an upper limit), although a variety of other techniques had also been used to produce scores.

4.3.2 Mapping and scoring the injury state descriptors

A group of 10 experts was selected whose valuations of the set of injury descriptors were to be measured. Some were economists, in health and transport, and the rest were research nurses working with patients involved in the work at Manchester University on the consequences of road accident injuries.

The experts were asked to rank each of the ten injury state descriptors shown in Table 5 on the visual analogue scale. For scaling the injuries using the other four indices, the injury state descriptors were sub-divided into the various phases of recovery, and the experts were asked to map each phase of each injury state, onto each of the four scales.

The point at which each expert mapped each phase of each injury state was then converted into a utility score from the matrix derived from the scores assigned from the sample of people involved in the original study which set up the scale. It was assumed that all four utility scaling matrices applied to a duration of one year (although this was true only for EuroQol). For each phase of each injury state, the median relative utility score was then weighted by the duration of that phase and the weighted scores for each phase were summed. Because the duration of phases was described in terms of a time span, this produced a minimum and maximum number of lost years of functioning for each injury state. For lack of better information, it was assumed that utility loss is directly proportional to the time spent in each phase of the consequences of the injury. For permanent injuries, it was assumed that the duration was half the remaining life span of an average working age road accident casualty - 39 years.

The number of lost years of functioning computed for each injury state was then weighted by the proportion of 'serious' casualties having that type of injury (shown in Table 6) to produce an overall number of lost years of functioning for 'serious' injuries. The lost years of functioning were then discounted. The value of life used by DoT for the value of avoidance of a fatality was then used to calculate the value of a life year, which enabled this number of years to be converted to a monetary value; the value of a life year was discounted. The full report shows the results of applying a range of discount rates from 0 to 10 per cent, and that the results were similar for all discount rates quoted because discounting lost years of functioning compensates for the increasing value of a life year as the discount rate is increased.

4.3.3 Results of relative utility loss study

The value of a 'serious' injury estimated using each of the scaling techniques is summarised in Table 9. The estimates are based on the value of avoidance of a fatality of £617,672, as explained in Section 4.2.6, and weighting using the revised proportion of casualties in each injury state group; the values are therefore different from those presented in the full report of the study. A 0 per cent discount rate was selected by DoT for calculating the value of a life year, on the basis that there is some controversy as to whether discount rates should be applied in this situation, and that the estimates did not vary much between different discount rates. This is the rate used for deriving the values in Table 9.

Although the scaling matrices were constructed on the basis of very different samples, and some sweeping assumptions were made in deriving values from them, three of the techniques produced very similar results. The Rosser index produced much lower values, which was attributed to the use of unbounded magnitude estimation to derive scores. The value derived from the visual analogue scale, which is methodologically similar to the contingent ranking exercise in the willingness to pay surveys, is in line with the estimates derived from the Contingent Valuation survey.

4.4 A CONSENSUS ESTIMATE FOR THE VALUE OF AVOIDANCE OF 'SERIOUS' INJURY

Dalvi, the independent expert who had been involved in deriving a consensus estimate for the DoT value of avoidance of a road accident fatality, was asked to recommend a consensus estimate on the basis of the results of the relative utility loss and willingness to pay studies, and evidence from other countries.

Dalvi (1992) pointed out that there were in fact possible downward biases in the SG technique, which had not been considered in comparing the results with the CV survey, which was recognised as having upward biases. However there was no evidence available which enabled the combined effect of these biases to be estimated.

Dalvi maintains that if consumer behaviour complies with conventional expected utility theory, different methods of measuring consumer choices under conditions of uncertainty should produce the same estimates of the values being traded. However he concluded that the relative utility loss approach employed in the research had not complied with conventional expected utility theory because it approached valuation *ex post* rather than *ex ante* (see Section 2.5), and it was based on participants completing a choiceless and riskless task. Thus Dalvi concluded that there was in principle no reason to expect that the relative utility loss study should produce similar values of avoidance of injury to those produced from the willingness to pay study. He also considered that the limitations of the original samples used to obtain utility loss scores and the arbitrary selection of 10 experts cast doubt on the robustness of the relative utility loss results.

He therefore based his recommendation of a consensus value for a 'serious' injury on the results of the willingness to pay study. Taking account of the fact that CV appeared to involve upward biases, the Rank Ratio argument appeared to set a minimum value, and that there appeared to be some factors causing unquantified downward bias in the SG figures, Dalvi recommended a value 10 per cent higher than that produced by the SG survey. However DoT recommended using the SG results in the absence of firm evidence of downward biases in the SG results. Given that the 1988 consensus estimate for the value of avoidance of a fatality was set 'conservatively' at £500,000, the most consistent approach was to opt for the valuation based on the actual SG result, recognising that this too may be a 'conservative' estimate.

At a value of £617,672 for the willingness to pay component of a fatality (see Section 4.2.6), this suggests a value of £58,494 for avoidance of a 'serious' injury.

4.5 VALUATION OF 'SLIGHT' INJURIES

The Contingent Valuation questionnaire in the willingness to pay survey included a question about the sum of

TABLE 9

Value of avoidance of a 'serious' injury estimated using relative utility loss scales

Scaling method	Minimum	Maximum
Rosser-revisited	£110,000	£115,000
Torrance	£131,000	£135,000
EuroQol	£116,000	£122,000
Rosser	£22,000	£23,000
Visual analogue scale	£229,300	

money that would 'just make up for' an injury involving minor cuts and bruises and a quick and complete recovery. The best estimate of this amount of money was £102, on average, with the minimum averaging £77 and the maximum averaging £136.

It has already been shown that values for injury states W and X could be used to derive values for avoidance of 'whiplash' injuries, the more severe component of injuries classified by DoT as 'slight'. Assuming that half of 'whiplash' injuries are equivalent to W and half are equivalent to X, and that 20 per cent of all 'slight' casualties in Stats19 have 'whiplash' neck injuries and that the value of avoidance of a fatality is £617,672, an overall value of avoidance of a 'slight' injury can be estimated, using the results of both the willingness to pay surveys and the relative utility loss study.

On the basis of the values derived in the willingness to pay surveys the value of avoidance of a 'slight' injury is estimated at £4405. Taking the figure of £102 from the willingness to pay survey, combining this with the relative utility loss for X and W, and discounting the lost years of functioning at a rate of 0 per cent, produces a relative utility loss-based estimate of £1665 for the value of avoidance of a 'slight' injury.

5. CASUALTY RESOURCE COSTS

The resource costs associated with each road accident casualty can be broadly divided into the provision of medical and other support services, loss of contribution to the economy (lost output) and costs of to the individual (or their family) of adapting to the consequences of injury. Depending on the nature and severity of the injury, these costs may be incurred immediately after the accident, or may continue in subsequent years. Costs therefore need to be discounted to present values to produce an overall cost in the year of the accident.

To date, the cost of medical and ambulance services and lost output have been included in the calculations, but costs of social services and other forms of support, and personal costs have been excluded. The only element of personal cost included was in Dawson's 1971 revision, which calculated the cost of bringing forward funeral expenses to the year of the accident from the year when the fatality would normally have been expected to occur.

This section covers the cost of medical and ambulance services and lost output. The research in progress (outlined in Section 2.5) will enable better estimates of these costs to be calculated, and will also provide information on social services and other support and personal costs. The estimates provided here are therefore seen as an interim revision of the resource costs associated with each road accident casualty.

5.1 MEDICAL AND AMBULANCE COSTS

Since 1977 these costs have been based on data provided by the Department of Health. The June 1990 costs are based on unit costs and rates of treatment for 1984/85, which have been uprated each year for inflation and growth in GDP. The basis for the calculations is summarised here. Until the results of the research in Manchester are available, the estimates will continue to be based on the information and assumptions outlined here.

5.1.1 Fatalities

DoT assume fatalities are admitted as in-patients in a quarter of cases, with an average length of stay per in-patient of 4.6 nights. A quarter of these in-patients are assumed to require blood transfusions, at an average rate of 6 pints per patient receiving blood. The medical costs for fatalities also include one ambulance journey, one attendance at an Accident and Emergency Department, capital costs for the ambulance service (5.4 per cent) and the hospital and blood transfusion service (18.9 per cent), and an overall administrative overhead of 3.9 per cent.

These costs were estimated to total £434 per fatality in June 1990 prices.

5.1.2 'Serious' injuries

DoT assume patients with 'serious' injuries are in-patients in 94 per cent of cases, with each in-patient staying in hospital for an average of 11.7 nights. As in the case of fatalities, a quarter of in-patients are assumed to require 6 pints of blood. In addition, the in-patients are assumed to make an average of 4 visits to out-patient departments. All 'serious' casualties are assumed to make one ambulance journey and one visit to an Accident and Emergency Department, and the costs also include an allowance for artificial limbs and appliances. The capital costs of the ambulance service, the hospital, the blood transfusion service and an overall administrative overhead are added at the same percentage rates as for fatalities.

At June 1990 prices, the total cost per 'serious' casualty was estimated at £2,499.

The information presented in Section 3 suggests that the proportion of 'serious' casualties treated as in-patients is substantially less that is assumed in these calculations, and that the average length of stay for in-patients is also rather different. However until more accurate information on unit costs and rates of use of all elements of health and ambulance service costs are available, no attempt will be made to make an interim revision of these estimates.

5.1.3 'Slight' casualties

For 'slight' casualties, DoT assumes that half require hospital treatment in an Accident and Emergency Department on one occasion and are taken by ambulance to hospital. No further treatment is included in the estimates. Capital costs of the ambulance and hospital service are added in the same way as for fatalities, as is the administrative overhead on all the costs.

In June 1990 prices, these costs were estimated to amount to £112 per 'slight' casualty.

The preliminary results of work in Manchester suggest that the proportion of 'slight' casualties treated in hospital is rather less than half, but this may be balanced by the number requiring treatment on more than one occasion. There is not yet sufficient information available to provide a basis for improving on the current method of estimation.

5.2 LOST OUTPUT

Different methods are used for calculating the lost contribution to the economy for fatalities and other casualties; loss of future production is estimated for both fatalities and non-fatal injuries. Loss of future consumption is estimated separately in the case of fatalities, to avoid double counting.

5.2.1 Fatal casualties: previous estimates

Dawson's 1967 estimate of accident costs assumed that a fatal road accident cost the community the removal of a member of the community, without any form of replacement. Replacement would take place if, for example, the parents of a child killed in a road accident subsequently bore an additional child or a worker's death resulted in the recruitment of an unemployed person to fill the vacancy. In the extreme, it is sometimes argued that all such fatalities can be replaced by additional children or reduction in the pool of unemployed labour if a cross section of the population is killed in road accidents.

Dawson calculated net lost output - in other words, lost output was offset by loss of consumption of goods and services. The justification for this approach was that the costs should be *ex post* - reflecting the cost to the community after the accident happened, which consisted of the loss of the present value of an individual's future output and the gain in not having to provide for that individual's consumption.

This led to negative allowances for non-productive individuals. To offset this the notional 'pain grief and suffering' allowance was added to the costs, based on the consumption of a non-productive person, to represent the minimum value to society of that individual's continued existence. See Section 4 for further details.

Dawson's 1971 revision took a different view - that figures for accident costs are needed to measure the benefits of accidents prevented, and therefore the costs need to be calculated for accidents which do not happen. Thus the benefit of a fatality prevented should take account of the fact that the individual is still alive and can continue to consume. When this gross output method was adopted, the 'pain grief and suffering' element was retained.

In the 1967 report, lost output was calculated separately for males and females, for 14 age groups. It was assumed that people killed in road accidents would have had average current and future earnings and consumption as other people of the same gender, and the same life expectancy and rates of employment as other people of the same age. Thus no account was taken of the change in patterns of earning between age groups and with progress through working life.

For males in each age group, the percentage working and the expectation of working life of people working or yet to start work were used to calculate a discounted value of working years lost per head. Lost output was then calculated as the number of fatalities in each age group who were estimated to be working multiplied by the discounted working years lost and the average annual earned income for all males. The saving of consumption was then calculated as the number of fatalities in each age group multiplied by the discounted average expectation of life at that age and the average annual consumption per head in the population of goods and services (consumer expenditure and public authorities' expenditure). Loss of production and saving of consumption were discounted at a rate of 6 per cent. Net lost output was calculated by subtracting saved consumption from lost production for each age group; values for each age group were summed to a total per male fatality.

For females, the calculation was rather different, to take account of the fact that some women take time out of employment for domestic responsibilities and that housewives' services represent a contribution to the economy which is not reflected in statistics on earnings. The following assumptions were made: output of housewives who were not in paid employment was valued at the average wage of employed women; for employed women who were also housewives there were two elements of output: as employees and as housewives. Output for housewives was valued at half the average wage rate of employed women; married women were assumed to be housewives while they were under 60. The calculations were then as for men except that the average value of lost production per head in each age group was calculated from the proportion of women in each age group who were married and the proportion of married and single women in each age group who were working then and projected to be working 10 years ahead.

The average net lost output per fatality calculated by Dawson in 1967 using 1963 figures, was £4,360 per male and -£1,120 per female, averaging £2,880 for all fatalities.

As mentioned earlier, Dawson revised his estimates in 1971, adopting a gross output approach. The current values in use by DoT are based on a further re-calculation carried out in 1979, using data for 1978 and these have been uprated each year for inflation and GDP.

The 1979 method is summarised in O'Reilly (1993), but the essential points are that gross output was estimated, using a 5 per cent discount rate and Treasury-recommended growth rates which varied between the short and long term. The figures for earnings were based on national income per capita, and therefore did not take account of changes in income levels at different ages; age-specific activity rates were applied to these overall average income figures. The output of housewives and employed women who were also housewives was valued in the same way as in Dawson's calculations.

At June 1990 prices, the gross lost output for fatalities using this method of estimation averaged £194,698 per fatality.

5.2.2 Revised estimate for fatalities

Lost output was calculated by assuming that current and future incomes of fatalities would be equal to the average for members of the population as a whole of the same age and gender. In summary, the methodology used was to estimate average earnings for various age and gender groups and for every fatality, of a specified age and gender, assume that they have average earnings and that as they get older they will earn the average of the subsequent age groups, taking into account activity rates, general growth in the economy and mortality rates. The stream of future income was discounted back to its present value: gross lost output. In the case of fatal casualties there is both a loss of potential productive capacity and of consumption. The willingness to pay component of the value of a fatality is considered to include consumption, as the ability to consume is seen as a benefit of being alive. Therefore consumption was deducted from gross lost output to produce a figure for net lost output per fatality.

As with Dawson's estimates, this methodology implicitly assumes that each person is unique and irreplaceable and there is therefore maximum loss from a fatality. It also assumes that the at risk population is the same as the average population.

The calculations were made in June 1990 prices, and therefore figures for the number of fatalities in each age group are from Stats19 for 1990, and data on earnings and consumption are also for 1990. The method is outlined here in Figure 2 and subsequent commentary, but more detail is available in O'Reilly (1993).

Characteristics of fatal casualties. Fatalities were differentiated by age and gender. The Leitch committee had recommended estimating lost output over the population at risk, separating road user types, instead of the whole population. However DoT considered this and concluded that by using data on present and future earnings according to the age and gender of fatalities, rather than Dawson's average income per male and female, the estimates were more accurate than those made at the time of the Leitch report. It was not considered appropriate to differentiate by mode since people use many modes and vary their use at different times in their lives. In any case, there are insufficient data on earnings of road accident casualties by road user type to make further improvements on the method adopted here. The number of age groups was smaller than that used by Dawson (11 instead of 14), so there was less sub-division of people over retirement age; average values were estimated for all those over the age of 70 in these calculations.

Value of potential production. Future earnings were estimated more accurately than in previous calculations. The distribution of income by age groups was estimated by combining the average income of employees and self employed persons, according to the proportion of the workforce they represent in each age and gender group. Because there were no data available on the distribution of income among self-employed people of different age and gender groups, it was assumed that all those earning (both employees and self employed people) had the same distribution of income according to age as employees. Overheads were added to earnings; employers' national insurance contributions were added to employees' incomes and employees' national insurance contributions were added to earnings of self-employed people to produce a figure for the total cost of maintaining a productive member of the labour force.

Activity rate. Those classified as 'active' were people working, those seeking work and those who are temporarily sick, plus those in the 'other' category of the inactive. The 'other' inactive category were assumed to include those who are making a contribution to the economy but who are not paid for it; examples would include household/family managers, unpaid carers and voluntary workers. The latter are making a contribution to the economy that would have to be replaced were they to be killed in a road traffic accident. By including this group, the figures for lost output reflect more accurately the potential lost of productive capacity. Unlike Dawson's method, there was no additional allowance for the contribution to household chores made by women in paid employment, because it was considered that such tasks were increasingly likely to be shared by males and females.

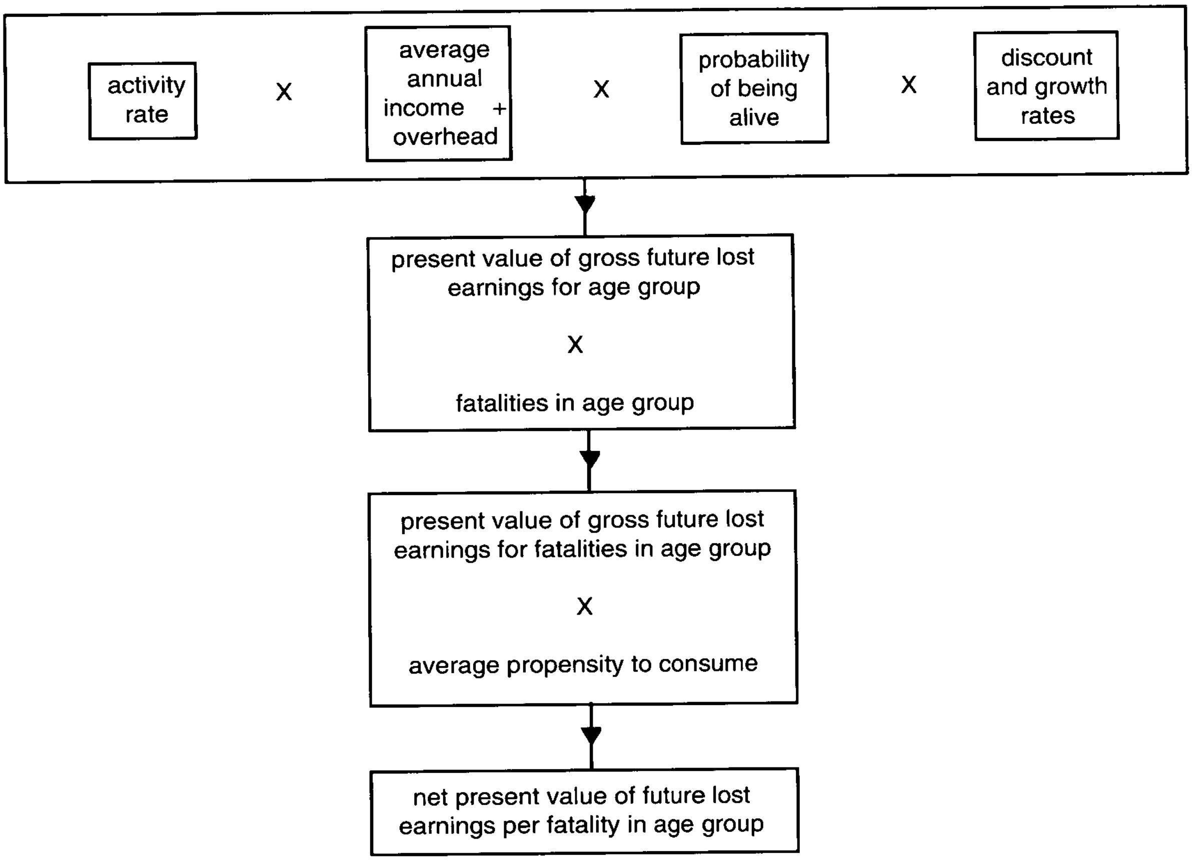
Future income, discount and growth rates. The future stream of income was estimated using life tables (for 1987-89) to take account of different lengths of life expectancy for people of different age and gender groups. It was assumed that income is worth more to an individual at present than it is in the future. Therefore the stream of future income, including overheads, was discounted, also taking account of the future growth rate of the economy. For each age group the net accumulated effect of growth and discount rates were calculated. A 2 per cent long term growth rate was selected; the rate was assumed to be positive and constant over the future lifetime. This rate is typical in Cost Benefit Analysis, and reflects historical performance of the UK economy. A discount rate of 6 per cent was used, this being the rate recommended by the Treasury for use in Social Cost Benefit Analysis.

Consumption. The Department of Transport assumes that for every fatality the economy loses both potential production and consumption, and therefore it is

FIGURE 2

Methodology for calculating lost output for fatalities

Males - each age group



considered most appropriate to estimate the net effect by deducting consumption from the estimated value of potential productive capacity. There is some controversy about this, and in France and Switzerland the figures for gross output loss are used in Cost Benefit Analysis. The approach adopted was similar to that used in Sweden. There are no published statistics on the distribution of consumption between age and gender groups of the population, so the method of estimating the distribution of consumption was less precise than the estimates for income distribution. The average propensity to consume in the UK in 1990 was calculated from figures in the national income accounts for the value of personal expenditure plus the value of government expenditure on goods and services. The accounts showed that approximately 80 per cent of the value of personal incomes were consumed. This suggested that the net lost output in each age group would be equivalent to 20 per cent of the gross figures. Applying the average per capita consumption took account of the fact that gross income figures included the unearned income attributed to the 'other' inactive group (voluntary workers, unpaid carers and household managers).

Main results. The overall average value of net lost output per fatality was estimated at £46,800 at a discount rate of 6 per cent and a growth rate of 2 per cent.

Table 10 shows the overall values for lost output per fatal casualty for males and females, and all casualties. The table shows both net and gross values.

The results are presented in more detail in O'Reilly (1992). The gross output estimate of £231,253 per fatality represents a modest increase on the figure of £194,000, which is the figure produced by uprating the 1979 estimate to 1990 prices.

5.2.3 Casualties with 'serious' injuries: previous estimates

Dawson's 1967 estimate assumed no replacement in the labour market, as for fatalities. The estimate was based on national statistics on claims for Industrial Injury Benefit and Sickness Benefit. These showed the average length of time off work for claimants who had been injured in road accidents in the course of work, and for Sickness Benefit claimants who had been injured in any kind of accident. In the first year after the accident, it was

TABLE 10

Overall value of lost output per fatal casualty by gender

	Males	Females	All casualties
Gross	£264,899	£149,661	£231,253
Net	£53,641	£30,306	£46,828

estimated that on average 41 working days were lost for each casualty with 'serious' injuries and that 1 per cent of casualties with such injuries would not have returned to work at the end of the year.

The value of working time lost in the year after the accident was calculated separately for males and females. For males, lost output was the proportion working multiplied by the number of casualties, multiplied by 41 days, multiplied by the average earnings for all males. For females, the calculation for employees was the same but an extra component was added: output for housewives was calculated at half the average earnings of employed women. The resulting figures averaged out at a cost of £82 per 'serious' casualty in the year after the accident.

For the second and subsequent years after the accident, there were no data available on time off work resulting from road accidents. Data on payments of permanent disability pensions and Sickness Benefit were used to derive two estimates of the present value of future lost output arising from road accident injuries. It was therefore implicitly assumed that the long term consequences of road accidents are similar to the consequences of illness and injuries from other causes. The resulting estimates averaged at £42 and £45 per casualty. A more extreme estimate was also made, assuming that the 1 per cent of casualties who did not recover in the first year were unable to work for the rest of their working life. The present value of the average cost per casualty of this extreme estimate was £98. An intermediate figure was decided on, of £66 per casualty in subsequent years, bringing the total cost of lost output, when rounded, to £150 per 'serious' casualty.

The 1979 revision also estimated lost output in the year after the accident and in subsequent years in different ways, and used Dawson's assumption that 1 per cent of casualties do not recover in the first year.

The assumed number of days off work in the first year was similar to Dawson's estimates: 40 for men and 43 for women. The estimate improved on Dawson's in that average earnings of males and females in each age group were estimated as a proportion of average earnings for all males and females in 1978, and applied to the age and gender distribution of casualties with 'serious' injuries to estimate the cost of the working days lost. The calculation of earnings took account of the cost of National Insurance and other overheads. The activity rate for women assumed that married women not in employment were active - in other words, the contribution which housewives make to the economy was taken into account by applying earnings both to employed women and to married women who were not in employment.

For the second and subsequent years after the accident, data on compensation, payments of invalidity pension and disability benefits were used to estimate recovery rates and the cost of lost output for the 1 per cent of casualties assumed to be out of productive work after the first year, with costs in future years discounted to present values. On average, the calculations implied that the total number of working days lost as a result of 'serious' injuries averaged 67 days per 'serious' casualty.

In June 1990 prices, these estimates amounted to an average of £2,455 per 'serious' casualty, or 12 per cent of the total cost per casualty.

5.2.4 Casualties with 'serious' injuries - revised estimates

The national statistics used previously to estimate working days lost following accidents are no longer available, so estimates have to be based on data collected specifically to assess the consequences of road accidents. Section 2.5 described two in-depth studies of road accident patients, and the preliminary results of these have been used to develop an interim revision of the estimated cost of lost output from 'serious' injuries.

The first of these studies covered patients treated for two specific types of injury 'whiplash' (classified by DoT as 'slight') and fracture injuries to upper or lower limbs (classified by DoT as 'serious') at three hospitals in the Greater Manchester area. The second study covered samples of patients with all other injuries classified as 'serious' or 'slight' treated at the same hospitals over a period of a year. Patients were interviewed shortly after the accident and at 6 month intervals, to establish the costs and consequences of the injury in detail, including an assessment of time off work. The results for the first two years for 'whiplash' and fracture patients are summarised in Tunbridge et al, (1990) and Murray et al (1992).

To date, the results of interviews with 'whiplash' and fracture patients are available over a two year period, while for 470 of the other patients, data are available for the year after the accident. The average number of days off work in the year after the accident was 72 days for fracture patients, 40 for those with other 'serious' injuries aged 16-59, 9 for 'serious' casualties aged 60 and over and 0 for those under the age of 16. In year 2, the fracture patients lost an average of 63 days.

The figures for the fracture and other serious injuries were weighted to reflect the overall probability of 'serious' patients treated at the three hospitals having fracture injuries to upper or lower limbs. It was also assumed that only those fracture patients aged 16-59 took time off work. The figures for lost output for the two types of injury were then combined into a weighted average for all serious injuries in year 1: 64 days for 16-59 year olds, 4 days for over 60s and 0 days for under 16s.

The estimate for lost output from 'serious' casualties was calculated by combining three separate estimates: first, the average loss of output after one year; then the loss of output for those who did not recover after one year but did eventually recover; and finally the loss of output from those 'serious' casualties that are permanently and severely disabled.

The proportion of 'serious' casualties in each of these three groups was estimated from the data on casualties in Manchester which formed the basis for the proportion of casualties in each injury state shown in Table 6. It was assumed that those with permanent restrictions on leisure activities would be able to resume paid employment within a year. (This assumption probably results in an under-estimate of lost output.) Those in the 'permanent disability with scarring' group (R) were assumed to be spread evenly between those recovering in a year, in 1-3 years and not recovering. The resulting figures for the proportions estimated to recover within each time period were: 61.8 per cent within a year, 36.5 per cent in 1-3 years and 1.7 per cent were assumed to be permanently unable to work.

For those that recovered after one year, the average annual income for each age group was calculated and the average number of days off work from the in-depth study in Manchester, for broad age groups, was applied. The figures for days lost were for all casualties, averaged over those that worked and those that did not, so there was no need to apply activity rates.

For the people who took 1-3 years to recover, it might be expected that more casualties would recover at the beginning of that 3 year period than at the end. However, in the absence of data it was assumed that on average such people took 2 years to recover. The age distribution of these casualties is not known so it was assumed that they have the same age distribution as all 'serious' casualties. The income for the second year was discounted at a rate of 6 per cent and a 2 per cent growth rate was used to derive the present value of lost output in this group.

Permanently and severely disabled people would not be expected to return to work for their remaining lifetime. Thus the gross lost output figures for fatalities could be applied to these 'serious' casualties to reflect the present value of the stream of future lost earnings. Such casualties would continue to consume for the remainder of their lifetime so consumption was not deducted. It is likely that the life expectancy of people in this group would be reduced, and therefore a more accurate estimate of lost output would take account of this by including only net, rather than gross lost output for the number of years by which life expectancy is reduced. However no information on the effect of disabling injuries on life expectancy was available, so the calculation estimated gross lost output for the full lifespan of this group, assuming that life expectancy was the same as for other people of the same age and gender.

The estimates of lost output were made for 'serious' casualties in three age groups: 0-15, 16-59 and over 60, and were made separately for men and women, although the figures on number of working days lost were averages for casualties in those age groups. This is clearly a rather broad age grouping, and more accurate estimates will be possible when more detailed data are available from the study in Manchester. Figure 3 summarises how the estimates were made.

The estimated lost output for each of the three groups of casualties is shown in Table 11, and the overall average value is shown as the weighted sum of the three groups.

The estimates are substantially higher than those based on up-rating the values derived from earlier estimates. There appear to be several factors explaining the difference. The data on time off work for the road accident casualties in Greater Manchester show that the average number of working days lost in the first year after the injury is over a third higher than that estimated by Dawson and assumed in the 1979 revision. The information from Manchester on rates of recovery suggests that a larger proportion of people take more than a year to recover, and a larger proportion become permanently unable to take paid employment, than the proportion estimated by Dawson and assumed in 1979. Also the value of gross earnings for those who become permanently disabled is larger than Dawson estimated.

5.2.5 Casualties with 'slight' injuries - previous estimates

At the time when Dawson's estimates were made there was no information on the loss of working time due to 'slight' injuries. Dawson observed that a third of accidents happened at weekends, and that many injuries of this type are extremely minor, so he assumed that on average working people lost one working day as a result of 'slight' injuries.

He used the distribution of slight casualties between males and females and different age groups and proportions in employment in these groups to estimate the number of 'slight' casualties who were working. At a rate of one day per worker, the working days lost were converted into working years lost by males and females and divided by average male earnings and average female earnings. This resulted in an average figure per casualty of £2.1.

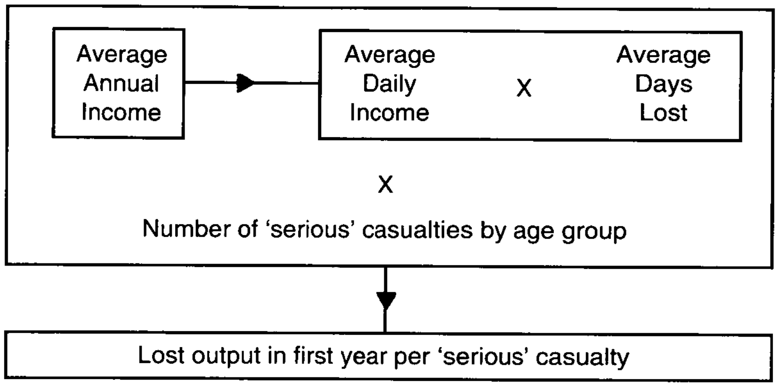
The 1979 revision of the lost output calculations again assumed the loss of one working day per person, in the

FIGURE 3

Method for estimating lost output for 'serious' casualties

1. Lost output after one year

Age group



2. Those that recover in 1-3 years

As above but apply to second year a discount rate for each age group

3. Those that never return to work

Take the gross present value of future lost earnings and apply the number of 'serious' casualties.

Combine 1, 2 and 3 according to the proportion accounted for by each in the distribution of 'serious' casualties.

TABLE 11

Estimated lost output for 'serious' casualties, 1990

Recovery period	Male	Female	All casualties
Up to one year	£2,514	£1,597	£1,911
1-3 years	£8,838	£6,203	£7,015
Never return	£294,033	£205,708	£264,146
Weighted sum	£9,776	£6,746	£8,230

absence of any information on the consequences of 'slight' injuries. As in the case of 'serious' casualties, the estimate improved on Dawson by estimating average earnings of males and females in each age group as a proportion of average earnings for all males and females, and applying these to the age and gender distribution of casualties with 'slight' injuries to produce the cost of the working days lost. As with 'serious' casualties, the calculation of earnings took account of the cost of National Insurance and other overheads and the contribution which housewives make to the economy was taken into account by applying earnings both to employed women and to married women who were not in employment.

These estimates have been uprated for inflation and growth in GDP and in June 1990 prices, the average cost of lost output per 'slight' casualty was estimated at £34, or 8 per cent of the total cost per 'slight' casualty.

5.2.6 Casualties with 'slight' injuries - revised estimates

The preliminary results from the studies in Manchester outlined in Section 5.2.4 were used to estimate average figures for working days lost per casualty with 'slight' injuries requiring hospital treatment. The 'whiplash' patients lost 31 working days in year 1 on average, and a further 11 days in year 2. It was assumed that all these days were lost in the 16-59 year age group. The other patients with 'slight' injuries aged 16-59 lost 13 days and those over 60 lost 2 days in the first year; almost all of this time was lost in the first 6 months after the accident.

About half of the total number of days lost by the 16-59 year olds was time off work taken by 7 individuals, who all had between 100 and 200 days off sick. Their injuries, although classified as 'slight', meant that they were unable to carry out tasks required for their work; several had back and neck sprains, one had a dislocation and one had blurred vision brought on by the stress resulting from the accident. One was made redundant after 198 days, and another took early retirement after 186 days. Clearly these individuals had a substantial effect on the average figure for lost output, but there is no reason to believe that another sample of casualties with injuries classified as 'slight' would not also include a few extreme cases where the effect of the injury was to prevent the casualty carrying out the physical tasks required for their occupation over a prolonged period of time. It was however considered that some downward adjustment of the figures should be made, to reflect the fact that a large proportion of the estimate of lost working days was based on a few cases, and that while the research to derive the final estimates of lost output is still in progress, it would be appropriate to be cautious in estimating lost output.

Before weighting the figures, an allowance had to be made for the casualties recorded by the police as 'slight' who did not require hospital treatment. Given the data on length of time off work for in-patients it was assumed that those who were not in-patients took 2-3 days off work, rather than the 1 day previously assumed by Dawson. Assuming that this group took 2 or 3 days off work as a result of their injuries reduced the average number of days lost by 16-59 year olds to 13. Taking account of the fact that about half of this time was accounted for by 7 individuals in a relatively small sample, it was decided to estimate lost output on the basis of a round figure of 10 days lost per 'slight' casualty aged 16-59.

The method used in the calculation for lost output for 'slight' injuries was similar to that used for 'serious' injuries. The weighted average number of days off work estimated from the Manchester study for year 1 provided the figure for the 80 per cent of non-whiplash casualties who were all assumed to recover within a year. Following the assumptions used in estimating the value of avoidance of a 'slight' injury, it was assumed that half of 'whiplash' casualties were equivalent to injury group W (and therefore recover in less than a year), while the other half take on average two years to recover. For the 10 per cent of 'slight' casualties who were assumed to take more than a year to recover, a 6 per cent discount rate and 2 per cent growth rate were applied to estimate the present value of their lost earnings in the second year. Table 12 shows the value of lost output per casualty in the first year, the value per casualty taking between 1 and 3 years to recover, and the weighted sum assuming that 90 per cent recover in the first year.

These estimates are over 30 times higher than the uprated values of the figures estimated by Dawson. His assumption that injuries classified by the police and DoT as 'slight' were so minor that they would only lead to one day off work on average was clearly an under-estimate of the severity of 'slight' injuries and their consequences. 'Whiplash' injuries clearly have a more severe disabling effect than other injuries classified as 'slight', and at the time when Dawson was working, such injuries were less common and little was known about their effects. However, even the number of days off work in the first year taken by non-whiplash patients was on average several times greater than Dawson assumed to be the case for all 'slight' injuries.

6. INTERNATIONAL COMPARISONS: CASUALTY-RELATED COSTS

Most developed countries put a value on road safety. Section 2 showed that there are a variety of approaches to placing a cost on road accidents or a value on their prevention: human capital (based on either gross or net

TABLE 12

Estimated lost output per 'slight' casualty

Recovery period	Male	Female	All casualties
Up to one year	£408	£284	£333
1-3 years ('whiplash')	£9,057	£6,617	£7,312
Weighted sum	£1,273	£917	£1,031

output); life insurance; court awards; implicit public sector valuation; and willingness to pay. The experts consulted by DoT concluded that if values are to be used in cost benefit analysis then the willingness to pay approach is theoretically superior. This view is widely accepted in other countries as the approach enables the preferences of the road users to be taken into account in investment decisions; however due to the difficulties involved in measuring people's WTP, many countries use other approaches or combinations of approaches.

Estimates of casualty-related costs in developed countries involve combining a number of elements. Common to all calculations are values for: medical costs; estimates of lost output; and a subjective element for either 'pain grief and suffering' or willingness to pay type values, representing the welfare element in the costs of preventing road traffic accidents. Other less common elements included in casualty-related costs are house conversion costs resulting from disability, hospital visiting costs, as included in Dutch calculations, and funeral costs, as in the USA.

This section summarises the range of methods used in other countries, and the types of information which form the basis of the resulting estimates of casualty-related costs.

6.1 METHODS OF CALCULATING LOST OUTPUT

For lost output calculations there are a variety of approaches that can be adopted. As can be seen from the latest calculations described in Section 5.2, many assumptions have to be made and many of these depend on the overall approach to costing of accidents. There is the question of whether to use gross or net values. Typically, those countries that do not include WTP elements in their costs tend to use gross output values - such as France, Belgium, Norway and Germany. Very few countries include WTP, and those that do tend to use net lost output for costing fatalities - such as Sweden, Finland and New Zealand. Others use net output if other elements, such as 'pain, grief and suffering', are seen as taking account of loss of consumption. Interestingly, the USA and Switzerland use gross lost output values; the latter then combines them with an estimate for 'the social willingness to pay' i.e. the marginal cost of a life.

In some cases the figure for average per capita earnings is used rather than a distribution of average earnings; this is said to take account of the black market and other productive activities that are not reported in the distribution of workers' wages. The value of unpaid contributions to productivity can also be taken account of by adjusting activity rates to include them. In the USA, household productivity is valued at the market value, so for example domestic chores are valued at the average wages paid for professional maid services. Household productivity is measured for both full time and part time house keepers and those with careers outside the home. Miller (1991) estimated that for all injured persons, an average of 2.1 hours per day were devoted to household production activities, and that these occurred every day of the week, rather than for the standard working week. There are also differences in definitions of the working population and ages at which people start work and retire. In Luxembourg, for example, it is assumed that people work from the age of 20. There are also simple differences in the definition of the number of working days per year - the USA valuations assume 243 days whereas the estimates in this report are based on 300 days.

The other main area of difference in lost output calculations is in discount rates. There is no definitive discount rate for the calculation of lost output: a variety of rates could be justified. Ideally, if using the willingness to pay approach, the individuals' time preference rate would be used, but this is difficult to gauge. Also, the individuals' rate of return on investment might be used, rather than the rate of return in all markets. It could be argued that an even higher rate is more appropriate since the final values are to be used in public sector cost-benefit analysis. A broad range of values for discount and growth rates are used in different countries; Germany uses a 0 per cent discount rate and a 1 per cent growth rate; while at the other extreme France and New Zealand use a 10 per cent discount rate and a 2 per cent growth rate; and in Austria it is assumed that in the long term the social time preference and growth rate will be equal. A study by Miller et al (1984) recommends a 4 per cent discount rate, which is currently used in the USA and is considered to reflect individuals' social time preferences.

6.2 MEDICAL AND SUPPORT COSTS

Often it is impossible to obtain medical data on every casualty and estimates have to be made. In Belgium, the calculations are based on average costs of treatment following accidents at work in transport undertakings. In Germany, a sample of 6,000 cases of sickness or accident between 1979-1980 is used as the basis for estimating medical costs. In the Netherlands, it is possible to identify road accident casualty in-patients both in hospital and in care/rehabilitation; to cost medical operations, the average cost of an operation is multiplied by 90 per cent of the number of road accident victims, implying that 90 per cent of casualties are operated upon. Also in the Netherlands house conversion costs are included; the average cost of conversion is multiplied by a fixed percentage of those disabled as a result of a road accident. In Norway, medical costs are based on average hospital costs but it is assumed that the cost of treating road accident casualties is higher than average. The cost of caring for disabled people is estimated for new additions to this category annually, but this underestimates the total costs. In the USA, the medical costs of fatalities are based on a study of trauma deaths in Maryland in 1986 (Rice et al, 1989). Funeral costs in the USA are calculated by taking the difference between the value of funeral costs in the present and the value at the end of the expected life span, discounted at 4 per cent.

6.3 DISABILITY AND LOST OUTPUT

Medical data are also used in lost output calculations, providing details of life expectancy and disability following injury. In the Netherlands, people who are disabled for more than a year after the accident are separated into two groups: those that recover within 14 years and those that do not recover within 14 years (who are assumed to be disabled for a further 15 years, i.e. the average remaining lifetime). In Austria, it is assumed that 70 per cent of out-patient treatment time is actual work lost. The German calculation assumes that casualties are 25 per cent unfit for work for a period of five years after the accident. In Sweden, days off sick are estimated on the basis of industrial accident statistics for varying degrees of injury. In Luxembourg, casualty cost calculations assume that severely injured casualties are 40 years old, and assumptions are then made about the length of time off work: all are assumed to be unable to work for 6 months, between 100 per cent and 20 per cent unable to work for the next 6 months and then 20 per cent unable to work for their remaining lifetime. In the USA, casualty costs are based on the MAIS (threat to life) score and data from a large sample of industrial compensation claims; it is assumed that casualties with injuries scoring MAIS 4 or 5 will have permanent and total disability (Blincoe and Faigin, 1992).

Research in the USA found that people in the workforce suffering 'minor' injuries in road accidents lost an average of 3.2 working days (Miller and Luchter, 1988).

Insurance data on compensation and court awards are also used for costing personal injury. The values produced by insurance companies are frequently modified in calculations of the costs of accidents to take account of unreported accidents and uninsured persons and the fact that they only take account of the innocent party. In Luxembourg, the insurance costs for personal injury are multiplied by a coefficient, estimated by dividing the total sum of damage to people by total compensation for personal damage. Court awards or insurance data are not always available, so for example in Germany it is assumed that half of all transport users are insured and that 40 per cent of all legal disputes are made as a result of road traffic accidents.

6.4 'PAIN, GRIEF AND SUFFERING' AND WILLINGNESS TO PAY

In some countries, such as Austria, insurance companies compensate victims for private costs of the accident and their pain, grief and suffering, and the value of compensation awards can be used for accident costing. Court awards are also used as a proxy for the cost of 'pain, grief and suffering', as in Belgium, France and Austria, and are often referred to as 'grief payments'. In Spain, the subjective costs of grief, pain and suffering of fatal casualties and those who are permanently disabled are set at 50 per cent of the value of lost production.

Elsewhere, values for prevention of accidents are estimated on the basis of users' Willingness To Pay, i.e. a welfare loss estimate. In Finland a value for minimum welfare loss is included, which is society's willingness to pay to provide resources to care for the victim. In Switzerland, there is a similar element termed 'risk induced costs' which is a marginal value for saving a life. This social WTP depends on the extent to which a person can influence the accident risk. Sweden, like Great Britain, uses willingness to pay estimates in valuing fatalities, while for non-fatal casualties an estimate is made of quality-adjusted life years using a general health index. In addition, the USA uses WTP methods to estimate the 'value of a life'.

6.5 THE VALUE OF AVOIDING ROAD ACCIDENT CASUALTIES

A comparison of values in Europe was produced by COST 313[3] (Willeke and Beyhoff 1990). Costs, in ECUs, are given per fatality. The highest values were for countries that incorporated WTP elements such as Finland, Sweden, Switzerland and Great Britain. The next highest values, from Austria and the Federal Republic of Germany, used gross values for lost output and did not incorporate a discount rate.

The valuation methods for fatalities in New Zealand and the USA are very similar to those used since 1988 in Great Britain, and the actual monetary values are very close; the figure for New Zealand is equivalent to about £650,000 and for the USA is a minimum value of £780,000, in 1992 prices.

From the same European review of methods for calculating accident costs, it is possible to consider the value of severe injuries relative to the value of fatalities. Such comparisons must be treated carefully because the definitions of fatal and serious casualties vary between countries. Estimates of the costs of severe casualties range from 0.7 per cent of the value of a fatality in Finland to nearly 29 per cent in Portugal. Sweden has the next highest value of a severe injury in relation to its value of a fatality - at 14 per cent, followed by Belgium - 11 per cent, Spain - 10 per cent, and France - 9 per cent. The ratios for Germany, Norway and Austria were between 3 and 5 per cent. By comparison, the revised cost per casualty in Great Britain which is shown in the following section is 10 per cent of the cost of a fatal casualty. It is also worth noting that in some countries, the resource costs associated with severely injured casualties may be higher than the value of fatalities.

In all calculations of casualty costs, a number of assumptions and estimates have to be made due to the lack of comprehensive economic, accident and health data. This can result in wide variations in values using the same broad approach. This revision of the casualty costs for Great Britain represents a significant improvement, and as better data become available further improvements to the calculation of the human capital elements will be made.

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[3] COST 313 is a Committee of European representatives of transport policy makers and researchers, who's objective is to put a value on the socio-economic cost of road accidents. It is set up by the EC as part of European Co-operation in the Field of Scientific and Technical Research.

7. SUMMARY OF REVISED CASUALTY-RELATED COSTS

This section brings together the estimates presented for the various components of casualty-related costs in the earlier part of the report. It is important to bear in mind that these represent an interim revision of the figures; the figures which formed the basis for estimating lost output for 'serious' and 'slight' casualties will be revised when the research projects on the consequences of road accident injuries are complete, and this research will also enable up-to-date estimates of medical, support service and ambulance costs to be developed.

Improvements in the data available in future will enable further refinements to be made to the estimates of the value of avoidance of injuries, and of the number of road accident casualties with different degrees of injury and disability, which will in turn affect estimates of lost output and medical and support costs. The national sample hospital survey which is commencing in November 1992 will be an important source of information, while research on disability scaling for road accident injuries will enable better predictions of the long term consequences of such injuries to be made.

It is also important to stress that these estimates of casualty-related costs represent minimum values for the benefit to the economy of reducing the risk of injury for accidents recorded in Stats19. As mentioned in Section 2.5, consequences of disability such as the reduction in life expectancy and the cost to carers, are not included, while it has only been possible to value personal safety, rather than taking account of the value of other people's safety as well.

The revised estimates of the value of avoidance of injury and lost output, combined with the current estimates of medical and ambulance costs, result in a doubling of the average cost per casualty compared with the previous methods. Table 13 shows that the average cost per casualty is now estimated at £27,000 compared with the current figure of £14,000 shown in Table 1. It is likely that the research on medical and support costs will result in some further increase in the estimated average cost per casualty.

At this interim stage in revising the cost estimates, the value of avoidance of injury accounts for a larger proportion of the costs than in the previous estimates. In the case of 'serious' injuries, this element comprises 85 per cent of the costs, compared with a figure of 75 per cent from the figures in Table 2; for 'slight' casualties, this has increased from 65 per cent to 79 per cent. For non-fatal injuries, the share of the casualty costs represented by lost output has increased, and the relative contribution of medical costs has decreased; this may be a temporary feature until the medical costs have been revised.

The arbitrary 'pain, grief and suffering' value for 'slight' casualties was set at 2 per cent of the value for 'serious' injuries; the willingness to pay value for the of avoidance of a 'slight' injury is 8 per cent of the value for a 'serious' injury. The value of lost output for 'slight' casualties was 1 per cent of the value for 'serious' casualties in the previous estimates, and is now 13 per cent of the value of lost output for a 'serious' casualty. Thus the overall value of a 'slight' casualty has moved closer to the value of a 'serious' injury. Much of the increase in the value of 'slight' casualty costs is due to the inclusion of whiplash injuries within this category which have been found to have much higher costs.

The increases in the casualty-related costs can be explained by three main factors. The introduction of the willingness to pay approach based on surveys of the general public, superseding the arbitrary amounts for 'pain, grief and suffering', has increased the contribution of the 'subjective' element of costs and linked the values directly with the value of a fatality. The lost output element has been estimated on the basis of better information on time off work following road accidents, and more refined techniques for estimating loss of earnings. The estimates for both lost output and the value of avoidance of injury have benefited from better information on the nature of road accident injuries, and on their consequences in terms of recovery rates and the extent of long term disability.

TABLE 13

Summary of revised costs per casualty: June 1990

Severity	Lost output	Value of avoidance of injury	Medical & Ambulance	Total
Fatal	£46,828	£617,672	£434	£664,930
Serious	£8,230	£58,494	£2,499	£69,220
Slight	£1,031	£4,405	£112	£5,550
Average	£3,007	£23,373	£540	£26,920

Comparison of Tables 1 and 14 shows that the revised estimates represent more than a 3-fold increase in the cost of 'serious' casualties and a 13-fold increase in the cost of 'slight' casualties.

The revision of the casualty-related costs affects the average cost per accident. Table 14 shows the revised accident costs, taking account of these revised casualty costs. Compared with the previous figures shown in Tables 1 and 2, the average cost of a fatal accident in 1990 increases by 3 per cent and the average cost of a 'serious' accident and a 'slight' accident increases by more than three times. These changes also affect the relative size of the total cost of accidents of different levels of severity. The total cost of 'serious' accidents is now higher than the cost of 'fatal' accidents, while the total cost of 'slight' accidents is higher than the cost of 'damage-only' accidents; however the research on accident-related costs may affect the relative scale of damage-only accident costs. Together, the increases in casualty-related costs mean an increase in the total cost of injury accidents on the roads of Great Britain in 1990 from £5,300 million to £9,700 million; total accident costs increase by 65 per cent from £6,800 million to £11,200 million.

In 1991 prices, the costs per casualty shown in Table 13 are: £683,200 per fatality, £71,000 per casualty with 'serious' injuries and £5,800 per casualty with 'slight' injuries. When these figures are applied to the number of accidents and casualties recorded in 1991, and the accident and casualty-related costs are uprated for inflation and GDP growth, then the costs per accident in 1991 were: £786,480 per fatal accident, £85,990 per 'serious' accident, £9,290 per 'slight' accident and £960 per damage only accident. The total costs of injury accidents in 1991 were £8,779 million. This is slightly lower than the cost in 1990 because fewer accidents were recorded in 1991 than in 1990, and in particular, fatal accidents were down by 12%.

The methods introduced for valuing non-fatal injuries and the revision of the estimates for lost output for fatalities have brought the methods used for costing fatal and non-fatal road accident injuries into line, so that the costs are on a consistent basis. When the results are used in evaluation of local road safety schemes, and decisions on road safety priorities, the effect of these changes will be to raise the relative priority given to saving injury accidents.

The increase in the average cost per casualty overall will result in raising the prominence of accident savings relative to time savings where COBA is used to evaluate road schemes. The proportion of the benefits of the average COBA scheme accounted for by accident savings will increase from about 15% to about 25%.

The adoption of the willingness to pay approach to valuing personal safety, and the refinement of the estimates of lost output, have brought the methodology used to value road accident injuries in Great Britain into line with current thinking in road safety world-wide. The improvement in methods for eliciting willingness to pay values through the research summarised here represents a significant advance, and as better data become available, further improvements in estimates of the human capital element of casualty costs in Great Britain will be made.

8. ACKNOWLEDGEMENTS

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TABLE 14

Revised accident costs: 1990

Severity	Cost per accident (£)	Total accident cost (£M)
Fatal	767,500	3,644
Serious	84,320	4,296
Slight	8,860	1,796
Damage only	950	1,426
All	14,070	11,193

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APPENDIX A

Department of Transport definitions of injury severity of road accident casualties

Fatal

Death from a road accident which occurs within 30 days of the accident.

Serious

Casualties who die as a result of their injuries more than 30 days after the accident.

All casualties who are admitted to hospital as an in-patient as a result of their injuries.

Casualties who are not detained in hospital but have any of the following injuries are also included: fractures, concussion, internal injuries, crushings, severe lacerations, and severe general shock requiring medical treatment.

Slight

Casualties with injuries such as a sprain, bruise or cut which are not judged to be severe, or slight shock requiring roadside attention.

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